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A Visual Approach to Community Bank Assessment of  
Agricultural Portfolio Risk Exposure

By

Glenn D. Pederson, Yu-Szu Chu and Wynn Richardson

Department of  
**APPLIED  
ECONOMICS**

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College of Food, Agricultural  
and Natural Resource Sciences

**UNIVERSITY OF MINNESOTA**

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Glenn D. Pederson, Yu-Szu Chu and Wynn Richardson

The authors are Professor, Graduate Student, and Extension Economist, respectively, in the Department of Applied Economics.

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## **Visual Assessment of Portfolio Risk**

In order to develop estimates of risk exposure in their asset portfolios, banks may resort to using stress tests. Stress testing generally refers to the method by which a bank determines the impact(s) of factors that cause changes in the performance of the asset portfolio. The stress factors might include, among other things, price level changes or policy changes and they typically represent shocks to the portfolio (e.g., a sudden decline in revenue, an energy price increase, or a sharp drop in asset values). Stress testing attempts to answer the question: "If this adverse event happens, what happens then?"

Stress testing may be accomplished by using various methods. One method is simulation analysis, where a representative portfolio is developed and various shocks are introduced to the portfolio in order to assess the set of financial consequences for the bank. The result is a better empirical understanding of how sensitive the portfolio is to a range of uncertain economic situations. Stress tests can be done by using an historical scenario, which may be composed of several related events, or by using a hypothetical situation (sensitivity test), which is a plausible single market event. By using stress tests, banks can evaluate the magnitude of their risk exposure, monitor risk in a particular asset class, or conduct contingency planning for times of market stress.

In particular, community banks are by definition small and they frequently lack the resources and data to carefully assess their risk exposure. Thus, community bankers may rely more on an adequate familiarity with their clients and their knowledge of their loan portfolio composition to determine the acceptable level of exposure. In the community bank setting stress tests can help the bank manager decide on an acceptable level of change in their portfolio and set limits for borrower or enterprise concentrations.

This paper is motivated by the perception that community banks need more tools to perform risk analysis at the loan portfolio and sub-portfolio levels of aggregation. Aggregation can be important when loan risk factors are correlated, since these systematic risks will not be reflected at the transaction level of analysis. Community banks may feel that they are doing an adequate job of assessing their transaction level risk exposures, but their ability to assess portfolio level risk exposure may be less sufficient due to the systematic risks they are experiencing. In this area there are two examples of visual tools that have been developed in recent years to assist bankers to manage portfolio risk. WebEquity has designed a "risk

management dashboard” and Wehrspohn (2003) has developed visual portfolio analysis. They are distinctly different tools for performing visual portfolio analysis.

The Webequity risk management dashboard can be used to stress test the bank’s portfolio by shocking any one (or more) of the identified key risk factors: liquidity ratio, repayment of term debt ratio, equity/assets ratio, debt /equity ratio, and debt/assets ratio. The visual side of the WebEquity dashboard illustrates the shift in the number of borrowers according to their risk rating level pre- and post-shock. The WebEquity dashboard represents one approach to visual portfolio analysis with a focus on migration of the number of borrowers. This paper employs a similar approach to stress-testing where we also employ risk rating information, but we stress test the exposure (loan volume) of the bank at the portfolio and sub-portfolio levels.

Wehrspohn (2003) presents a more comprehensive visual approach to portfolio analysis that captures the relationship between exposure and the contribution to risk at the sub-portfolio (segment) levels. The Wehrspohn model is applied to bond portfolios, but it could be applied to loan portfolios with some modification and access to adequate historical data on probability of default and loss given default. Wehrspohn plots exposure “bubbles” that represent sub-portfolios. Bubble size indicates relative risk concentration (contribution to total risk) and bubble position in the chart suggests the location of each sub-portfolio relative to exposure limits that the bank has established. Visually displaying all the bubbles in one chart provides the manager with a tool to see the portfolio more clearly. Wehrspohn also plots the risk-adjusted return on capital (RAROC) versus risk per unit of exposure of each sub-portfolio to provide a visual treatment of the trade-off between portfolio risk and return. This paper employs elements of the Wehrspohn approach that are less data intensive. We develop charts that plot sub-portfolio bubbles by enterprise type and by borrower size groups in return-risk space. We shock the portfolio to observe where subsequent risk migration moves the exposure bubbles relative to the bank’s risk and return targets.

A visual approach to stress testing can help a bank manager to identify the most sensitive market factors in their individual, enterprise, and whole portfolio exposures. Banks may use such an approach to portfolio analysis to assess credit risk as an early warning system or as a benchmark to show where they are now. Also, visual portfolio analysis can give banks an idea of a prospective watch list of loans and/or clients. As we will see, a visual approach can help banks

manage portfolio risk, but they also require historical data on clients and their loans in order to implement the method of analysis.

Our overall research objective is to identify and stress the financial factors that lead to shifts in risk exposure, as reflected by changes in risk ratings that can be monitored at the transaction level and/or at the enterprise level. The objectives of this paper are: 1) to identify a visual model for stress testing that can be adopted by community banks, and 2) to illustrate stress tests that are suitable for community banks to use in their loan portfolios. This will be done by applying stress testing to a case bank portfolio. The model is developed in an Excel spreadsheet format.

### **Structuring a Case Bank Analysis**

The case bank in this research is a typical community bank located in the Midwest. It performs credit risk portfolio analysis to predict the current year's profitability and full-year analysis to predict the following year's profitability. The bank conducts annual stress tests and offers each customer a report that compares trends in individual financials with averages of their other customers. The case bank provided their client-level data on agricultural loans - a balance sheet, an income statement, an earned equity summary, and loan balances. The bank has a maximum of five years of historical data for most but not all clients. The bank does not have loan default data. The bank has a department that focuses on agricultural loans and they use credit scores to evaluate client creditworthiness.

Complete historical financial data varies for each borrower, yet most of the borrowers have data for 2009. Thus, in this study we include only those borrowers who have complete 2009 data. The case bank does have a credit scoring model and we use the same financial measures and the same risk weightings as they use in order to obtain consistent results. The financial measures include: current ratio, equity/asset ratio, average term debt coverage ratio, average operating expense ratio, earned net worth, and loan/collateral ratio. We do not include the subjective score for management ability of each client in the analysis. Based on the risk rating results, borrowers have credit scores ranging from 1 to 8. The risk ratings are: 1(excellent), 2 (good), 3 (pass), 4 (pass/watch), 5 (special mention), 6 (substandard), 7 (doubtful), and 8 (loss). We use the bank's interpretation for each risk rating score. The bank's exposure is evaluated at

the transaction (borrower) level, at the enterprise level (sub-portfolio level), and at the whole portfolio level.

We develop sub-portfolios by borrower loan exposure size and by enterprise type. To group sub-portfolios by loan exposure size, we add up all loans for each client and then sort the clients in increasing order, then create four size groups as in Table 1. The case bank uses a similar approach.

Table 1. Four Borrower Loan Exposure Size Groups

Group	I	II	III	IV
Exposure Range	Up to \$123,000	\$123,000 - \$262,000	\$262,000 - \$500,000	More than \$500,000
Borrowers	39	39	38	39
Total Exposure	\$2,505,987	\$7,398,644	\$13,474,288	\$48,644,302

For simpler exposition of the visual model approach, we develop sub-portfolios by enterprise type using the farm types that were originally identified by the bank. We determine which enterprise types have financial characteristics that make them similar to other types and group them together as a new (composite) enterprise type. There are two approaches that might be used to perform this grouping. One approach is to use correlation analysis (using enterprise-level gross margin data, for example, as the correlate variable). The second method is to consult with the bank and other experts. The bank tracks 10 enterprise types:

- Grain Farming
- Other Crop Farming
- Cow/Calf Operations
- Cattle Feeder Operations
- Hog and Pig Farming
- Dairy Cattle and Milk Production
- Combination Cow/Calf and Grain Operations
- Combination Cow/Calf and Feeder Operations
- Combination Cow/Calf, Feeder, and Grain Operations, and
- Combination Feeder and Grain Operations.

Since the number of borrowers for several of these enterprises is small, the correlation method was investigated but, due to data variability and low levels of statistical significance, it was not used as the final approach. Rather, we consulted with the bank and created 3 sub-portfolios by enterprise type. They include: **Crop enterprises** - Grain Farming and Other Crop Farming (61 borrowers); **Livestock enterprises** - Cow/Calf Operations, Hog and Pig Farming, and Dairy Cattle and Milk Production (46 borrowers); and **Mixed enterprises** - Combination Cow/Calf and Grain Operations; Combination Cow/Calf and Feeder Operations; Combination Cow/Calf, Feeder, and Grain Operations; and Combination Feeder and Grain Operations (48 borrowers).

Table 2. Median Statistics for Financial Measures by Enterprise Type

Financial Characteristic	Crop enterprise	Livestock enterprise	Mixed enterprise
Total Exposure (range)	\$220,926 (0 – 2.17 mill.)	\$270,080 (23,153 – 4.73 mill.)	\$370,011 (0 – 3.29 mill.)
Equity-to-Asset Ratio (range)	0.60 (0.25 - 0.93)	0.57 (0.16 - 0.96)	0.54 (0.26 - 0.95)
Current Ratio (range)	1.40 (0.2 - 56.1)	1.13 (0.3 - 5.7)	1.32 (0.2 - 6.7)
Average of Term Debt Coverage Ratio (range)	1.55 (-0.5 – 11)	1.13 (-3.4 - 3.7)	1.31 (-3.2 - 26.1)
Loan/Collateral Value Ratio (range)	42.5 (0 - 88.6)	49.6 (0 - 84.9)	51.3 (3.6 - 110.7)
Earned Net Worth Change category (range)	2 (1 - 5)	3 (1 - 5)	2 (1 - 5)
Average Operating Expense Ratio (range)	0.76 (0.59 - 0.96)	0.66 (0.41 - 1.66)	0.66 (0.53 – 0.85)

It is helpful to clarify how the Earned Net Worth Change category variable is calculated in Tables 2 and 3. Earned Net Worth Change is defined as: last year’s Net Worth minus this year’s Net Worth +/- any market value changes in term assets that were not earned. The ENW Change categories in Tables 2 and 3 are defined as: ENW change >1% gain in each of the last 4

years = 1, ENW change >1% gain in each of the last 2 years = 2, ENW change >1% gain in 2 out of the last 3 years = 3, ENW change >1% gain in 2 out of the last 4 years = 4, all others = 5.

In Table 2 we observe that the median size of exposure is relatively similar across the three enterprise types, although the mixed enterprises tend to borrow slightly more. Overall the livestock enterprises appear to exhibit slightly weaker financial positions than the other farm enterprise groups. They have lower liquidity, lower term debt coverage, weaker collateral position, and slower earned net worth change than the other enterprise groups in the bank. In Table 3 the median statistics suggest that there is also uniformity across borrower size groups. Size groups I and II have slightly stronger equity, earned net worth and liquidity, and stronger term debt coverage and collateral positions. This implies that farms in the smaller exposure categories will have better risk ratings.

Table 3. Median Statistics for Financial Measures by Loan Exposure Group

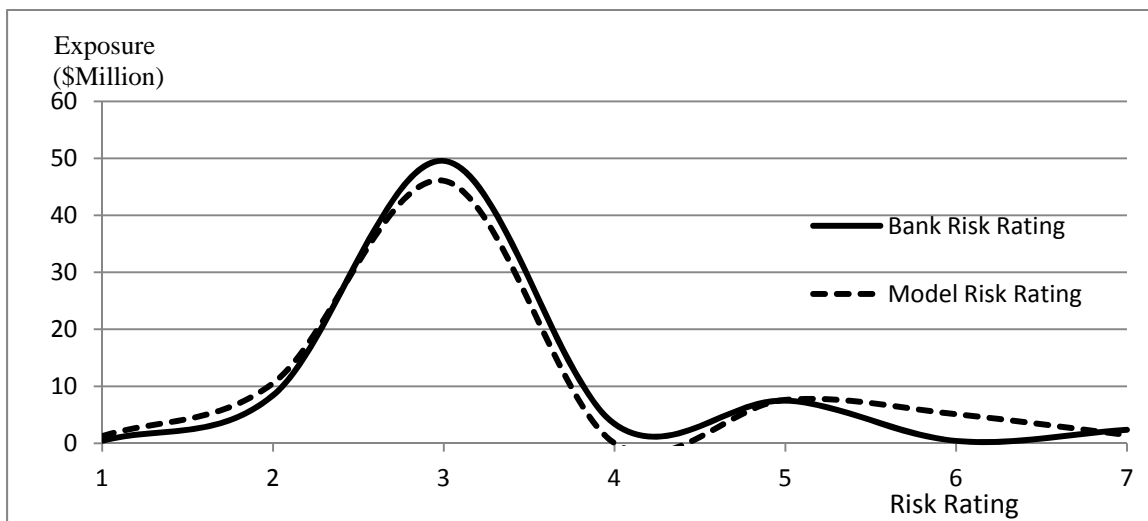
Financial Characteristic	Group I < \$123,000	Group II \$123,000 - \$262,000	Group III \$262,000 - \$500,000	Group IV > \$500,000
Equity-to-Asset Ratio (range)	0.67 (0.28 - 0.96)	0.62 (0.33 - 0.93)	0.58 (0.16 - 0.92)	0.49 (0.25 - 0.75)
Current Ratio (range)	1.36 (0.3 - 8.9)	1.27 (0.2 - 17.9)	1.20 (0.5 - 56.1)	1.06 (0.5 - 9.4)
Average of Term Debt Coverage Ratio (range)	1.70 (-0.9 - 12.7)	1.48 (0.4 - 4.9)	1.22 (0.2 - 26.3)	1.14 (-0.5 - 5.4)
Loan-to-Collateral Value Ratio (range)	35.9 (0 - 110.7)	45.8 (1.8 - 84.9)	51.2 (0 - 102.2)	55.1 (9.9 - 96.3)
Earned Net Worth Change category (range)	2 (1 - 5)	2 (1 - 5)	2 (1 - 5)	3 (1 - 5)
Average Operating Expense Ratio (range)	0.67 (0.45 - 1.66)	0.76 (0.56 - 0.90)	0.66 (0.41 - 1.1)	0.71 (0.55 - 1.08)

## Credit Risk Exposure Baseline Results

Seven risk ratings are used to represent the case bank credit scoring model. Risk ratings less than 3 are “lower risk,” while risk ratings above 4 are “higher risk.” None of the borrowers scored an 8 (loss). The model-generated risk rating results are compared with those originally provided by the case bank in Figure 1.

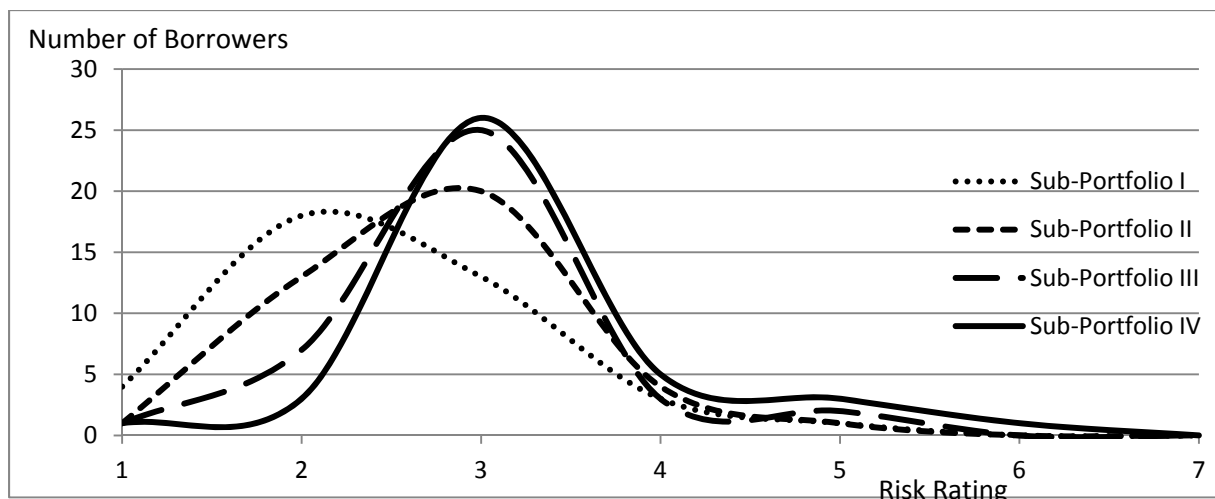


Figure 1. Comparison of the Baseline Model Risk Rating with the Bank's Risk Rating Exposure



Overall the model results replicate the bank's original risk rating data reasonably well, although not perfectly. For risk rating scores of 1 and 2, the model produces slightly larger exposures than the bank data and for a risk rating of 3 the bank's exposure is larger than that of the model. Also, at a risk rating of 6, the model exposure is larger than the bank data suggests. A risk rating of 6 means "special mention." We note that there are no borrowers at the 7 or 8 levels of risk rating in the bank's portfolio. In our further analysis, we will also classify risk ratings 5-8 as "near default" ratings.

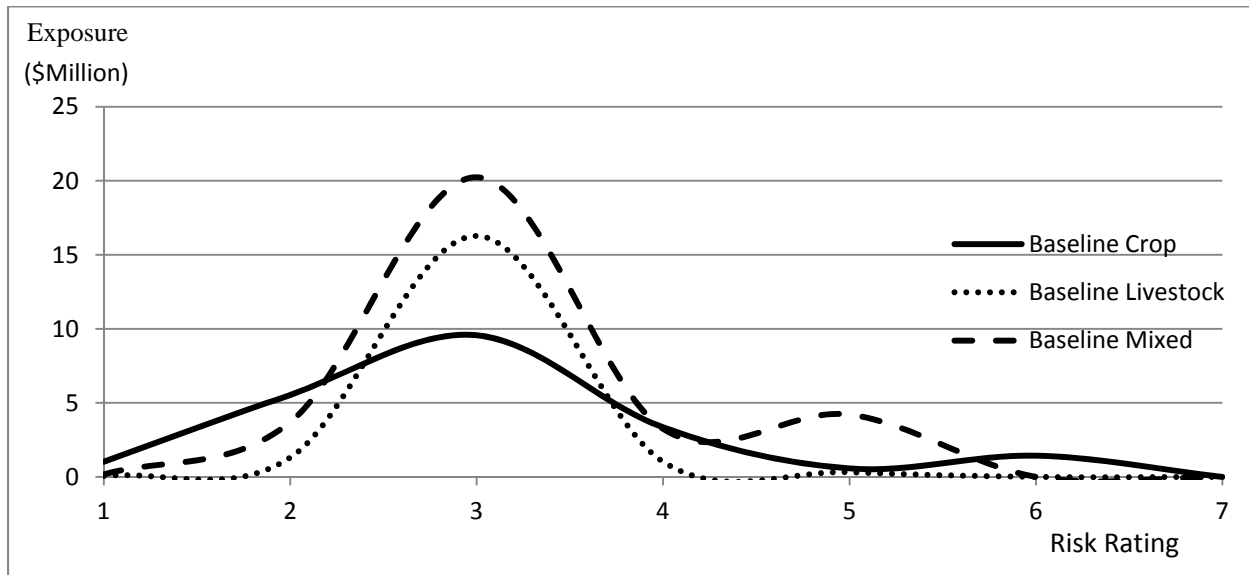
Figure 2. Comparison of Baseline Model Risk Rating Results for Four Loan Exposure Groups by Number of Borrowers



For the four loan exposure size sub-portfolios the distribution of borrowers appears to concentrate around risk ratings 2 and 3, as shown in Figure 2. In the largest exposure group (IV), borrowers tend to fall more often in the higher risk ratings (5-7). Among the smaller exposure groups (I and II) more borrowers fall into the stronger risk ratings (1-3).

In Figure 3 we provide the baseline distributions of loan risk exposure by enterprise type. We see that the crop sub-portfolio, the livestock sub-portfolio, and the mixed sub-portfolio all have greater exposure concentrations at risk rating 3, which is an acceptable (pass) rating for the bank. About 9% in the crop enterprise loan exposure is at the near default level. The livestock sub-portfolio represents a relatively safer exposure in the baseline model with only 2% of loan volume in the “near default” rating. In the mixed enterprise sub-portfolio most of the loan exposure is concentrated at the risk rating 3, but it has 13% exposure in risk rating 5. Visually, the crop and mixed enterprise sub-portfolios appear to have greater credit risk exposure, while the livestock enterprise sub-portfolio is relatively less risky.

Figure 3: Comparison of Baseline Model Risk Rating Results for Three Enterprise Types by Loan Exposure Level



### Stress-Testing the Credit Risk Exposures

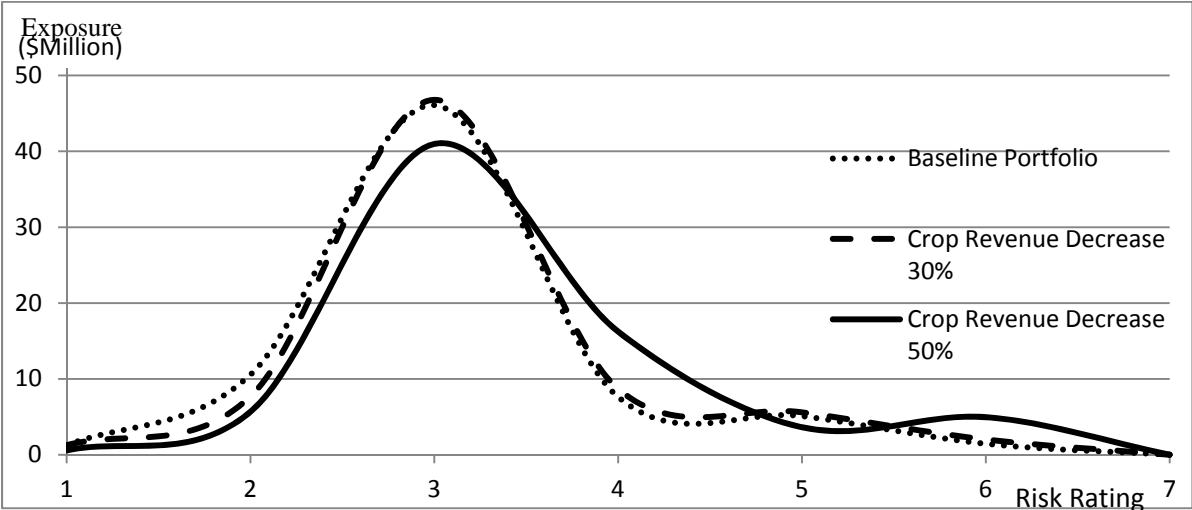
Visual stress-testing is used to observe how loan exposure migrates from one risk rating profile to a subsequent risk rating profile as the result of a negative shock. A negative shock to borrower revenue or asset values is expected to lead to out-migration from low risk ratings and

in-migration to high risk ratings and an overall increase in risk exposure. In addition to out-migration from low risk ratings to high risk ratings, there is also the possibility that the level of default can increase. Since the case bank does not track loan default rates, the stress-testing application is used also to observe changes in the level of “near-default” risk ratings (5-8) in the bank portfolio as a result of a shock.

*Portfolio Risk Migration for a Crop Revenue Shock*

Adverse crop revenue shocks could emanate from a sudden crop failure, or a sudden decline in market price received by farm borrowers, or a combination of these events. The examples shown here do not specify the exact reason for the revenue shock. We only assume that occurs and that it affects all farm borrowers of the bank in proportion to their base year (2009) crop revenue. A negative crop revenue shock is expected to significantly shift loan exposure to higher risk ratings when compared with the baseline distribution of loan exposure.

Figure 4. Exposure Migration Due to Adverse Crop Revenue Shocks



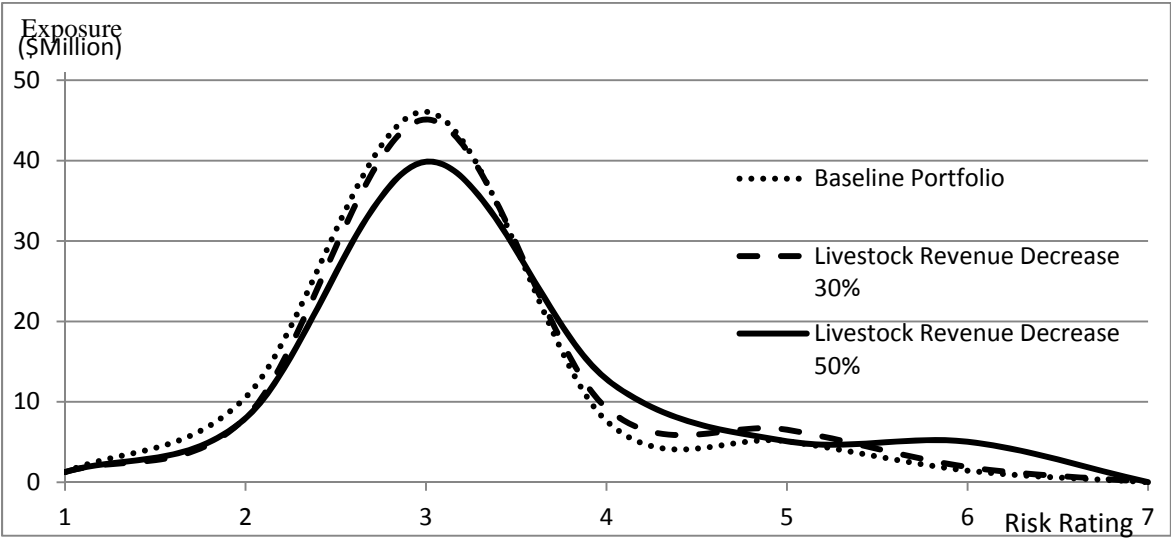
Credit Risk Rating	Change when crop revenue decreases by 30%	Change when crop revenue decreases by 50%
1	0%	-54%
2	-27%	-46%
3	2%	-11%
4	14%	113%
5	10%	-29%
6	40%	244%
Near Default Rate	11%	12%

As show in Figure 4, a large 50% crop revenue decrease leads to more than a 100% increase in exposure at risk rating 4, while at risk rating 6 (substandard) exposure increases more than 200%. Loan volume in the “near default” ratings (5-8) increases to 12% of total loan volume. As a comparison, the risk migration to “near default” ratings for a 30% crop revenue shock increases to 11% of loan volume. Thus, a crop revenue shock can be shown to have a significant negative impact on the distribution of loan volume beyond the crop enterprises alone, as the livestock and mixed enterprise segments are also sensitive to adverse crop revenue shocks.

*Portfolio Risk Migration for a Livestock Revenue Shock*

Similar to the approach with a crop revenue shock, a livestock revenue shock assumes that all borrowers with livestock revenue experience a negative shock to their livestock revenue in proportion to their 2009 livestock revenue. The whole loan portfolio appears to be sensitive to livestock revenue decreases as illustrated in Figure 5.

Figure 5. Exposure Migration Due to Adverse Livestock Revenue Shocks



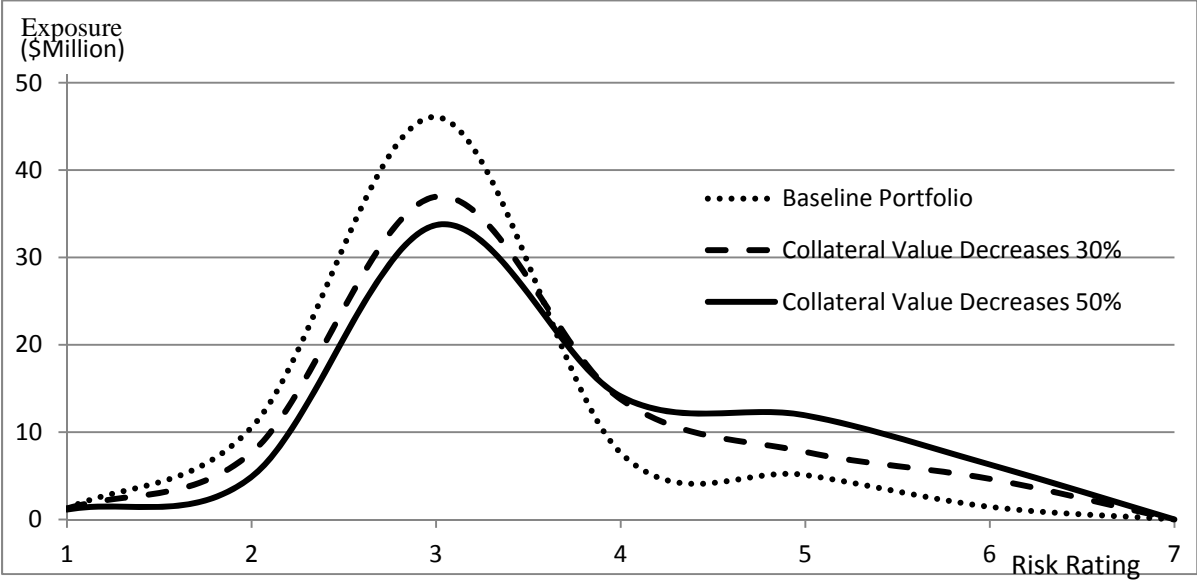
Credit Risk Rating	Change when livestock revenue decreases by 30%	Change when livestock revenue decreases by 50%
1	0%	0%
2	-24%	-25%
3	-2%	-13%
4	21%	68%
5	28%	0%
6	31%	250%
Near Default Rate	12%	14%

An adverse livestock revenue shock has a relatively larger impact on exposure at the higher risk ratings than at the lower risk ratings. This is because at the higher risk rating levels a lower percentage of total exposure belongs to the crop enterprise sub-portfolio but a higher percentage of total exposure belongs to the livestock and mixed enterprise sub-portfolios. When we compare the results in Figures 4 and 5, we find that a 50% decrease in livestock revenue causes the portfolio “near default” rate to increase from 9% to 14%, while a comparable 50% decrease in the level of crop revenue causes near default volume to increase from 9% to 12%. In effect the bank’s portfolio is more sensitive to livestock revenue shocks than crop revenue shocks.

*Portfolio Risk Migration for a Collateral Value Shock*

A collateral value shock has a dramatic effect on exposure migration in the portfolio. Just a 30% decrease of collateral value significantly increases risk exposure as shown in Figure 6.

Figure 6. Exposure Migration Due to an Adverse Collateral Value Shock



Credit Risk Rating	Change when collateral value decreases by 30%	Change when collateral value decreases by 50%
1	0%	-10%
2	-27%	-54%
3	-20%	-27%
4	81%	85%
5	52%	134%
6	223%	337%
Near Default Rate	17%	25%

Some of the exposure shifts more than two risk rating levels. With a 30% decline of collateral value exposure at risk rating 5 increases 52%, the exposure at risk rating 6 (substandard) increases more than 200%. These are considerable exposure migrations and they cause the overall portfolio near default rate to increase from 9% to 17%. With a 50% collateral value drop, risk exposure shifts even more to the right in Figure 6. These lower collateral values represent increased levels of debt distress in the portfolio. A dramatic 50% decrease in collateral values causes the near default rate to increase from 9% to 25%.

*Enterprise Sub-portfolio Risk Migration for a Crop Revenue Shock*

Negative crop revenue shocks can have a relatively large negative impact on the mixed enterprise with significant exposure shifts at all risk ratings as shown in Figure 7a. The mixed enterprise is especially sensitive to a 50% adverse crop revenue shock, increasing exposure at risk rating 4 (pass/watch) by about 236%. Thus, even the more diversified mixed enterprise segment of the portfolio is sensitive to a crop revenue shock.

Figure 7a. Mixed Enterprise Exposure Migration Due to Adverse Crop Revenue Shocks

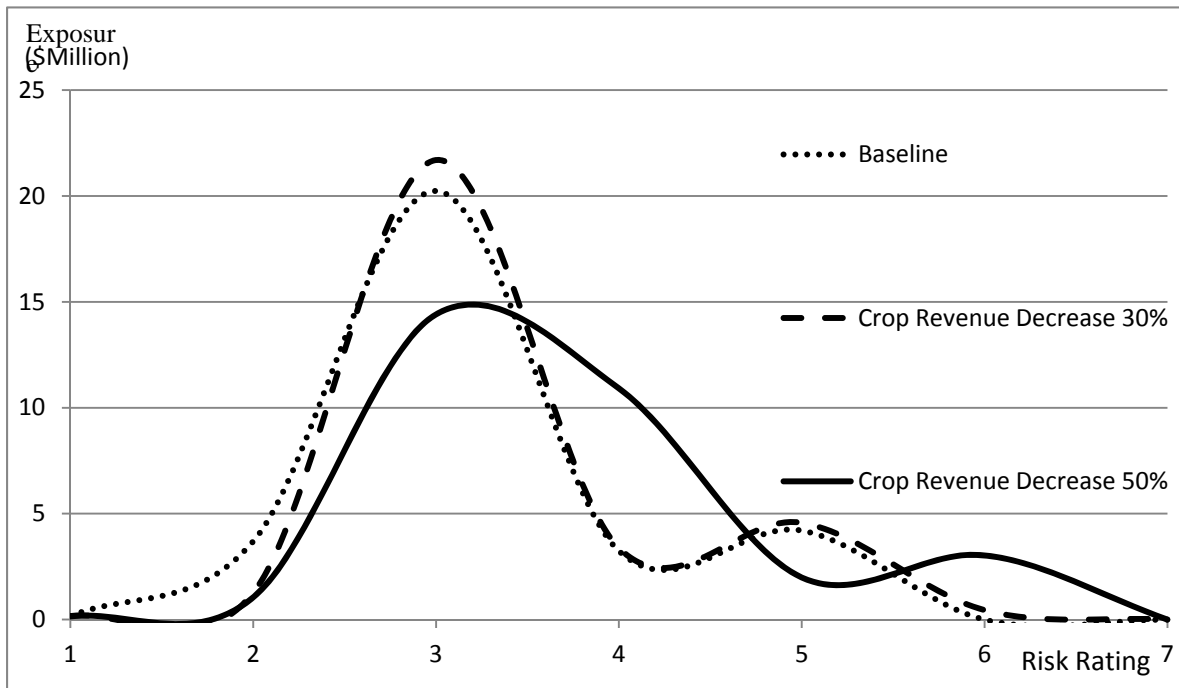
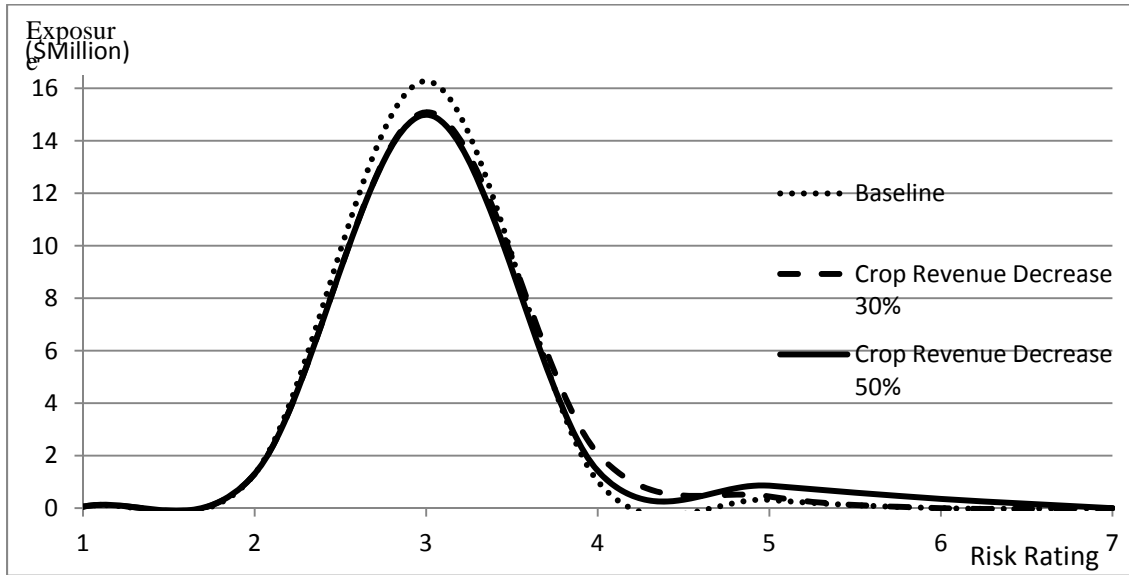
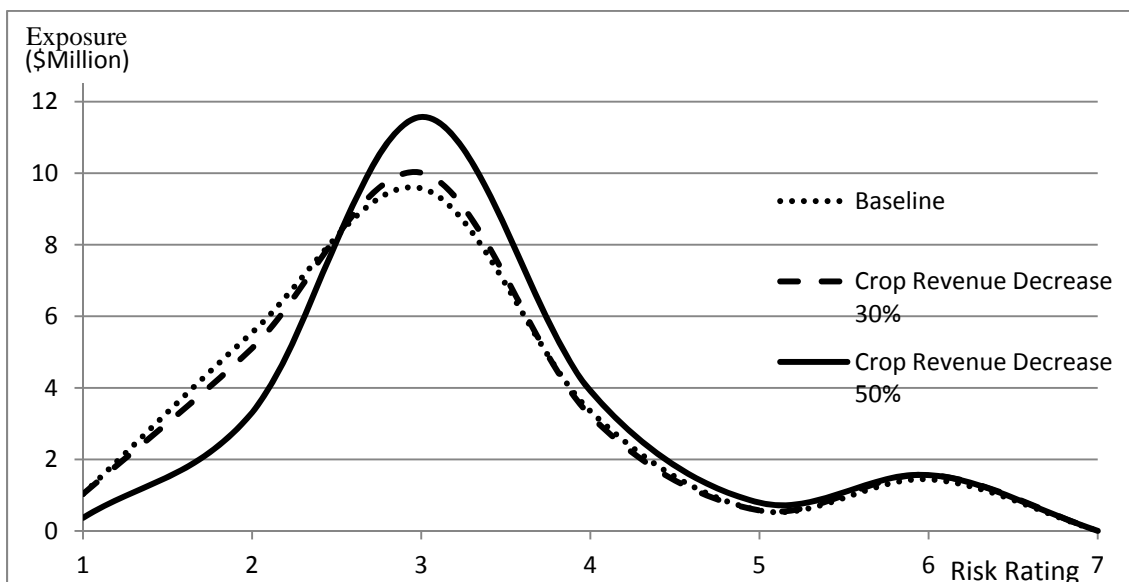


Figure 7b. Livestock Enterprise Exposure Migration Due to Adverse Crop Revenue Shocks



The livestock sub-portfolio shows some sensitivity to negative crop revenue shocks as illustrated in Figure 7b. Also, the migration to near default risk ratings increase from 2% with a 30% adverse crop revenue shock to about 6% when crop revenue declines by 50%. Most of the livestock enterprise sensitivity to the 50% decrease in crop revenue occurs in risk rating 4 (an increase in exposure of 38%) and risk rating 5 (a 170% increase). Both of these increases in risk exposure are in addition to the increases that occur when crop revenue declines by 30%.

Figure 7c. Crop Enterprise Exposure Migration Due to Adverse Crop Revenue Shocks



Credit Risk Rating	Crop Enterprise		Livestock Enterprise		Mixed Enterprise	
	Change when crop revenue decreases by 30%	Change when crop revenue decreases by 50%	Change when crop revenue decreases by 30%	Change when crop revenue decreases by 50%	Change when crop revenue decreases by 30%	Change when crop revenue decreases by 50%
1	0%	-65%	0%	0%	0%	-9%
2	-8%	-40%	0%	0%	-66%	-72%
3	5%	21%	-7%	-8%	7%	-29%
4	-4%	17%	103%	38%	4%	237%
5	0%	38%	41%	170%	9%	-53%
6	9%	9%	0%	2%	1%	10%
Near Default Rate	10%	11%	2%	6%	16%	16%
Note: Baseline Near Default Rate	9%		2%		13%	

The crop enterprise sub-portfolio is not highly sensitive to a 30% decrease in crop revenue, but that sensitivity escalates when a 50% crop revenue decrease occurs. In this scenario the most significant risk migration is out of risk ratings 1-2 into risk ratings 3-5 as shown in Figure 7c. In contrast the mixed enterprise sub-portfolio is quite sensitive to crop revenue shocks at all risk ratings, and the near default risk rating level rises to 16% given a 30% decrease in crop revenues.

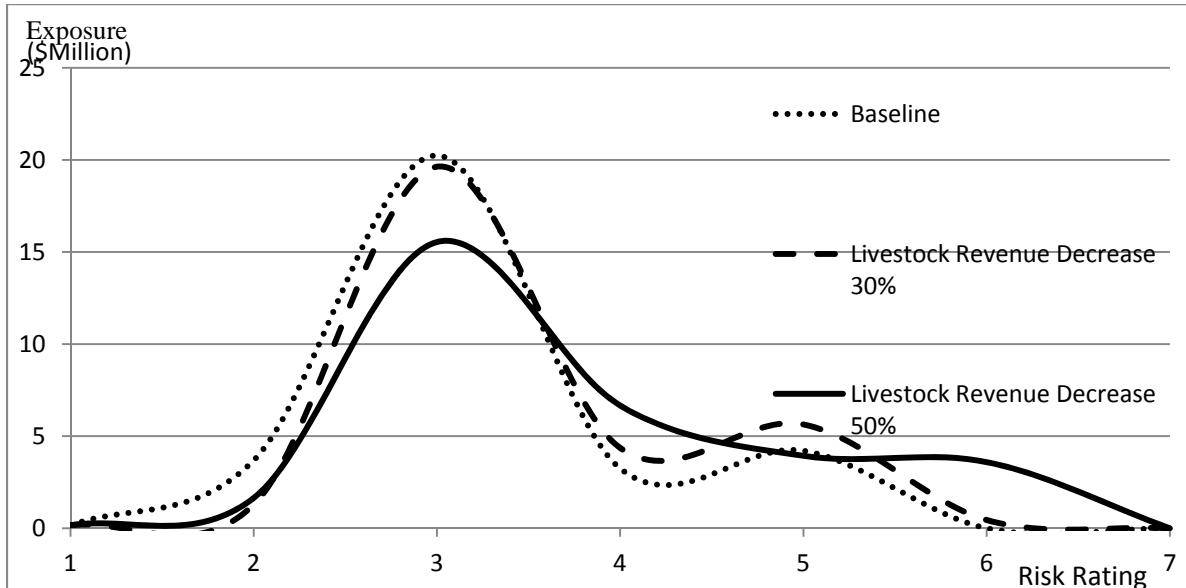
#### *Enterprise Sub-portfolio Risk Migration for a Livestock Revenue Shock*

When there are negative shocks to livestock revenue the most dramatic exposure migrations occur in the mixed enterprise sub-portfolio, as reflected in Figure 8. Significant out migration occurs from risk ratings 2-3 and that volume migrates to risk ratings 4-5. The near default rate for the mixed sub-portfolio rises significantly from 13% in the baseline scenario to 19% (for a 30% revenue shock) and 24% (for a 50% revenue shock). The livestock portfolio also exhibits significant migration to higher risk ratings, but the overall level of near default remains relatively stable, rising only slightly from 2% to 3%. As expected, the livestock sub-portfolio is more sensitive to a 50% livestock revenue shock than to a 30% shock, as shown in the table following Figure 8. The livestock revenue shocks cause substantially less exposure migration in



the crop sub-enterprise with only slight exposure out-migration occurring at the lower risk rating levels.

Figure 8. Mixed Enterprise Exposure Migration Due to Adverse Livestock Revenue Shocks



Credit Risk Rating	Crop Enterprise		Livestock Enterprise		Mixed Enterprise	
	Change when livestock revenue decreases by 30%	Change when livestock revenue decreases by 50%	Change when livestock revenue decreases by 30%	Change when livestock revenue decreases by 50%	Change when livestock revenue decreases by 30%	Change when livestock revenue decreases by 50%
1	0%	0%	0%	0%	0%	0%
2	-1%	-2%	-5%	-36%	-65%	-55%
3	1%	1%	-3%	-10%	-3%	-23%
4	0%	0%	49%	175%	35%	105%
5	0%	0%	0%	88%	34%	-7%
6	0%	0%	0%	0%	1%	11%
Near Default Rate	9%	9%	2%	3%	19%	24%
Note: Baseline Near Default Rate	9%		2%		13%	

### Enterprise Sub-portfolio Risk Migration for Collateral Value Shocks

Collateral value shocks result in a sharp exposure shift from lower risk to higher risk and a corresponding significant increase in the near default rate in all three enterprise types, as shown in Figures 9a - 9c. Asset values are frequently used as a stress test in loan portfolios and this result suggests that the bank is sensitive to declining overall asset values. The shifts to higher risk ratings lead to more financial stress throughout the entire loan portfolio. As illustrated in Figure 9a. Crop Enterprise Exposure Migration Due to Adverse Collateral Value Shocks

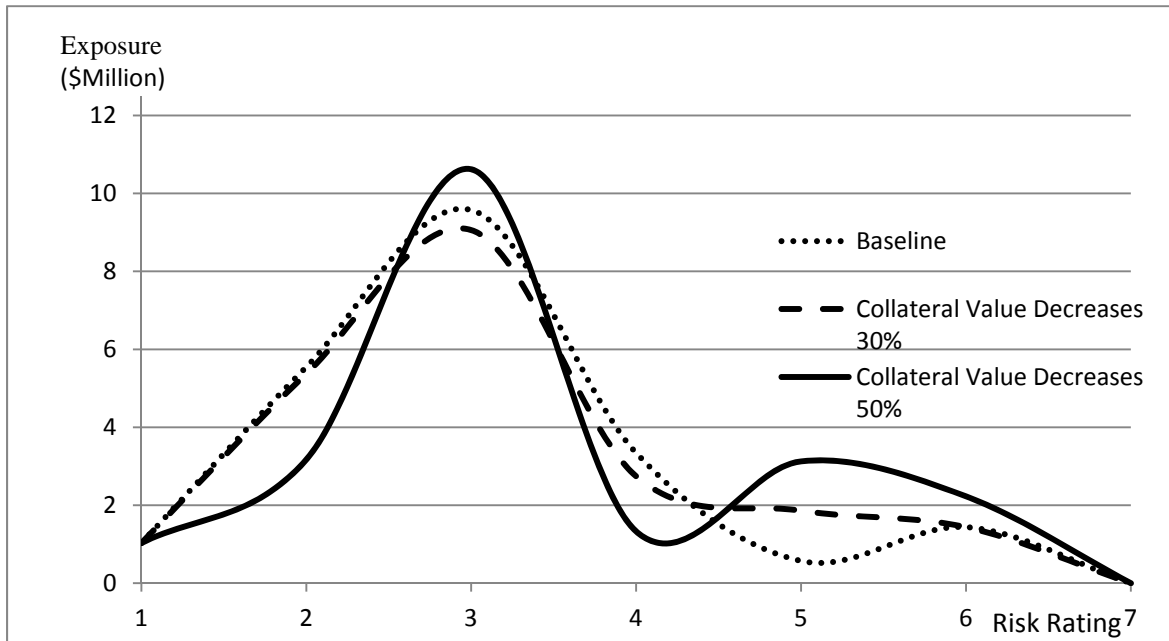


Figure 9a (and the adjoining table, the near default rate rises from 9% in the baseline crop portfolio to 15% (for a 30% collateral value decline) and to 25% (for a 50% collateral value decline). A similar sharp increase in the near default rate is found in the mixed enterprise sub-portfolio as shown in Figure 9c (and the adjoining table), where the escalation in risk exposure is from 13% to 22% (for the 30% collateral value decline) to 31% (for the 50% collateral value decline).

Figure 9b. Livestock Enterprise Exposure Migration Due to Adverse Collateral Value Shocks

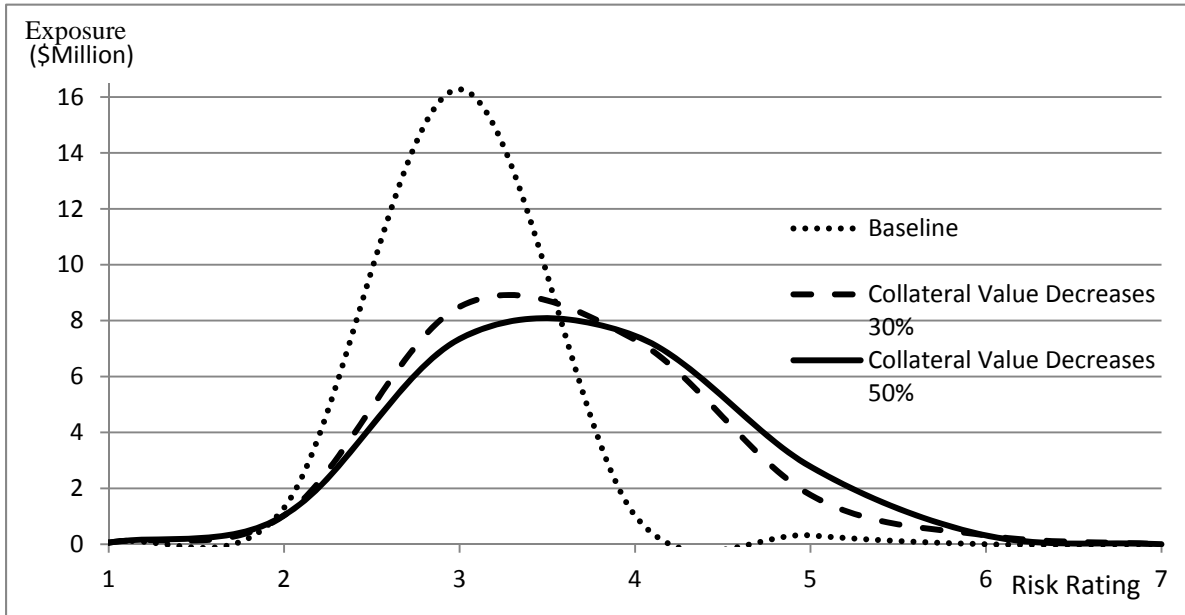
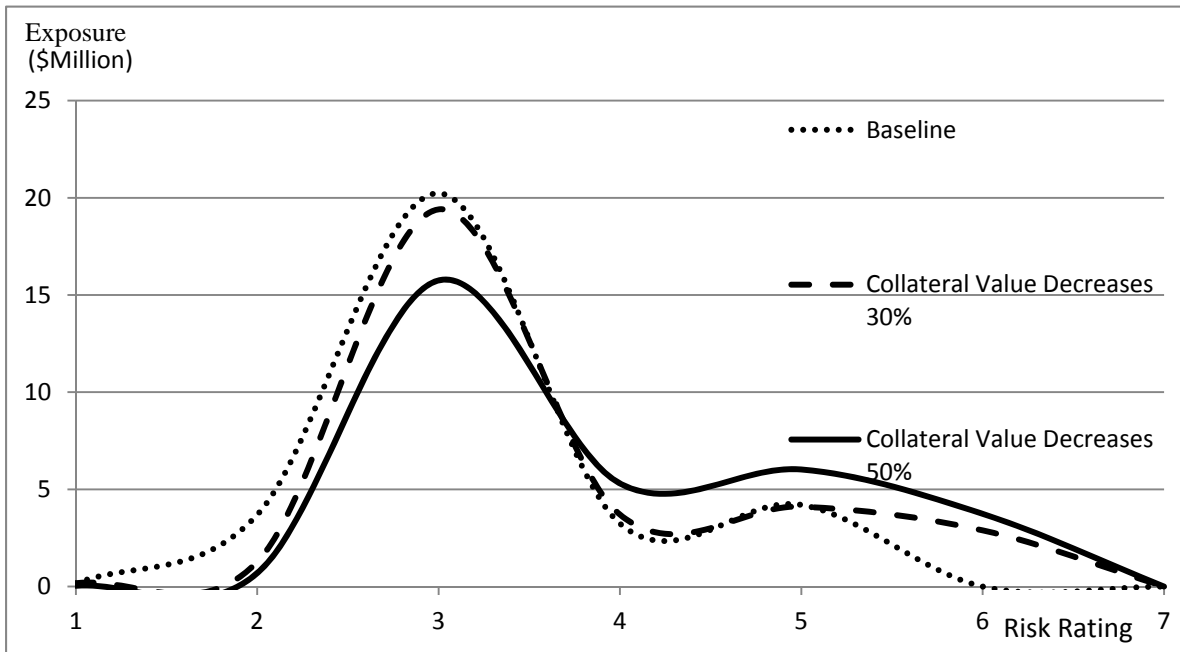


Figure 9c. Mixed Enterprise Exposure Migration Due to Adverse Collateral Value Shocks



	Crop Enterprise		Livestock Enterprise		Mixed Enterprise	
Credit Risk Rating	Change when collateral value decreases by 30%	Change when collateral value decreases by 50%	Change when collateral value decreases by 30%	Change when collateral value decreases by 50%	Change when collateral value decreases by 30%	Change when collateral value decreases by 50%
1	0%	0%	0%	0%	0%	-76%
2	-3%	-43%	-21%	-21%	-66%	-81%
3	-5%	11%	-48%	-55%	-4%	-22%
4	-18%	-60%	613%	627%	14%	64%
5	226%	448%	457%	777%	-2%	43%
6	0%	55%	2%	2%	9%	12%
Near Default Rate	15%	25%	11%	16%	22%	31%
Note: Baseline Near Default Rate	9%		2%		13%	

### *Exposure Group Risk Migration for Collateral Value Shocks*

A collateral values shock is the strongest shock among all stress tests for the loan portfolio of the bank. We find that a 30% negative collateral value shock is quite harmful for four borrower exposure sub-portfolios. The increases in the near default rate reflect underlying shifts from generally lower risk ratings to higher risk ratings. In the smaller borrower groups (sub-portfolios I and II) the near default rate increases from 3-4% to 13% due to the 30% collateral value shock. As the collateral value shock deepens from 30% to 50%, the larger borrower sub-portfolios tend to reflect steeper increases in risk migration as the near default rate for sub-portfolio II rises first to 12% and then to 19%. Similarly, the near default rate for borrower group IV rises from 11% to 20% and then to 29%.

Table 4. Borrower Size Group Exposure Migration Due to Collateral Value Shocks

Credit Risk Rating	Change for borrower size group I		Change for borrower size group II		Change for borrower size group III		Change for borrower size group IV	
	30% shock	50% shock	30% shock	50% shock	30% shock	50% shock	30% shock	50% shock
1	0%	0%	0%	-100%	0%	0%	0%	0%
2	-17%	-20%	-9%	-13%	-28%	-46%	-39%	-87%
3	17%	20%	-9%	-17%	-12%	-18%	-24%	-32%
4	-100%	-100%	-25%	48%	97%	93%	100%	97%
5	153%	35%	232%	21%	29%	86%	44%	154%
6	4%	8%	3%	9%	3%	7%	172%	211%
Near Default Rate	13%	13%	13%	13%	12%	19%	20%	29%
Note: Baseline Near Default Rate	4%		3%		7%		11%	

### *Exposure Group Risk Migration for a Farm Financial Crisis Scenario*

The early 1980s was a period of “financial crisis” for agriculture. Data from the U.S. Department of Agriculture indicates that interest rates rose to 20%, while crop revenue decreased 35%, livestock revenue decreased 25%, and collateral value dropped by about 60%. To illustrate the potential impact on exposure migration we assume these factors jointly change in a 1980s type farm financial crisis scenario.

The financial crisis shock leads to a major exposure shift. All three enterprises experience more severe risk migrations than is seen in any of the previous stress tests. Crop enterprise exposure shifts from a single mode at risk rating 3 (in the baseline) to a bi-modal risk rating at 3 and 6, as shown in Figure 10. Initially, 9% of the baseline crop sub-portfolio was near default, but after the shock 34% of the total exposure is near default. The livestock enterprise sub-portfolio also experiences a dramatic exposure migration as illustrated in Figure 11. Typical livestock risk rating increases from 3 to 4-5, and the “near default” rate increases from 2% to 27%.

Figure 10. Crop Enterprise Exposure Migration Due to a 1980's Type Farm Financial Crisis

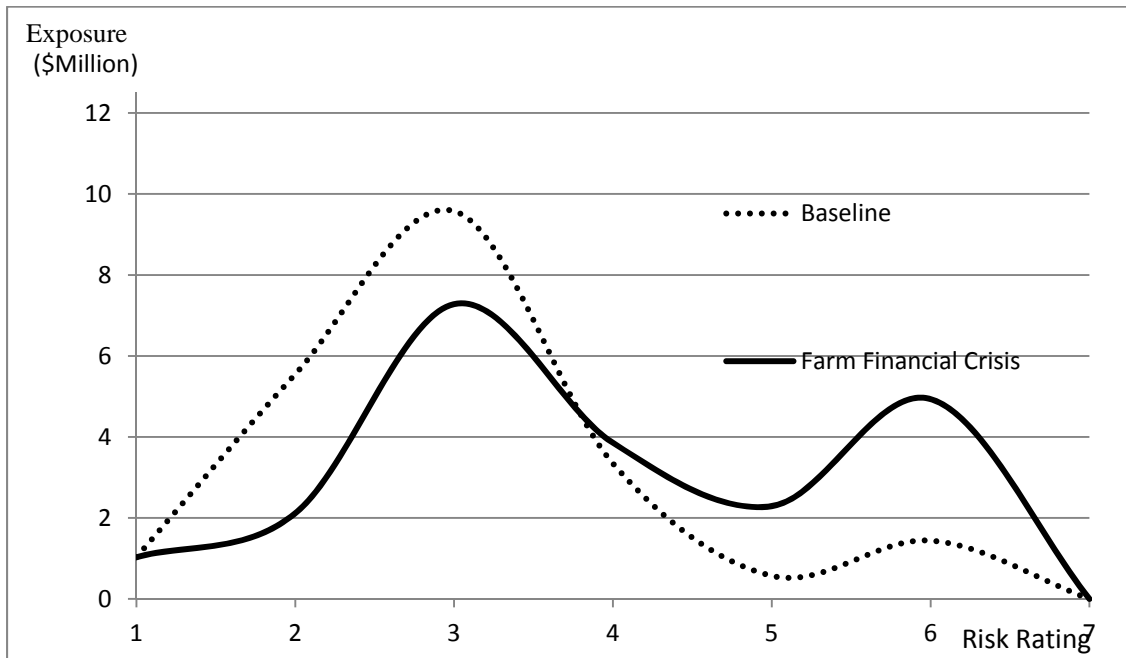


Figure 11. Livestock Enterprise Exposure Migration Due to a 1980's Type Farm Financial Crisis

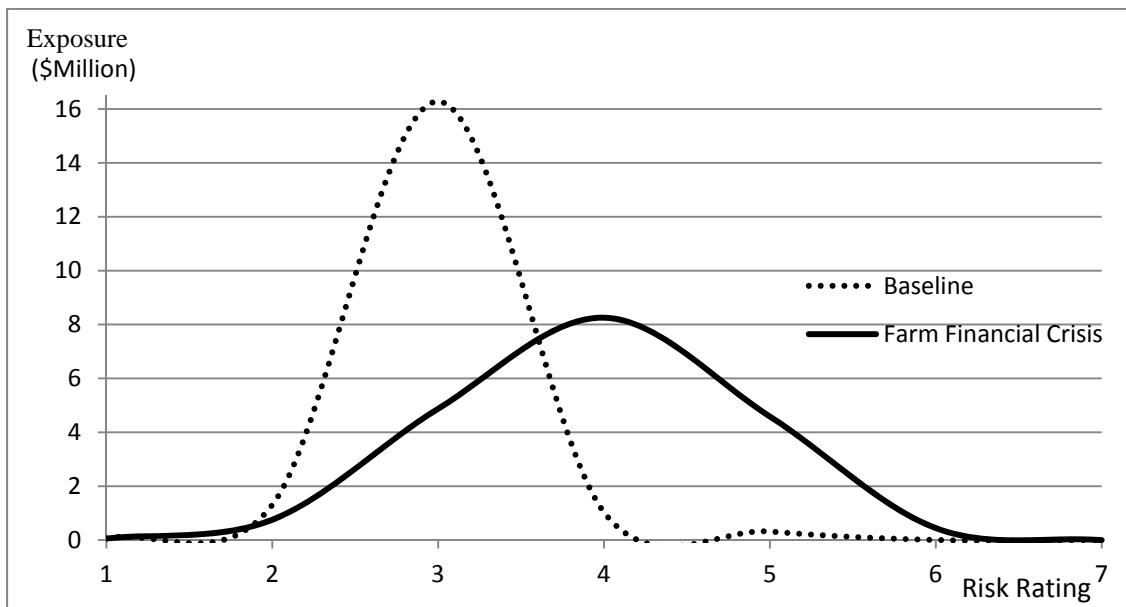
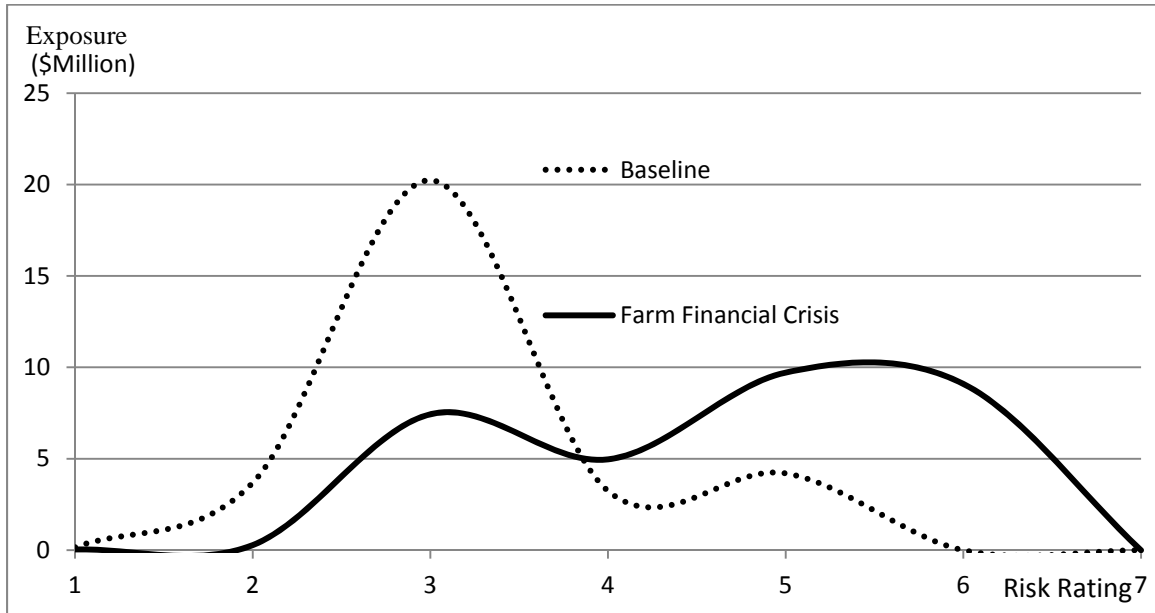


Figure 12. Mixed Enterprise Exposure Migration Due to a 1980's Type Farm Financial Crisis



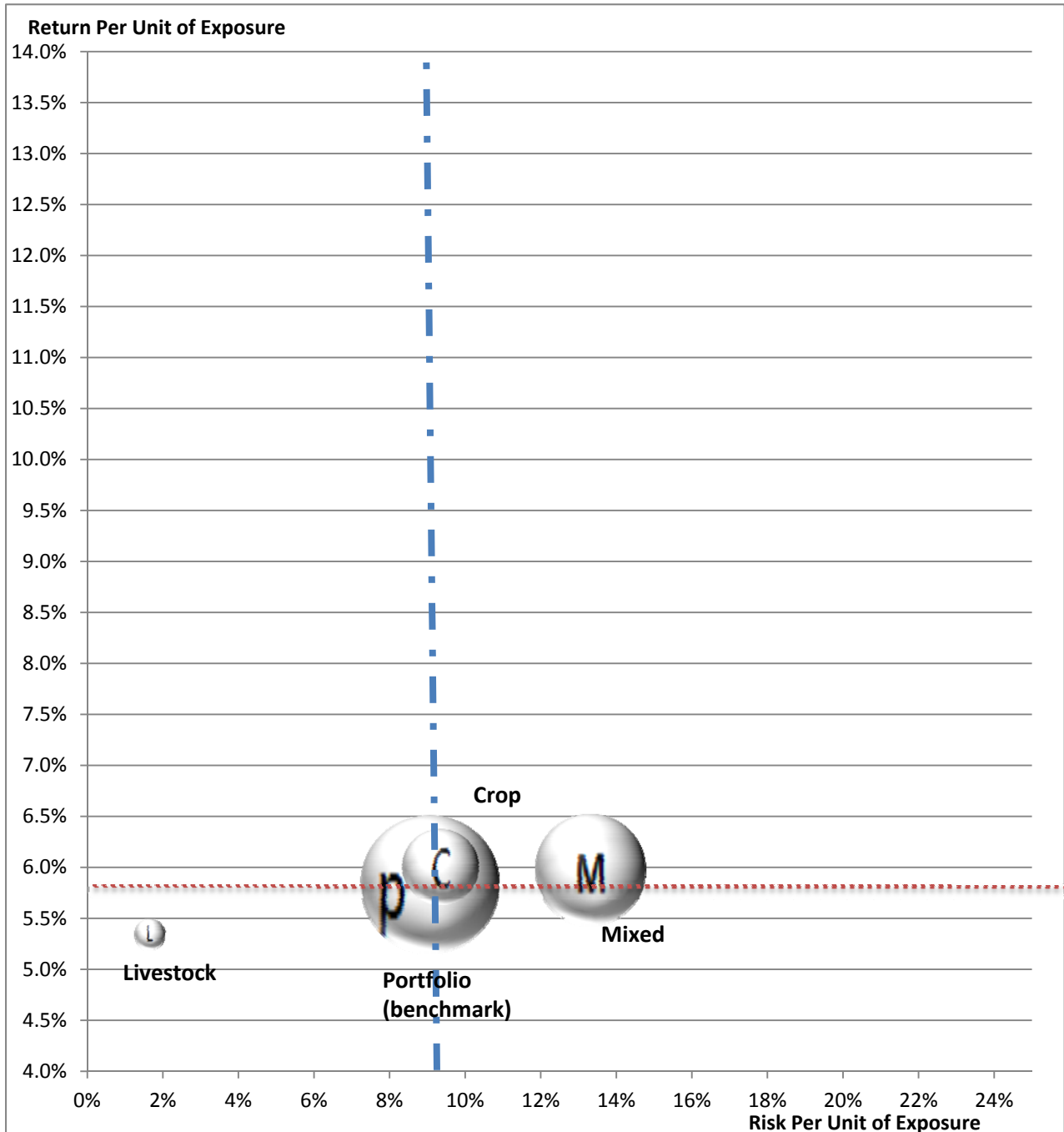
Credit Risk Rating	Crop Enterprise	Livestock Enterprise	Mixed Enterprise
1	0%	0%	-76%
2	-62%	-42%	-92%
3	-24%	-70%	-63%
4	15%	705%	53%
5	302%	1,350%	131%
6	243%	2%	29%
Near Default Rate	34%	27%	60%
Note: Baseline Near Default Rate	9%	2%	13%

Perhaps the most visually dramatic negative impact of the financial crisis is seen in the mixed enterprise sub-portfolio in Figure 12. After the shock the mode of the risk rating distribution shifts from 3 (in the baseline) to 6. Also, the “near default” rate increases from 13% to 60%. The mixed sub-portfolio is quite sensitive to revenue shocks in the crop and livestock sectors and the interest rate change.

## Evaluating Return and Risk Exposure Migration

The previous results illustrate exposure migration in reaction to specific shocks. Our next step is to combine the impacts of a specific shock on exposure, concentration risk, and an indicator of returns. We can think of this as a risk-return visual approach.

Figure 13. Baseline Exposure, Risk and Return by Enterprise Type





In Figure 13 we depict the baseline bank portfolio and the enterprise type sub-portfolios. The horizontal axis indicates the level of risk per unit of exposure. Here we use the percentage of the exposure that is near default as a proxy for default risk. The vertical axis indicates the level of return per unit of exposure. Here we use the average interest rate earned on those loans as a proxy for the rate of return to the bank. In a more complete analysis the risk indicator could be a measure of the default rate and the return indicator could be the expected profitability of the loan to the bank using an approach such as customer profitability analysis.

The “bubbles” in the graph denote the exposure of the overall loan portfolio and the various enterprise sub-portfolios. The size of each exposure “bubble” indicates the percentage of the total agricultural exposure of the bank, i.e., the concentration of risk. In these charts, size is calculated as the ratio of the “near default” rate in each sub-portfolio to the “near default” rate of the whole portfolio. Thus, the size of the whole portfolio exposure bubble is 1, while the size of the mixed enterprise exposure bubble (in Figure 13) is 0.64. As shocks occur, the size and location of these exposure bubbles change and they migrate to new positions in the graph.

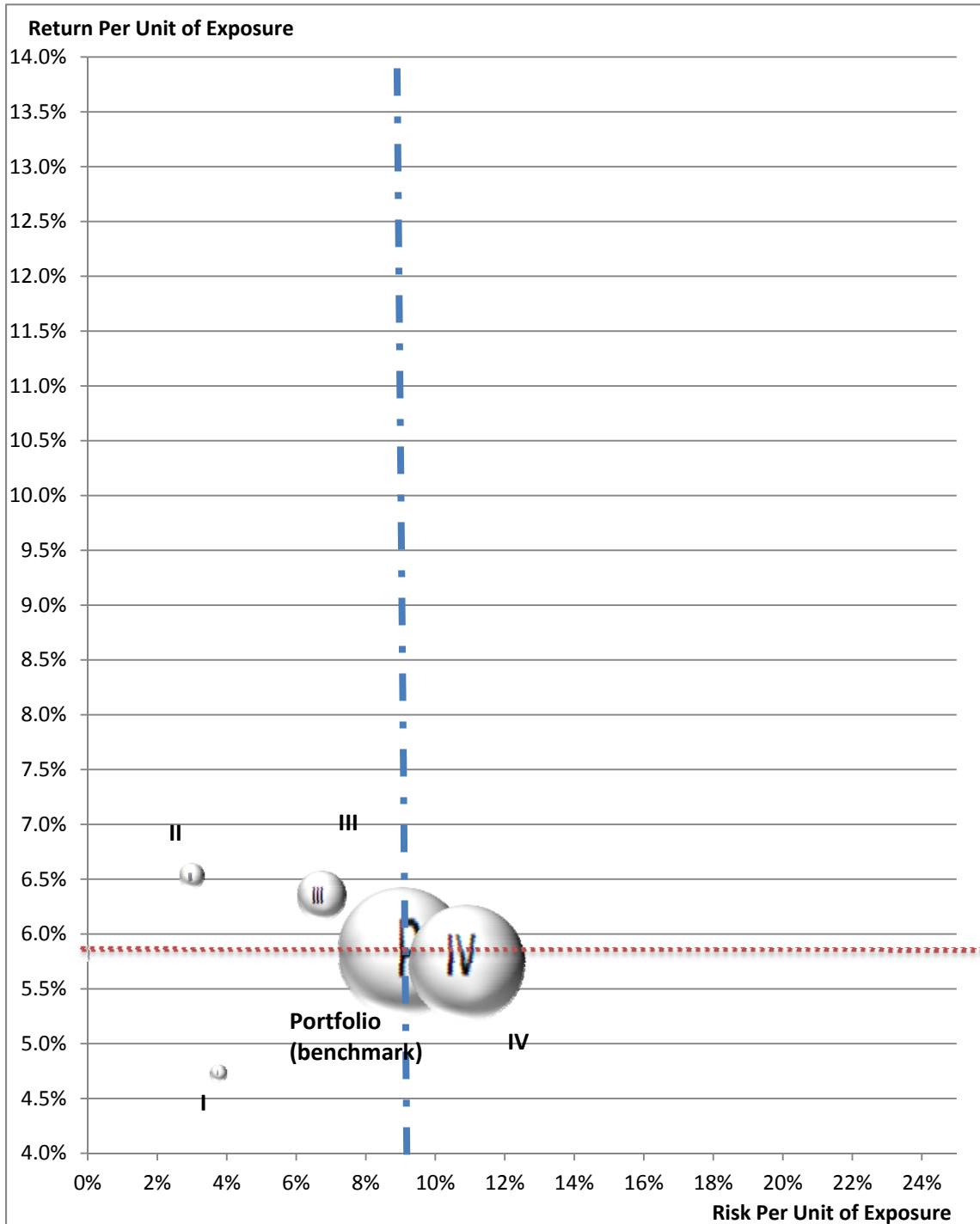
Four quadrants are identified within each chart with each quadrant identifying a level of risk and return. The center of this quadrant plot is located at the point of the whole portfolio baseline exposure with the average return and the average near default rate as the coordinates in the chart. Visually we can compare the positions and sizes (concentrations) of each of these sub-portfolios to the combined agricultural portfolio of the bank. The risk exposure is measured in terms of the “near default” rate. That near default rate for the benchmark portfolio is 9%. The benchmark portfolio return is 5.8%. A higher degree of both risk and return is found in the upper right quadrant, and a lower degree of both risk and return is found in the bottom left quadrant. A risk-averse bank’s preferred position is in the upper left quadrant where risk is relatively lower and returns are relatively higher. The crop enterprise sub-portfolio falls in the upper right quadrant of the chart. It has a slightly higher risk than the benchmark, but the return on the crop sub-portfolio exceeds that of the overall portfolio of the bank. The mixed enterprise sub-portfolio represents another significant concentration of the bank, as reflected by the relative size of the exposure bubble. The mixed enterprise loans earn a slightly higher return than the overall portfolio benchmark. However, the mixed sub-portfolio carries significantly more risk per unit of exposure, which far exceeds the risk level of the benchmark portfolio. Consequently, it has a relatively lower return/risk ratio. The livestock enterprise sub-portfolio exposure bubble is

relatively small, and it falls in the lower left quadrant. The livestock return per unit of exposure is below the portfolio benchmark, and it has a risk exposure that is also lower than that of the overall portfolio. As risk migration occurs in the portfolio, the exposure bubbles migrate to different quadrants, or from one position to another within the same quadrant. Thus, we get a visual report on the level and type of risk migration that is expected to occur.

The chart could be used also to visualize the bank's lending policy. The vertical line through the baseline portfolio might be set at different levels to reflect the bank's credit risk threshold. This risk threshold could be set to the right of the line shown in the chart if the bank is willing to take on risks that are higher than the average risks of the portfolio, or to the left of that line if the bank wants to reduce its overall risk exposure. Enterprise risk exposure bubbles to the right of the risk threshold are those that may be gradually reduced in size or repositioned by the bank to achieve an alternative risk profile. Similarly, the horizontal line through the baseline portfolio represents a target return below which the bank may not want to go. By setting the return target above the average return of the portfolio the bank would be striving to raise its overall return per unit of exposure.

In Figure 14 we illustrate the four exposure group sub-portfolios. Once again the cross-hairs of the chart run through the baseline of 9% near default rate and 5.8% average return. Exposure group I has lower risk (about 4%) and a lower return (about 4.75%) than the overall benchmark portfolio. Its return-to-risk ratio is higher than the overall portfolio. Exposure group II also has relatively low risk per unit of exposure but it has a higher level of return than the benchmark portfolio. Size group II is also a relatively small part of the bank's overall risk exposure but is the bank's most profitable exposure group. Although the return indicator does not account for the cost of servicing these smaller clients, the implication is that the bank could increase its return/risk position by increasing loan volume in these two sub-portfolios. Similarly, exposure group III earns a slightly higher return than the benchmark but has a slightly lower risk than the overall benchmark. The large loan exposure group (IV) has lower average return per unit of exposure and a higher level of risk per unit of exposure than the benchmark. In addition group IV has the highest concentration risk of all the borrower size group sub-portfolios.

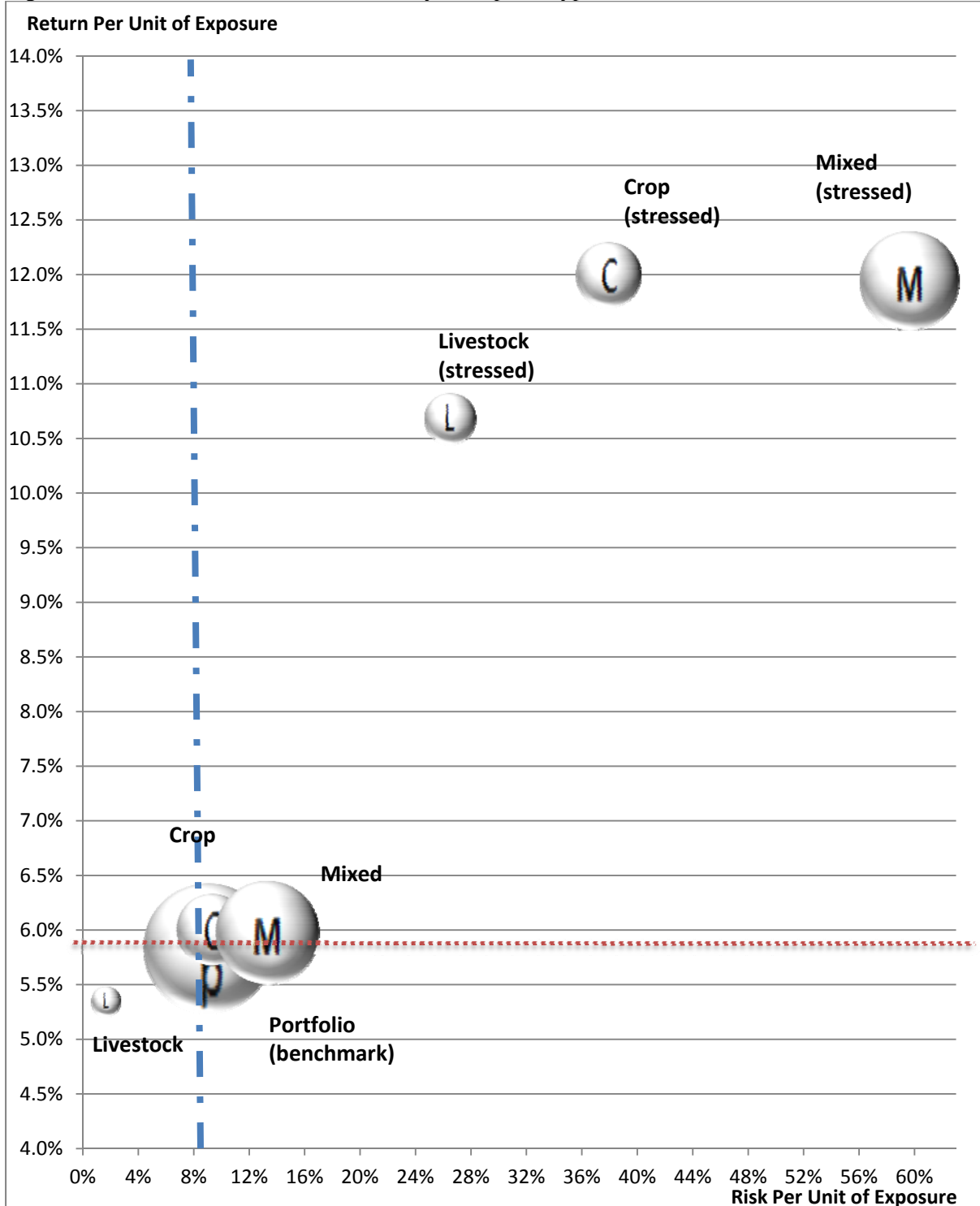
Figure 14. Baseline Exposure, Risk and Return by Exposure Group (I – IV)



In Figure 15 we observe the effect of the farm financial stress scenario on the bank’s agricultural loan portfolio. This figure can be compared to Figure 13 as a baseline. Financial stress leads to a significant migration of all three enterprise portfolios from their baseline positions to the upper

right quadrant. This signifies that the level of near default rises dramatically. The sharpest increases in risk exposure occur in the crop and mixed enterprise sub-portfolios. We note that

Figure 15. Farm Financial Stress Scenario by Enterprise Type



the enterprise bubbles also rise to higher levels of returns during this scenario. This reflects the initial increase in interest rates that occurred during the 1980s financial crisis. In actuality, lenders probably witnessed a decrease in their rate of return on loans due to the increase in defaults and falling profitability of the loan portfolio. The alternative financial crisis (with decreasing profitability) scenario would cause the bubbles to migrate into the lower right quadrant, representing higher risk and lower returns per unit of risk exposure.

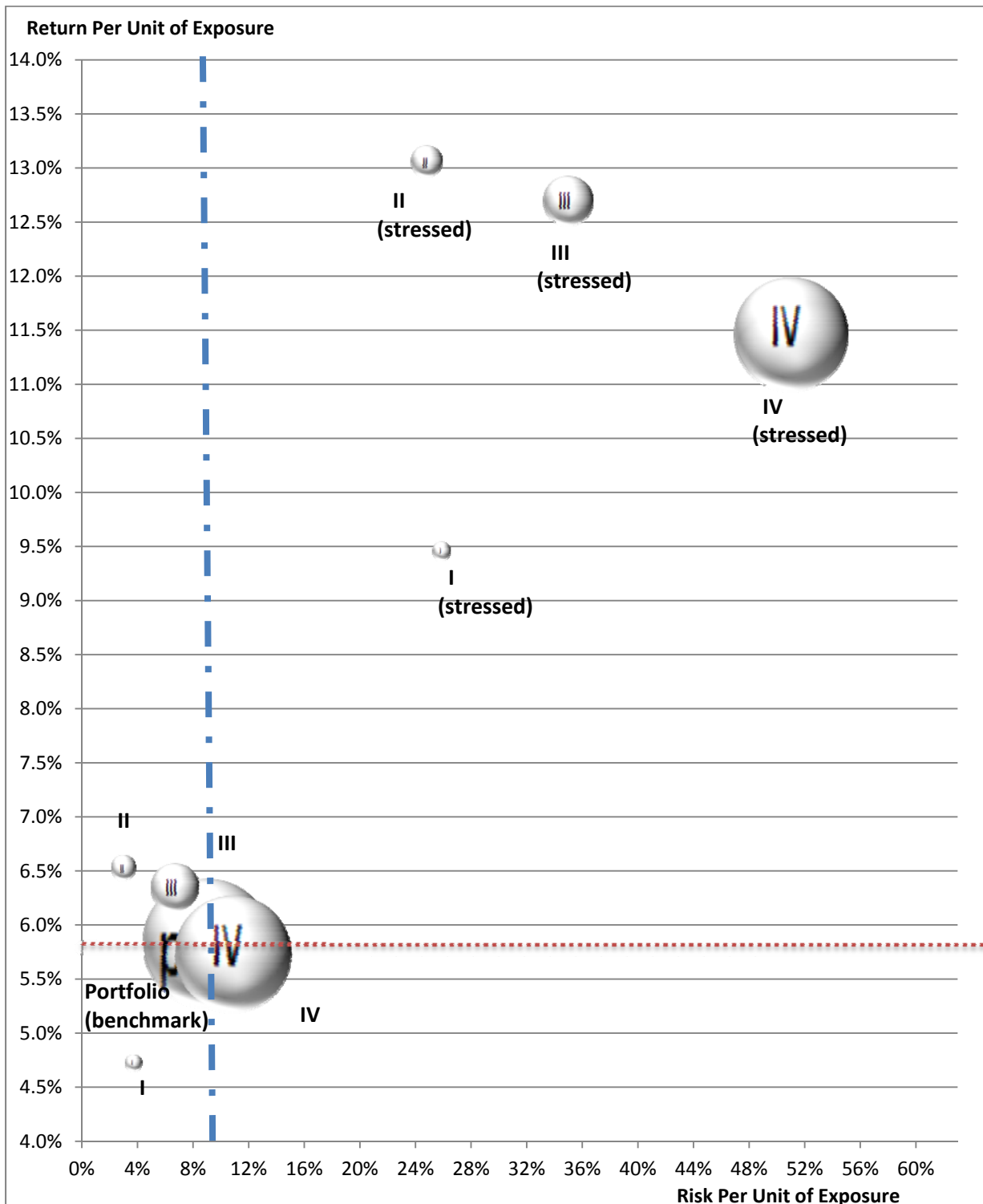
In Figure 16 we observe the analogous migration of loan exposure according to the exposure size categories of the bank when farm financial stress occurs. Once again the bubbles migrate into the upper right quadrant as the level of risk exposure increases sharply. The chart suggests that the exposure migration to the right is relatively greater in the larger loan categories (III and IV). Here again, the financial crisis scenario implies that loan returns increased along with risk exposure, as interest rates increased. However, if loans generated higher defaults and lower profitability, due to those defaults, the bubbles probably migrated into the lower right quadrant as a result of financial crisis conditions.

## **Conclusions**

This paper has been motivated by the perception that community banks need more tools to perform risk analysis at the loan portfolio and sub-portfolio levels of aggregation. Aggregation can provide important diagnostic information when loan risk factors are correlated, since the resulting systematic risks will not be reflected at the individual customer, transaction level of analysis.

Understanding and measuring these risks in the loan portfolio is becoming a requirement of all banks, including the smaller community banks. The visual tools discussed here can be used to quantify what credit officers in those banks may have been doing internally to manage risk exposure. This visual approach to risk management can be helpful to sort out the “risk cloud” into identifiable parts - - systematic risks that are shared across loan sub-portfolios, enterprise-specific risks that are more isolated yet shared across customers within those enterprise groups, and transaction-level risks that are borrower specific in nature. The tools that are illustrated here can be adapted by community bank to measure and monitor these risks and perform various stress tests on their loan portfolio exposures.

Figure 16. Farm Financial Stress Scenario by Exposure Group (I – IV)



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