The Effect of Mergers on US Bank Risk in the Short Run and in the Long Run

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Abstract

We examine changes in risk following US bank mergers in the period 1981-2014. Short-run (two-year) increases in acquirer risk following mergers occur only in the first few mergers undertaken by the same acquirer, not in the later ones. They occur only in the stocks' sensitivity to banking industry risk and not in bank-specific risk. The equity volatility of acquirers does not increase, but diversification benefits are entirely dissipated. Using a new approach to measure the long-run effect we find that these results persist, consistent with banks maintaining a constant level of total equity risk in the long run. We measure the loss of diversification of the US bank industry associated with mergers and find it to be 40% of the risk level in 1981. Almost all of this occurred prior to 2004. In addition, there has been a large increase in correlations between the largest banks, much of which has come from sources other than mergers.

JEL classification: G01, G21, G28, G32, G34

Key words: Bank mergers, bank risk, bank regulation, too big to fail, concentration-fragility

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1. Introduction

In the last forty years the structure of the US banking industry has changed beyond recognition. In 1980 there were 14,434 FDIC-insured commercial banks in the United States. By March 2018 this number had fallen to 4,880. Much of this change has happened by merger, with very large banks emerging from successive combinations between smaller banks. A result of these mergers is that the major acquirers during this period now account for a much larger proportion of bank assets than 40 years ago. In 1980 Bank of America owned less than 0.5% of commercial bank assets. In March 2018 it accounted for 14%. Its assets are over 500,000 times those of the smallest bank. Between them the six largest banks in the United States account for 64% of US commercial bank assets. The 5,000 or so other banks account for the remaining 36%.

The increased concentration of the industry has led to concerns about the effect of mergers on bank risk. Some specific questions are whether the diversification benefits from mergers have reduced the risk of merging banks, whether the motive for merger has been to increase risk and to exploit the bank's "too big to fail" quality or the depositor put, what has been the overall effect of the large number of mergers on the risk of the industry, and what would be the likely effect of breaking up major banks.

In this study we use a large sample of US bank mergers between 1981 and 2014 to measure the effect of mergers on the equity and asset risk of merging banks. We first measure short-run changes and then apply a new methodology to check whether these results hold in the long run. All results are consistent with banks having fully dissipated the potential diversification gains from the mergers they have made. Rather than their total risk decreasing, as would have been the case if the diversification benefits of the mergers had persisted after merger, the total risk of their assets and equity remained unchanged. This is consistent with the risk characteristics of the target firm converging to those of the acquirer. It is not, however, consistent with aggressive exploitation of the depositor put, the value of which increases with total volatility.

The only significant change in risk that is associated with mergers is an increase in systematic risk, measured by the beta with respect to the bank index and correlation with that index. This occurs only for mergers early in the sequence by a single acquirer and not for later ones. For the major acquirers in our sample, changes in all risk measures are insignificant for all mergers beyond the fifth. Given the importance of these banks in the sample, measurement of the effect of mergers on risk is misleading if it ignores the dependence on the position of the merger in a sequence by a single acquirer.

To assist with the thought experiment of what would happen if mergers could be reversed, we measure the lost diversification gains from the mergers undertaken by the five largest acquirers. As discussed above, these are a large part of the banking industry at the end of the period, and their mergers are a large part of our sample. To measure the lost diversification we track the entire portfolio of precursor banks in the 'tree' of mergers leading to these survivors. The total diversification benefit dissipated by these banks is 40% of their 1981 risk level. Almost all of this occurred before 2004, primarily because the later mergers by these major banks involved combining banks that were highly correlated before the merger. This high correlation had arisen mainly from sources other than mergers.

Thus the two big risk effects we find to be related to mergers, dissipation of diversification benefits and increases in systematic risk, both occurred for the early mergers by the major acquirers but not for the later ones. In the Conclusions section we discuss the implications of this for policy.

We make three methodological innovations. First, we show that the position of the merger in a sequence is an important variable in explaining the impact of the merger on risk. This is not subsumed by other variables such as size. Second and third, we introduce two new ways of measuring the long-run effect of mergers on risk. To measure the long-run effect on the risk of the acquirer we use the 'Last-First' method where the unit of analysis is a single acquirer which may have made multiple acquisitions. The dependent variable is the change in risk from just before the first merger to just after the last. Explanatory variables are measured to be consistent with this. To measure the long-run impact of lost diversification benefit relative to the portfolio of merged firms, we introduce the 'Tree' method, which tracks the risk of the entire portfolio of precursor firms that eventually result in a single major acquirer. Each of these innovations contributes significantly to the measurement and interpretation of the effects we find in this study.

Where the long-run results differ from the short-run results, such as in the effect of the early mergers that resulted in increased geographic diversification, we show that they are more consistent with other evidence than are the short-run results.

The next section reviews the literature, develops the hypotheses, and explains the methodology. Section 3 describes the data. Sections 4 and 5 give the main results for short-run and long-run risk changes. Section 6 presents robustness tests. Section 7 gives conclusions.

2. Literature review, hypotheses, and methodology

2.1 Literature review

Our study is related to several strands of literature: measurement of the short-run effect of bank mergers on risk, the more limited number of investigations of the long-run effects of mergers on risk, studies of the time-series properties of risk changes, and the debate about the causes and consequences of bank risk. In this section we briefly summarize some relevant literature and develop hypotheses about the long-run impact of bank mergers on risk.

The standard way to estimate the short-run effect of bank mergers on risk is an event study. The typical event study pools all mergers and uses control variables to adjust for the effect of variables such as the size of the acquirer, the relative size of the target, and changes in industry risk. These studies have obtained mixed results. Some have found evidence that diversification from bank mergers reduces risk (Craig and Cabral dos Santos (1997), Emmons et al (2004), Mishra et al (2005)). Others reject the hypothesis that post-merger risk is equal to the risk of the pre-merger portfolio of the acquirer and target (Shaffer (1994), Akhavein et al (1997), Baele et al (2007), Lepetit et al (2008), Mercieca et al (2007)).

Other studies have found no evidence of risk-reduction from diversification but also no increase in acquirer risk (Amihud et al (2002)), Vallascas and Hagendorff (2011)). In some recent studies, not only is there no benefit from diversification but acquirer risk is found to increase following merger (Weiβ et al (2014)). Partly, the difference in results may be due to different sample periods and measurement windows. Different studies also use different measures of risk. These have included default probability and distance to default (Emmons et al (2004), Vallascas and Hagendorff (2011)), volatility of accounting rates of return (Craig and Cabral dos Santos (1997)), and measures of systemic risk such as marginal expected shortfall and lower tail dependence (Vallascas and Hagendorff (2010), Knapp and Gart (2014), Weiβ et al (2014)).

In a broader context, Furfine and Rosen (2009) have tested whether mergers in general increase or decrease default risk and found that on average they increase default risk despite the potential for diversification. Their results suggest that the increased default risk may arise from aggressive managerial actions that increase risk following a merger. Consistent with the view that mergers increase risk for the acquirer Carbo-Valverde et al. (2012) suggest that European bank mergers between 1993 and 2004 were primarily driven by the bidders' wish to shift risk onto the EU safety nets. Similarly, Weiβ et al (2014) find that bank mergers not only dissipate the gains from diversification but that they even increase the equity risk of the acquirer either because of an increase in operating risk or an increase in financial leverage. This may occur because the acquiring bank wishes to exploit their "too big to fail" trait or because greater market power may allow the bank to

increase the interest rates on its loans, which will in turn eliminate the least risky' customers (the "concentration-fragility" hypothesis).

Regarding the long-run effect of mergers on risk, Bharath and Wu (2006) show that for US mergers there is a difference between short-run and long-run effects. They show that "... the increase in volatility following a merger is at least in part due to post-merger integration risk, and the risk is greater and lasts longer for firms that make multiple acquisitions." There is also evidence that acquirers modify the operations of the target to have a level of risk similar to their own (Craig and Cabral dos Santos (1997)). This is consistent with acquiring banks having a stable risk-culture, which leads them to maintain a constant level of risk in the long run (Fahlenbrach et al (2012)). Similarly, Sarin and Summers (2016) find that bank risk appears to be relatively unresponsive to regulatory changes.

There is an added complexity for the very important set of banks that have engaged in many mergers. Bharath and Wu (2006) show that the average effect on risk of a sequence of mergers is not the same as that of a single merger. Also, Weiβ et al (2014) find that larger banks and less risky banks have smaller increases in risk from merger. As the multiple acquirers in our sample have merged with successive targets, they have become larger and more risky, implying that the incremental effect of mergers on risk should have changed as their characteristics changed.

In a related result, studies of changes in risk following non-bank corporate events find that risk changes are smaller in the long run (Pan et al (2015)). An information-based model suggests that measures of volatility may rise in the short run because of uncertainty about the effect of a change in management, but then decay back to their previous levels as that uncertainty is resolved. This effect is likely to be less pronounced for measures of industry-related risk.

2.2 Hypotheses

Our tests are related to various hypotheses about the way banks manage their risk. Some of these hypotheses could have several interpretations in terms of what they imply for bank risk changes around mergers. In this section we say how we interpret them.

One hypothesis that has been conclusively rejected in previous work is that the acquirer's post-merger risk is the same as that of the pre-merger portfolio of merged firms. We also conclusively reject that hypothesis, and instead adopt a set of hypotheses that relate the post-merger risk of the acquirer to the pre-merger risk of the acquirer.

Two related hypotheses are *risk convergence* and *risk culture persistence*. These both say that the risk of the acquirer is constant in the long run. Risk convergence says that the operating characteristics of the target bank converge to those of the acquiring bank so that the asset risk of the acquiring bank is constant. Similarly, *risk culture persistence* says that banks maintain a constant level of equity risk in the long run, the difference from risk convergence being that this also includes the effect of leverage choices. In summary:

H1: The risk of the acquirer is constant in the long run. Version H1(A): Asset risk convergence: Asset risk is constant. Version H1(B): Risk culture persistence: Equity risk is constant.

Both asset risk convergence and risk culture persistence imply that potential diversification gains are dissipated. Either the acquirer takes on higher risk activities to offset the benefits of diversification, or the effect of imposing the acquirer's structure and operating system on the target offsets the diversification benefits that existed when the two banks operated independently.[1] Also, both could apply in the long run even if they do not show up in short-run risk changes. Changes in operating characteristics and leverage take time to implement and their effects could show up only after several years.

Two alternative hypotheses imply that banks increase risk after mergers. One is that they do this in order to take advantage of either the *depositor put* or their *"too-big-to-fail"* protection (John et al. (1991)). A bank seeking to exploit the depositor put would need to increase total volatility, since the value of the put option depends on total volatility rather than systematic risk:

H2: Depositor put exploitation: Banks increase asset and equity volatility after mergers.

Another hypothesis which implies increased risk is the *concentration-fragility* hypothesis, which we take to imply that mergers will be followed by increased levels of industry-related risk, but not necessarily increased specific risk (Winton (2000), Kane (2000), Campa and Hernando (2008), Carbo-Valverde and Kane (2008), and Uhde and Heimeshoff, 2009, Weiß et al (2012)):

H3: Concentration-fragility: Industry-related risk of banks increases after mergers.

Unlike asset risk convergence and risk culture persistence, these hypotheses are not explicit about whether the changes should show up in the short run or in the long run.

[1] A striking example of how mergers can increase idiosyncratic risk occurred with the creation of Mizuho Bank by the merger of three banks. The decision to link the computer systems of the three banks created a substantial idiosyncratic risk that became apparent when Mizuho experienced the biggest banking system failure in history.

In addition to these hypotheses about the nature of risk changes resulting from mergers, we also hypothesize that the effect of a bank merger on risk depends on its position in the sequence of mergers undertaken by a single bank. For example, the potential diversification gains decline as more mergers are undertaken. Also, the capital market may anticipate future mergers. Even if these mergers will increase operating risk, that effect may be impounded into the behavior of the acquirer's share price following the first merger. Hence the signal about risk given by a merger is likely to depend on the prior history of mergers by that bank, resulting in this dependence:

H4: Sequence dependence: The effect of a merger on risk depends on its position in the sequence by that acquirer.

In the Conclusions section below we summarise the implications of our results for these hypotheses and the related issue of regulatory policy.

2.3 Methodology

We use three techniques to improve the econometric properties of our tests of the effect of mergers on risk. First, in all our tests we use the information regarding the standard error of the risk estimates to calculate the variance of the change in risk measures. Denote Y_B as a risk measure before a merger and Y_A as the same risk measure after a merger. Denote S_A and S_B as the standard errors of these. The risk change is $y = Y_A - Y_B$ with an estimated variance of $(S_A^2 + S_B^2)$. We use the inverse of this variance to calculate precision-weighted means in our tests of averages, and we also use it as the weight in our weighted least squares procedures. As discussed below, this significantly increases the power of our tests and controls for the high degree of non-normality of some variables. Appendix 1 describes the way we use the standard errors.

In the tests of short-run risk changes, the unit of measurement is a single merger and the variable y is measured as the change in risk from before until after that single merger. Denote the change in risk for the jth merger in the sample as y_j, and the explanatory variables for that merger as the vector X_j. The regression for short term risk changes is:

$$y_j = a + bX_j + \text{error}$$

Our second innovation is to control for the position in the merger sequence by including two dummies: 2-5 acquisition is a dummy that takes the value of 1 if the acquisition is between the 2nd and 5th made by that acquirer, 6+ acquisition is a dummy that takes the value of 1 if the acquisition is between the 6th and 30th made by that acquirer. We also control for the following: change in bank leverage is the change in leverage between the year prior to the merger announcement and the first full year after

completion from the Compustat banking file, where leverage is defined as the book value of long-term debt/(book value of long-term debt + market value of stockholders' equity), Change in index volatility is the change in the volatility of the equally weighted bank index between the pre-merger and post-merger periods, Relative size is the ratio of the market capitalization of the target 28 days before the merger announcement to that of the acquirer, Acquirer size is the log of the market capitalization of the acquirer 28 days before the merger announcement standardized by changes in the market capitalization of the bank index[2], Change in loan-to-deposit ratio is the change in the ratio of loans (net of total allowance for loan losses) to total deposits between the pre- and post-merger periods, from the Compustat file, In-state is a dummy that takes the value of 1 for in-state mergers, Hot period: is the number of mergers in our sample occurring within 100 days of each merger. The Hot period variable is highly correlated with the merger wave that occurred in the period 1992-98 following geographic deregulation and we also examine the effect of that period.

We measure acquirer size, the proportion of the target, and the hot-merger-period variable as deviations from the sample average. Thus the constant term measures the change in risk in an average merger period, for a merger that is the first merger in the sequence, has average acquirer size, average target proportion, has no change in leverage or in the loan-to-deposit ratio, is out-of-state and where there is no change in the volatility index. The fixed effects for later cohorts are calculated by adding the coefficient of their dummies to the constant.

The regressions differ by the measure of risk (volatility, beta, residual risk, and correlation with the banking index), by pre-merger benchmark (portfolio of acquirer and target or just acquirer), and whether it is asset or equity risk that is used. The four hypotheses correspond to the following:

H1: There is no significant constant term for any risk measure or any cohort when the acquirer is used as the pre-merger benchmark.

H2: The total risk of the acquirer increases after merger, especially for large acquisitions.

H3: The systematic risk of the acquirer relative to the banking industry increases after merger.

H4: The change in risk is smaller for later mergers in a sequence by a single acquirer.

Our third innovation concerns measurement of the long-run effect of multiple mergers. To do this we use a technique which we call 'Last-First'. This applies to those changes that use the acquirer as the pre-merger benchmark. The unit of measurement becomes a single acquirer, regardless of the

[2] An alternative would be to use book assets as a measure of size. However, this is neither available on a daily basis nor for our whole sample of banks.

number of mergers that they have undertaken. The risk measure Y_B is the risk just before the first merger undertaken by that acquirer, and the risk measure Y_A is the risk just after the last merger by that acquirer. Thus the risk change, y, measures the cumulative change across the entire merger program. Note that the period of measurement for this variable depends on the timing of the first and last mergers by that acquirer, and is therefore different for different acquirers. We divide the cumulative risk change by the number of mergers, n, to give the average change in each risk measure for the mergers made by an acquirer, and we use that as the dependent variable for the firm. We use the inverse of the estimated variance of this average as the weight in the precision-weighted average change, and also in the weighted least squares procedure when we regress the change in risk on explanatory variables. In that regression the unit of observation is a single acquirer, rather than a single merger. The independent variables are measured in a way that is consistent with the dependent variable. For example, changes in market volatility are measured as averages across the mergers and cohort variables are measured as the proportion of mergers by that acquirer which fall within that cohort. The interpretation of the hypotheses is the same as for the short-run tests.

When examining the long-run effect of mergers on an acquirer with multiple mergers, the last-first method has several advantages over the event study method. Appendix 2 shows that it is more powerful, in the sense of having a lower standard error of measurement of the average change. It also captures any changes in risk that occur outside the event-study periods. For example, it captures any serial dependence in the risk changes for the same acquirer. Unlike the event study method, it deals easily with overlapping windows, when an acquirer undertakes more than one merger in a short time period. It is, thus, a more precise indication of the effect of multiple mergers on risk than extrapolation of the results of an event study. The unit of analysis is the cumulative effect of a given number of mergers rather than simply the passage of a given amount of calendar time. This is consistent with our finding that early mergers by a single acquirer have very different effects on risk than later mergers. It also has the advantage that the period of measurement is different for different acquirers, since it is determined by the acquirer-specific dates of the first and last mergers. This limits the degree of correlation of the residuals between results for different acquirers and thereby improves the quality of the estimation.

The 'last-first' method measures long-run changes where the acquirer serves as the pre-merger benchmark. It is harder to examine long-run hypotheses about changes in risk relative to the pre-merger *portfolio* of banks. When a bank has made multiple acquisitions, the pre-merger portfolio at the beginning of a sequence of mergers includes all banks that have been subsumed by the bank that emerges at the end of the entire period. Hence, to calculate the risk of this portfolio it is necessary to

reconstitute the 'tree' of all individual banks that ultimately became part of the survivor bank. We undertake this exercise for five large banks, each of which emerged from the effect of many mergers. These five banks comprise a large proportion of the US bank sector at the end of the data period. For each of these banks we calculate the cumulative difference between their risk at the end of the period and the risk of the entire portfolio of precursor banks that comprise them.

3. Data

3.1 Merger sample

Our sample consists of all completed unconditional mergers[3] on SDC Platinum between January 1981 and December 2014 where:

1. The acquirer's ultimate parent and the target were public US-registered banks, bank holding companies, or savings institutions.[4]
2. The merger involved the acquisition of 100% of the target's equity;
3. Returns for the acquirer were available on CRSP.[5]

The result was a sample of 1,668 mergers with announcement dates after December 31 1980 and completion dates before January 1 2015. These mergers involve over 60% of the US banks with data on the CRSP security file. Of the total sample, returns data were available for the acquiring bank for 1,613 mergers and for both the acquirer and target banks for 1,108 mergers. The larger sample involved 401 separate acquirers, of which 248 undertook more than one acquisition. About 60% of the mergers were between two national, or state, chartered banks, and a further 20% involved the acquisition of a savings institution by a chartered bank. The sample does not include all mergers by each acquirer. In particular it omits acquisitions of overseas banks and unlisted banks. It omits partial acquisitions including purchases and disposal of assets such as bank branches and acquisition of bank shares as part of investment banking activities.

For some of our tests we use measures of asset risk calculated by deleveraging the equity returns. Availability of leverage data restricts the sample slightly, to give 1,364 mergers where we can measure

[3] We use the term "merger" to denote any combination of banks.
[4] These were defined by the following SIC codes: SIC 6021, 6022, and 6029 (commercial banks), 6035, and 6036 (savings institutions), and 6712 (bank holding companies).
[5] For inclusion in the sample returns data were required for 20 weeks before the announcement of the merger until 20 weeks after completion.

acquirer asset risk before and after the merger and 715 where we can also measure the risk of the portfolio of acquirer and target before the merger.

Figure 1 shows the breakdown of mergers by year of announcement. There was a significant degree of clustering during the bank merger boom of the 1990s. In our controls we include a variable measuring hot merger periods.

Most mergers were undertaken by banks that undertook multiple mergers, emphasizing the importance of understanding the cumulative effect. To investigate the cumulative effects of multiple mergers, we sort banks into cohorts where the cohorts are determined by the position of a merger in a sequence conducted by the same acquirer. For example, cohort 2 consists of the second merger undertaken by all banks that have undertaken two or more mergers. We average the risk changes for the mergers in cohorts 2-5 and for those in cohorts 6-30. The total number of mergers is 299 in Cohort 1, 428 in Cohorts 2-5, and 381 in Cohorts 6-30.[6]

3.2 Measurement of returns

Weekly returns (from Tuesday to Tuesday) are calculated from CRSP for the premerger and postmerger period. We choose weekly rather than daily returns to reduce the problem of thin trading in the stocks of small banks. With weekly returns we need a sample period of 52 weeks to ensure statistically significant estimates of variances. The premerger period is therefore defined as the nearest Tuesday to 393 days before the announcement until 28 days before, and the postmerger period as 28 days after completion until 393 days after. We also calculate returns for more prolonged postmerger periods.

In addition to computing returns for the target and acquirer, we also compute weekly premerger returns for a portfolio of both companies' stocks where the weights are the series of weekly market capitalizations of the two stocks.

3.3 Risk measures

We measure total bank risk by the standard deviation of the weekly returns. However, as Figure 2 shows, there was substantial time-series variation in bank volatility that was not restricted to the banking crisis. To control for these changes we regress weekly bank returns on the returns of the Fama-French equally-weighted bank index. Therefore in addition to reporting total risk, we also report

[6] Since single merger acquirers occur only in Cohort 1, while multiple acquirers are represented in both Cohort 1 and the other cohorts, cohort membership is also a function of the *number* of mergers by an acquirer. In Section 6, we test whether estimates of the effect of cohort membership is affected by omission of single acquirers.

the beta, residual risk and correlation from this regression.[7] For convenience we refer to all these statistics as risk measures.

These standard measures of share price risk are related to other measures of risk. Volatility is related to measures of default probability, such as distance to default and CDS spreads. Similarly, the beta against the bank index may serve as a proxy for systemic risk.[8] Measures of default probability and leverage are also affected by the level of the stock price, and abnormal returns are related to the focus or diversification of bank mergers (DeLong (2001). So we examine the change in asset risk measures as well as equity risk measures.

3.4 Summary Statistics

Table 1 provides measures of central tendency and dispersion before the announcement of the merger, measures of changes, and the standard errors of changes.[9] Not surprisingly, acquirers are much larger than the targets. They have higher betas relative to the banking index, but have less idiosyncratic risk presumably because they are more diversified. Acquirer and target leverage and loan/deposit ratios are similar. After the merger the acquirer's leverage rises. Consistent with this, in 77% of the mergers for which we have leverage data for both acquirer and target, the acquirer's long-term debt after the merger was higher than the combined long-term debt of the acquirer and target before the merger. There is also an increase in the loan/deposit ratio, on average. Both of these (increased leverage and increased loan/deposits) suggest a more risky policy following merger.

Many of the variables are far from normally distributed, with high degrees of skewness and leptokurtosis. The bottom two rows of Table 1 show that the estimated standard errors of the measured changes in volatility and beta are large and vary widely across the sample. To take account of the variation in the standard errors of risk estimates, for means we compute the precision-weighted means, and for regressions we use weighted least squares as described above.

The availability of data for the target limits some of the analysis of changes in risk relative to the pre-merger portfolio of the target and acquirer. Specifically, calculating asset risk measures for this portfolio requires leverage information for a traded target and this reduces the sample significantly.

[7] We do not use a value-weighted (VW) bank index because that reflects primarily large banks. Especially towards the end of our data period mergers by large banks dominate our sample, so using a value-weighted benchmark will bias the comparison. Using an equally weighted index reduces this problem.
[8] See, for example, Nucera et al (2016).
[9] Note that each merger is given equal weight in the descriptive statistics, so multiple acquirers will be included more than once when calculating each of the statistics. However, their characteristics are measured at the time of the merger and are therefore different for each merger.

Table 2 shows the same statistics for three sub-groups, the acquirer's first merger, its 2nd to 5th merger, and its 6th to 30th merger. There are some substantial differences between the characteristics of the three cohorts, particularly the 6+ group. Later acquisitions involve much larger acquirers and targets, but the relative size of the target is smaller. The later acquisitions also have higher acquirer beta but lower idiosyncratic risk, higher leverage and higher loan/deposit ratios. They also involve smaller increases in leverage and loan/deposit ratios around the merger. These differences suggest that the effects of mergers on risk may differ according to the position of the merger in a sequence of mergers undertaken by the same acquirer. One particularly important feature of Table 2 is that the average change in index volatility is both positive and larger for Cohorts 2-5 and 6+ than for Cohort 1.

Table 3 shows the correlation matrix for the variables used in the regressions. It shows that changes in index volatility are strongly positively associated with changes in acquirer volatility and idiosyncratic risk following the merger. Controlling for this turns out to account for a large part of the average increase in risk following the mergers in our sample, especially for the later mergers in a sequence by the same acquirer.

There is a significant positive correlation between the change in each of the risk measures and the change in bank leverage, and the leverage change is also correlated with the change in industry volatility. In contrast, there are only weak correlations between the changes in risk measures and changes in the loan-to-deposit ratio. Size is also correlated with other variables. Among acquiring banks, large banks are more prone to merge across states and to be multiple acquirers.

4. Results: Short-run risk changes

We first employ a standard event-study methodology to measure short-run changes in risk following mergers. We compare the risk measures for the acquirer after the merger both with those of the acquirer before the merger and with those of the portfolio of the acquiring and target banks before the merger. As noted above, the changes in risk are highly heteroskedastic and the standard errors of the changes vary widely, so we report precision-weighted means.

Table 4 shows the event-study averages. Panel A shows average changes in equity risk and Panel B average changes in asset risk. To estimate the asset risk of each bank we use the market leverage measures to unlever the equity risk. To preserve power we use the largest sample available for each row of the table. This means that the samples in each row are different. Table 12 in the robustness section below contains the results for all samples for each row and shows that the results are not sensitive to the sample choice.

In both panels of Table 4 all measures of risk increase relative to those of the pre-merger *portfolio*, and the changes are highly significant. In Panel B for asset risk, all risk measures rise relative to the portfolio of the merged banks suggesting that a large part of the diversification gains are dissipated. The rise in equity volatility of 0.349% per week is roughly ten percent of the average volatility level. However, residual asset risk falls relative to the asset risk of the acquirer suggesting that some part of the diversification benefit remains, on average, as the asset risk of the acquirer does not revert fully to its prior level, but this effect disappears once we include control variables.

The first row of Table 4 Panel A shows the comparison with the pre-merger equity of the acquirer. The total equity risk of the acquirer increases. Although the effect is statistically significant, the increase of 0.084% is very small relative to the mean value of 3.75% for the acquirer's risk before the merger. Exposure to banking industry risk, as measured by beta and by correlation with the index, rises significantly and is more economically significant. Despite the fact that there is a potential diversification benefit for the acquirer, the acquirer's idiosyncratic equity risk is unchanged. This suggests that the fall in asset risk for the acquirer is offset by the increase in leverage on average.

4.2 The effect of multiple mergers

Because we are interested in the effect of the large numbers of mergers carried out by a few frequent acquirers we examine whether the position of a merger in a sequence of mergers is related to the changes in risk. Table 5 shows the risk changes for the different merger cohorts. In the case of the portfolio benchmark (Panel B) all changes are significantly positive for all groups. In the case of the acquirer benchmark (Panel A) all changes are significantly positive other than changes in idiosyncratic risk. Thus the broad pattern of average results that we observed for the entire sample in Table 4 also holds for individual cohorts.

However, the effects on risk are attenuated for later mergers by banks making multiple mergers. This is evidenced by the tests of difference at the bottom of each panel, which show that for both benchmarks the average change for the 6+ group is significantly lower than the single merger group for all risk changes. The 2-5 group also shows significantly lower risk changes in four of the eight instances. Thus there is evidence that later mergers by multi-acquisition banks had a much smaller effect on risk than the first merger made by any bank including those that made only one acquisition. We later test whether this effect holds when we include only multiple merger banks.

4.3 Event study with control variables

To eliminate the effect of factors others than the mergers, we regress the changes in each of our risk measures on a vector of control variables. The changes in risk are highly heteroscedastic, so we report

results using weighted least squares (WLS) where the estimated standard error of the change in risk is used to determine the weights.

Table 6 gives the results. The dependent variables are the change in equity risk relative to the pre-merger acquirer (Panel A), the change in asset risk relative to the pre-merger acquirer (Panel B), and the change in equity risk relative to the pre-merger portfolio (Panel C). The change in leverage is excluded from the asset-risk regression since it is used in calculating the change in asset risk.

Even with this relatively small set of variables the explanatory power is high. For example, Panel A shows that the regression can explain 51 percent of the variation in the change in the acquirer's total equity risk. The results are largely consistent across the three panels. The change in index volatility is highly significant and is associated with increased bank volatility and idiosyncratic risk. However, the proportionate change in the acquirer covariance with the bank index is less than the change in the index variance, so that the overall effect of increased index volatility is a smaller change in beta. In Panels A and C changes in equity volatility, beta and idiosyncratic risk are positively associated with changes in leverage. There is also, unexpectedly, a consistently negative relationship between changes in risk and changes in the loan-to-deposit ratio and this is significant in the case of beta. As we show below, this disappears when we look at long-term changes. Changes in total risk, beta, and idiosyncratic risk, are positively associated with hot-merger periods and changes in beta are somewhat associated with interstate mergers.

The removal of geographic restrictions in the 1990s on intrastate and interstate banking (Berger, Kashyap, and Scalise 1995; Jayaratne and Strahan 1996) was a major driver of M&A activity. As Figure 1 shows, the pattern is an upward trend through 1997, followed by a downward trend. This pattern is largely driven by developments leading up to the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 (IBBEA). We examine the effect of this deregulation by replacing the Hot Period variable with a dummy for the period 1992-98. The results are essentially unchanged, showing that the Hot Period variable is capturing this effect. Consistent with the results in Table 6, the hot merger period increased total risk and systematic risk in the short run. However, as we show below (Table 10), this effect did not persist in the long run. Our long-run results show either no change or a small decrease in risk from these mergers, consistent with Goetz et al. (2016).

The relative size of the target is insignificant in explaining changes in risk relative to the pre-merger acquirer benchmark, but in Panel C it is an important variable in explaining changes in risk relative to the pre-merger portfolio. Larger relative target size gives more diversification benefit and when this is dissipated the increase in risk is greater.

We are principally interested in the fixed effects of mergers on risk once we control for the other variables. Table 7 shows the fixed effects for each cohort.[10] Panel C shows the results relative to the pre-merger portfolio benchmark. For Cohort 1 all measures of risk increase significantly. They also increase for Cohorts 2-5 and Cohort 6+, but in these cases the changes are largely insignificant. This confirms the earlier results from averages showing that the effects of mergers on risk are larger for the early mergers in a sequence by a single acquirer. However, now the results are even stronger with insignificant risk changes for the later mergers once controls are included. Panels A and B show the changes in risk relative to the premerger acquirer after allowing for the controls in the regression. These confirm the fact that later mergers have insignificant changes in risk and even for Cohort 1 changes in total risk and idiosyncratic risk are now insignificant, consistent with the complete dissipation of the diversification benefits represented in the pre-merger portfolio risk. Relative to the pre-merger acquirer benchmark, there is a change only in the beta against the industry index and only for Cohort 1.

The fixed effects reported in Table 7 assume the average merger characteristics and zero change in leverage and loan/deposit ratio. To allow for the average change in leverage and the loan/deposit ratio, we add to the fixed effects the coefficients on these variables reported in Table 6 multiplied by the averages reported in Table 2. This does not change the significance or sign of any of the results shown in Table 7.

We also examined the effect of the business cycle on changes in risk. We define a dummy that is one for the peak-to-trough period of NBER contractions. Including this variable does not change the fixed effects of mergers on risk in our sample, but it does pick up a cyclical dependence of risk changes from mergers. For mergers that occur in downturns, total risk (volatility) tends to decrease more than for other mergers, and this comes from residual risk rather than systematic risk. Thus mergers that occur in downturns appear to have a different effect on risk. Since the bulk of the mergers do not occur in downturns, this does not affect our overall conclusions regarding the effect of bank mergers on risk.

4.4 Summary: Event-study results

In summary, using the event-study approach we find results that are broadly consistent with the earlier literature. Relative to the pre-merger portfolio benchmark there is an increase in risk, but not relative to the acquirer benchmark once controls are included. Related to the finding of Weiß et al (2012), there is an association between increased total risk for the acquirer and for the industry, but there is no increase in total risk for the acquirer once the industry change in total risk is included as a

[10] For the 2-5 and 6+ cohorts, the figure shown is the sum of the constant term and the cohort dummy.

control. However, there is an increase in industry-related risk for the acquirer, even when the industry total risk control is included.

Extending earlier results, we find heavy dependence of the risk changes associated with bank mergers on the position of the merger in the sequence carried out by a single acquirer. Once factors such as industry risk are controlled for, changes in risk for the acquirer are concentrated in the early mergers in a sequence, and on sensitivity to industry risk rather than total risk or idiosyncratic risk. Relative to the pre-merger portfolio there are larger increases in risk including total risk and idiosyncratic risk, but these are also concentrated in the earlier mergers in a sequence by a single acquirer.

We do not find evidence of exploitation of the depositor put. Although diversification gains are dissipated which could be considered evidence of a desire to keep risk high, increases in risk are concentrated in industry-related risk, and occur only in the early mergers in a sequence by a single acquirer. So the results are not consistent with aggressive use of the too-big-to-fail protection by larger banks.

The increase in risk we find relative to the pre-merger portfolio is consistent with the concentration-fragility hypothesis, and the fact that equity risk increases occur only for industry-related risk is also consistent. However, the evidence that increases in the systematic measures of risk (beta and correlation) do not occur for the later mergers in a sequence by the same acquirer is not consistent with the concentration hypothesis.

5. Results: Long-run risk changes

We are interested in whether the short-run changes in risk persist in the long run. To examine this we conduct three tests. The first uses a standard event-study approach but lengthens the post-merger window. For our sample that is made difficult because subsequent mergers by the same bank preclude using non-overlapping windows of any length for most of the mergers. To eliminate overlapping windows, we use the final merger made by any bank and track risk changes over a 3-year period. This period is free from other mergers. This restricts the sample, but is similar to the non-overlapping window approach used in other studies.

We then use two other tests which allow us to include all mergers in the sample. For an acquirer that carried out multiple mergers both of these tests involve measuring the changes in risk from before the first merger until after the last merger. Hence they encompass all changes in risk that occurred during this interval. These tests measure not only the short-run effect of mergers on risk but also the effect of any other long-run factors. For example, they capture learning by investors about the impact of mergers on risk, and also long-term changes in operations and leverage in response to the mergers.

5.1 Extended event study

Table 8 shows the result of extending the event window for three years after the final merger in the sequence by any acquirer. The sample is smaller than for the earlier results, with 285 mergers satisfying this condition. The columns show the cumulative change in each risk measure for the entire window indicated.

Consistent with the fact that this sample contains the mergers from Cohort 1, there is a significant average increase in acquirer risk in the year following the merger. As we lengthen the period, there is no clear pattern in the cumulative change in risk. Thus there is no apparent mean reversion, and the changes in risk appear to be permanent for the horizon shown. This result differs from that found for other corporate events by Pan et al, where risk changes revert back towards zero quite quickly as a result of learning about risk behavior. Based on this result and the cohort analysis, any learning in our sample appears to be learning about the risk attitude of an individual acquirer that has made multiple mergers and not about the risk consequences of a single acquisition.

5.2 Last-First average results

Table 9 shows the average risk changes using the pre-merger acquirer as the benchmark. Panel A shows the short-run results from the event-study methodology. Panel B uses the Last-First method.[11] In the latter case there is no variable which is equivalent to the position of the merger in the sequence. Therefore in Table 9 we group companies by the number of acquisitions that they made rather than the merger's position in the sequence. For the single-merger firms the results using the two methodologies are by definition the same. Panel C gives the t-statistics for a test of difference in the means for the other two groups of cohort. In all cases where there is a significant difference the Last-First averages are lower, indicating that there is a potential difference in long-run results. We examine this further including controls below.

The lower averages using the Last-First methodology are more consistent with the fixed effects from the regressions shown in Table 7. For example, the average change in total risk for banks making between 2 and 5 acquisitions is 0.153 using the event-study methodology but only 0.045 using the Last-First methodology. Even so, because the Last-First measure has much more power than the event study approach, the average change is still significant.

[11] Some acquirers made acquisitions of targets for which we do not have data and which are therefore not in our sample. Where this is the case, for the event study we calculate the average change in risk using only the number of targets for which there are available data. By contrast, when we use the last-first methodology, we use the *total* number of U.S. mergers undertaken by each acquirer.

5.3 Last-First regression results

Table 10 shows the result of regressing the Last-First change in risk on the same controls variables as used for the event-study changes in Table 6. To implement this regression we treat each acquirer as an observation. For leverage, index volatility, and the loan-to-deposit ratio we measure the change from before the first merger to after the last merger, to match the period of measurement of the risk change. For relative size of the target, log size of the acquirer, the hot-period index and the instate/interstate dummy we use the average of these across the mergers undertaken by that acquirer. We base the cohort dummies on the proportion of the mergers undertaken by that acquirer which fall into that cohort.

We add another variable (Average elapsed time) to measure the average time elapsed between the first and last merger for that acquirer. If there is mean-reversion in risk we expect the coefficient on this variable to be negative, indicating that a longer elapsed time has given more time for risk attenuation through investor learning. As in the case of the event study, we control for the means of the relative size of the target, size of the acquirer, the hot merger variable, and the proportion of interstate mergers, so that the constant terms and cohort dummies have a similar interpretation to that regression. We use weighted least squares, where we compute the standard error of the estimated average change for that acquirer and use that as an estimate of the residual standard deviation.

Table 10 shows the results of this regression for the change in acquirer equity risk relative to the pre-merger acquirer benchmark. We expect the results in Table 10 to pick up any long-run effects, which could be especially important for the sub-set of banks that undertook many mergers. Panel A uses a specification where the acquiring banks are assigned to three cohorts according to the cumulative number of mergers they undertook. Panel B uses a more granular specification where the fixed effect is a linear function of the log of the number of mergers.[12]

The regressions explain in excess of 20% of the variance in the changes in each risk measure. Leverage changes and index volatility changes are again strongly significant, both with positive signs. However, the leverage coefficients are lower than for the event study regression, consistent with leverage changes having a more limited effect in the long run than in the short run. The coefficients on the loan-to-deposit ratio are now insignificant, resolving the anomaly in the event study

[12] This specification has two advantages. It reflects the declining incremental impact of successive mergers that we find, and it corresponds to a similar specification for the short-run changes in the event study, because the integral of log(n) is (nlog(n)+n), so if the effect of an individual merger is log(n), then the average effect of n mergers is also a linear function of log(n).

regression. The coefficient on the average elapsed time variable does not show up as significant, confirming the result from the extended event study window, that we do not have learning effects of the Pan et al type. Other than for the correlation change, the coefficients on acquirer size are significantly negative. In the long run larger banks are associated with smaller average increases in risk from mergers after controlling for other factors. Also, although the coefficient on the hot-merger period remains significant in the case of total and idiosyncratic risk, its sign has switched and the absolute size is small suggesting that merger activity that spans hot merger periods is associated with slightly smaller increases in risk in the long run.

In Panel B we assume that the average change in risk is a linear function of the log of the number of mergers. We report only that part of the results, with the coefficients of the other variables remaining essentially unchanged. The result confirms the pattern using the dummy variables for cohorts. There are significant increases in beta and correlation from early mergers in a sequence. This is attenuated in a non-linear manner as the number of mergers increases. When we insert a total of 30 mergers in the function, the average change of beta and correlation across the entire sequence is almost zero. There is no significant change in total risk, but the change in residual risk is now significantly negative for the early mergers in a sequence. This effect is attenuated as the number of mergers increases.

The increased power from using the Last-First approach shows up in the high levels of significance of the coefficients in Panel B of Table 10. Similar regressions (unreported here), where the dependent variables are the event study changes in risk, produce largely insignificant coefficients on the log of the merger's position in the sequence.

Table 11 shows the fixed effects for the Last-minus-First regressions (Panel B) and for the event study (Panel A).[13] In both cases, the fixed effects show significant increases in beta for single acquirers, but no effects for volatility and idiosyncratic risk. The coefficients on the dummy variable for multiple acquirers are insignificant and close to zero.

Overall, the fixed effects from the two sets of regressions in Table 11 largely confirm those from the event study regression in Table 6 and the extended event window using the pre-merger acquirer as the benchmark. Risk changes are concentrated in sensitivity to industry risk (beta), for single acquirers

[13] Note that the fixed effects for the event regressions differ from those in Table 7. This is because, in order to provide a comparison with the Last-minus-First estimates the dummies have been redefined in terms of the number of mergers rather than their position in the sequence, so these are average effects whereas the Table 7 measures are marginal effects.

and in the early mergers in a sequence. There is no increase in equity volatility or idiosyncratic risk resulting from these mergers, either in the short run or in the long run.

5.5 Merger tree methodology

For the reasons given above, the Last-First methodology does not allow us to examine changes relative to the pre-merger portfolio benchmark. To do this it is necessary to reconstitute the entire tree of banks which came together to form the final surviving bank. We form these trees for a sample of the most active acquirers (the 'tree banks'). For example, during the period 1980 to 2014 there were 149 banks that were acquired either directly by Wells Fargo or by a target that eventually became part of the Wells Fargo group. Therefore, we compare the risk of Wells Fargo with the risk of the portfolio of Wells Fargo and the 149 target banks. This enables us to measure the difference between the risk of that portfolio and the risk of Wells Fargo at any point in the past and gives an indication of the potential diversification benefit from the mergers that may have been dissipated.

We reconstruct the tree for 5 large multiple acquirers. They are Wells Fargo, JP Morgan Chase, Bank of America, US Bancorp, and Bank of New York Mellon.[14] We refer to these banks as the surviving banks. These banks accounted for about 42% of the total market capitalization of the bank index at the end of 2014 and had acquired directly or indirectly 458 banks during our sample period. This amounts to 41% of our total sample of acquisitions.

Many of the banks in these trees were public companies at the time of acquisition, but not at the start of our sample period. Therefore we follow the risk of each portfolio from the start of 1990, by which point data are available for most banks that were to become future targets. The changes in risk of the surviving bank are dominated by declines in idiosyncratic risk starting in 2003 and by even sharper rises in 2008 as the banking crisis unfolded. Even after controlling for industry effects, the changes are too noisy to be very informative about the effect of the merger activity on the risk of the survivor. The trees are however informative about the *relative* risks of the survivor and the tree portfolio at different dates in the past.

5.6 Merger tree results

Figure 3 shows the average evolution of the risk of the acquirer and tree banks. We have expressed the total risk of the two sets of banks by dividing by the total risk of the equally weighted bank index. In each chart there are two lines. One is for the bank that was the acquirer (i.e. the surviving bank at

[14] We omit Citibank. It was not a frequent acquirer and its merger with Travelers, a non-bank company, would add noise to our estimates.

the end of the data period). The other is for the portfolio of banks (the tree banks) that ultimately formed the surviving bank. This represents the risk that the acquiring bank would have had if it had simply combined the tree banks passively without affecting their risks. The difference between the two lines represents the average effect the acquirers have had on the risk of their portfolio of banks, relative to the risks that they inherited from the acquired banks. Thus it is the long-run test analogous to using the pre-merger portfolio benchmark.

There are three striking things about the charts. First, in 1990 the survivor banks were on average 2.5 times riskier than the bank index. By contrast, the risk of the trees at that time was 1.8 times that of the index. In other words, at the beginning of the period the risk of the acquirers was 40% higher than the portfolio that ultimately comprised them at the end of the period. The lower initial risk of the tree portfolio was not a reflection of a lower beta (the average initial beta of the trees was 1.14 versus 1.09 for the acquirers). Instead the lower risk of the portfolio of tree banks arose from its lower idiosyncratic risk.

The second feature is that the correlation of the acquirers with the index rises during the period, whereas the correlation of the tree portfolio does not. If the dissipation of diversification were achieved by the target firm becoming like the acquirer, the correlation of the acquirer with the index would not rise. Nor can the rise in correlation be caused by the acquirer's choice of financial or operating leverage, because correlation is unaffected by leverage. This suggests that the rise in correlations is due to shifting exposure to risk factors that affect the broader banking industry.

The final striking feature is that for all risk measures the two lines are almost the same from 2004 onwards. So the dissipation of diversification gains was effectively complete by 2004.

5.7 Correlations between large banks and tree portfolios

The average pairwise correlation between the returns of the acquiring banks rose from about 0.3 in the 1980s to over 0.7 in recent years. This increase is too large to be explained by the increasing correlation of the banks with the equally-weighted banking index. We computed the rolling pairwise correlation between the idiosyncratic returns of the acquiring banks, where idiosyncratic risk is measured relative to the equally-weighted bank index. Figure 4A shows that this correlation increased significantly over the period. In contrast, Figure 4B shows the same calculation for the tree portfolios, and there was no such increase.[15] Thus, in addition to the increased correlation of the acquiring banks with the bank index, there was a highly significant increase in the correlation between the

[15] The correlations between the residuals from a regression on the S&P Composite Index show a similar pattern.

idiosyncratic risks among large banks. This is consistent with the increased connectedness of large banks, as reported by Billio et al (2012).

These results confirm and strengthen those in the previous section: the industry-related risk of the acquiring banks increased both because they became more correlated with the equally weighted banking index and because their extra-index correlations increased. This reflected far more than the risk of their targets converging to be perfectly correlated with the risk of the acquirers, because that would have implied a constant correlation between those acquirers. Therefore, the changes in correlations between the risk of the acquiring banks over this period contains a large component that did not come simply from the effects of the mergers. Nor did the increased risk come simply from the larger size of these banks. The final column of Table 10 shows that the change in correlation with the bank index was not related to the size of the acquirer.

6. Robustness Tests

6.1 Relative target size

The market capitalization of many of the targets was very small relative to that of the acquirer, and in these cases any effects of the merger may be obscured by noise. We therefore divided our sample into two subsamples according to whether the market capitalization of the target was greater or less than 20% of that of the acquirer. As expected, we found a much stronger rise in equity risk for the relatively larger targets, but even the acquisition of very small targets appears to be associated with an increase in risk.

6.2 Thin trading

Many of the smaller targets and many of the smaller index banks were thinly traded and this potentially biases our estimates of premerger risk. For example, if the merged bank is more liquid than the unmerged ones, the effect may be to create an illusion of an increased beta. To test whether this affects our results we repeated the event-study estimates by using Dimson betas and by changing the differencing interval over which risk was measured. We found similar results.

6.3 Unweighted Means

We repeated the event study results in Table 4 using equally-weighted means. Since large estimated changes in risk are associated with large standard errors, the apparent increase in risk over the period of the merger is larger, but less significant. As one would expect, the extra increase in risk shows up in the measure of residual risk. We consider these estimates to be substantially less reliable than the precision-weighted estimates that we report elsewhere in the paper.

6.4 Overlapping Mergers

If a bank undertakes two or more mergers within a short period, the event-study methodology may lead to a biased estimate of any change in risk. This is because the combined effect on risk of several mergers will be attributed to each merger. In Table 8 we sidestepped this problem by focussing only on the last merger for each acquirer. As a further check, we repeated the event study omitting all cases for each acquirer where there is any overlap between the post-merger periods. The results continue to show significant short-run changes in risk.

6.5 Effect of sample choice

Due to data restrictions the sample used varies across tests. To provide some reassurance that our results are not dependent on the choice of sample, we repeated the event study tests with different sample sizes. Table 12 shows the precision-weighted mean changes in the four risk measures. The choice of sample has little effect on the direction, size, and significance of these means.

6.6 The effect of single acquirers

The cohort dummies are correlated with the number of mergers. As a check, we confirmed that the regression coefficients are largely unchanged if single acquirers are omitted.

6.7 Choice of Index

To control for changes in the risk of the banking sector as a whole, we regressed the returns of merging banks on the banking industry index. This might not be appropriate if, for example, the returns on the banking index were contaminated by merger activity. We, therefore, examined whether our results continue to hold if we control for changes in a broad market index. The changed definition does not affect the change in total risk, but, as one would expect, the shift in the sensitivity to the index is reduced and correspondingly more of the change in risk is shifted onto the residual.

6.8 The Financial Crisis

Although some bank mergers during the financial crisis were particularly newsworthy, the total *number* of mergers during this period accounted for only about 2% of our sample. Also, due to the high error variance in their risk measures, each of these mergers received a relatively low weight both in tests of averages and in the regression results. Mergers during the crisis period resulted in above-average increases in total and idiosyncratic risk. These were dramatic in the case of a few individual instances, but the effect was not large enough to change significantly our overall results.

7. Conclusions

We have measured the effect of mergers on bank risk in both the short and long run. Short run changes in acquirer risk following mergers occur only in the early mergers by a single acquirer and only in industry-related risk and not total risk. Diversification benefits are entirely dissipated but the volatility of the acquirer does not increase. Using a new approach to measure the long-run effect, we find that the change in risk associated with mergers depends in a non-linear way on the total number of mergers undertaken by a particular acquirer. Short-run changes are attenuated by multiple mergers and disappear in the long run, consistent with banks maintaining a constant level of total risk.

The results for total risk are consistent with the emerging literature on the stability of the risk culture of individual banks even as industry structure and regulation has changed (Fahlenbrach et al (2012), Sarin and Summers (2016)). They do not appear to be consistent with there being a significant incentive to gamble induced by the 'too-big-to-fail' put option, which implies an incentive to use mergers to increase volatility especially for larger banks.

In addition, there has been a large increase in correlations between the largest banks, much of which has come from sources other than mergers. The increase may be in part a consequence of increased connectedness among large banks of the type analysed by Billio et al (2012).

We track the entire portfolios of the major acquirer banks to measure the loss of diversification of the US bank industry associated with mergers. This has been 40% of the risk level in 1981. Almost all of this occurred prior to 2004.

The two big risk effects we find to be related to mergers, dissipation of diversification benefits and increases in systematic risk, both occurred for the early mergers by the major acquirers but not for the later ones. Mergers early in the period and early in the sequence of mergers by the emerging major banks did increase systematic risk with respect to the banking index, and therefore also increased systemic risk. However, that was not the case for the later mergers by these banks, and the increase in correlation between large banks in the later part of the period was not associated with mergers.Hence, if one wanted to reduce the risk of the banking system by demerging major banks one would have to reach back to the structure that existed early in our data period (i.e. before 2004). Simply reversing recent mergers would not have much effect on any of our measures of risk.

Finally, we note two topics which we believe merit further investigation. There has been an increase in the correlation between major banks but this has not been related to mergers, certainly not in the more recent period. It would be interesting to know what in the structure of the banking industry has caused this, specifically whether it is to do with technology such as networks or a common factor caused by regulation. The other area of interest is whether it is asset risk or equity risk that is stable

in the long run. In our sample it is hard to disentangle the two, since leverage changes have not been big enough to cause a significant difference in patterns. In other contexts, such as other countries, there may be more scope to differentiate between these hypotheses.

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Appendix 1: Estimation of weighted means and weighted least squares regressions

In calculating the weighted means and the weighted least squares regression we use the estimated standard error of the change in the risk measure. This is calculated from the standard errors of the risk measures before and after the merger, assuming independence of the errors in the two estimates. The precision-weighted estimate of the mean change is given by $\widehat{M} = \frac{(\sum_i m_i/\sigma_i^2)}{\sum 1/\sigma_i^2}$, where σ_i^2 is the error variance of the estimated change in risk and m_i is the change in risk for merger i.

The error variance of the estimated change is the sum of the variances of the risk measures before and after the merger. In the weighted least squares regressions we assume that the standard deviation of the error term for each observation is proportional to the estimated standard error of the change in the risk measure.

Appendix 2: Last-First methodology

Consider a sequence of N mergers by a single acquirer, index these as n=1, N. Let the measured beta before merger i be β_{Bi} and the beta after merger i be β_{Ai}. Assume that each beta is measured with standard error σ_β. Assume that there is no overlap between the data periods and assume that the measurement errors in beta are independent. Assume that there is no predictable drift in beta other than what happens at merger dates, when it jumps by an expected amount Δ. The observed beta change for merger i is (β_{Ai} - β_{Bi}), which has a variance equal to $2\sigma_\beta^2$. The observed total beta change across all mergers has variance equal to $2N\sigma_\beta^2$. The average beta change per merger has variance equal to $2\sigma_\beta^2/N$. This is the error variance using the event-study method.

Now consider an alternative procedure, which simply takes the beta before the first merger, β_{B1}, and subtracts it from the beta after the last merger, β_{AN}, to give an estimate of the total beta change. This difference has variance equal to $2\sigma_\beta^2$. Divide this total by N to give an estimate of the average change, Δ. This average has variance equal to $2\sigma_\beta^2/N^2$. Thus the variance of the estimate using the last-minus-first method is lower by a factor of N than the variance from the average of the beta changes of the individual mergers (event-study method).

Figure 1. The number of mergers by year of announcement.

The sample consists of 1668 completed 100% mergers between listed U.S. banks and savings institutions between 1981 and 2014. (Data source: SDC Platinum).

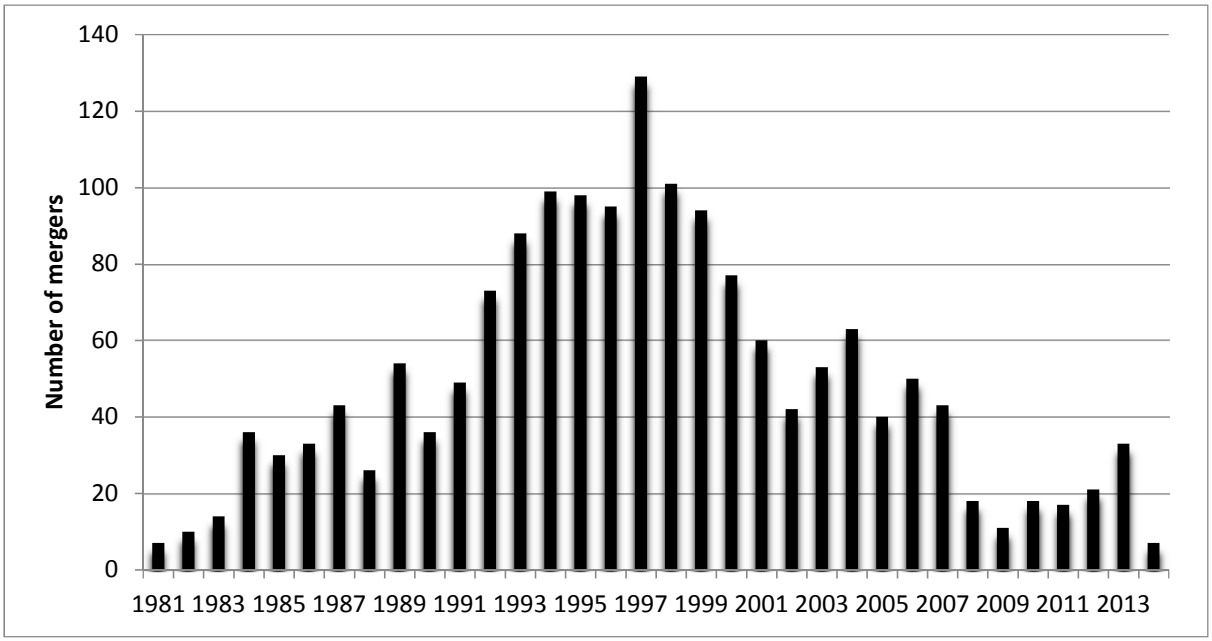


Figure 2. Rolling window of annualized 365-day standard deviations of returns on the Fama-French equally-weighted (EW) bank index.

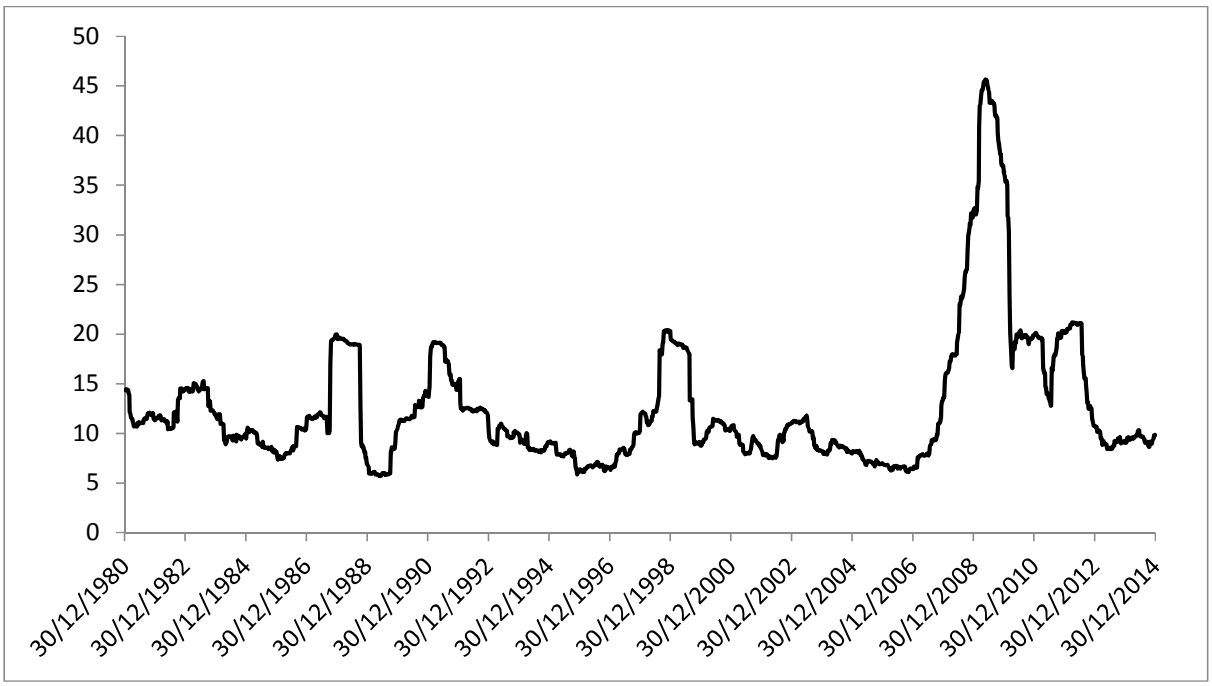
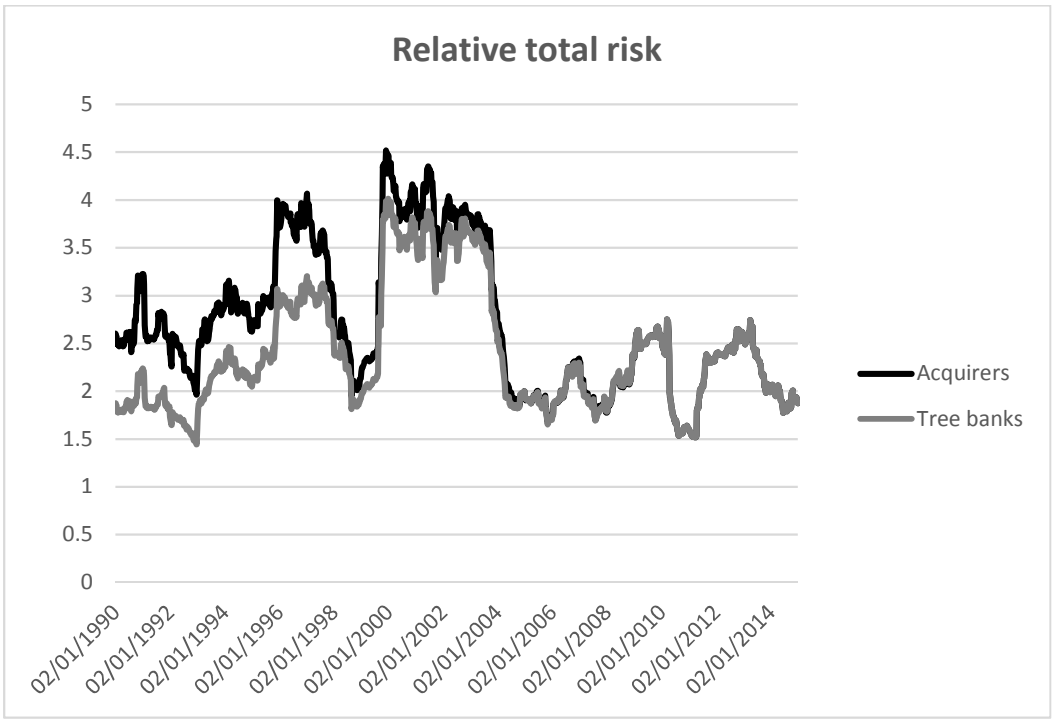
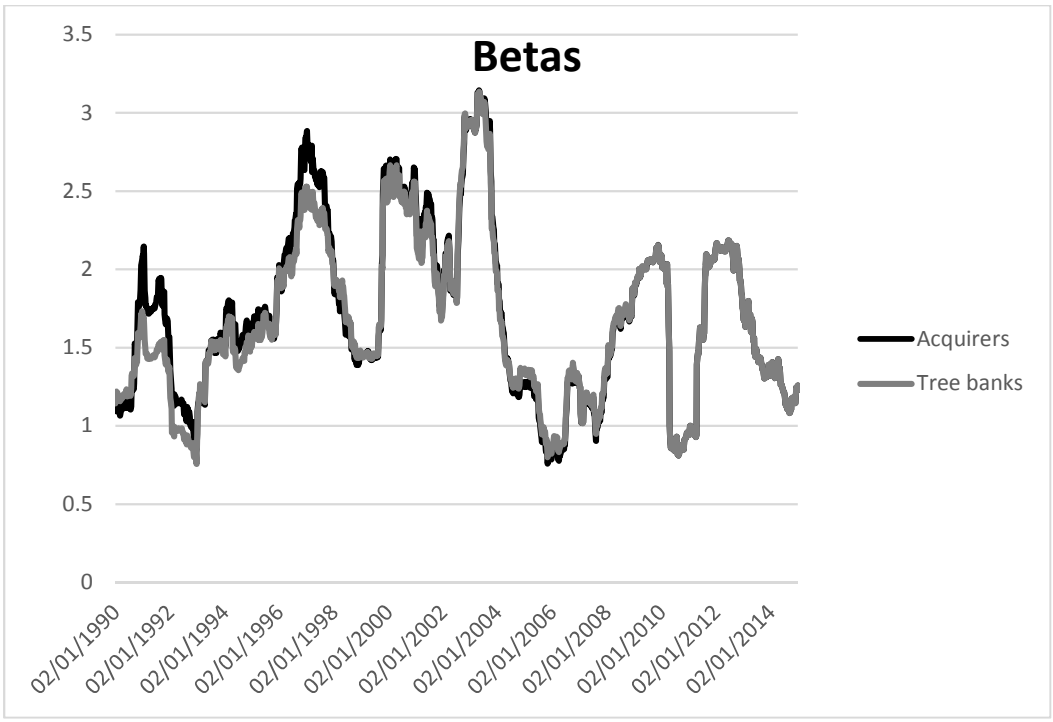
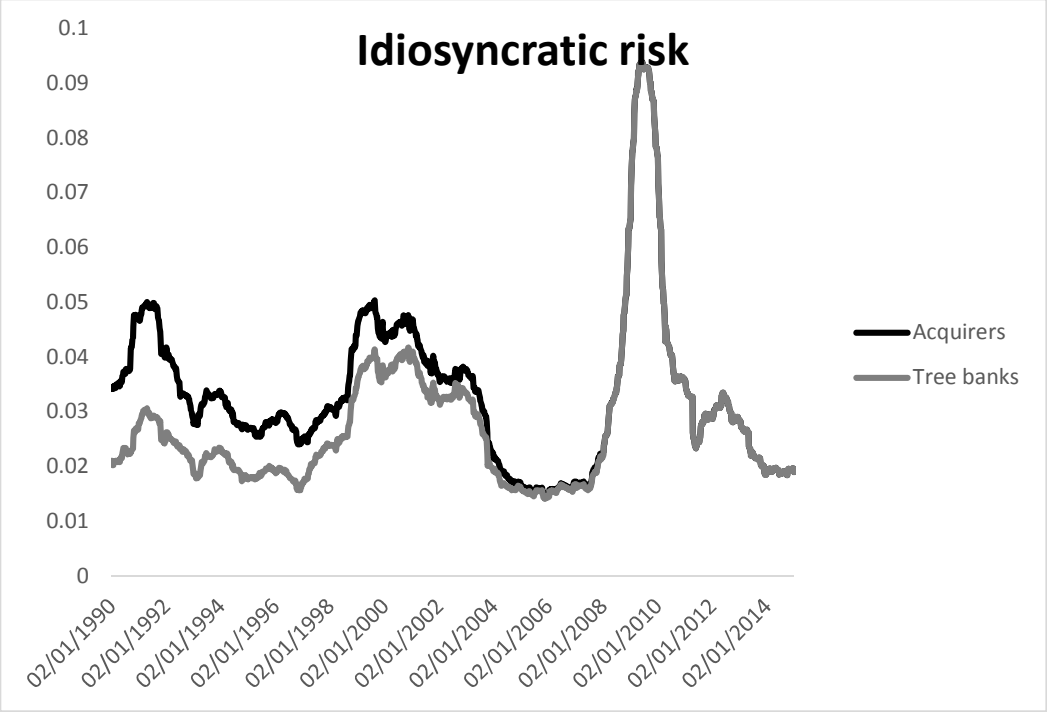


Figure 3. Average risk levels for 5 active acquirers and the portfolios of tree banks

The figures show the average risk levels for the sample of 5 active acquirers and the portfolios of tree banks that they acquired (tree). Relative total risk is the level of bank volatility as a proportion of the volatility of the equally weighted bank index. Beta is beta measured relative to the equally weighted bank index. Idiosyncratic risk is the residual risk from a regression of bank returns on the returns of the equally weighted bank index. Correlation is the correlation with the equally weighted bank index.






Idiosyncratic risk
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
02/01/1990
02/01/1992
02/01/1994
02/01/1996
02/01/1998
02/01/2000
02/01/2002
02/01/2004
02/01/2006
02/01/2008
02/01/2010
02/01/2012
02/01/2014
Acquirers
Tree banks

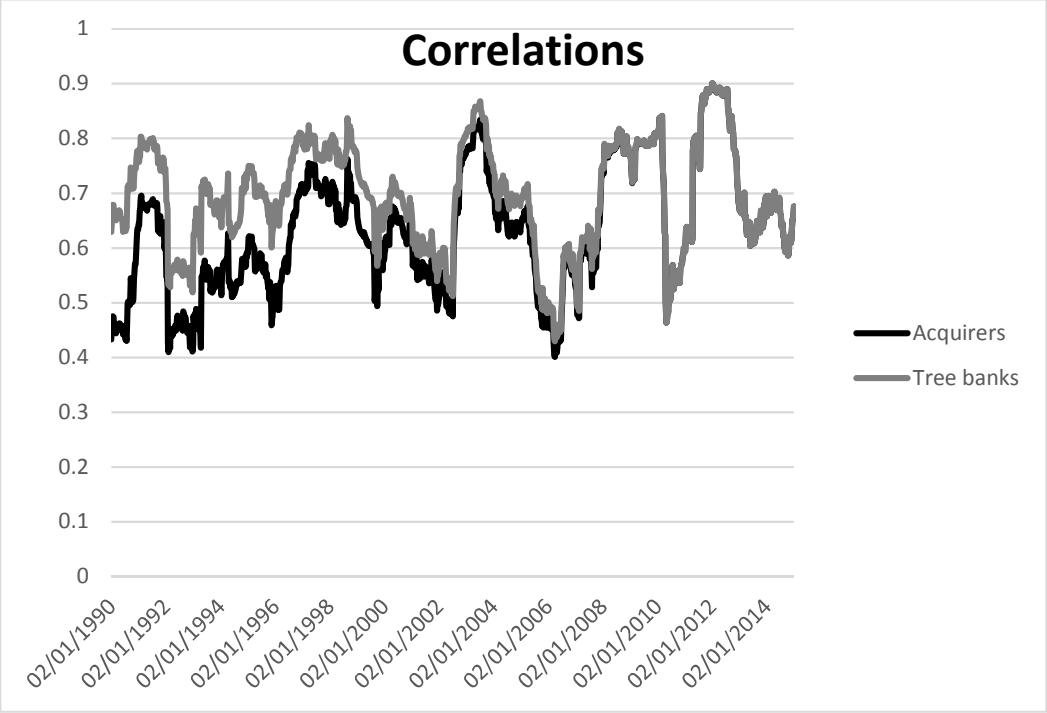

Correlations
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
02/01/1990
02/01/1992
02/01/1994
02/01/1996
02/01/1998
02/01/2000
02/01/2002
02/01/2004
02/01/2006
02/01/2008
02/01/2010
02/01/2012
02/01/2014
Acquirers
Tree banks

Figure 4. Average correlations between residuals

The figures show average pairwise correlations between the idiosyncratic returns of the 5 active acquirer banks (4A) and the corresponding tree portfolios (4B). Correlations are calculated using residuals from the regressions on the equally weighted bank index, using 52-week trailing returns The period is December 1990-December 2014.

Figure 4A: Average residual correlations among the 5 active acquirers

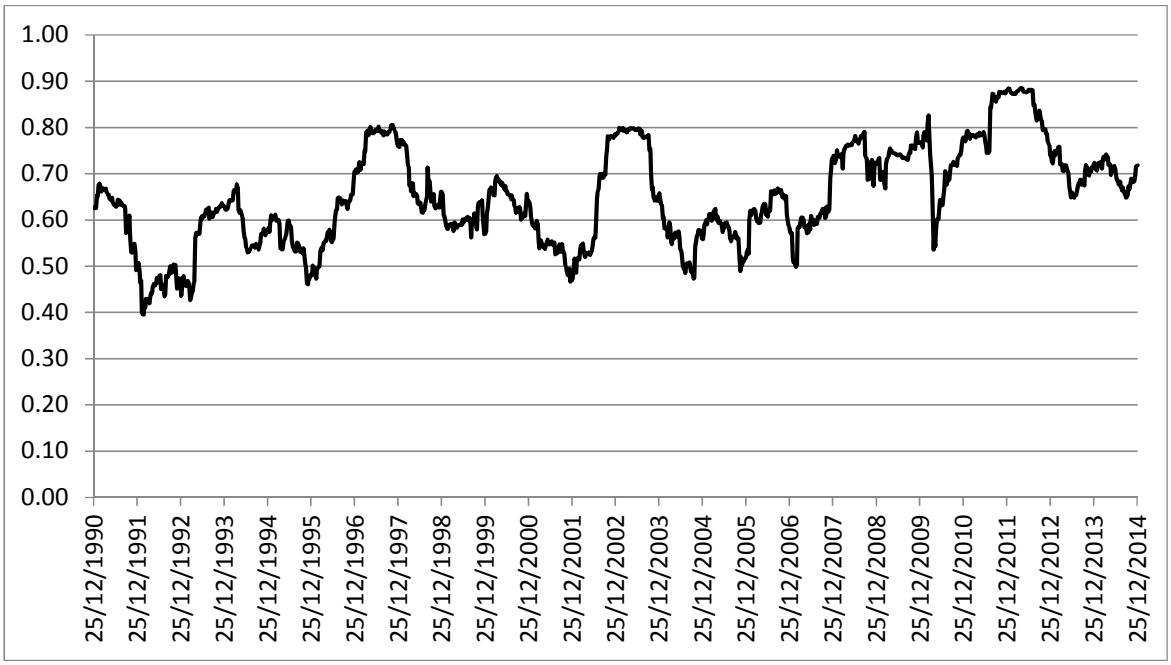


Figure 4A: Average residual correlations among the tree portfolios of the 5 active acquirers

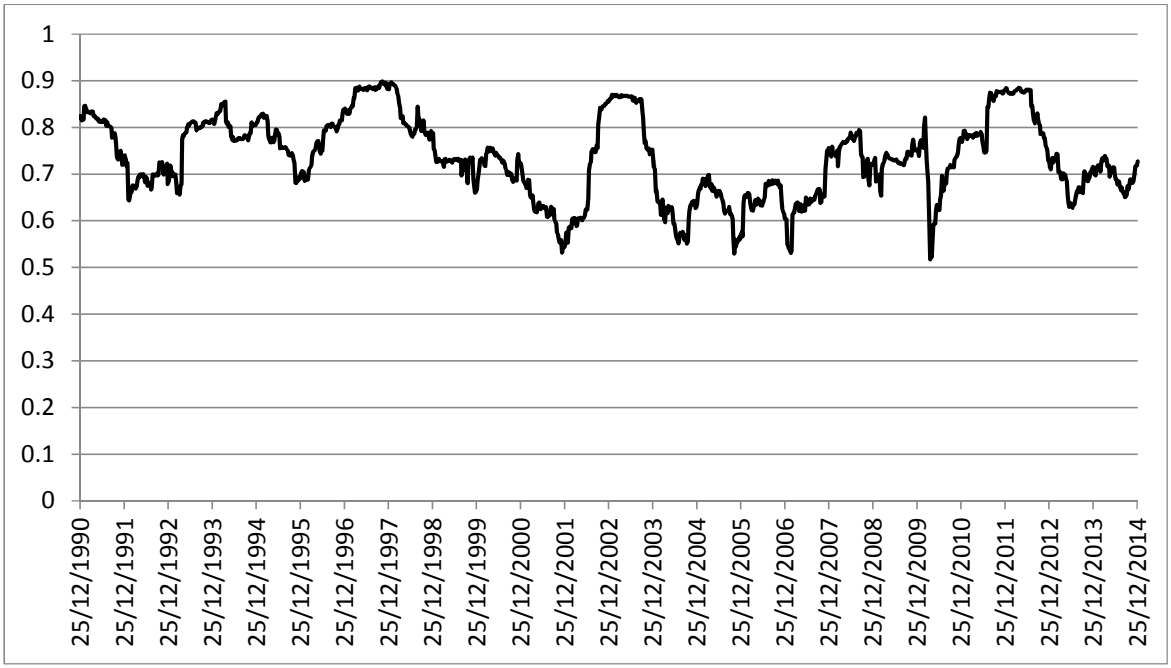


Table 1. Descriptive statistics for the entire sample

The table provides measures of central tendency and dispersion of variables used in this study. Value is the market capitalization 28 days before the merger announcement. Market capitalizations have been adjusted to a common date by multiplying by one plus the change in the bank industry index between the time of the merger and December 2014. Volatility is the weekly standard deviation of equity returns over the period 393 days to 28 days before the merger announcement. Beta is the regression coefficient from a regression of percentage weekly bank returns on the corresponding returns on the Fama-French equally-weighted bank index. Idiosyncratic risk is the standard error of that regression, and correlation is the correlation coefficient. Leverage is the ratio of the book value of the long-term debt to the sum of the book value of long-term debt and the market value of equity. Loan/deposit ratio is the ratio of loans to deposits. Index volatility is that of the Fama-French equally-weighted bank index. Standard errors of changes are computed as in Appendix 1.

	N Obs.	Mean	Median	Quartile 1	Quartile 3	Std. Dev.	Skewness	Kurtosis
Before the merger:								
Acquirer value ($millions)	1108	5,070	1,010	298	3,435	16,507	8.32	90.09
Acquirer equity volatility, %	1108	3.75	3.49	2.82	4.43	1.49	2.27	14.49
Acquirer equity beta	1108	1.225	1.232	0.789	1.650	0.664	0.06	3.06
Acquirer equity idiosyncratic risk, %	1108	3.17	2.96	2.34	3.67	1.28	2.52	16.86
Acquirer correlation	1108	0.478	0.510	0.346	0.639	0.219	-0.63	2.93
Acquirer leverage	1027	0.304	0.274	0.148	0.419	0.203	0.68	2.99
Acquirer loan/deposit ratio	1004	0.835	0.835	0.741	0.936	0.200	-0.88	7.63
Target value ($millions)	1102	636	79	33	238	3,239	10.73	140.73
Ratio target value/acquirer/value	1102	0.210	0.107	0.037	0.278	0.278	3.70	29.15
Target equity volatility, %	1108	4.61	3.91	3.07	5.17	3.40	6.34	63.66
Target equity beta	1108	0.844	0.730	0.320	1.239	0.818	1.88	13.52
Target equity idiosyncratic risk, %	1108	4.32	3.65	2.89	4.89	3.36	6.54	66.58
Target correlation	1108	0.278	0.261	0.120	0.438	0.221	0.14	2.54
Target leverage	789	0.303	0.282	0.080	0.482	0.239	0.41	2.13
Target loan/deposit	736	0.830	0.816	0.705	0.948	0.222	-.022	5.75
Changes in:								
Acquirer leverage	957	0.026	0.015	-0.067	0.118	0.171	0.23	4.01
Acquirer loan/deposit ratio	921	0.062	0.055	-0.024	0.136	0.170	1.43	10.02
Index volatility	1108	0.110	-0.16	-0.414	0.526	0.011	1.43	7.62
Standard errors of changes:								
Acquirer equity volatility, %	1108	0.570	0.525	.427	.646	0.225	2.32	12.36
Acquirer equity beta	1108	0.453	0.430	.355	.430	0.154	1.51	7.90

Table 2. Descriptive statistics for mergers divided into cohorts by their position in the sequence of mergers undertaken by a single acquirer

The table provides measures of central tendency of variables used in this study. The sample is divided according to the position of a merger in the sequence of mergers undertaken by a single acquirer. For example, Cohort 1 is the first merger in the sequence and Cohort 2 is the second merger. Value is the market capitalization 28 days before the merger announcement. Market capitalizations have been adjusted to a common date by multiplying by one plus the change in the bank industry index between the time of the merger and December 2014. Volatility is the weekly standard deviation of returns over the period 393 days to 28 days before the merger announcement. Beta is the regression coefficient from a regression of percentage weekly bank returns on the corresponding returns on the Fama-French equally-weighted bank index. Idiosyncratic risk is the standard error of that regression, and correlation is the correlation coefficient. Leverage is the ratio of the book value of the long-term debt to the sum of the book value of long-term debt and the market value of equity. Loan/deposit ratio is the ratio of loans to deposits. Index volatility is for the Fama-French equally-weighted bank index. Standard errors of changes are computed as in Appendix 1.

	Cohort 1			Cohorts 2-5			Cohorts 6+		
	N Obs.	Mean	Median	N Obs.	Mean	Median	N Obs.	Mean	Median
Before the merger:									
Acquirer value ($millions)	299	1,263	191	428	1,531	786	381	12,034	4,274
Acquirer volatility, %	299	4.00	3.59	428	3.70	3.49	381	3.63	3.36
Acquirer beta	299	0.972	0.901	428	1.194	1.217	381	1.459	1.402
Acquirer idiosyncratic risk, %	299	3.63	3.38	428	3.14	2.95	381	2.83	2.73
Acquirer correlation	299	0.350	0.380	428	0.469	0.491	381	0.588	0.603
Acquirer leverage	226	0.301	0.254	420	0.280	0.239	381	0.332	0.327
Acquirer loan/deposit ratio	214	0.809	0.793	412	0.811	0.809	378	0.877	0.876
Target value ($millions)	297	106	41	425	279	67	380	1,449	182
Ratio target/acquirer	297	0.341	0.225	425	0.200	0.107	380	0.118	0.041
Target volatility, %	299	4.99	4.09	425	4.56	3.83	381	4.36	3.89
Target beta	299	0.730	0.632	428	0.797	0.626	381	0.988	0.970
Target idiosyncratic risk, %	299	4.79	3.91	428	4.31	3.57	381	3.96	3.55
Target correlation	299	0.222	0.223	428	0.261	0.227	381	0.342	0.348
Target leverage	165	0.302	0.268	300	0.309	0.296	324	0.297	0.280
Target loan/deposit	156	0.820	0.809	277	0.834	0.819	303	0.830	0.829
Changes in:									
Acquirer leverage	209	0.036	0.014	393	0.030	0.021	355	0.016	0.009
Acquirer loan/deposit ratio	194	0.071	0.070	393	0.072	0.063	344	0.046	0.042
Index volatility, %	299	0.067	-0.167	428	0.143	-0.153	381	0.110	-0.168

Table 3. Correlations

The table shows correlations of the variables used in cross-sectional regressions. Δσ is the difference between the standard deviation of the acquirer's weekly percentage returns in the post- and pre-merger periods, where the pre-merger period is defined as 393 days before the merger announcement until 28 days before the announcement, and the post-merger period is defined as 28 days after completion until 393 days after completion. $\Delta\sigma_I$ is the corresponding difference in the pre- and post-merger standard deviation of the percentage returns on the Fama-French equally-weighted bank index. Δβ, Δse, and Δz are the differences in the pre- and post-merger beta, residual standard error and Fisher's z statistic from a regression of the acquirer's returns on the returns of the bank index. Δ(D/V) is the difference in the acquirer's market leverage ratio between the first fiscal year-end after merger completion and the last year-end before announcement. Δloan/dep is the equivalent difference in the acquirer's loan-to-deposit ratio. Ln Cap is the natural log of the market capitalisation of the acquirer N days before the merger announcement, and Cap_T/Cap_A is the ratio of the market capitalisation of the target to that of the acquirer N days before the merger announcement. Hot is a measure for hot merger periods and is the total number of mergers between U.S. listed banks and savings institutions within 100 days of the merger. 2-5 is a dummy that takes the value of 1 if the merger lies between the second and fifth merger undertaken by the acquirer, and 6-30 is the equivalent dummy for a merger that lies between the sixth and thirtieth undertaken by the acquirer. In-State is a dummy that takes the value of 1 for mergers within a state.

	Correlation coefficients between variables used in cross-sectional regressions (balanced sample, N = 874)												
	Δσ	Δβ	Δse	Δz	Δ(D/V)	Ln Cap	Cap_T/Cap_A	Δloan/dep	$\Delta\sigma_I$	Hot	2-5	6-30	In-State
Δσ	1	.33	.93	.33	.34	.10	.01	-.08	.77	.03	.00	.04	.04
Δβ		1	.19	.65	.19	-.06	.07	-.05	-.03	.11	-.03	-.02	.09
Δse			1	.04	.34	.11	.01	-.07	.66	.00	.00	.05	.01
Δz				1	.10	-.11	.03	-.06	.38	.06	.02	-.08	.11
Δ(D/V)					1	.01	.00	.08	.20	.04	.03	-.03	.05
Ln Cap						1	-.35	-.05	.05	.05	-.23	.63	-.37
Cap_T/Cap_A							1	-.05	-.01	.01	.01	-.21	.16
Δloan/dep								1	-.07	.16	.06	-.06	.08
$\Delta\sigma_I$									1	-.01	.02	.00	.05
Hot										1	-.01	.09	-.01
2-5											1	-.66	.11
6-30												1	-.27
In-State													1

Table 4. Event-study post-merger average changes in risk

This table shows the precision-weighted mean changes in four risk variables between the pre- and post-merger periods. The variables are: total risk measured as the weekly standard deviation of percentage returns (σ), beta relative to the equally-weighted bank index (β), idiosyncratic risk measured as the weekly residual standard deviation (se), and the Fisher-z measure of correlation with the equally-weighted banking index (z). The pre-merger period is defined as 393 days before the merger announcement until 28 days before, and the post-merger period as 28 days after completion until 393 days after. Changes are measured for equity risk in Panel A and for asset risk in Panel B. Asset risk is deleveraged using the quasi-market ratio of equity to equity plus long-term debt. The first row in each panel compares the risk of the acquirer in the post-merger period with that of the acquirer in the pre-merger period. The second row compares the risk of the acquirer in the post-merger period with that of a value-weighted portfolio of the acquirer and target in the pre-merger period. The sample in each case is the largest in our dataset for which all relevant information is available. ***, **, * denote changes that are significant at the 1%, 5%, and 10% levels respectively. T-statistics are in parentheses.

Sample size	Measure	Benchmark	Δσ	Δβ	Δse	Δz
Panel A: Equity risk						
1,613	Equity	Acquirer	0.084*** (7.06)	0.124*** (12.65)	-0.005 (-0.52)	0.070*** (13.91)
1,108	Equity	Portfolio	0.349*** (24.91)	0.167*** (15.00)	0.238*** (20.99)	0.042*** (6.93)
Panel B: Asset risk						
1,364	Asset	Acquirer	0.062*** (7.87)	0.048*** (7.73)	-0.091*** (-7.36)	0.094*** (17.27)
715	Asset	Portfolio	0.216*** (21.30)	0.068*** (8.63)	0.144*** (9.01)	0.054*** (7.17)

Table 5. Post-merger changes in risk as a function of the position of each merger in the sequence of mergers by an acquirer

This table shows the precision-weighted mean changes in four risk variables between the pre- and post-merger periods. The variables are: total risk measured as the weekly standard deviation of percentage returns (σ), beta relative to the equally-weighted bank index (β), idiosyncratic risk measured as the weekly residual standard deviation (se), and the Fisher-z measure of correlation with the equally-weighted banking index (z). The pre-merger period is defined as 393 days before the merger announcement until 28 days before, and the post-merger period as 28 days after completion until 393 days after. Panel A shows the change in risk of the acquirer between the pre- and post-merger periods. Panel B compares the risk of the acquirer in the post-merger period with that of a value-weighted portfolio of the acquirer and target in the pre-merger period. The table shows the fixed effects of mergers by cohort, where the cohorts are determined by the position of a merger in a sequence conducted by the same acquirer. For example, cohort 2 consists of the second merger undertaken by all banks that have undertaken two or more mergers. Cohort 1 contains 299 mergers, Cohorts 2-5 contain 428 mergers, and Cohorts 6+ contain 381 mergers. The bottom two rows in each panel test the difference between Cohorts 2-5 and 6+ relative Cohort 1. ***, **, * denote changes that are significant at the 1%, 5%, and 10% levels respectively. T-statistics are in parentheses.

Panel A: Equity risk, acquirer benchmark				
	Δσ	Δβ	Δse	Δz
	Average	Average	Average	Average
Cohort 1 (N = 299)	0.136*** (4.68)	0.185*** (7.26)	0.023 (0.88)	0.085*** (7.22)
Cohorts 2-5 (N = 428)	0.146*** (6.32)	0.139*** (7.51)	0.024 (1.26)	0.089*** (9.10)
Cohorts 6+ (N = 381)	0.056** (2.32)	0.111*** (5.97)	-0.015 (-0.81)	0.057*** (5.48)
T-statistics for test of difference				
2-5 minus first	0.56	-3.11***	0.08	0.49
6+ minus first	-4.28***	-4.98***	-2.51**	-3.65***
Panel B: Equity risk, portfolio benchmark				
	Δσ	Δβ	Δse	Δz
	Average	Average	Average	Average
Cohort 1 (N = 299)	0.524*** (19.19)	0.224*** (9.43)	0.406*** (16.73)	0.047*** (4.00)
Cohorts 2-5 (N = 428)	0.381*** (17.08)	0.173*** (9.83)	0.267*** (14.59)	0.052*** (5.36)
Cohorts 6+ (N = 381)	0.178*** (7.47)	0.128*** (7.09)	0.118*** (6.55)	0.027*** (2.60)
T-statistics for test of difference				
2-5 minus first	-8.32***	-3.65***	-9.53***	0.65
6+ minus first	-19.33***	-6.72***	-19.97***	-2.63***

Table 6. Regressions of the event-study change in acquirer risk on a set of control variables

The following regression is estimated: $\Delta Risk_j = a + bX_j + u_j$. $\Delta Risk_j$ in each regression is the change in a measure of the risk of acquirer j estimated using the event-study methodology and X_j is a vector of control variables for bank j. The control variables are: two dummies showing whether the merger was between the 2nd and 5th merger by that acquirer or between the 6th and 30th merger, the change in leverage, the change in the standard deviation of the bank index, the ratio of the market capitalization of the target to that of the acquirer, the log of the market capitalization of the acquirer adjusted by the return on the bank index up to December 2014, the change in the loan-to-deposit ratio of the acquirer, a dummy for in-state mergers, and an index of hot merger periods. The regressions employ four different measures of the dependent variable: the change in the weekly standard deviation of percentage returns (Δσ), the change in beta relative to the equally-weighted bank index (Δβ), the change in the weekly residual standard deviation (Δse), and the change in the Fisher-z measure of correlation with the equally-weighted banking index (Δz). The dependent variable in Panel A is the change in acquirer equity risk. In Panel B it is the change in acquirer asset risk. In Panel C it is the change in equity risk relative to the pre-merger benchmark of the portfolio of the acquirer and target. Estimation is by weighted least squares with the weights estimated using the standard error of the change in the dependent variable, as described in Appendix 1. ***,**,* denote significance at the 1%, 5%, and 10% levels respectively. T-statistics are in parentheses.

Panel A: Equity risk, acquirer benchmark				
Dependent variable	Δσ	Δβ	Δse	Δz
Constant	0.008 (0.08)	0.202*** (3.15)	-0.073 (-0.85)	0.088*** (3.10)
Dummy 2-5	0.031 (0.31)	-0.096 (-1.46)	0.038 (0.44)	-0.031 (-1.10)
Dummy 6+	0.004 (0.03)	-0.115 (-1.46)	0.010 (0.09)	-0.035 (-0.95)
Leverage change	1.350*** (6.06)	0.885*** (6.35)	0.958*** (5.04)	0.055 (0.91)
Index volatility change	1.198*** (28.13)	-0.050*** (-3.08)	0.686*** (20.83)	0.104*** (11.61)
Relative size target	0.202 (1.63)	0.131 (1.57)	0.175 (1.61)	-0.029 (-0.79)
Log size acquirer	0.018 (0.61)	-0.001 (-0.03)	0.029 (1.20)	-0.019** (-2.15)
Change in loan/deposit ratio	-0.235 (-1.06)	-0.469*** (-3.00)	-0.193 (-0.98)	-0.121* (-1.87)
Dummy for interstate	0.082 (1.15)	0.087* (1.92)	0.022 (0.38)	0.036* (1.68)
Hot period	0.010** (2.22)	0.007** (2.55)	0.007* (1.79)	0.004*** (2.72)
N	874	874	874	874
Adjusted R-square	0.509	0.062	0.375	0.162

Table 6: Continued

Panel B: Asset risk, acquirer benchmark				
Dependent variable	Δσ	Δβ	Δse	
Constant	-0.028 (-0.38)	0.030 (0.74)	-0.088 (-1.22)	
Dummy 2-5	0.051 (0.70)	-0.007 (-0.17)	0.032 (0.44)	
Dummy 6+	0.089 (0.93)	0.036 (0.71)	-0.049 (-0.55)	
Index volatility change	0.530*** (18.28)	-0.052*** (-5.34)	0.365*** (15.98)	
Relative size target	0.129 (1.55)	0.078 (1.56)	0.011 (0.11)	
Log size acquirer	-0.015 (-0.70)	-0.015 (-1.28)	0.033 (1.59)	
Change in loan/deposit ratio	-0.073 (-0.60)	-0.196*** (-2.99)	-0.699*** (-4.06)	
Dummy for interstate	0.011 (0.20)	0.080*** (2.71)	0.006 (0.11)	
Hot period	0.010*** (2.77)	0.005*** (2.81)	0.003 (1.10)	
N	874	874	874	
Adjusted R-square	0.288	0.059	0.249	
Panel C: Equity risk, portfolio benchmark				
Dependent variable	Δσ	Δβ	Δse	Δz
Constant	0.260*** (2.78)	0.211*** (3.47)	0.187** (2.31)	0.055* (1.94)
Dummy 2-5	-0.002 (-0.02)	-0.072 (-1.16)	0.018 (0.22)	-0.036 (-1.24)
Dummy 6+	-0.012 (-0.10)	-0.094 (-1.25)	-0.013 (-0.13)	-0.038 (-1.02)
Leverage change	1.361*** (6.41)	0.758*** (5.71)	0.978*** (5.42)	0.105 (0.55)
Index volatility change	1.182*** (28.48)	-0.044*** (-2.87)	0.663*** (20.76)	0.033*** (11.78)
Relative size target	0.532*** (4.57)	0.042 (0.54)	0.615*** (6.12)	-0.153*** (-4.20)
Log size acquirer	-0.035 (-1.24)	-0.015 (-0.85)	-0.013 (-0.55)	-0.021** (-2.43)
Change in loan/deposit ratio	-0.175 (-0.82)	-0.371** (-2.49)	-0.101 (-0.55)	-0.137** (-2.10)
Dummy for interstate	0.060 (0.88)	0.078* (1.77)	0.002 (0.04)	0.038* (1.76)
Hot period	0.010** (2.21)	0.005** (2.08)	0.007* (1.90)	0.004*** (2.70)
N	869	869	869	869
Adjusted R-square	0.526	0.050	0.396	0.173

Table 7. Fixed effects on risk of mergers at different stages of the sequence by a single acquirer

This table shows the fixed effects of mergers by cohort, where the cohorts are determined by the position of a merger in a sequence conducted by the same acquirer. For example, Cohort 2 consists of the second merger undertaken by all banks that have undertaken two or more mergers. The fixed effects are calculated from the regressions shown in Table 6. For Cohort 1 the fixed effects are the constants in those regressions. For the 2-5 and 6+ cohorts, the figures shown are the sum of the constant term and the cohort dummy. In Panel A the average change in equity risk is estimated relative to that of the pre-merger acquirer. Panel B shows the change in asset risk relative to that of the pre-merger acquirer. Panel C shows the change in equity risk relative to that of the pre-merger portfolio of acquirer and target. The pre-merger period is defined as 393 days before the merger announcement until 28 days before, and the post-merger period as 28 days after completion until 393 days after. ***,**,* denote significance at the 1%, 5%, and 10% levels respectively. T-statistics are in parentheses.

Panel A: Equity risk, acquirer benchmark				
Dependent variable	Δσ	Δβ	Δse	Δz
Cohort 1	0.008 (0.08)	0.202*** (3.15)	-0.073 (-0.85)	0.088*** (3.10)
Cohorts 2-5	0.039 (0.28)	0.106 (1.16)	-0.035 (-0.28)	0.057 (1.40)
Cohorts 6+	0.012 (0.08)	0.087 (0.86)	-0.063 (-0.46)	0.053 (1.15)

Panel B: Asset risk, acquirer benchmark			
Dependent variable	Δσ	Δβ	Δse
Cohort 1	-0.028 (-0.38)	0.030 (0.74)	-0.088 (-1.22)
Cohorts 2-5	0.023 (0.22)	0.023 (0.39)	-0.056 (-0.55)
Cohorts 6+	0.060 (0.50)	0.065 (1.01)	-0.138 (-1.20)

P*anel C: Equity risk, portfolio benchmark*				
Dependent variable	Δσ	Δβ	Δse	Δz
Cohort 1	0.260*** (2.78)	0.211*** (3.47)	0.187** (2.31)	0.055* (1.94)
Cohorts 2-5	0.258* (1.95)	0.139 (1.60)	0.205* (1.78)	0.020 (0.48)
Cohorts 6+	0.248 (1.62)	0.117 (1.22)	0.174 (1.35)	0.018 (0.38)

Table 8. Equity risk changes following the last acquisition by each acquirer.

This table shows the precision-weighted mean change in four risk variables in each of years 1 to 3 following the latest merger in the sequence of mergers by each acquirer. The variables are: total risk measured as the weekly standard deviation of percentage returns (σ), beta relative to the equally-weighted bank index (β), idiosyncratic risk measured as the weekly residual standard deviation (se), and the Fisher-z measure of correlation with the equally-weighted banking index (z). The columns show the cumulative change between the acquirer's premerger risk and its risk over one, two, and three years following the merger. ***,**,* denote changes that are significant at the 1%, 5%, and 10% levels respectively. T-statistics are in parentheses.

(N = 285)	1-year change	2-year change	3-year change
Δσ	0.195*** (6.72)	0.156*** (5.13)	0.316*** (9.64)
Δβ	0.219*** (9.36)	0.184*** (7.81)	0.211*** (8.84)
Δse	0.106*** (4.24)	0.072*** (2.75)	0.193*** (6.83)
Δz	0.072*** (6.02)	0.074*** (6.20)	0.068*** (5.60)

Table 9. Comparison of event-study and last-first results: post-merger changes in risk grouped by the number of mergers made by each acquirer

This table shows the precision-weighted mean change in four risk variables between the pre- and post-merger periods. The variables are: total risk measured as the weekly standard deviation of percentage returns (σ), beta relative to the equally-weighted bank index (β), idiosyncratic risk measured as the weekly residual standard deviation (se), and the Fisher-z measure of correlation with the equally-weighted banking index (z). In Panel A the average change in risk is estimated using the event-study methodology. Panel B uses the Last-First methodology in which the difference between the risk after an acquirer's last merger and the risk before its first merger is divided by the number of mergers undertaken by that acquirer. Panel C shows the t-statistics for a test of the difference in means between the Last-First mean and the Event-study mean. The pre-merger period is defined as 393 days before the merger announcement until 28 days before, and the post-merger period as 28 days after completion until 393 days after. Acquirers are grouped according to the number of acquisitions they made during the sample period. N_A is the number of acquirers, N_M is the number of mergers. ***,**,* denote changes that are significant at the 1%, 5%, and 10% levels respectively. T-statistics are in parentheses.

PANEL A: Event-study methodology

	N_A	N_M	Δσ	Δβ	Δse	Δz
1 acquisition	239	239	0.060* (1.85)	0.198*** (7.10)	-0.004 (-0.14)	0.051*** (3.84)
2-5 acquisitions	178	510	0.153*** (7.02)	0.156*** (8.64)	0.033* (1.76)	0.095*** (10.60)
More than 5 acquisitions	80	864	0.052*** (3.23)	0.092*** (7.13)	-0.025* (-1.91)	0.061*** (8.86)

PANEL B: Last – First methodology

	N_A	N_M	Δσ	Δβ	Δse	Δz
1 acquisition	239	239	0.060* (1.85)	0.198*** (7.10)	-0.004 (-0.14)	0.051*** (3.84)
2-5 acquisitions	178	510	0.045*** (3.54)	0.166*** (15.93)	-0.076*** (-6.97)	0.102*** (20.25)
More than 5 acquisitions	80	864	0.012*** (2.99)	0.062*** (17.52)	-0.021*** (-6.24)	0.034*** (17.83)

Panel C: t-statistics for test of difference

2-5 acquisitions L-F minus event	-4.27***	0.49	-5.05***	0.71
More than 5 acquisitions L-F minus event	-2.38**	-2.23**	0.28	-3.79***

Table 10. Regressions of the Last-First change in acquirer risk on a set of control variables

The following regression is estimated: $\Delta Risk_j = a + bX_j + u_j$. $\Delta Risk_j$ in each regression is the change in a measure of the risk of acquirer j estimated using the Last-First methodology and X_j is a vector of control variables for bank j. The control variables are: two dummy variables for the number of mergers made by that acquirer, the change in leverage, the change in the standard deviation of the bank index, the ratio of the market capitalization of the target to that of the acquirer, the log of the market capitalization of the acquirer adjusted by the return on the bank index up to December 2014, the change in the loan-to-deposit ratio of the acquirer, the proportion of in-state mergers, the index of hot merger periods, and the average elapsed time between mergers. The regressions employ four different measures of the dependent variable: the change in the weekly standard deviation of returns (Δσ), the change in beta relative to the equally-weighted bank index (Δβ), the change in the weekly residual standard deviation (Δse), and the change in the Fisher-z measure of correlation with the equally-weighted banking index (Δz). In Panel A the fixed effect for Cohort 1 is estimated by the constant term. For Cohorts 2 and 3 it is estimated as the sum of the constant term and the coefficient on the cohort dummy. In Panel B the fixed effect is estimated as a linear function of the log of the number of mergers by that acquiror (n). Panel B does not report the other coefficients in the regression, which are similar to those for Panel A. Estimation is by weighted least squares with the weights estimated using the standard error of the change in the dependent variable, as described in Appendix 1. ***,**,* denote significance at the 1%, 5%, and 10% levels respectively. T-statistics are in parentheses.

Panel A: With cohort dummies				
Dependent variable	Δσ	Δβ	Δse	Δz
Constant	0.108 (0.67)	0.242*** (2.97)	-0.011 (-0.08)	0.091** (2.32)
Dummy 2-5 acquisitions	-0.102 (-0.60)	-0.047 (-0.54)	-0.129 (-0.85)	0.038 (0.91)
Dummy more than 5 acquisitions	-0.117 (-0.68)	-0.147* (-1.68)	-0.037 (-0.24)	-0.048 (-1.15)
Leverage change	0.249*** (2.65)	0.097** (2.21)	0.175** (2.25)	0.045** (2.13)
Index vol change	0.193*** (8.32)	0.003 (0.48)	0.116*** (6.96)	0.001 (0.28)
Relative size target	-0.203 (-1.44)	-0.038 (-0.54)	-0.170 (-1.39)	0.006 (0.17)
Log size acquirer	-0.047** (-2.34)	-0.031*** (-3.77)	-0.038** (-2.33)	-0.002 (-0.47)
Change loan/deposit ratio	-0.066 (-0.57)	-0.042 (-0.84)	-0.079 (-0.83)	-0.030 (-1.29)
Dummy for interstate	0.023 (0.34)	0.072** (2.30)	-0.049 (-0.89)	0.027 (1.65)
Hot period	-0.000*** (-3.18)	-0.000 (-1.03)	-0.000** (-2.54)	0.000 (0.13)
Average elapsed time	-0.000 (-0.45)	-0.000 (-0.95)	-0.000 (-0.62)	-0.000 (-0.86)
N	211	211	211	211
Adjusted R-square	0.281	0.222	0.229	0.214
Panel B: With non-linear fixed effect equal to (constant + coefficient*log(number of mergers))				
Constant	0.013(1.31)	0.293***(7.86)	-0.141**(-2.09)	0.169***(9.37)
Coefficient of log(n)	-0.057(-1.57)	-0.088***(-5.10)	0.031(1.00)	-0.050***(-6.09)

Table 11. Fixed effect on risk of mergers at different stages of the sequence by a single acquirer*[grouped by the number of acquisitions made by an acquirer]*, using the event study and Last-First methodologies

This table shows the changes in four risk variables between the pre- and post-merger periods. The variables are: total risk measured as the weekly standard deviation of percentage returns (σ), beta relative to the equally-weighted bank index (β), idiosyncratic risk measured as the weekly residual standard deviation (se), and the Fisher-z measure of correlation with the equally-weighted banking index (z). The pre-merger period is defined as 393 days before the merger announcement until 28 days before, and the post-merger period as 28 days after completion until 393 days after. All figures are for the change in equity risk relative to that of the pre-merger acquirer. Mergers are grouped according to the number of acquisitions made by each acquirer. The fixed effects for each group are estimated using the event study methodology (Panel A) and using the Last-First methodology (Panel B). ***[Should we say that control variables are as in T10?]*** For single acquirers the fixed effects are the constants in those regressions. For the other two groups of acquirer, the figures shown are the sum of the constant term and the dummy. ***,**,* denote significance at the 1%, 5%, and 10% levels respectively. T-statistics are in parentheses.

Panel A: Event study				
Dependent variable	Δσ	Δβ	Δse	Δz
1 acquisition	0.158 (0.13)	0.190** (2.13)	0.049 (0.41)	0.044 (1.13)
2-5 acquisitions	0.126 (0.66)	0.242* (1.87)	-0.011 (-0.06)	0.090 (1.59)
More than 5 acquisitions	-0.024 (-0.12)	0.052 (0.40)	-0.078 (-0.45)	0.056 (0.98)

Panel B: Last-First				
Dependent variable	Δσ	Δβ	Δse	Δz
1 acquisition	0.108 (0.67)	0.242*** (2.97)	-0.011 (-0.08)	0.091** (2.32)
2-5 acquisitions	0.006 (0.02)	0.195 (1.64)	-0.140 (-0.67)	0.128** (2.25)

More than 5 acquisitions	-0.009 (-0.04)	0.095 (0.79)	-0.048 (-0.23)	0.043 (0.74)

Table 12: Event study post-merger changes in risk: Results for different samples

This table shows the precision-weighted mean changes in four risk variables between the pre- and post-merger periods. The variables are: total risk measured as the weekly standard deviation of percentage returns (σ), beta relative to the equally-weighted bank index (β), idiosyncratic risk measured as the weekly residual standard deviation (se), and the Fisher-z measure of correlation with the equally-weighted banking index (z). The pre-merger period is defined as 393 days before the merger announcement until 28 days before, and the post-merger period as 28 days after completion until 393 days after. Panel A shows the change in equity risk, and Panel B shows the change in asset risk, where asset risk is calculated using the quasi-market ratio of equity to equity plus long-term debt. Benchmark A compares the risk of the acquirer in the post-merger period with that of the acquirer in the pre-merger period and benchmark P compares the risk of the acquirer in the post-merger period with that of a value-weighted portfolio of the acquirer and target in the pre-merger period. Sample 1 is the sample of 1,613 mergers for which we have information on acquirer equity risk before and after the merger. Sample 2 is the sample of 1,108 mergers for which we have information on the equity risk of the portfolio of acquirer and target before the merger and the equity risk of the acquirer after the merger. Sample 3 is the sample of 1,364 mergers for which we have information on asset risk for the acquirer before and after the merger. Sample 4 is the sample of 715 mergers for which we have information on asset risk for the portfolio before the merger and the acquirer after the merger. ***, **, * denote changes that are significant at the 1%, 5%, and 10% levels respectively. T-statistics are in parentheses.

Sample	Measure	Benchmark	Δσ	Δβ	Δse	Δz
Panel A: Equity risk						
1 (N = 1,613)	Equity	A	0.084*** (7.06)	0.124*** (12.65)	-0.005 (-0.52)	0.070*** (13.91)
2 (N = 1,108)	Equity	A	0.111*** (7.68)	0.138*** (11.80)	0.008 (0.66)	0.076*** (12.62)
3 (N = 1,364)	Equity	A	0.079*** (6.13)	0.153*** (14.74)	-0.020** (-1.92)	0.094*** (17.27)
4 (N = 715)	Equity	A	0.113*** (6.45)	0.174*** (12.64)	-0.009 (-0.66)	0.111*** (14.81)
2 (N = 1,108)	Equity	P	0.349*** (24.91)	0.167*** (15.00)	0.238*** (20.99)	0.042*** (6.93)
4 (N = 715)	Equity	P	0.334*** (19.86)	0.163*** (12.46)	0.215***(16.19)	0.054*** (7.17)
Panel B: Asset risk						
3 (N= 1,364)	Asset	A	0.062*** (7.87)	0.048*** (7.73)	-0.091*** (-7.36)	0.094*** (17.27)
4 (N = 715)	Asset	A	0.091*** (8.61)	0.052*** (6.21)	-0.068*** (-4.07)	0.111*** (14.81)
4 (N = 715)	Asset	P	0.216*** (21.30)	0.068*** (8.63)	0.144***(9.01)	0.054*** (7.17)