

**BENEFITS OF MARKET VALUE CALCULATIONS FOR CREDIT UNIONS**

by

Leonie Wilcke

MSc Mathematics, Heinrich-Heine-University 2013

BSc Mathematics, Heinrich-Heine-University 2011

PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF  
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN FINANCE

In the Master of Science in Finance Program  
of the  
Faculty  
of  
Business Administration

© Leonie Wilcke 2017

SIMON FRASER UNIVERSITY

Fall 2017

*This work was supported by Mitacs through the Mitacs Accelerate program.*

All rights reserved. However, in accordance with the *Copyright Act of Canada*, this work may be reproduced, without authorization, under the conditions for *Fair Dealing*. Therefore, limited reproduction of this work for the purposes of private study, research, criticism, review and news reporting is likely to be in accordance with the law, particularly if cited appropriately.

# Approval

**Name:** Leonie Wilcke

**Degree:** Master of Science in Finance

**Title of Project:** Benefits of market value calculations for credit unions

**Supervisory Committee:**

---

Andrey Pavlov, Ph.D.  
Senior Supervisor  
Professor of Finance

---

Carlos da Costa  
Second Reader  
Visiting Lecturer

**Date Approved:**

## **Abstract**

This research paper focuses on two different interest rate risk measures used by credit unions in Canada, described by regulatory standards as complementary and indispensable. These two measures pertain either sensitivity of market value or net interest income, caused by changes in interest rates. Whereas credit unions can relate to and understand the latter perspective, market value does not seem as relevant as credit unions hold assets and liabilities until maturity and are not exposed to changes in market value. We use data from three credit unions to explain the two measures and show that one can be expressed by the other, which in fact discredits the perceived complementary nature of both measures. Additionally, we further develop the concept of net interest income sensitivity to overcome the weaknesses of market value by employing a more realistic measurement of interest rate risk and a reduction of required capital which eventually would enable credit unions to operate more profitably.

**Keywords:** interest rate risk management in the banking book; market value; net interest income; credit unions; non-trading portfolio; regulatory capital requirements; Basel

## **Acknowledgements**

First and foremost, I would like to thank Scott McCaffrey from the partner organization PRO Financial Solutions for his incredible support, his patience, and for encouraging me to think outside the box. The collaboration with him enabled me to rethink concepts and frameworks, to learn a lot about credit unions, and made the process of my final thesis an unforgettable experience.

I would also like to thank my supervisor Andrey Pavlov for his invaluable and thoughtful input and for always making time to discuss aspects of the project with me.

Additionally, I would like to thank my second reader Carlos da Costa, who has shown great interest in the project content and consulted on the structure of the paper.

Lastly, I would like to thank my partner Leonardo Bonisolli for being there from start to finish of the MSc Finance program, for doing groceries, laundry, and cooking for me. Without him, I would have starved and would not have been able to focus 100% on my academic development.

## Table of Contents

Approval.....	ii
Abstract .....	iii
Acknowledgements .....	iv
Table of Contents .....	v
<b>1. Introduction .....</b>	<b>1</b>
<b>2. Background.....</b>	<b>6</b>
<b>3. Market value model.....</b>	<b>10</b>
3.1 Market value.....	10
3.2 The ALM model.....	12
3.3 ALM model results.....	12
3.4 $\Delta$ MV and the banking book.....	14
<b>4. Net Interest Income Model .....</b>	<b>17</b>
4.1 Net interest income.....	17
4.2 The NII model .....	23
4.3 NII results.....	24
<b>5. Conclusion.....</b>	<b>33</b>
<b>6. References .....</b>	<b>35</b>

## 1. Introduction

The following research paper was written in cooperation with the partner organization PRO Financial Solutions (PRO) and supported by Mitacs through the Mitacs Accelerate program. All data used in this paper has been modified to protect proprietary information from PRO and their clients. The paper focuses on credit unions in Canada, but the ideas and results arising from this paper can be applied to any financial institution.

Credit unions generate profits by lending money to customers at a certain interest rate – in the form of mortgages and loans – and funding these assets by collecting money from customers through deposits – such as chequing accounts – and other short-term liabilities. Credit unions operate sustainably and profitably when earning higher interest rates from customers than those they are paying. The difference between interest rates for lending and borrowing, also known as “the spread”, is the main driver of a credit union’s profitability. The predominant interest rate environment, expressed by the yield curve, influences the rates at which credit unions can lend and borrow and therefore directly impacts the firm’s profitability. It is crucial for credit unions to think about potential changes in the yield curve and how they could affect interest income. For instance, if the yield curve changed enough to cause higher overall interest rates payments to customers than those received by the credit union, that institution would realize losses, harming their own stability and ability to operate. As a

result, managing interest rate risk plays a major part in a credit union's overall risk management process.

The importance of financial regulation and risk management has experienced increased attention after the financial crisis of 2008. The Basel Committee on Banking Supervision (BCBS) published standards for managing interest rate risk in the banking book (IRRBB). According to these standards, financial institutions are recommended to apply two different measures for a holistic management of interest rate risk (Basel Committee on Banking Supervision (BCBS), 2016). Both measures approach interest rate risk in a different way by looking either at the change of market value or the change of interest income.

Market value is the amount of money a credit union would receive when selling assets or pay when refinancing liabilities. It is calculated by discounting all expected future cash flows under the current yield curve and, being a function of fixed cash flows and variable discount curves, it is sensitive to changes in the yield curve.

On the other hand, net interest income is calculated as difference between interest income and expense.

Given the descriptions above, the first risk measure aims to capture the exposure of credit unions to changes in market value. However, credit unions do not trade with assets and liabilities and therefore we would like to question whether credit unions should or should not care about the sensitivity of market value when measuring interest rate risk.

The second measure focuses on the institution's earnings, or "the spread", as discussed earlier. In contrast to market value, where the usefulness for non-trading financial institutions is unclear, the second risk measure is far more tangible as it analyses net interest income – the main profit and loss driver.

In the current regulatory standards and research, these two measures are always perceived as complementing each other and are described as necessary for a successful management of interest rate risk. Yet, it is exactly the usefulness of market value sensitivity and the relationship between these two measures that PRO and their clients struggle to demonstrate. This research paper explains and compares the two risk measures and challenges their complementary nature as well as the importance they both hold for credit unions.

In order to familiarize the reader with the current consensus on interest rate risk management for credit unions and to provide more details, chapter 2 will provide an overview over existing regulation and research.

Based on the current research, we will focus on the market value perspective in chapter 3. We will define the sensitivity of market value in Section 3.1, describe the model used for calculating the sensitivity for three different credit unions and show the results in section 3.2 and 3.3 respectively. We will close chapter 3 with a discussion of the meaning of market value for credit unions in section 3.4 and will explain that the risk calculated with this tool, instead of measuring interest rate risk, actually estimates liquidity risk. Since liquidity risk is already captured under different regulatory standards we raise the concern, that the market value perspective exposes credit unions to capital



requirements that are too conservative. As a result, credit unions assume to have a risk tolerance far below their ability to take on risk, eventually jeopardizing profits.

Keeping these doubts in mind, chapter 4 discusses the sensitivity of net interest income. We start with its definition in section 4.1 and provide a basic example showing under which conditions market value sensitivity equals net interest income sensitivity. This example rebuts the complementary nature of the two risk measurement tools and seriously casts a shadow of doubt over the usefulness of the recommended regulatory requirements, in other words, if both measures should be used by credit unions. One major assumption in this example is our decision to force an artificial cost on equity, increasing net interest income risk to the same amount as market value risk. In order to exclude the unreal cost of equity, section 4.2 extends the basic example to a more complex and realistic situation and explains how the model has to be adjusted for this matter. Section 4.3 discusses the results, explains the effect that the forced cost for equity has over the measurement of risk, and ultimately challenges the general understanding that market value is an adequate measure for interest rate risk in the banking book. Overall, chapter 4 not only disproves the need for a parallel use of both risk measures, but also indicates that market value sensitivity – compared to interest income sensitivity – imposes an absurd additional capital requirement for holding equity. This fact is especially surprising, as holding equity is the safest way to fund assets and should therefore support risk taking and not diminish it.

Finally, chapter 5 summarizes our findings suggesting credit unions should focus on net interest income when measuring risk rather than using market value as the

former measure portrays a more realistic calculation of risk, demonstrates an increased ability to take on risk, and ultimately leads to increased returns.

## 2. Background

This research project investigates the benefits or disadvantages that market value sensitivity and earnings sensitivity in the banking book bring to credit unions and other financial institutions not subject to fair market valuation. Credit unions in British Columbia are regulated by the Financial Institutions Commission (FICOM) under the Financial Institutions Act (Financial Institutions Commission (FICOM), 1990) which is primarily based on Basel I. The capital regulation was written over 20 years ago and does not contain a market risk perspective. Most credit unions in BC are highly capitalized and are therefore already compliant to Basel III capital requirements. The research objective of this paper mainly arises from the requirements for interest rate risk in the banking book (IRRBB) and aims at questioning their usefulness to credit unions and other financial institutions (Basel Committee on Banking Supervision (BCBS), 2016). According to the IRRBB, two risk measures, one with a market value perspective and one with an earnings approach, together provide a comprehensive understanding of interest rate risk for non-trading portfolios. The market value or economic value of equity looks at the current balance sheet of a financial institution, projects all cash flows until maturity, and therefore measures the long-term sensitivity to changes in the yield curve. The earnings based measure assumes a constant balance sheet including growth and renewal assumptions, but assesses the interest income at risk over a shorter time horizon. Despite affirming that both metrics are crucial for a successful management of

financial risks, the IRRBB does not clarify why changes in market value in the banking book – which contains assets being held to maturity – are of interest to financial institutions. The partner organization PRO, while having implemented a risk measure based on the market value perspective, realized that they are currently facing the problem that this approach is not tangible to credit unions. As a consequence, the following question arises: “What insights can market value sensitivity calculations bring to banking books and how can they be leveraged by credit unions in order to increase return on equity in the long run?”.

A major concern for credit unions is the formulation of risk appetites based on market value sensitivities without having a real understanding of what those mean to their own balance sheet. Currently, there is very little research in this area. Only one paper written by Roberto Nygaard (Nygaard, n.d.), analyzes the relationship of earnings based measure and market value measure, but according to his findings, only the market value perspective only should be used to assess interest rate risk in the banking book. This consideration is the result of Nygaard’s analysis of the net interest income approach as it does not include any repricing of assets and liabilities and therefore does not provide a realistic picture of the risk profile. In this paper we will challenge Nygaard’s opinion. First, we will show that market value in reality is not a good measure for interest rate risk in the banking book. In a second step, we will further develop the net interest income approach by including a longer-time horizon and repricing of assets and liabilities, ultimately overcoming Nygaard’s main point of critique. This measure will

provide a suitable measure for interest rate risk in the banking book and, according to our findings, is clearly superior to market value.

Unfortunately, other than the publication by Nygaard, no other researcher discussed the impact of market value perspective to the banking book, namely assets that be held to maturity, nor demystified what risk this approach actually measures, and how it relates to profitability. As a result, this paper will contribute crucial insights into this topic and will hopefully inspire various discussions in the future.

In the past few years, a few researchers analyzed the market value view by focusing on its predictive power with regards to future market value. In 2002 an article by Jorion (Jorion, 2002) proved the importance Value at Risk (VaR) publications of U.S. commercial banks as powerful means to predict the volatility of future market value, but his research focused only on the effectiveness they hold on financial institution's trading books and is therefore not applicable in our situation.

A few years later Préfontaine and Desrochers (Préfontaine & Desrochers, 2006) went a step further and evaluated whether earnings could also be used as an indicator for future volatility of interest income, but, unfortunately, they did not find any conclusive proof to support their thesis. According to their studies, some U.S. banks have been using VaR, a market value measure, metrics for non-trading portfolios, but they did not provide further details on how this information is being used, if VaR has been actively used in the management of the non-trading portfolios, or if performance has been increased. A qualitative paper from 2007 (Randy Payant, 2007) supports the thesis that future interest income is contained in the economic value of equity which relates to the

issue discussed in this paper. However, the paper does not deliver any actual proof about the benefits for financial institutions when actively managing their portfolio following both short-term and long-term.

In this project, we will focus our efforts to tie in with the previous research and we will try to provide a valuable insight of market value based risk measures. Additionally, we will provide examples of how PRO's clients are currently being affected by it, what it means in terms of earnings and how they can improve their long-term portfolio management with respect to risk and return. To our knowledge, no such research exists that could deepen the market value based risk measures understanding of PRO's clients and therefore help improve their financial performance.

### 3. Market value model

#### 3.1 Market value

The market value of a liquid asset can usually be observed directly in the market. This is an important concept for traders, following investment strategies and holding most of their assets with the intention of selling them prior to maturity. As a result, knowing how the market value of the portfolio behaves is crucial for generating profits from investing activities. If no reliable market value is observable, the market value, or fair value can be calculated as sum of all discounted future cashflows. This concept calculates market value of fixed income instruments as function of its fixed cash flows and the variable – shocked – interest rates used for discounting. As a result, complete variable rate instruments will always have the same market value no matter the shock scenario, assuming that the variable rate is related to the risk-free rate used for discounting. Variable rate instruments therefore do not have a change in market value in the ALM model. This technique can be utilized for assets, liabilities, and equity. For the purposes of this paper, we calculate sensitivity of market value ( $\Delta MV$ ) as a change in market value for a 1% shock interval. In other words, we take the current yield curve and apply a parallel 50 bps shock up and down for the stress scenarios.  $MV^{Up}$  is the market value of equity in the 50 bps up scenario and  $MV^{Down}$  is the market value of equity in the 50 bps down scenario.  $\Delta MV$  is then calculated as the difference of these two market values like in the following formula.

$$\Delta MV = MV^{Up} - MV^{Down}$$

In terms of an investment portfolio, this sensitivity directly estimates the risk related to changes in interest rates. If a trader's portfolio loses market value, he is experiencing a loss. On the contrary, selling an asset when the market value is higher than the entry price, would result in a gain therefore directly affecting his profitability. We will later also express  $\Delta MV$  as percentage of the market value of equity in the base scenario to compare sensitivities across different financial institutions.

The calculation of  $\Delta MV$  is first calculated for assets and liabilities, and then we can derive total sensitivity for equity by using the following formula, where equity is essentially inheriting the market value sensitivity from assets and liabilities.

$$\Delta MV = \Delta MV_{Equity} = \Delta MV_{Assets} - \Delta MV_{Liabilities}$$

The results of this paper focus on the change in market value of equity, if not indicated otherwise,  $\Delta MV$  refers to equity sensitivity.

It is worth noting, that  $\Delta MV$  expresses the absolute difference of 2 market values. A negative  $\Delta MV$  therefore results from a lower market value in the up scenario than in the down scenario. Overall, as value of equity decreases with rising rates and increases with falling rates, a negative  $\Delta MV$  indicates an exposure to rising interest rates and, on the contrary, a positive  $\Delta MV$  expresses an exposure to falling interest rates.



## **3.2 The ALM model**

For the purposes of this paper, we are calculating  $\Delta$  MV with a typical asset liability management model (ALM model) utilized by PRO. The ALM model takes the current portfolio of a credit union as run off, without imposing any growth or renewal assumptions, and projects all future cash flows until the last asset or liability matures. In a second step,  $\Delta$  MV is being calculated with the two stress scenarios mentioned in section 3.1. This method is like taking a snapshot of the credit union's current balance sheet and provides insights about what would happen in case of a parallel change of the yield curve, all else being equal. When an asset or liability matures prior to the final cash flow of the ALM model, an asset or liability balancer will invest the amount matured at variable rates. As explained above, due to the variable nature of these balancers, they do not have an impact on  $\Delta$  MV.

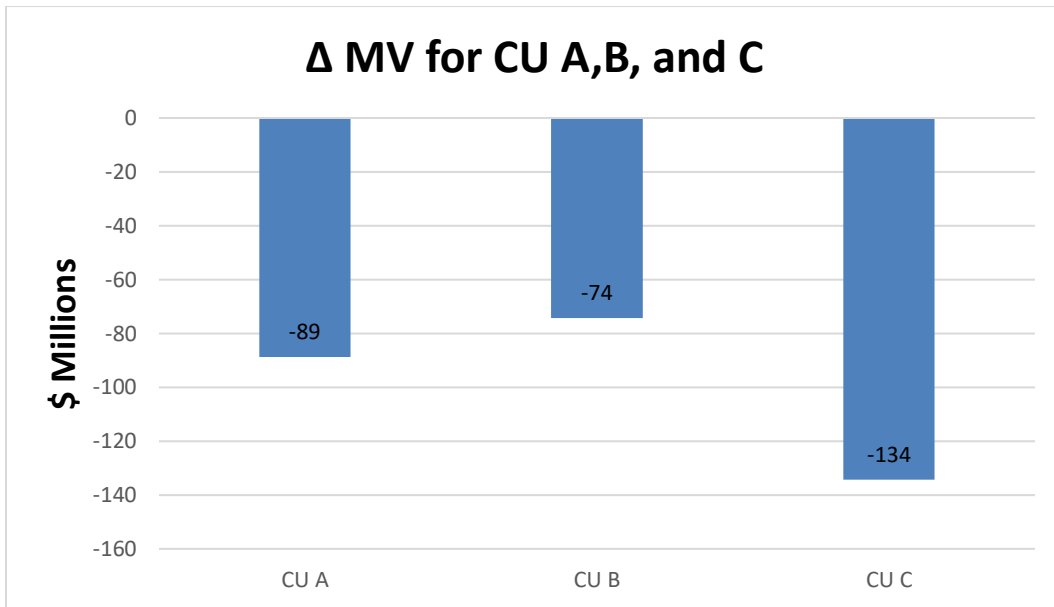
## **3.3 ALM model results**

In this section, we will calculate  $\Delta$  MV for 3 different credit unions after modifying the raw data to protect proprietary information of PRO and PRO's clients. We will refer to them as credit unions A, B, and C or CU A, CU B, and CU C. All credit unions A, B, and C in our example have a total book value of assets of \$10 billion on July 31, 2017. Starting from this day, the ALM model projects 10 years into the future as this is the point in time where the last asset matures for all three credit unions.

Figure 3-1 provides an overview of the different market value sensitivities for CU A, CU B, and CU C. Although they all have an asset book value of \$10 billion in July 2017,

they have quite different sensitivities of market value to changes in interest rates. Credit union B has with \$-72 million the lowest absolute exposure, credit union C has with \$-134 almost twice as much sensitivity than credit union B. CU A lies with \$-89 slightly above CU B.

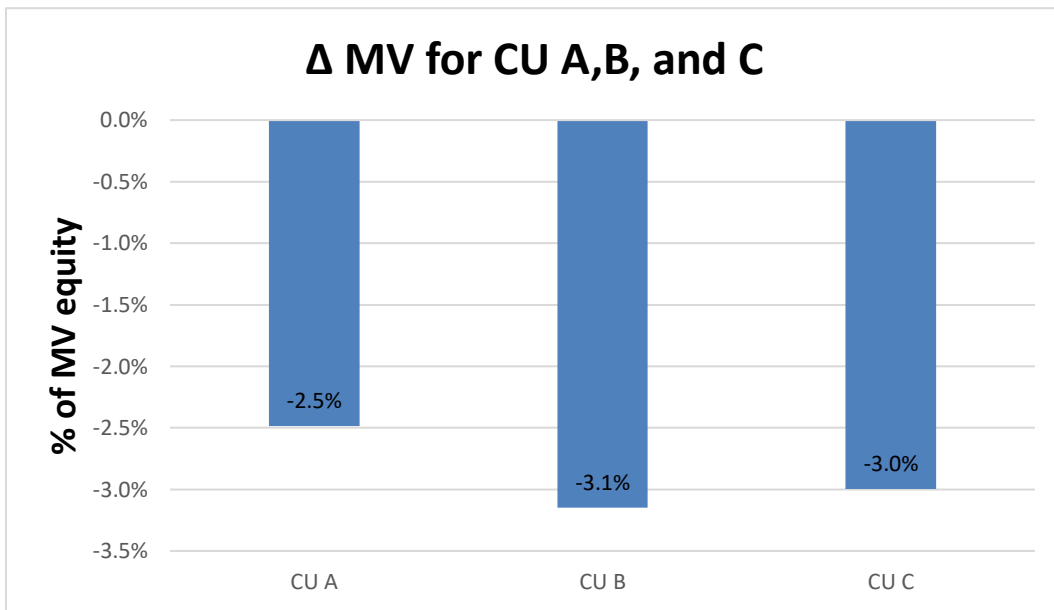
Figure 3-1 Results of  $\Delta$  MV with data from July 31, 2017 for CU A, B, and C in \$ millions.



To provide an overview that allows for better comparison across the three credit unions, Figure 3-2 shows the results as percentage of market value of equity in the base – unshocked – scenario. The percentage overview highlights, that in relative terms CU has the lowest exposure and CU B the highest. CU C has a similar risk exposure compared to CU B. When comparing Figure 3-1 and Figure 3-2 especially credit union B strikes our interest. CU B had the lowest risk measured in absolute terms, but – when expresses as % of equity – shows the highest exposure amongst the tree credit unions. This indicates, that the relative sensitivities should be used when comparing risks of different financial institutions, and we will use this technique in chapter 174 when

comparing NII and MV sensitivity for credit unions A, B, and C. Even though the percentage sensitivity seems low compared to equity, non-prudent interest rate risk management can jeopardize credit union's financial stability. As a result, limit systems where sensitivities and their breaching of certain limits – the risk tolerance – are monitored regularly and are crucial for the profitability of credit unions.

Figure 3-2 Results of  $\Delta$  MV with data from July 31, 2017 for CU A, B, and C as % of equity



We take this results as a starting point to show in chapter 4 how market value and net interest income sensitivities are related.

### 3.4 $\Delta$ MV and the banking book

As mentioned earlier,  $\Delta$  MV is a crucial tool for trading activities, namely for the trading book. However, it is still unclear which benefits  $\Delta$  MV can bring for a credit union, or other financial institution, holding most of their assets until maturity. Or in other words, what insights does  $\Delta$  MV provide to interest rate risk in the banking book?

The business model of a credit union is not focused on generating profits through trading activities, but rather by investing in long-term assets such as loans and mortgages, funded by mostly short-term liabilities like deposits. As a result, credit unions earn the spread between lending and borrowing, and they are not affected by the change in market value in the banking book, as losses would only be materialized when assets are sold. As described earlier, assets in the banking book are usually held until maturity and this scenario is highly unlikely. The only realistic situation, where credit unions would sell assets from their banking book would be when they are forced to sell assets in order to generate additional cash. But is this still interest rate risk? Since the only situation where  $\Delta MV$  can affect credit unions is a liquidity crisis, we are actually measuring the aftermaths of liquidity risk under the name of interest rate risk. This means  $\Delta MV$  would provide us with an understanding of possible losses that would follow a liquidity crunch. This situation is particularly interesting, as Basel standards discuss tools to measure liquidity risk such as liquidity coverage ratio (LCR) and Net Stable Funding Ratio (NSFR) which measure liquidity risk over a 30 day and 1-year period respectively and calculate the capital required to avoid a liquidity event (Basel Committee on Banking Supervision (BCBS), 2014). Overall, the calculation of  $\Delta MV$  in the banking book and the derivation of capital requirements appears to be a double count of liquidity risk and leads to a very conservative capital reserve. If we exclude  $\Delta MV$  from the tools to measure interest rate risk in the banking book, what do we have left and what really is the interest rate risk in the banking book?

The main purpose of this paper is to challenge the meaning of  $\Delta MV$  for credit unions and to investigate the relationship between  $\Delta MV$  and  $\Delta NII$  – the sensitivity of net interest income and ultimately the profitability of credit unions. Both are standard risk management tools for interest rate risk in the banking book and, as the IRRBB states, “banks should pay attention to the complementary nature of economic value and earnings-based measures in their risk and internal capital assessments” (Basel Committee on Banking Supervision (BCBS), 2016). According to the BCBS the importance of both measures is especially highlighted by a few opposing components. They provide different results (net present value and earnings sensitivity), different time horizons (12 months versus long-term), and different approaches to the balance sheet (run off versus going concern assumption). While there is no doubt regarding the existing differences of these two risk measures, it is the relationship of these two and the meaning of market value perspective for interest rate risk in the banking book that credit unions struggle with. To answer this question, chapter 4 investigates  $\Delta NII$  and its relationship to  $\Delta MV$  in more detail.

## 4. Net Interest Income Model

This chapter will focus on the sensitivity of earnings. Understanding this process will allow us to better compare this method to  $\Delta MV$  discussed above and to define the benefits they both bring to credit unions and other financial institutions.

### 4.1 Net interest income

As mentioned above, credit unions generate profits by earning the spread between lending and borrowing. The difference in interest earned and interest paid during a certain period is called net interest income (NII). NII is usually calculated for a 12 months period and is therefore used as a short-term risk measure. Nonetheless, we will calculate  $\Delta NII$  for the same period as we calculate  $\Delta MV$  to then – in a third step – compare these two measures and show their connection. Like  $\Delta MV$ , we define  $\Delta NII$  as sensitivity of future earnings under the same parallel 50 bps up and down shock scenarios used for  $\Delta MV$ . To compare the two measures, we will also express  $\Delta NII$  as percentage of market value of equity in the base scenario. In practice, net interest income is always reported at future value, consistent to accounting standards. For the goal of this paper – and to show the relationship between  $\Delta NII$  and  $\Delta MV$  – we are defining  $\Delta NII$  as the difference in discounted earnings, with the respective shocked discount factors, of the run off portfolio.

$$\Delta NII = NII^{Up} - NII^{Down}$$

In contrast to current regulatory standards of calculating earnings risk, more specifically the assumption of a constant balance sheet, we are not imposing any growth or renewal assumptions to the portfolio and measure earnings risk of the run off portfolio exactly as we previously did using the ALM model. These modifications differ from IRRBB standards, but are necessary to explain the similarities and differences of the two approaches.

The methods used in this paper to calculate  $\Delta MV$  and  $\Delta NII$  are similar to those discussed by Roberto Nygaard (Nygaard, n.d.). We will start with the same methodologies, develop them further, but ultimately, arrive at a different conclusion. Nygaard raises concerns, over how the net interest income perspective does not include any repricing risk for assets and liabilities and therefore suggest the use of market value instead. As we showed above, market value is not suitable for measuring interest rate risk in the banking book. To overcome this issue, we are including repricing risk in the NII model and are therefore further developing the NII measure currently used in the industry and cited by Nygaard (Nygaard, n.d.). The following example illustrates the calculation of  $\Delta MV$  and  $\Delta NII$  for a simplified balance sheet. The example does not intend to replicate a realistic balance sheet of a credit union, but rather provide a basic understanding for  $\Delta MV$  and  $\Delta NII$ . In section 4.3, we will apply the methodologies to the entire balance sheet of three different credit unions, to make the two risk measures more tangible. For this example, we are looking at a single loan with a principal of \$10,000 and yearly coupon payments of 7% (see Exhibit 4-1). This loan is funded by term deposits maturing in three years and a coupon of 6%. After maturity, an asset

balancer kicks in and invests the principal at the implied forward rates, until the loan matures. One of the major points of criticism which Nygaard raised to the  $\Delta$  NII concept was its lack of repricing risk. As a consequence of using the asset balancer, we managed to introduce pricing risk to the earning risk measure and therefore resolved one of the main concerns with  $\Delta$  NII. In addition to Nygaard's basic example, we are employing partial funding through equity as well as the different development of the portfolio under the shock scenarios Up and Down as introduced in chapter 10. We assume, that cash flows received each year are not reinvested, as this would violate the run off character of our methodology.

*Exhibit 4-1 Example parameters*

<b>Assets</b>	<b>Principal</b>	<b>Coupon</b>	<b>Maturity</b>
Loan	\$ 10,000	7%	10
<b>Liabilities</b>			
Term Deposit	\$ 9,000	6%	3

Exhibit 4-2 shows how the loan and the term deposit develops over time in the Up and Down scenarios. The loan pays a yearly interest of 7% and the constant cash flows are discounted with the respective shocked discount factors. The Term deposit pays a yearly coupon of \$540 (6% on \$9,000) and matures in year 3. In year 4 the asset balancer invests the principal at the implied shocked forward rates, i.e. the interest payment is variable from year 4. The summary table in Exhibit 4-2 shows the sensitivity in market value for assets, liabilities and the portfolio sensitivity  $\Delta$  MV of \$-533, calculated from the discounted cash flows (DCF). The discounted earnings  $\Delta$  NII show an overall portfolio sensitivity of \$-497.  $\Delta$  MV and  $\Delta$  NII are different values and interestingly,  $\Delta$  MV



indicates a higher risk than  $\Delta$  NII. What causes these two numbers to differ? Could it be the introduced equity component? Equity is like funding assets at 0 cost, as a result  $\Delta$  NII is 0 for equity as no interest is paid or earned. Additionally, equity is exposed to changes in market value, as the future value of equity also changes in the Up and Down scenario. This example introduces the doubt that equity increases risk when measured with  $\Delta$  MV, even though funding assets with equity is considered very safe as no leverage exists. If a credit union were to fund all assets with equity, then all risk would be driven by the investments, and the credit union would not be exposed to risk of net interest income losses as long as lending rates stayed positive. Considering that credit unions normally do not sell their assets, as long as they do not face a liquidity crisis, is it correct to punish low leverage with higher capital requirements?

Exhibit 4-2  $\Delta$  MV and  $\Delta$  NII for a loan funded by Liabilities and Equity at 0 cost

Assets							Liabilities						
Year	Up 50 bps			Down 50 bps			Year	Up 50 bps			Down 50 bps		
	Interest	Principal	DCF	Interest	Principal	DCF		Interest	Principal	DCF	Interest	Principal	DCF
1	700	-	690	700	-	697	1	540	-	532	540	-	537
2	700	-	673	700	-	686	2	540	-	519	540	-	529
3	700	-	650	700	-	669	3	540	-	501	540	-	516
4	700	-	622	700	-	647	4	406	-	361	316	-	292
5	700	-	589	700	-	619	5	497	-	419	407	-	360
6	700	-	553	700	-	586	6	588	-	465	498	-	417
7	700	-	514	700	-	550	7	680	-	499	590	-	463
8	700	-	474	700	-	511	8	771	-	522	681	-	498
9	700	-	432	700	-	471	9	863	-	533	773	-	520
10	700	10,000	5,975	700	10,000	6,569	10	955	9,000	5,559	865	9,000	6,056
$\Sigma$	11,172			12,005			$\Sigma$	9,910			10,190		

Summary		
	$\Delta$ MV	$\Delta$ NII
Assets	-833	-278
Liabilities	-280	220
A - L	-553	-497

Based on the previous example, we want to examine if the difference of calculated risk indeed arises from the introduction of equity, namely funding the loan partially at 0

cost. Instead of assuming 0 cost for funding the remaining \$1,000 by equity, we introduce a variable cost of equity as second source of funding, which can be interpreted as variable dividend payments, paying the implied shocked forward rates in the Up and Down scenario. As a matter of fact, after introducing the artificial dividend payments, which results in additional costs that the credit union would never experience in reality, the two risk measures  $\Delta MV$  and  $\Delta NII$  match exactly. In more detail, equity does not introduce any additional market value sensitivity, because it is a variable rate instrument. On the other hand,  $\Delta NII$  of equity introduces additional risk to the earnings measure, which increases the earnings risk by \$56, resulting in  $\Delta MV$  and  $\Delta NII$  of \$-533.

Exhibit 4-3  $\Delta$  MV and  $\Delta$  NII for a loan funded by Liabilities and Equity with variable cost

Assets							Liabilities						
Year	Up 50 bps			Down 50 bps			Year	Up 50 bps			Down 50 bps		
	Interest	Principal	DCF	Interest	Principal	DCF		Interest	Principal	DCF	Interest	Principal	DCF
1	700	-	690	700	-	697	1	540	-	532	540	-	537
2	700	-	673	700	-	686	2	540	-	519	540	-	529
3	700	-	650	700	-	669	3	540	-	501	540	-	516
4	700	-	622	700	-	647	4	406	-	361	316	-	292
5	700	-	589	700	-	619	5	497	-	419	407	-	360
6	700	-	553	700	-	586	6	588	-	465	498	-	417
7	700	-	514	700	-	550	7	680	-	499	590	-	463
8	700	-	474	700	-	511	8	771	-	522	681	-	498
9	700	-	432	700	-	471	9	863	-	533	773	-	520
10	700	10,000	5,975	700	10,000	6,569	10	955	9,000	5,559	865	9,000	6,056
$\Sigma$			11,172			12,005	$\Sigma$			9,910			10,190

Summary		
	$\Delta$ MV	$\Delta$ NII
Assets	-833	-278
Liabilities	-280	220
Other L	0	56
A - L	-553	-553

Equity						
Year	Up 50 bps			Down 50 bps		
	Interest	Principal	DCF	Interest	Principal	DCF
1	15	-	15	5	-	5
2	25	-	24	15	-	15
3	35	-	33	25	-	24
4	45	-	40	35	-	32
5	55	-	47	45	-	40
6	65	-	52	55	-	46
7	76	-	55	66	-	51
8	86	-	58	76	-	55
9	96	-	59	86	-	58
10	106	1,000	618	96	1,000	673
$\Sigma$			1,000			1,000

These two examples confirm, that the two measures  $\Delta$  MV and  $\Delta$  NII are in fact related and furthermore, they treat capital structure differently. While  $\Delta$  NII actually exposes credit unions to interest risk by taking only assets and liabilities into consideration,  $\Delta$  MV – compared to  $\Delta$  NII - imposes an additional risk premium for equity. As previously discussed, equity is not causing interest rate risk in the first place, but instead facilitates the risk-taking ability of financial institutions. Looking back at the previous examples, a shadow of doubt is being casted upon whether  $\Delta$  MV really is a reasonable long-term risk measure for interest rate risk in the banking book. Not only is

$\Delta$  MV measuring outcomes of a liquidity crises as highlighted in section 3.4, but it also punishes financial institutions with additional capital requirements for holding equity.

To further shed some light over this considerations and work with a more realistic example, we will build a similar model for entire balance sheets of three credit unions in the following section.

## **4.2 The NII model**

This section ties in with the previous example and investigates the relationship of  $\Delta$  MV and  $\Delta$  NII for the entire balance sheet of the three different credit unions CU A, CU B, and CU C discussed in section 3.3. To implement the methodologies of the previous example into the model framework of PRO, we are taking the ALM model as a basis and perform necessary modifications in order to measure  $\Delta$  NII appropriately. Fortunately, the NII model allows us to calculate  $\Delta$  MV and  $\Delta$  NII at the same time, as it does not impact the  $\Delta$  MV calculations in any way.

As a starting point for the NII model, we use the same assets, liabilities and time horizon of 10 years as in the ALM model and calculate  $\Delta$  NII by employing monthly accrued interest and the shocked discount factors.

In a first step, we take equity and all other non-interest sensitive (NIS) assets and liabilities as a total sum and impose variable costs. For the purposes of this paper, when we are talking about equity, we mean equity and other NIS instruments. Like in the previous section, the cost for funding with equity can be interpreted as paying a variable dividend. The cost on equity and other NIS instruments, as seen in the basic example,

are variable rate instruments and do not introduce additional market value sensitivity. To follow the same run off strategy as in the previous example, we create a counter position to retained earnings, as cash earning the variable 1 months implied forward rates (1 months CDOR). This cash position cancels out the effect that retained earnings would otherwise have on our calculations. Additionally, since it also represents a variable interest rate instrument in the NII model, it does not have any impact on  $\Delta MV$ . This first step is intended to show that the identity of  $\Delta MV$  and  $\Delta NII$  still holds after introducing a cost for funding with equity, when we expand the basic example to a more complex situation.

In a second step, we exclude the artificial effect that equity now has on the risk measure  $\Delta NII$  and calculate the actual earnings risk credit unions would face, when being funded by debt and equity with 0 cost. Section 4.3 summarizes the results for CU A, CU B, and CU C and confirms the theory that  $\Delta MV$  might expose credit unions to capital requirements that are too high for the nature of risk they are intended to measure, namely interest rate risk in the banking book.

### **4.3 NII results**

Figure 4-1, Figure 4-3, and Figure 4-5 show the discounted earnings sensitivity  $\Delta NII$  for each year and as total compared to  $\Delta MV$  for CU A, CU B, and CU C respectively. All numbers are expressed as percentage of market value of equity in the base scenario. These outcomes support our thesis that the results from the basic example still hold true even when applied to a more realistic case like a full balance sheet. For all three

credit unions,  $\Delta NII$  (expressed as blue bars) almost exactly sums up to  $\Delta MV$  (red bars). The minor differences of  $\Delta NII$  and  $\Delta MV$  is due to rounding errors and modifications such as creating a counter position of cash to retained earnings in order to fulfil the “no reinvestment of cash flows” assumption of our example. These modifications bring us very close to a perfect match. However, these small differences are neglectable and overall the examples illustrate that the earnings based measure  $\Delta NII$  equals the market value measure  $\Delta MV$ , if all NIS instruments are excluded and invested at variable rates. As argued before, the additional risk that cost for equity and NIS instruments introduce are not reasonable, as they are caused by assumed dividend payments, but in reality, would never result in interest income or expense.

To gauge the effect of the cost for funding with equity, Figure 4-2, Figure 4-4, and Figure 4-6 break down  $\Delta NII$  (black squares) into the artificial component of  $\Delta NII$  from other liabilities (red bars) and  $\Delta NII$  actual (blue bars), the earnings sensitivity excluding the position of equity. All numbers are expressed as percentage of market value of equity in the base scenario. Although the three credit unions show different exposure to interest rate risk, three observations are true for all three credit unions. Firstly, equity dominates  $\Delta NII$ , and drives the actual exposure to changes in interest rates. If we compare the black squares indicating  $\Delta NII$  to  $\Delta NII$  actual, represented by the blue bars as  $\Delta NII$  excluding the forced cost for equity, we can clearly see that  $\Delta NII$  is, in most cases, being shifted from a negative to a positive number. Keeping in mind that the sum of the black squares equals the overall  $\Delta MV$ , it becomes clear how  $\Delta MV$  is including unnecessary additional risk that was imposed on the credit unions balance

sheet. The shift from negative  $\Delta$  NII to positive  $\Delta$  NII actual is significant. This means,  $\Delta$  NII (and therefore  $\Delta$  MV) suggests an increased risk to rising interest rates compared to falling rates as the discounted earnings would lose in value in the Up scenario compared to the Down scenario. Given the fact that  $\Delta$  NII is mostly driven by cost for equity which imposes a huge amount of variable debt to the portfolio, drastically reduces NII as rates rise, because assets reprice at a later time than the variable dividend payments. It is clear to see in the three figures, that most  $\Delta$  NII actual is in the first 5 years when liabilities reprice, but most assets are still generating the same fixed coupon. After year 5, when most assets matured, net interest income risk almost disappears, due to the pure variability of asset balancer and other liabilities. On the other hand,  $\Delta$  NII actual being positive has the opposite interpretation, implying that credit unions would – under the current market conditions – profit from rising interest rates, as the low leverage provides a buffer for funding assets.

Secondly, all three credit unions illustrated how a short-term perspective of 12 months is not really a good representation of the credit union's exposure to interest as  $\Delta$  NII and  $\Delta$  NII actual change significantly over time. CU B has its highest potential to benefit from rising interest rates in year 1 as more assets reprice compared to liabilities. In year 2 the sensitivity drops to a negative value, as less assets reprice compared to equity and liabilities. After year 2  $\Delta$  NII actual changes back to positive and continues to increase, highlighting the chance to benefit from rising interest risks in the long term as the entire portfolio reprices. A similar pattern is observable for CU A, with the difference that  $\Delta$  NII actual never becomes negative and CU A has its highest potential to benefit from rising

interest rates in year 6, after all fixed rate assets matured. CU C overall shows a more consistent exposure to  $\Delta$  NII actual, slightly decreasing in year 2 and also showing the highest opportunity to generate NII in year 6 after the last asset matured and all assets are completely reinvested in variable interest rates by the asset balancer. The different patterns and sensitivities to  $\Delta$  NII actual across different years, indicate that  $\Delta$  NII actual provides valuable information about the real exposure to interest rate risks and should therefore be taken into consideration for the long term. Lastly,  $\Delta$  NII indicates an interest rate risk of almost 0 for all three credit unions from year 6 to 10, however the more realistic measure  $\Delta$  NII actual has a significant sensitivity for these 5 years. This fact indicates that  $\Delta$  MV is not only imposing unnecessary capital requirements caused by equity, but in some instances, underestimates the actual sensitivity. It appears that credit unions are not facing any interest rate risk from year 6 onwards, but in reality, as interest rates decline all assets and liabilities are repriced at variable rates directly exposing the credit unions to falling net interest income.

Exhibit 4-4 summarizes the total sums for  $\Delta$  MV,  $\Delta$  NII,  $\Delta$  NII actual, and the leverage ratio implied from the NII model. The leverage ratio is calculated by dividing liabilities by equity. As mentioned before,  $\Delta$  NII and  $\Delta$  NII actual differ significantly as they often show opposite values, from positive to negative. Overall,  $\Delta$  NII, which is the equivalent to  $\Delta$  MV in our model, punishes credit unions for holding capital with additional risk calculated, whereas  $\Delta$  NII actual considers more equity correctly as a mitigation of risk and therefore highlights the increased risk-taking ability.



In conclusion, calculating interest rate risk in the banking book through the market value perspective of  $\Delta$  MV does not seem reasonable considering it is highly driven by holding equity and therefore overstating the risk. Additionally,  $\Delta$  MV does not represent the outcomes of a liquidity crisis and therefore not only measures liquidity risk under the name of interest rate risk, but also calculates the aftermaths of a liquidity crisis as actual risk itself. On the contrary,  $\Delta$  NII provides a reasonable measure of interest rate risk for the banking book, as it measures what credit unions are really exposed to: changes in net interest income or in other words – their profitability. Although  $\Delta$  NII is usually assumed to be a short-term measure, we find the presented results provide enough reasons to expand the concept to the long-term and as a result better understand the actual interest rate in the banking book for credit unions and any other financial institution.

Figure 4-1 CU A: Relationship of  $\Delta$  MV and  $\Delta$  NII

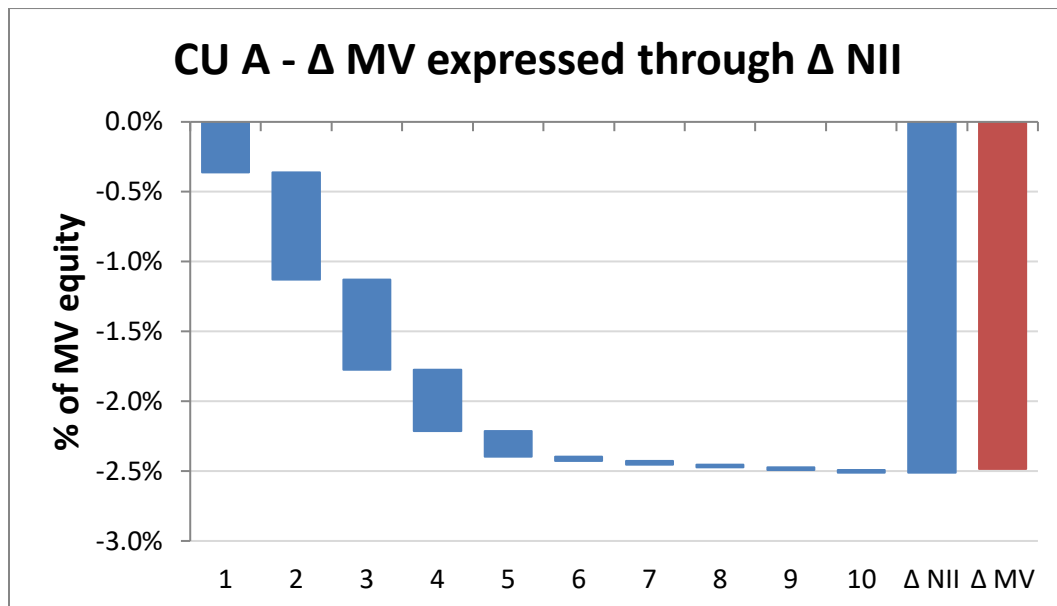


Figure 4-2 CU A:  $\Delta$  NII versus  $\Delta$  NII actual

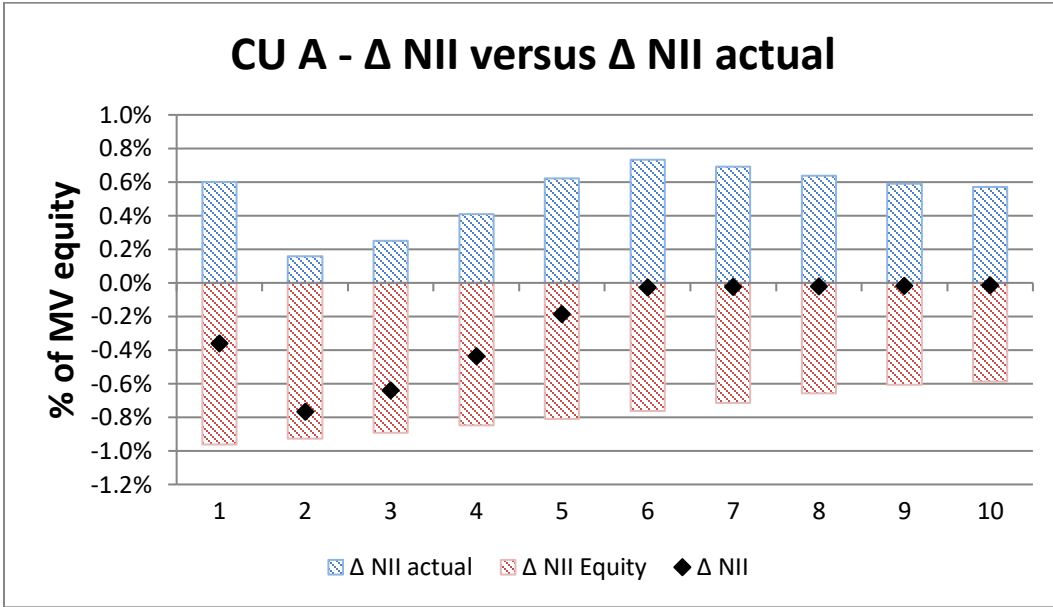


Figure 4-3 CU B: Relationship of  $\Delta$  MV and  $\Delta$  NII

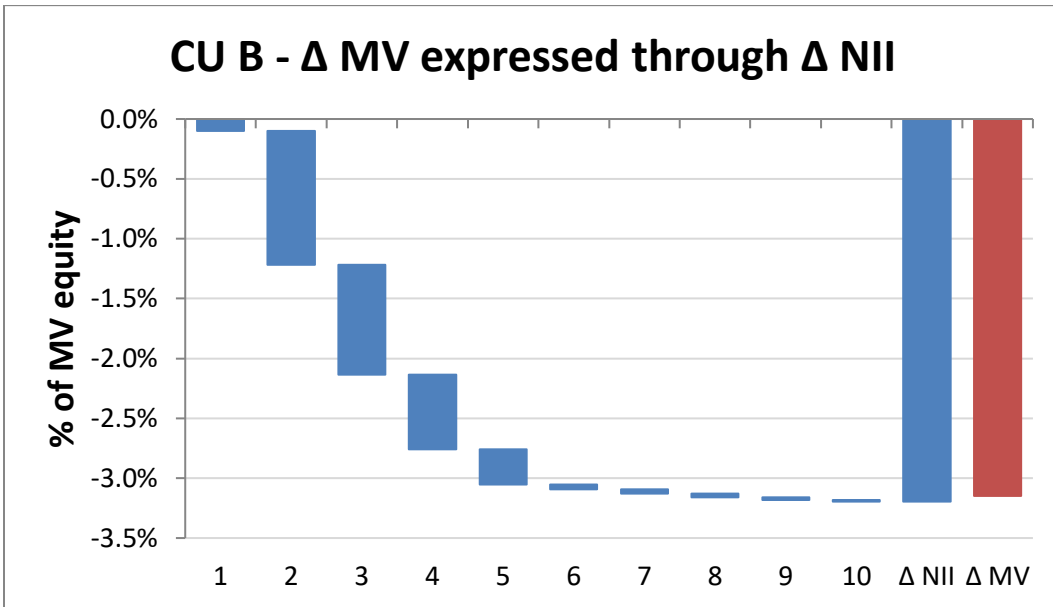


Figure 4-4 CU B:  $\Delta$  NII versus  $\Delta$  NII actual

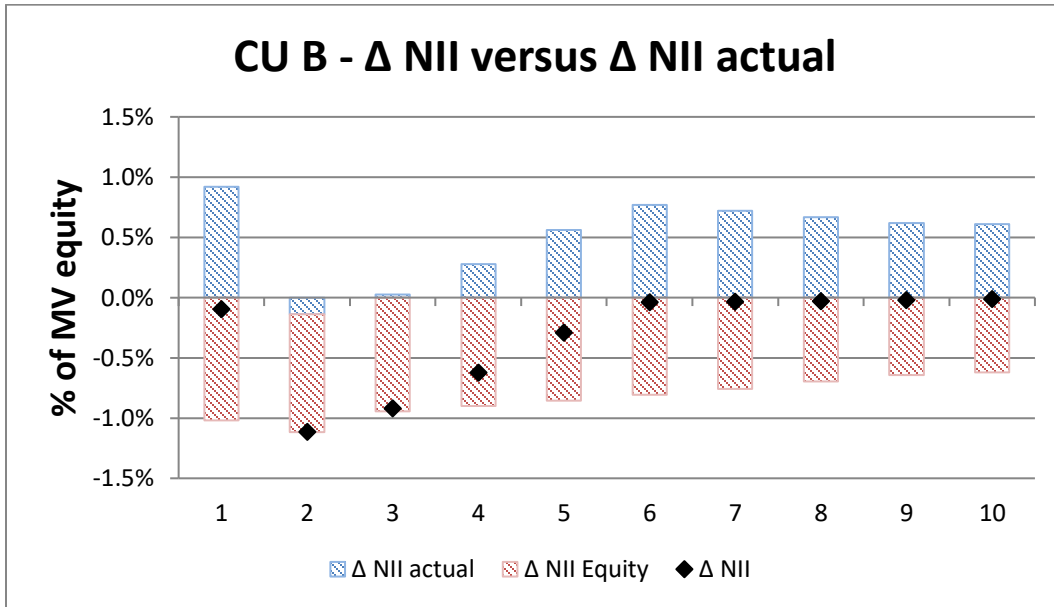


Figure 4-5 CU C: Relationship of  $\Delta$  MV and  $\Delta$  NII

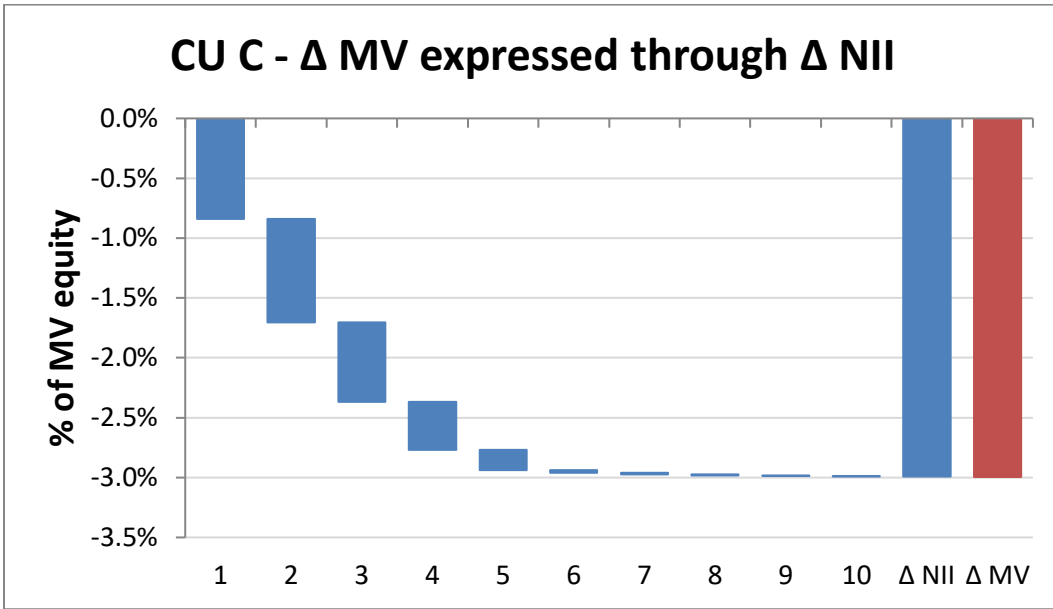
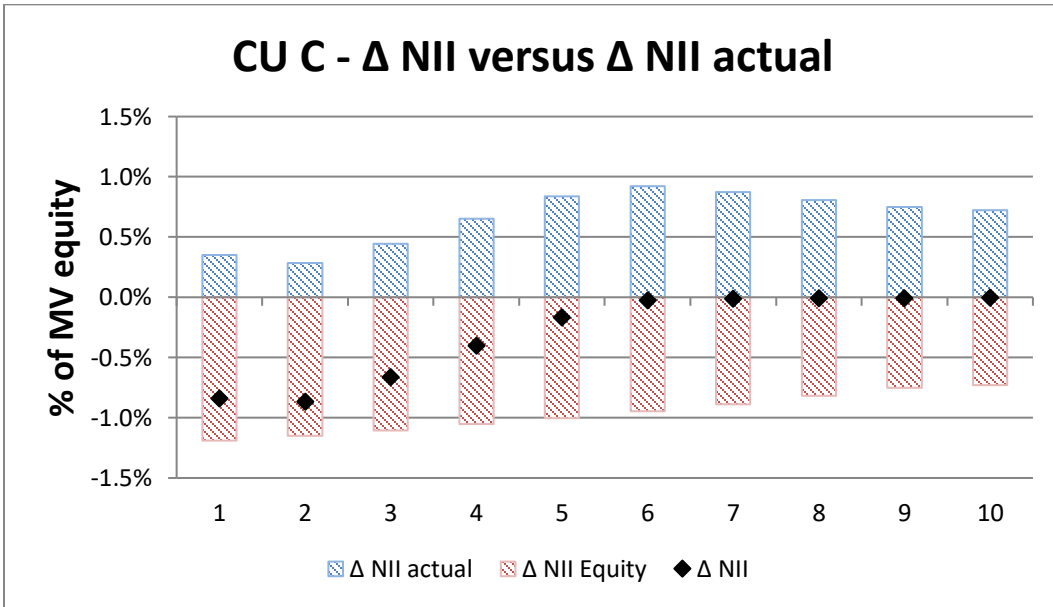


Figure 4-6 CU C:  $\Delta$  NII versus  $\Delta$  NII actual



*Exhibit 4-4 Summary sensitivities as % of MV equity and leverage*

	<b>Δ MV</b>	<b>Δ NII</b>	<b>Δ NII actual</b>	<b>Leverage</b>
CU A	-2.5%	-2.5%	5.3%	1.88
CU B	-3.1%	-3.2%	5.0%	3.11
CU C	-3.0%	-3.0%	6.6%	0.85

## 5. Conclusion

In conclusion, we provided a better understanding of the two risk measures  $\Delta MV$  and  $\Delta NII$  and their relation. We discovered that  $\Delta MV$  might not be suitable for measuring interest rate risk in the banking book for two reasons. Firstly,  $\Delta MV$  actually measures the effects of a liquidity crisis and therefore should not be captured under interest rate risk as it imposes additional capital requirements for liquidity risk, which are already covered under liquidity risk management. Specifically,  $\Delta MV$  is causing a double count of a liquidity crunch, forcing higher capital requirements on financial institutions. The second reason is that  $\Delta MV$  equals  $\Delta NII$  only when we impose an artificial cost for equity and other NIS securities. This modification highlights that  $\Delta MV$  is including a punishment for holding capital, but in general capital should reduce financial risk for credit unions and other financial institutions and not cause it.

We explored  $\Delta NII$  and the adaption of this measure to the long-term. After we showed the relation between  $\Delta NII$  and  $\Delta MV$ , we calculated  $\Delta NII$  actual, which measures the actual earnings risk of credit unions excluding the artificial cost for capital that was introduced. According to our research,  $\Delta NII$  actual should be given a higher importance than  $\Delta MV$  when managing interest rate risk in the banking book for three reasons.  $\Delta NII$  actual measures the interest rate risk arising from the banking book, namely the profitability of credit unions. It does not discipline credit unions for holding

equity. When expanded to the long-term, it provides crucial information about credit union's risk exposure that a 12 months measure cannot demonstrate.

We highly recommend challenging the meaning and usefulness of  $\Delta$  MV when managing interest rate risk in the banking book and recommend expanding the horizon of earnings based measures to the longer-term, as  $\Delta$  NII actual can valuable insight to manage risk and, as a result, improve profitability.

## 6. References

- Basel Committee on Banking Supervision (BCBS). (2014). Basel III: the net stable funding ratio.
- Basel Committee on Banking Supervision (BCBS). (2016). Interest rate risk in the banking book.
- Financial Institutions Commission (FICOM). (1990). Financial Institutions Act.
- Jorion, P. (2002). How Informative Are Value-at-Risk Disclosures? *The Accounting Review*, 77(4), 911-931.
- Nygaard, R. (n.d.). *Interest Rate Risk in the Banking Book and Capital Requirement - Issues on EVE and EaR*. Retrieved 11 25, 2017, from <http://asbaweb.org>: <http://asbaweb.org/E-News/enews-37/contrs/01contrs.pdf>
- Préfontaine, J., & Desrochers, J. (2006). How Useful Are Banks' Earnings-At-Risk And Economic Value Of Equity-At-Risk Public Disclosures? *International Business & Economics Research Journal*, 5(9).
- Randy Payant. (2007). Economic value of equity—the essentials . *Financial Managers Society*.