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DEPARTMENT OF RISK MANAGEMENT

CAN INTEREST RATES PREDICT PROPERTY/CASUALTY PERFORMANCE?

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ABSTRACT

Interest rates are among the many variables in an actuary's calculations. They are used when calculating an insurer's technical provisions, and they are the force behind turning idle money into pure profit. Yet despite their power over an insurer's competitive strategy, interest rates are victim to the whims of markets and central banks. Noting the role of interest in many facets of insurance, an actuary is left to wonder whether interest rates have the capacity to predict the performance of the property/casualty insurance industry.

This paper will look to find whether such predictive capabilities exist. It will analyze this relationship by examining the effects of interest rates on various property/casualty industry-aggregate accounting values, profitability measures, and lines of business.

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First and foremost, thank you to Zhongyi Yuan for the time and dedication you gave to helping me construct this thesis. Without your guidance, this paper would have been nothing more than a summary with a conclusion wrongly in contrast to the evidence I found (or rather, failed to find) through data-backed research.

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Chapter 1

Introduction

The purpose of this thesis is to explore whether a predictive relationship exists between interest rates and several measures of performance for the property/casualty (P&C) insurance industry. The hypothesis of this paper is that interest rates have a significant predictive effect on insurance.

This chapter outlines the rest of the paper, and it provides an introduction to interest, demonstrating its power in everyday life. Also, this chapter gives a brief background of recent monetary policy in the United States in order to explain today's interest rate environment.

Chapter 2 explains the role of interest rates in a P&C insurance company's calculations, and it establishes the expectations for how interest is hypothesized to be able to affect an insurer's performance.

Chapter 3 examines US aggregate P&C insurance industry data in order to determine whether the hypothesized predictive relationship between interest rates and P&C industry performance characteristics exists.

The Everyday Power of Interest

As one of the richest men in the world, and as the partial or full owner of many banks and insurance companies, Warren Buffet is on the forefront of financial happenings in the United States. When the Oracle speaks, markets move. Yet Mr. Buffet claims his fortune is a result of only three things: “My wealth has come from a combination of living in America, some lucky genes, and compound interest.” (Buffet)

Throughout history, many other impactful thinkers have acknowledged the value of interest. It is said that Benjamin Franklin wanted to show the fledgling United States the power of interest (and also, he wanted to challenge a French mathematician, Charles-Joseph Mathon de la Cour, who teased Franklin about his fascination with the subject), so upon his death, he willed £1000 (which at the time was about $5000) to each of the cities Boston and Philadelphia. He stipulated that the funds must be invested in accounts earning interest for 200 years. In 1990, 200 years after Franklin’s death, the funds were measured, and it was found that the £1000 donated to Philadelphia had accrued to $2,256,952.05, and the money donated to Boston had accrued to well over $5 million. (DeLeon)

Franklin’s gifts to Philadelphia and Boston had earned, on average, returns of 3.1% and 3.5%. These returns are slightly better than what is commonly considered the safest investment on earth; the current 30-yr US treasury yield is 2.75%[1] (CNBC), but even the slightest change in return can have a momentous impact on accumulation, as demonstrated by the .4% difference between the average returns earned in Philadelphia and in Boston.

[1] A yield of 2.75% was quoted for a US 30 year treasury bond on March 13, 2016 on CNBC.com. The extended quote yield is 2.7485% (CNBC).

Interest is not only important to those accumulating wealth. In contrast to those who accumulate interest (lenders) are those who pay interest (borrowers). Borrowers take a variety of forms, including individuals looking to buy homes or cars, or students looking for loans for tuition. Borrowers can also be businesses taking out money for capital expenditures, or they can even be banks accepting deposits. A borrower must be mindful of the powerful effect of compounding.

Take for example a new homeowner who is borrowing $400,000 to purchase a home. In Table 1 (below), monthly payments on a 30-year mortgage are listed based on various interest rates[2]:

Interest Rates	2%[3]	3.87%[4]	4.5%	6%
Monthly Payments	$1,478.48	$1,879.80	$2,026.74	$2,398.20
Total Payment	$532,225.80	$676,729.63	$729,626.40	$863,352.00
Interest Paid	$132,225.80	$276,729.63	$329,626.40	$463,362.00

Table 1 30-Year Mortgage Payments

A homeowner who borrows $400,000 at 2% will pay over 20% more than the initial face value of the loan over 30 years, even if they are borrowing at a rate as low as 2%. Yet, a borrower who borrows at a rate of 6%, will pay over 100% more than the value of the loan over the 30 years of payment. Figure 1 (below) shows the average 30-year fixed mortgage rate in the US from 1985 through 2012. The figure shows that before 2002, the average mortgage rate was

[2] 30-year mortgages are common because they demand a lower payment per month than shorter term mortgages (like 10 or 20-year). The payments in the table are calculated based on the nominal rate listed, compounded monthly, and they are strictly the loan amortization payments. They do not include insurance payments, taxes, or other fees.
[3] It seems nonsensical to consider a 30-year mortgage rate lower than the rate of a 30-year US Treasury since an individual borrower would not have better credit than the US government. However, 2% is picked arbitrarily to illustrate the powerful effects of even a miniscule interest rate.
[4] 3.87% is the 30 year fixed refinance rate, quoted on bankrate.com on March 13, 2016 (Bankrate)

well above the 6% calculated in Table 1 (Bankrate). This means that due to interest, homebuyers frequently used to pay well over double (at 12.5% as seen in 1985, almost quadruple) the value of their homes to pay off the loans taken out to acquire the homes in the first place.

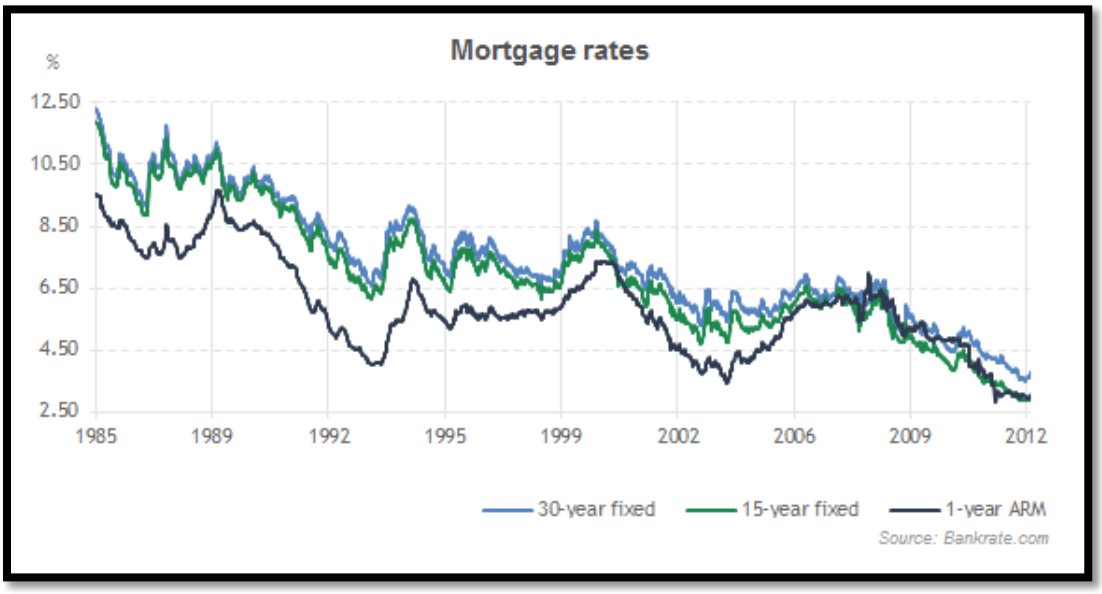


Figure 1 Average 30-Year Fixed Mortgage Rate, 1985-2012[5]

A simple example like this can demonstrate the financial impact of interest in an individual's life. For financial institutions, many of which manage hundreds of millions of contracts with varying interest assumptions, and some of which use probabilistic models to actuarially estimate values, interest becomes even more involved.

[5] (Bankrate)

Monetary Policy and Recent Interest Rates in the United States

Interest rates are a direct result of monetary policy. In the United States, banks are required to hold a portion of their deposits as reserves. To satisfy these requirements, banks can keep money deposited at the Federal Reserve. Banks that do not have the required reserves deposited at a Federal Reserve Bank can temporarily borrow these funds from banks that have excess reserves in the Federal Reserve System. The Fed controls the "overnight" interest rate that these banks charge each other to temporarily borrow money. This rate is called the federal funds rate. Since it is only available to institutions deemed to be highly creditworthy by the Federal Reserve, the federal funds rate is the benchmark interest rate in the United States. With this benchmark as the baseline rate, lenders charge riskier borrowers relatively more interest.

Monetary policy has a rich history in the United States. As early as 1781, the United States chartered its first central bank, the Bank of North America. In an initiative to tighten the government's control over monetary policy, Alexander Hamilton proposed the First Bank of the United States to succeed the Bank of North America. The First Bank was the mechanism the US government used to assume and pay off states' Revolutionary War debts, to raise money for the government, and to establish a national currency. Like any government project, the legality of the First Bank was hotly debated, which lead to it eventually losing its charter in 1811. The Second Bank of the United States succeed the First Bank in 1817. Its purpose was much like that of the First Bank: to manage the financial state of the United States following the War of 1812. After the war, the country faced a period of severe inflation and diminishing national credit. Issuing another national bank was seen as necessary to combat these problems. This bank lasted until President Andrew Jackson killed its charter in 1836.

Since the early days of national banking, the country has attempted to manage monetary policy through a variety of measures including "free banking," nationally chartered banks, and a series of metal-backed initiatives. In 1913, through the Federal Reserve Act, the US government created the roots of the Federal Reserve System in place today (Wikipedia).

Over the past several decades, the Federal Reserve has used manipulation of the federal funds rate as a tool to manage monetary policy. In the late 1970s, Paul Volcker, the Chairman of the Federal Reserve at the time, raised the federal funds rate to as high as 20% to combat the high inflation of the 70s (NY Fed). As the economy began to falter, he gradually lowered the federal funds rate until national inflation reached the target 2.5% (Joshi). The graph below shows the historical federal funds rate since 1950. The monetary adjustments mentioned are highlighted on the graph:

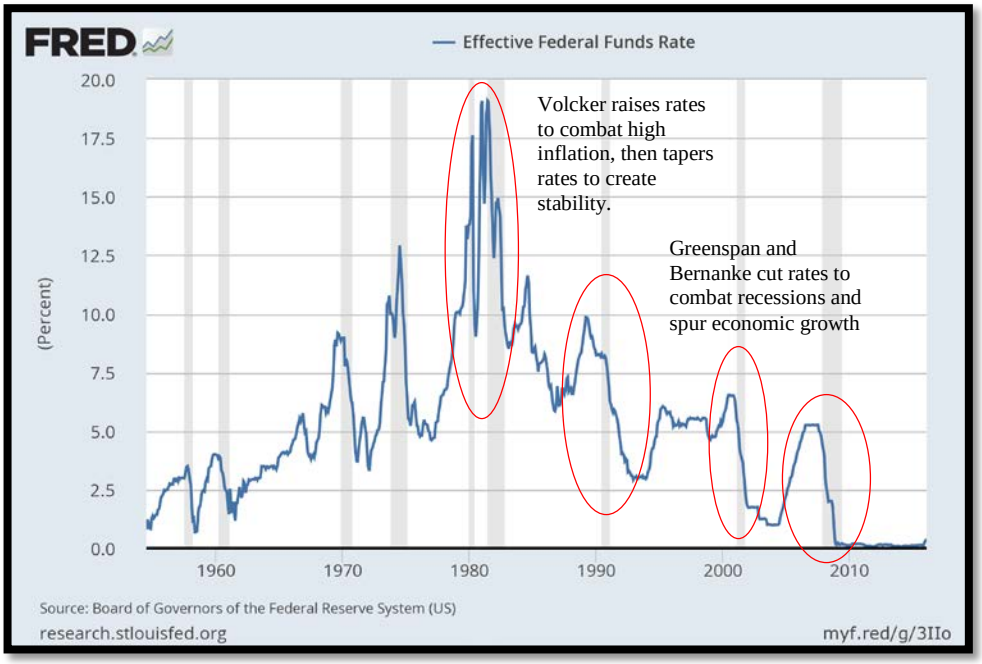


Figure 2 Historical Federal Funds Rate[6]

[6] (FRED)

During Alan Greenspan's tenure as Chairman of the Federal Reserve, the Fed experimented in using reduced interest rates as a means to fight an economic downturn. In 1987, Greenspan reduced rates in response to a stock market crash, and in 1988, he hiked rates in response to heightening inflation. Some claim that these "shocks" resulted in a recession in the early 1990s. But as the economy recovered, Greenspan kept interest rates low. This was the beginning of the country's long-term journey of relatively low interest rates. After another brief recession in the early 2000s, the Fed pushed the federal funds rate to 1%, which at that time was an all-time low (Joshi).

Ben Bernanke took over as Chairman of the Fed in 2006, and he lead the Fed through its greatest challenge since the Great Depression. After 17 consecutive rate hikes starting in 2004, Bernanke slashed the federal funds rate in response to the economic collapse from the burst of the housing bubble. He set rates at a historic low of near zero, and in 2008 he initiated a bond-buying program (quantitative easing) to further stimulate economic growth (Joshi). Total assets on the Fed's balance sheet began to swell.

Janet Yellen succeeded Ben Bernanke as Chairwoman of the Fed in 2014. In October of that year, faced with erratic taper tantrum from financial markets, she concluded the bond-buying program initiated by Ben Bernanke in 2008. In December 2015, Yellen raised the federal funds rate for the first time since the financial crisis. Currently, Janet Yellen and the board of the Federal Reserve are evaluating the state of the economy, developing a strategy to raise the federal funds rate until national inflation returns to the target 2% level established in 2012 (Joshi). The Federal Reserve raised its key benchmark rate on December 16, 2015 for the first time since the financial crisis (Gillespie), however, as of March 29, 2016, it "expects economic

conditions will evolve in a manner that will warrant only gradual increases in the federal funds rate." (Yellen)

In early 2016, the European Central Bank and Bank of Japan initiated negative interest rate policies in response to respective growth concerns. Although, due to the relatively strong growth and employment prospects in the United States, the possibility of negative interest rates as a means to spur economic growth currently seems like an unlikely solution. However, in February 2016, Janet Yellen commented on the legality of negative rates, saying, "I would say that remains a question that we still would need to investigate more thoroughly… I am not aware of anything that would prevent us from doing it, but I'm saying we have not fully investigated the legal issues – that still needs to be done." (Boesler) Many financial observers have translated this to mean that she is not ruling out negative interest rates in the United States if the need for them arises.

Chapter 2

The Technical Effects of Interest on Property/Casualty Insurance

The focus of this chapter will be to establish ways that interest rates impact P&C insurers. Also, this chapter will develop the intuition for why interest rates might influence several performance measures.

This study will use Liberty Mutual Holding Company, Inc. as an example of a P&C insurance company. Although it writes several long-tailed[7] lines like workers compensation, Liberty Mutual generates the largest share of its business from personal auto insurance (Liberty Mutual), which is a short-tailed line. This section will use the 2015 year-end balance sheet of Liberty Mutual Holding Company, Inc. for reference (Liberty Mutual). The assets and liabilities sections are individually displayed for reference.

[7] "Long-tailed" refers to lines of business in which a long period of time may pass before specific loss amounts are known. "Short-tailed" refers to lines of business in which specific loss amounts are known soon after the claim occurs. (Chubb)

The Balance Sheet

Assets

Liberty Mutual Holding Company Inc.

Consolidated Balance Sheets

(dollars in millions)

	December 31, 2015	December 31, 2014
Assets:		
Investments		
Fixed maturities, available for sale, at fair value (amortized cost of $61,393 and $59,951)	$ 62,794	$ 63,176
Equity securities, available for sale, at fair value (cost of $2,571 and $2,603)	2,909	3,145
Short-term investments	272	626
Commercial mortgage loans	2,317	1,808
Other investments	5,691	5,373
Total investments	73,983	74,128
Cash and cash equivalents	4,227	4,003
Premium and other receivables	10,137	9,919
Reinsurance recoverables	13,575	13,979
Deferred income taxes	795	575
Deferred acquisition costs	3,164	3,001
Goodwill	4,758	4,834
Prepaid reinsurance premiums	1,098	1,192
Other assets	9,970	10,206
Assets held for sale	-	2,456
Total assets	$ 121,707	$ 124,293

Figure 3 Liberty Mutual, Balance Sheet Assets, 2015 Year-End

The above table depicts the 2015 year-end assets, cropped from the full balance sheet, of Liberty Mutual Holding Company, Inc. Interest rates have direct and indirect effects on many of the items listed.

"Investments" is the most significant contributor to Liberty Mutual's assets, composing just over 60% of Liberty's total assets. "Fixed maturities, available for sale, at fair value (amortized cost of $61,393 and $59,951)" are the most significant of Liberty's investments. The majority of these are likely corporate bonds[8] (NAIC), followed by various types of government

[8] At year end 2013, the NAIC estimated that 53% of bond exposure to insurers consisted of corporate bonds. (NAIC)

bonds. "Fair value" refers to the market value of an asset if the market for the asset is liquid[9] (CASAct). Notice that the "fair value" is higher than the "amortized value." Why might this be? As the adage goes, *as rates go up, prices go down. As rates go down, prices go up* (SEC). Based on this, Liberty Mutual may have bought many of their bonds when interest rates were higher. As rates fell, Liberty would have recorded the prices of bonds already held higher than the amortized value to match the value of bonds on the market. Doing this would be in compliance with GAAP fair-value standards. This increase is reflected by the higher asset values listed on Liberty Mutual's balance sheet. Thus, falling rates cause the market value of already held (bond) investments to increase, likely causing assets to increase.

Several of Liberty Mutual's other asset items are calculated with a present value component too, including "Premium and other receivables," "Reinsurance recoverables," "Prepaid reinsurance premiums," and "Deferred acquisition costs" to name a few. Any number based on a present value calculation will change in value the way that bonds do – holding other factors constant, an increase in rates will cause a decrease in present value, and a decrease in rates will cause an increase in present value.

This valuation effect is most direct on marked-to-market bonds. As a part of Liberty Mutual's portfolio, these bonds were discussed above as "Fixed maturities, available for sale, at fair value." They make up over 51%[10] of Liberty Mutual's assets. According to the NAIC, as of the end of 2013, bonds made up over 56% percent of the P&C industry's asset mix. With this similarity, the effect that interest rates have on industry bond holdings should be similar to the effect suggested regarding Liberty Mutual's bond holdings.

[9] According to the NY Fed in Oct. 2015, there was "ample" liquidity in the corporate bond market. (Long)
[10] $62,794,000 out of $121,797,000 total assets.

Due to this relationship, the hypothesized predictive effect that interest rates will have on assets is: there is a negative relationship between prior interest rates and P&C industry aggregate assets. This is **Hypothesis 1**.

On the other hand, it must be noted that interest rates may also have a confounding positive relationship on assets. Interest rates are directly related to the yields on new bonds. For insurers purchasing new bonds, higher rates would likely lead to a higher yielding bond portfolio. Higher yielding portfolios should lead to more investment income for insurers. These investment returns are another way that insurers' assets can grow. Thus, higher rates may instead lead to higher asset growth via investment income, therefore suggesting that interest rates may have multiple effects on P&C industry assets. Nonetheless, this study will focus on testing the negative relationship.

Liabilities

Liabilities:		
Unpaid claims and claim adjustment expenses and future policy benefits:		
Property and casualty	$ 49,323	$ 49,970
Life	9,262	9,030
Other policyholder funds and benefits payable	6,601	5,870
Unearned premiums	16,951	16,855
Funds held under reinsurance treaties	205	210
Current maturities of long-term debt	249	-
Long-term debt	6,982	7,232
Other liabilities	12,893	13,242
Liabilities held for sale	-	1,593
Total liabilities	102,466	104,002

Figure 4 Liberty Mutual, Balance Sheet Liabilities, 2015 Year-End

The above table depicts the year end 2015 liabilities, cropped from the full balance sheet, of Liberty Mutual Holding Company, Inc. Interest rates have direct and indirect effects on many of the items listed.

"Unpaid claims and claim adjustment expenses and future policy benefits" is the most sizable liability for Liberty Mutual, and it refers to several items. "Unpaid claims" refers to the expected present value of losses that an insurer will have to pay for claims that have already happened (but not necessarily been reported yet). "Claim adjustment expenses" refers to money set aside to pay to assess a loss before settlement. "Future policy benefits" refer to the money set aside to pay claims in which the losses have not yet happened. This is the expected present value of losses as determined at the onset of the policy (Marion).

Interest has a similar effect on these liabilities as it does on assets. As interest rates fall, the present value of future liabilities will be less discounted, and thus the technical provisions[11] will rise. The extent at which liabilities rise can only be determined through inspection of the company's book of business. Generally speaking, this effect is more pronounced on long-tailed liabilities where discounting is applied over a long period of time.

Due to this relationship between interest rates and the calculation of liabilities, the hypothesized predictive effect that interest rates will have on aggregate P&C liabilities is: there is a negative relationship between prior interest rates and P&C industry aggregate liabilities. This is **Hypothesis 2**.

However, the opposite relationship could hold true in some instances. All else constant, the "unpaid claims" portion of liabilities would rise if the insurer wrote more business. Higher rates would cause the prices for some lines of business to fall, and these lower prices may be attractive to consumers. More consumers may purchase certain lines of business in this scenario, which would increase the liabilities on insurers' books related to those lines. Depending on the elasticity of the insurance product (and thus the product's sales), the increase in business may

[11] "Technical provisions" refers to the expected present value of an insurer's liabilities. The term's use is most common in reference to Solvency II calculations.

offset the decrease in the present value of future obligations already on an insurer's books, thus explaining how a rise in interest rates could lead to a rise in liabilities. As illustrated above, there are many assumptions that would need to hold in order to propose hypothesis 2 as a positive relationship between rates and liabilities. Therefore, via Occam's razor, this study will hypothesize the negative relationship.

Profitability and Float

Product Pricing and Premiums Written

When interest rates fall, the present value of expected future cash flows rises. Since premiums are directly related to these calculations, one might expect a rise in rates to warrant a higher premium for affected lines of business. In particular, longer-tailed liabilities such as workers compensation and accident and health would more likely be affected than shorter-tailed lines. In these lines, there may be a long period of time before an insurer can fully settle a claim. Thus, interest rates would have a more notable discounting effect on the future liabilities (or they might have a more dramatic inflationary effect on claims costs until the time of payment). If the premiums for a certain line of business were higher, then the P&C industry could expect to collect more aggregate premiums from that line of business if the same amount of insurance was sold. In practice, the amount of a line of business sold would be subject to market demand for that line based on its new, higher price. The inverse should also be true. Under the same assumptions, as interest rates rise, the necessary premiums for certain lines of business should fall, and the industry should expect to collect fewer premiums from that line given the same amount of insurance sold, or in the case of a growing market, they should expect the aggregate

premium growth to not be as great. Therefore, **Hypothesis 3** is: prior interest rates and the growth of both net premiums written and certain lines of business have a negative relationship.

However, this relationship would also be confounded by the forces discussed with hypothesis 2. If the demand for a line of business was elastic enough, then the price change resulting from an interest rate change may cause a more substantial change to the amount of business sold. If the change in amount of insurance sold was enough, additional (or fewer) premiums collected might overcome the change in the premiums resulting from the price change of the product. This possible-positive relationship between interest rates and premiums growth would rely on the assumption that the quantities of insurance sold are affected by supply-side forces. But with the data collected, that assumption cannot be made. For that reason, hypothesis 3 is proposed as a negative relationship between rates and premium growth (aggregate and by line of business).

Combined Ratio

The combined ratio is an important profitability measure for P&C insurers. It is the sum of incurred losses and expenses over a period divided by the earned premium in the same period (Investopedia). Below is a graph of the industry-average P&C combined ratio since 1990. The graph also depicts the real US interest rate, several other segments' combined ratios, and linear trends for each set of ratios:

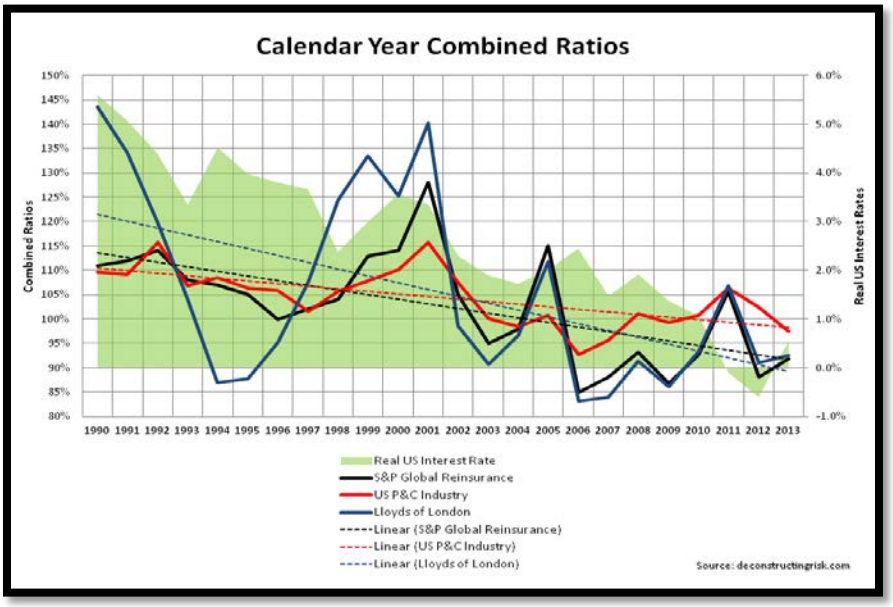


Figure 5 P&C Combined Ratio and US Interest Rate Graph[12]

By inspection alone, one can see the loose relationship between P&C combined ratios and US interest rates. Since 1990, US interest rates and P&C combined ratios have both been on the decline (although perhaps the decline in interest rates has been even more severe). It makes sense that interest rates would be a leading indicator of insurance combined ratios even so interest rates are not a part of the combined ratio calculation.

When an insurance company writes an insurance policy, it considers the amount of money that it can make on investing the premiums collected before paying out a claim. If interest rates are high, an insurer can collect premiums and expect to earn a high rate of return, even in the short run. If this assumption can be made, the insurer might feel comfortable selling policies with lower premiums, which would cause earned premiums in the combined ratio calculation to fall, causing the combined ratio to rise. Likewise, if an insurer does not expect to make much on investing premiums, the insurer will have to raise premiums in order to make sure that they

[12] (Deconstructing Risk)

collect enough money to pay all of their claims. This return is measured by the company's "investment income ratio," and it is another measure of insurer profitability (Investopedia). In addition, rates may influence premiums charged for insurance. If a decrease in interest rates were to cause an increase in premiums via higher-premium policies, a company's combined ratio would likely fall as the denominator of the combined ratio increased. The inverse would likely also be true: if an increase in rates caused a decrease in premiums, then the combined ratio would increase due to a fall in the denominator. Finally, high interest rates could lead to claims inflation, which would increase the insurer's losses, increasing the numerator of the combined ratio. These reasons lead to **Hypothesis 4**: prior interest rates and combined ratio have a positive predictive relationship.

Float

Float is the money that an insurance company holds from the time it collects premiums until the time it pays our claims (Insurance Journal), and it is a reason that Warren Buffet likes insurance companies. Through Berkshire Hathaway, he owns GEICO, Gen Re, and National Indemnity, to name a few of his insurers. He likes them because he can take the money they collect up front (the premiums) and invest it. Then, he can collect the interest and returns until the money is needed to pay out claims.

Warren Buffet probably didn't invent the concept of investing float, but he has taken it to an extreme. Berkshire Hathaway controls over $77 billion in float (McFarlane). This is a tremendous amount of money to "play with" without actually owning. If Berkshire made a simple 1% return from it's float, it would add $770 million to its bottom line. This money adds income to the company aside from the premiums the company already collects. Interest rates

directly affect money made on float since, as discussed in the subsection “Assets,” insurers invest primarily in bonds and interest-dependent products. This leads to the fifth hypothesis: prior interest rates and investment income have a positive relationship **(Hypothesis 5)**.

There is also the possibility that interest rates have an adverse force on net investment income. When interest rates are lower, alternative investments like stocks may be more attractive to investors. Insurers also own these investments in their portfolios along with their bond holdings. If stock returns are actually inversely related to bond returns, then depending on how insurers’ stock portfolios perform, in low-rate environments, insurers’ stock and alternative investment portfolios may pick up the slack in the return on their bond portfolios, confounding the effects of interest on investment income. However, because insurers’ own far more bonds than stocks, this report still expects a positive relationship between interest rates and investment income.

Chapter 3

Can Interest Rates Predict U.S. P&C Industry Performance?

This chapter explains how the hypotheses established in Chapter 2 were tested and the results of those tests. The hypotheses established in Chapter 2 are:

	Hypothesized Responses				
Relationship to Rates	**Assets**	**Liabilities**	**Premiums**	**Combined Ratio**	**Investment Income**
	Negative	Negative	Negative	Positive	Positive

Table 2 Hypotheses

This study uses industry aggregate data collected from "Best's Aggregates and Averages," 2004 and 2014 editions (A.M. Best Company), and historical 5-year U.S. Treasury bond yield information published online by the St. Louis Fed (FRED). The 5-year bond yields are the average yields available in their respective calendar years. This study refers to these rates as "prior year 5-year rates," or simply "prior year rates." 5-year bond yields chosen as the benchmark for this study, although different-duration bonds would have provided the same results. This is because bond yields on different-duration U.S. Treasuries are highly correlated[13]. The same tests were performed with 10-year bond yields for comparison, and all of the conclusions are identical.

To test for the presence of these predictive relationships, the response variables were regressed on both the prior year 5-year rates and year-over-year U.S. GDP growth[14] using

[13] A regression of 10-year rates on 5-year rates has an R^2 value of .98655. A regression of 30-year rates on 5-year rates has an R^2 value of .96591.
[14] The St. Louis Federal Reserve (FRED) also publishes the year-over-year U.S. GDP growth data used.

multiple linear regression. The study used GDP growth as a second input variable since GDP growth is correlated with both P&C insurance industry growth[15] and interest rates. Its correlation with both the input and the response variable make GDP growth a confounding variable. Therefore, it must be included in the regression so that the interest rates' effects on the responses can be measured with less likelihood of spurious results from confounding factors.

For assets, liabilities, net premiums written (overall aggregate, and line of business aggregates), and net investment income, to remove non-constant variance, the data is logged. In addition, all of the data except for "combined ratio" is differenced so that the response measured is the change in the data; thus the hypotheses tested are whether prior-year interest information can explain the changes in the aforementioned measures.

[15] After finding a significant relationship between interest rates and a response variable, the study performed a SLR to test the individual relationship between GDP growth and the respective response variable. Results are published in the relevant corresponding sections below.

Hypothesis 1

To test this hypothesis, the differenced logs of aggregate P&C industry assets from 1995-2013 were regressed on prior year rates. Below is the scatterplot with rates on the x-axis and the response on the y-axis:

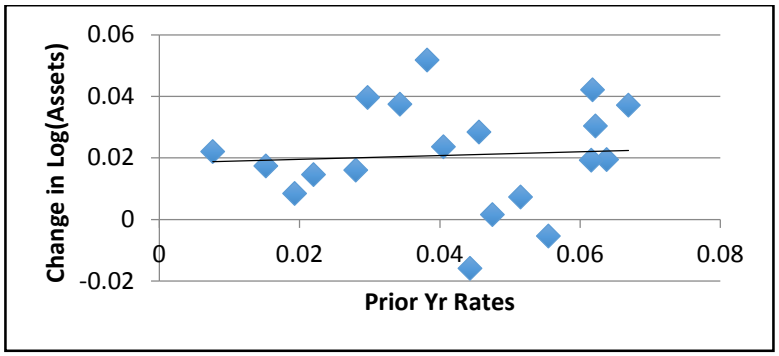


Figure 6 Change in Log(Assets) vs. Prior Year Rates

Unfortunately, this plot does not show any apparent linear relationship. The multiple regression results also suggest that there is no significant relationship:

Linear Regression

Regression Statistics

R	0.32553
R-square	0.10597
Adjusted R-square	-0.00578
S	0.01719
N	19

Diff(Log(Assets)) = 0.0107 + 0.27485 * GDP Growth Rate - 0.04969 * Prior Yr % Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.00056	0.00028	0.94826	0.40814
Residual	16.	0.00473	0.0003		
Total	18.	0.00529			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	0.0107	0.01166	-0.01401	0.03542	0.91797	0.37226	*accepted*
GDP Growth Rate	0.27485	0.20358	-0.15672	0.70642	1.35008	0.19578	*accepted*
Prior Yr % Rate	-0.04969	0.23942	-0.55724	0.45786	-0.20753	0.83822	*accepted*

T (5%) 2.11991

LCL - Lower value of a reliable interval (LCL)

UCL - Upper value of a reliable interval (UCL)

Table 3 Change in Log(Assets) vs. Rates and GDP Growth Regression Results

The regression suggests a regression coefficient of -.04969 with a standard error of .23942 for interest rates. There is clearly not significant evidence that this regression coefficient differs from zero, so this test fails to suggest that interest rates have a predictive relationship to the change in insurer assets. Thus, this study does not support hypothesis 1.

There are several reasons that may explain the lack of influence interest rates have over the changes in assets. First, as illustrated in Chapter 2, fixed-maturity assets only make up approximately half[16] of Liberty Mutual's (and industry aggregate, as per the NAIC report) assets, so one can expect interest rates to have a direct effect on only half of insurer assets. The other half would be subject to other market forces. Further research could explore the changes in P&C industry aggregate bond holdings or perhaps the bond holdings as a percentage of insurers' total portfolio in response to interest rates.

In addition, interest rates do not retrospectively account for managerial decisions made that could influence an insurer's balance sheet. Through mergers and acquisition, an insurer could inflate the size of its assets and liabilities by issuing debt to acquire a new company. It is possible for a U.S. insurer to acquire a foreign company. Doing so would inflate the U.S. P&C aggregate assets and liabilities for a year, although this acquisition would be unrelated to interest rates in the United States.

[16] $62,794,000 out of $121,707,000 total assets, or 51.59%

Hypothesis 2

To test this hypothesis, the differenced logs of aggregate P&C industry liabilities from 1995-2013 were regressed on prior year rates. Below is the scatterplot with rates on the x-axis and the response on the y-axis:

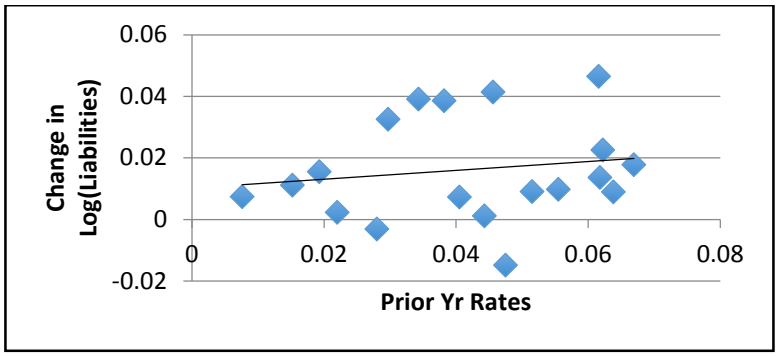


Figure 7 Change in Log(Liabilities) vs. Prior Year Rates

By examination of the scatterplot, it appears that no significant linear relationship exists. The multiple regression results suggest the same thing:

Linear Regression

Regression Statistics

R	0.28723
R-square	0.0825
Adjusted R-square	-0.03218
S	0.0169
N	19

Diff(Log(Liabilities)) = 0.00462 + 0.06165 * Prior Yr % Rate + 0.20213 * GDP Growth Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.00041	0.00021	0.71937	0.50215
Residual	16.	0.00457	0.00029		
Total	18.	0.00498			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	0.00462	0.01146	-0.01968	0.02892	0.40298	0.6923	*accepted*
Prior Yr % Rate	0.06165	0.23539	-0.43736	0.56066	0.26189	0.79675	*accepted*
GDP Growth Rate	0.20213	0.20015	-0.22218	0.62643	1.00986	0.32759	*accepted*

T (5%) 2.11991

LCL - Lower value of a reliable interval (LCL)

UCL - Upper value of a reliable interval (UCL)

Table 4 Change in Log(Liabilities) vs. Rates Regression Results

The regression suggests a regression coefficient of .06165 with a standard error of .23539. There is clearly not significant evidence that this regression coefficient differs from zero, so this test fails to suggest that interest rates have a predictive relationship to the change in insurer assets. Thus, this study does not support hypothesis 2.

Similar to an insurer's assets, an insurer's liabilities are not strictly composed of interest-dependent obligations. Figure 4 in Chapter 2 shows the 2015 year-end liabilities for Liberty Mutual. Two large components not discussed in Chapter 2 are "Unearned Premiums" and "Other Liabilities." Together, the two sets of liabilities make up 29.13%[17] of the company's liabilities. Unearned premiums are the premiums that the company is holding that have not yet been recorded as revenue for the insurer. These are the result of policyholders paying premiums up front either annually or monthly but insurance being provided continuously throughout the year. For short term insurance, the unearned premiums have relatively short duration, and are hence less affected by interest rate changes. In addition, "other liabilities" is a catch-all category for insurer liabilities that have not been predetermined to fall into a more defined category. An observer cannot realistically comment on the effects of interest on these liabilities since they could include a variety of things. Of course, other insurers would have different allocations of such liabilities, although the liability categories (and their functions) would likely be similar.

Finally, as mentioned in regards to assets, interest rates do not retrospectively account for managerial decisions made that could influence an insurer's balance sheet. Mergers and acquisitions or other strategic decisions that have little relation to interest rates could tremendously affect an insurer's balance sheet.

[17] Unearned Premiums: $16,951,000,000; Other Liabilities: $12,893,000,000; Total Liabilities: $102,466,000,000.

Hypothesis 3

To test this hypothesis, several regressions were run. First, the differenced logs of aggregate P&C industry net premiums written from 1995-2013 were regressed on prior year rates. Below is the scatterplot with rates on the x-axis and net written premiums on the y-axis:

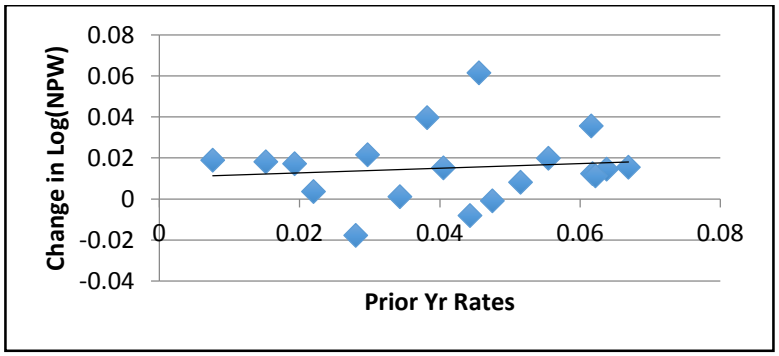


Figure 8 Change in Log(NPW) vs. Prior Year Rates

From the graph, it appears that no significant linear relationship exists. The regression results also support this:

Linear Regression

Regression Statistics

R	0.27308
R-square	0.07457
Adjusted R-square	-0.04111
S	0.01791
N	19

Diff(Log(NPW)) = 0.00445 + 0.02462 * Prior Yr % Rate + 0.21821 * GDP Growth Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.00041	0.00021	0.64464	0.53795
Residual	16.	0.00513	0.00032		
Total	18.	0.00554			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	0.00445	0.01215	-0.0213	0.0302	0.36601	0.71915	*accepted*
Prior Yr % Rate	0.02462	0.24944	-0.50417	0.55341	0.09869	0.92261	*accepted*
GDP Growth Rate	0.21821	0.2121	-0.23142	0.66784	1.02881	0.31887	*accepted*
T (5%)	2.11991						

LCL - Lower value of a reliable interval (LCL)
UCL - Upper value of a reliable interval (UCL)

Table 5 Change in Log(NPW) vs. Rates and GDP Growth Regression Results

The regression suggests a regression coefficient of .02462 with a standard error of .24944. There is clearly not significant evidence that this regression coefficient differs from zero, so this test fails to suggest that interest rates have a predictive relationship to net premiums written.

However, it is possible that the relationship lies within the data for an individual line of business. Interest is more involved in the calculations and underwriting of certain lines of business, specifically long-tailed lines, so perhaps interest rates have a predictive relationship to aggregate premiums for a specific line of business.

This study examined four lines (workers compensation (WC), private passenger auto (PPA), group accident and health (GAH), and general liability (GL)). The regression results suggested that interest rates are not a significant predictor for the latter three (PPA, GAH, GL), but they are for workers compensation. The insignificant results are listed in the appendix, and the significant results for workers compensation are explained below:

Linear Regression

Regression Statistics

R	0.57981
R-square	0.33618
Adjusted R-square	0.25321
S	0.03901
N	19

Diff(Log(WC)) = 0.00866 - 1.19036 * Prior Yr % Rate + 1.13601 * GDP Growth Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.01233	0.00617	4.05152	0.0377
Residual	16.	0.02435	0.00152		
Total	18.	0.03668			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	0.00866	0.02646	-0.04744	0.06476	0.32731	0.74767	*accepted*
Prior Yr % Rate	-1.19036	0.54341	-2.34234	-0.03838	-2.19054	0.04364	*rejected*
GDP Growth Rate	1.13601	0.46206	0.15649	2.11553	2.45857	0.02573	*rejected*
T (5%)	2.11991						

LCL - Lower value of a reliable interval (LCL)
UCL - Upper value of a reliable interval (UCL)

Table 6 Change in Log(WC) vs. Rates and GDP Growth Regression Results

This multiple regression suggests that both prior-year interest rates and GDP growth are significant predictors of the change in WC premiums written at the 5% significance level. In regards to interest, the regression suggested a coefficient of -1.19036 with a standard error of .54341. The negative coefficient supports Hypothesis 3 (premiums written and rates have a negative relationship). However, the intercept for this model is insignificant with a p-value of .74767. Below are the regression results for the model that excludes the intercept term:

Linear Regression

Regression Statistics

R	0.60091
R-square	0.36109
Adjusted R-square	0.3235
S	0.03797
N	19

Diff(Log(WC)) = - 1.08485 * Prior Yr % Rate + 1.20905 * GDP Growth Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.01385	0.00693	4.80386	0.02219
Residual	17.	0.02451	0.00144		
Total	19.	0.03837			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	0						
Prior Yr % Rate	-1.08485	0.42583	-1.98326	-0.18643	-2.54763	0.02081	*rejected*
GDP Growth Rate	1.20905	0.39383	0.37814	2.03997	3.06997	0.00694	*rejected*

T (5%) 2.10982

LCL - Lower value of a reliable interval (LCL)

UCL - Upper value of a reliable interval (UCL)

Table 7 Change in Log(WC) vs. Rates and GDP Growth, ex. Intercept Regression Results

These results further suggest the use of interest rates as a predictor for the change in WC premiums. The regression excluding an intercept yields a regression coefficient of -1.08485 for interest rates with a standard error of .42583. This provides a p-value of .02081, which is significant at the 5% level, but not at the 1% level. By removing the intercept term, the adjusted

R^2 for the model is increased to .3235. The negative regression coefficient agrees with hypothesis 3 that interest rates may have a negative relationship to premiums written, at least for certain lines of business.

Suggested next steps would be qualitative research to discover the evolution of workers compensation insurance over the past several decades. In addition, further research should include analysis of the relationship between interest rates and units of insurance sold (rather than overall net written premiums). This might uncover a relationship between interest rates and the health of the WC business, and it might suggest that interest rates have a relationship to the underwriting of WC business.

Altogether, these results show mixed support for hypothesis 3. The lack of significance that interest rates have as a predictor for aggregate NPW and certain lines of business suggest that hypothesis 3 should be rejected, however, the significant results for interest as a predictor for workers compensation suggest this study cannot wholly reject hypothesis 3.

The lack of evidence to support interest effects on aggregate premiums and on certain lines of business could be a result of several factors. For instance, certain lines of business - and what specifications on the insurance within those lines must be bought - are highly regulated. For instance, all drivers are required to purchase private passenger auto insurance in the United States, however drivers are required to purchase policies with different specifications in different states. For example, some states require drivers to buy their own injury protection insurance, whereas other states require that coverage as a part of the at-fault driver's liability coverage. The number of states that require this personal injury protection, or "PIP," changes often. Regulation affects all lines of business in some way, not just PPA. In addition, the popularity of certain types of insurance will ebb with market demand. Recently, cyber insurance has been exploding in

popularity as cyber attacks become more and more prevalent and damaging to companies. Given these reasons, it is likely that other market trends have a greater impact on certain lines of business than interest rates.

Hypothesis 4

To test this hypothesis, the P&C industry aggregate combined ratios from 1963-2013 were regressed on prior year rates. Below is the scatterplot with rates on the x-axis and the response on the y-axis:

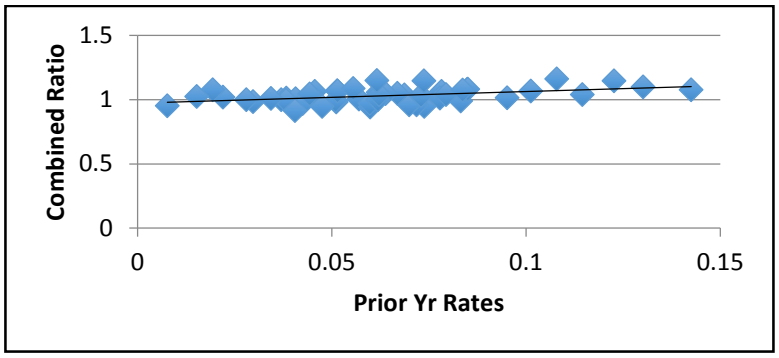


Figure 9 Combined Ratio vs. Prior Year Rates

Upon initial inspection, it appears that there may be a slight positive linear relationship in the data. Below are the multiple regression results.

Regression Statistics	
R	0.6
R-square	0.36001
Adjusted R-square	0.33334
S	0.04616
N	51

CR / 100 = 1.00574 + 1.24047 * Prior Yr % Rate - 0.80886 * GDP Growth Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.05752	0.02876	13.50033	0.00002
Residual	48.	0.10225	0.00213		
Total	50.	0.15977			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	1.00574	0.01864	0.96827	1.04322	53.96242	0.	*rejected*
Prior Yr % Rate	1.24047	0.24802	0.74179	1.73915	5.00146	8.02164E-6	*rejected*
GDP Growth Rate	-0.80886	0.24289	-1.29723	-0.32049	-3.33012	0.00167	*rejected*
T (5%)	2.01063						

LCL - Lower value of a reliable interval (LCL)
UCL - Upper value of a reliable interval (UCL)

Table 8 Combined Ratio vs. Rates and GDP Growth Regression Results

Finally, a significant result. The regression suggests a regression coefficient of 1.24047 with a standard error of .24802. With a p-level of 8.02164E-6, this result is very significant. GDP Growth is also suggested to be a significant predictor, as it appears to be significant at the .01 significance level too. Observing the R^2 value, this model explains over 33% of the variation in the response, which isn't bad for only two input variables. The p-value for the overall model is .00002. Based on these evidence, this study can not reject hypothesis 4: *There may be a positive relationship between prior interest rates and the industry's combined ratio.*

Further research (perhaps further multiple regressions with more independent variables) should be done to confirm this relationship. In addition, future researchers should reach out to P&C insurance underwriters to investigate the role that known and past interest rates play in the underwriting process.

At this point, the hypothesized underlying relationship between interest rates and combined ratios is: when interest rates are high, management decides to sell insurance at a lower premium with respect to expected losses. This would result in the denominator of the combined ratio decreasing, which would have an overall increasing impact on the combined ratio. Selling insurance at a lower premium would be for the purpose of competitive pricing. To investigate this theory, as mentioned above, further research would need to include a qualitative investigation of underwriting practices.

Hypothesis 5

To test this hypothesis, the differenced logs of P&C industry aggregate net investment incomes (NII) from 1968-2013 were regressed on prior year rates. Below is the scatterplot with rates on the x-axis and the response on the y-axis:

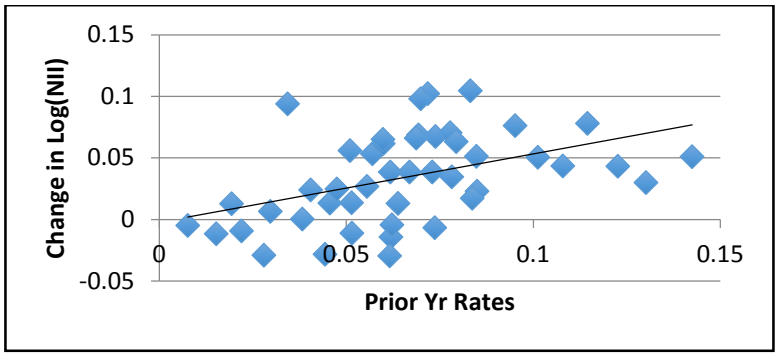


Figure 10 Change in Log(NII) vs. Prior Year Rates

Inspection of the graph suggests that there may be a positive linear relationship between interest rates and the change in net investment income for the P&C industry. Below are the multiple regression results:

Linear Regression

Regression Statistics

R	0.79165
R-square	0.6267
Adjusted R-square	0.60934
S	0.02272
N	46

Diff(Log(NII)) = - 0.0337 + 0.14879 * Prior Yr % Rate + 0.86965 * GDP Growth Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.03726	0.01863	36.09503	6.29723E-10
Residual	43.	0.0222	0.00052		
Total	45.	0.05946			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	-0.0337	0.00943	-0.05272	-0.01469	-3.575	0.00088	*rejected*
Prior Yr % Rate	0.14879	0.12886	-0.11108	0.40867	1.15467	0.2546	*accepted*
GDP Growth Rate	0.86965	0.1241	0.61937	1.11993	7.00749	1.25503E-8	*rejected*

T (5%) 2.01669

LCL - Lower value of a reliable interval (LCL)

UCL - Upper value of a reliable interval (UCL)

Table 9 Change in Log(NII) vs. Rates and GDP Growth Regression Results

Alas, these regression results do not support what visual inspection of the scatterplot might have suggested. In the multiple regression, prior year interest rates are not a significant predictor of the change in net investment income. Although the adjusted R^2 value is high (this model apparently explains over 60% of the variation in the change of investment income…that's a lot!), the model's capabilities are not because of interest rates as a predictor – there is a more descriptive, underlying variable influencing the response: GDP Growth. Therefore, this analysis of the data ultimately fails to support hypothesis 5.

A possible explanation for this lack of relationship refers back to the reason that assets (and liabilities) might not be related to interest rates. Although bond holdings are a large portion of an insurer's portfolio, insurers have many other investments too. Generally speaking, investments do well when the economy does well, which would explain why GDP growth was a strong predictor for investment income. In addition, GDP growth could also suggest as to what types of investments an insurer holds. An insurer may feel more comfortable holding "riskier" assets like stocks when the economy is doing well, even further removing interest as an indicator variable.

Further research on net investment income should include an analysis of the distribution of P&C industry investments over time. This may reveal other trends not yet considered.

Analysis Summary

The analysis of the data collected fails to support hypotheses 1, 2, and 5. However, it cannot wholly reject hypothesis 3, and it supports hypothesis 4. Based on these results, interest rates probably have little to no predictive capabilities for the P&C insurance industry in regards to assets, liabilities, aggregate premiums written, premiums written for certain lines, or investment income. However, prior year interest rates seem to be related to the change in workers compensation premiums and to the industry-wide combined ratio. Further research as suggested above should scrutinize these findings.

Chapter 4

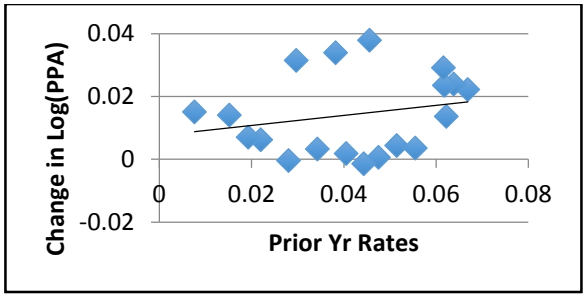
Conclusion

Interest rates are a common force in everyday life, and they are a frequent variable in an actuary's calculations. They are powerful as a tool for growing wealth, and they are necessary for discounting future obligations. Based on the data analyzed in this study, although interest rates may have a predictive capability in regards to the change in workers compensation and to the industry's combined ratio, they probably do not have the capability of predicting many other aspects of the P&C insurance industry, such as its year to year change in assets, liabilities, premiums written, and investment income.

Appendix

Private Passenger Auto (PPA)

Below is a scatterplot with prior rates on the x-axis and the change in the log of PPA premiums on the y-axis, followed by the multiple regression results from the model regressing the change in the log of PPA premiums against both prior rates and GDP growth. The scatterplot does not suggest a clear linear trend. The multiple regression results also suggest a lack of linear relationship: the regression coefficient for interest rates has a p-value of .50724, and the overall model has a p-value of .56510. Based on these results, this study cannot suggest a relationship between prior rates and the change in PPA premiums.



Linear Regression

Regression Statistics

R	0.26241
R-square	0.06886
Adjusted R-square	-0.04753
S	0.01311
N	19

Diff(Log(PPA)) = 0.00515 + 0.12389 * Prior Yr % Rate + 0.08794 * GDP Growth Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.0002	0.0001	0.59161	0.5651
Residual	16.	0.00275	0.00017		
Total	18.	0.00295			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	0.00515	0.00889	-0.01371	0.024	0.57867	0.57087	*accepted*
Prior Yr % Rate	0.12389	0.18263	-0.26328	0.51105	0.67835	0.50724	*accepted*
GDP Growth Rate	0.08794	0.15529	-0.24126	0.41715	0.5663	0.57905	*accepted*

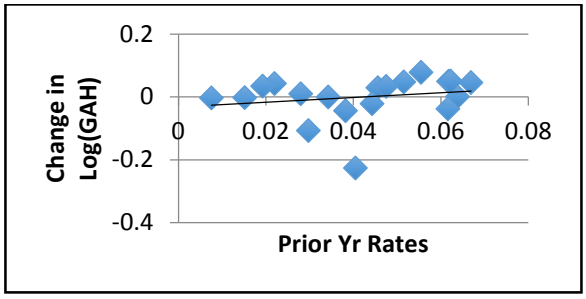
T (5%) 2.11991

LCL - Lower value of a reliable interval (LCL)

UCL - Upper value of a reliable interval (UCL)

Group Accident and Health (GAH)

Below is a scatterplot with prior rates on the x-axis and the change in the log of GAH premiums on the y-axis, followed by the multiple regression results from the model regressing the change in the log of GAH premiums against both prior rates and GDP growth. The scatterplot does not suggest a clear linear trend. The multiple regression results also suggest a lack of linear relationship: the regression coefficient for interest rates has a p-value of .34762, and the overall model has a p-value of .60743. Based on these results, this study cannot suggest a relationship between prior interest rates and the change in GAH premiums.



Linear Regression

Regression Statistics

R	0.24579
R-square	0.06041
Adjusted R-square	-0.05704
S	0.07155
N	19

Diff(Log(GAH)) = - 0.01789 + 0.96432 * Prior Yr % Rate - 0.52303 * GDP Growth Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.00527	0.00263	0.51437	0.60743
Residual	16.	0.0819	0.00512		
Total	18.	0.08717			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	-0.01789	0.04853	-0.12077	0.08499	-0.36862	0.71724	*accepted*
Prior Yr % Rate	0.96432	0.99656	-1.14829	3.07694	0.96765	0.34762	*accepted*
GDP Growth Rate	-0.52303	0.84737	-2.31938	1.27332	-0.61723	0.54577	*accepted*

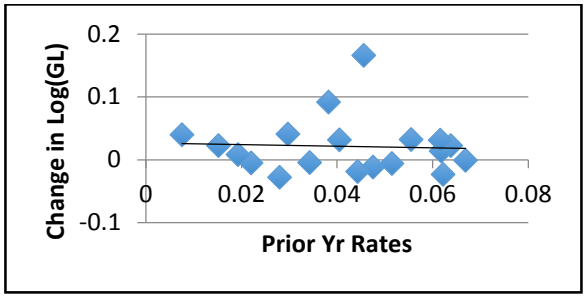
T (5%) 2.11991

LCL - Lower value of a reliable interval (LCL)

UCL - Upper value of a reliable interval (UCL)

General Liability (GL)

Below is a scatterplot with prior rates on the x-axis and the change in the log of GL premiums on the y-axis, followed by the multiple regression results from the model regressing the change in the log of GL premiums against both prior rates and GDP growth. The scatterplot does not suggest a clear linear trend. The multiple regression results also suggest a lack of linear relationship: the regression coefficient for interest rates has a p-value of .71183, and the model has a p-value of .84649. Based on these results, this study cannot suggest a relationship between prior rates and GL premiums.



Linear Regression

Regression Statistics

R	0.14358
R-square	0.02062
Adjusted R-square	-0.10181
S	0.04752
N	19

Diff(Log(GL)) = 0.01814 - 0.24891 * Prior Yr % Rate + 0.30628 * GDP Growth Rate

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2.	0.00076	0.00038	0.1684	0.84649
Residual	16.	0.03613	0.00226		
Total	18.	0.03689			

	Coefficient	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%)*
Intercept	0.01814	0.03223	-0.0502	0.08647	0.56261	0.5815	*accepted*
Prior Yr % Rate	-0.24891	0.66194	-1.65215	1.15434	-0.37603	0.71183	*accepted*
GDP Growth Rate	0.30628	0.56284	-0.8869	1.49945	0.54416	0.59383	*accepted*
T (5%)	2.11991						

LCL - Lower value of a reliable interval (LCL)

UCL - Upper value of a reliable interval (UCL)

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Academic Vita of Matthew Mielnik

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Exams & VEE

- Exam 1/P, Exam 2/FM, Exam 3F/MFE, Exam MLC, Exam 4/C: Passed
- VEE Economics, VEE Corporate Finance Completed
- VEE Applied Statistics Scheduled to Complete Spring 2016

Education

The Pennsylvania State University University Park, PA | Fall 2012 – Spring 2016

***Schreyer Honors College**, Smeal College of Business* **Graduation:** May 2016

Major: Risk Management – Actuarial Science (B.S.)

Minors: Statistics, Chinese Language

Work Experience

Liberty Mutual Insurance Boston, MA | Summer 2015

Actuarial Intern - Liberty International

- Used Microsoft Excel and VBA to produce Solvency II projection tools
- Compiled Group statistics to help determine International business's TP and SCR
- Learned to create comprehensible work that can easily be integrated into a larger framework
- Developed a better understanding of Actuarial professionalism

M Consulting and Inspection Duncansville, PA | Summer 2014

Specialist's Assistant

- Help install new and improve existing radon mitigation systems
- Developed handyman skills by learning to use handheld tools and basic construction techniques

Involvement

Penn State Actuarial Science Club Penn State University | Fall 2014 - Present

Vice President

- Create, organize, and oversee new programs within the Club to serve the needs of and better educate Penn State Actuarial students
- Coordinate club speaker series, in which prominent Actuaries are invited to Penn State to present to students
- Manage an officer-development board of student liaisons
- Coordinate resume and interview workshops, exam review sessions, tutor programs, and other educational programs for students

Penn State Actuarial Science Department

Risk Management 410 Grading TA Penn State University | Spring 2016

- Asses students progress by grading all assignments and managing the grade book for the course
- Organize and assess homework presentations given by students
- Assist the professor in communicating with students, evaluating the appropriateness of the course's workload and difficulty, and assessing whether the course is effective for students

Risk Management 411 Student TA Penn State University | Spring 2015

- Assist the course professor with gauging the course's rigor and the appropriateness of its assignments with respect to time and content
- Assist the professor with communication among graduate TAs and among students

Actuarial Program Tutor Penn State University | Fall 2016, Spring 2016

- Meet weekly with a student to help her understand and practice material for several classes
- Evaluate her progress and develop an effective study plan to prepare her for Exam 2/FM