



BSAMC

Bocconi Students Asset Management Club

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DERIVATIVES ON FIXED INCOME



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Introduction on Fixed Income Scenario and Outlook

In 2022, the “Golden age” of fixed income came to an end: it was in fact the worst year for bond markets since the beginning of the 20th century. The reasons for the bad performance of the bond market were various, such as the bull market of equities, the geopolitical crisis between Russia and Ukraine, supply-chain issues, loose monetary policy, and huge fiscal spending packages that governments launched as a reaction to the Covid-19 crisis.

Now, there seem to be positive expectations about the fixed-income market outlook in 2023, and the confidence comes mainly from:

- Decline in inflation: the peak of inflation has most likely already happened, and it is supposed to trend steadily downwards after hitting a 40-year high in 2022, due mostly to the energy crisis caused by the Russia-Ukraine conflict.
- Potential end of the tightening cycle: Central banks are expected to start increasing rates in smaller increments than 2022, and with inflation decreasing raises in interest rates will not be as aggressive.
- High yields: both nominal and real starting yields are the highest in years; High-quality corporate bonds currently offer higher yields than dividend stocks.

Generally, markets are expected to return to traditional behaviour, so fixed income should go back to providing capital preservation, income, and diversification benefits to investors. In particular, capital preservation will be achieved thanks to decreasing inflation, which creates room for long-term yields to fall, and due to the fact that normally yields and bond prices move in opposite directions, this would imply a raise in bond prices.

The low-interest rate environment is now considered to be behind, so with yields moving higher, bonds become a source of stable income, thanks to the periodic coupon payments, which will be paid while investors wait for the markets to stabilize. In the past couple of years, the relationship between bond and stock price movements has been positive, but it is expected to go back to normal, i.e., negative correlation between the two.

The environment today remains uncertain: since the U.S Federal Reserve started raising interest rates in the first quarter of 2022, uncertainty has been prevailing in the markets, and a general concern over the health of the banking system at the beginning of 2023 made institutional investors move to safer assets, creating a high volatility regime in the fixed-income market. In particular, the fixed-income market is expected to stay volatile in the first half of 2023, but companies that are not highly leveraged and have ample access to cash or capital are probably in the best position to ride out this uncertain period. The market of bonds has increased quality in the past two decades, and even if it is probable for the default rates to increase, the higher quality of the market should keep defaults near historic averages.

In the past, mild recessions have had a very contained impact on high-quality, high-yield issuers. For example, during the 2008 recession bonds outperformed equities by a wide margin, especially if you consider high-quality fixed-income investments. So historically, investors that continued investing in high-yield in periods of volatility were rewarded with long-term returns since the sector generally does not require strong economic growth to perform well.

Derivatives on Fixed Income

Derivatives are a particular category of financial instruments whose value is linked to the value or cash flows of one or more underlying assets, which may be equities, bonds, currencies, commodities, etc. These financial instruments are usually used for hedging or speculative purposes; purposes that can be pursued through the adoption of various investment strategies (particularly in the case of options).

Derivatives have undergone a profound evolution over the past few years; in fact, not only has there been a sharp increase in the types of derivatives that are available in the market and OTC today, but there has also been an evolution in the pricing or settlement methodologies of pre-existing types. Here we simply identify and briefly define the main classes of derivative financial instruments: futures and forwards, swaps, and options (we refer only to plain vanilla bonds).

Futures and forwards are financial instruments that involve an agreement between two parties to deliver a specified quantity of an underlying asset at a predetermined price and date. The differences between the two types of contracts are to be found in their characteristics, in fact, while futures are standardized contracts and traded in regulated markets, on the contrary, forwards are non-standardized instruments and traded in OTC markets, furthermore, in the regulation of futures contracts, clearing systems are used, which guarantee a reduction in counterparty risk.

Options are derivative instruments which give the buyer the right to buy or sell the underlying asset at a predetermined price, specifically, we speak in the first case of call options and in the second case of put options.

Swaps are derivative financial instruments in which the counterparties assume the obligation to exchange periodic cash flows with each other, specifically the flows are calculated by applying a fixed interest rate and a variable interest rate to a principal (called notional).

Derivative financial instruments find wide use in fixed income, so much so that the expression fixed income derivatives is sometimes used with reference to a wide variety of derivative products such as interest rate swaps, inflation swaps, forward rate agreements (FRAs), etc. The use of derivatives in fixed income is grounded in two different reasons:

- To protect the investment portfolio from risks related to the price of the instruments included within it.
- To hedge issuer-related risk, particularly of government bonds.

Alongside these objectives, there is also an important advantage which turns out to be offered by the so-called fixed-income derivatives and interest rate derivatives that is, the so-called leverage effect. The leverage effect presented by derivatives is to amplify the gains and losses that can potentially be pursued on the underlying. In fact, in transactions carried out with derivatives, the amount of the initial investment turns out to be a fraction of the counter value of the underlying, however at the same time the gains and losses are related to the underlying itself. This leverage turns out to be quantifiable on the basis of the ratio between the value of the underlying and the initial investment.

At this point it is possible to proceed with a brief description of what are usually considered to be the main fixed-income derivatives.

Short-term interest rate futures

Short-term interest rate futures are derivatives having as their underlying asset a financial instrument with a maturity of less than one year (one would otherwise speak of long-term interest rate futures). This category of futures, similar to the family of derivatives to which it belongs, can provide for settlement by delivery of the underlying asset or by cash. Short-term interest rate futures with cash settlement are commonly used in fixed income. In this type of contract, the underwriter (long side) receives the interest accrued on the notional.

Short-term interest rate futures are standardized contracts both with reference to the underlying, for which type and quantity are predetermined, and with regard to maturities, which are also predetermined. In addition, since futures are traded on regulated markets, a centralized clearing system is used to limit counterparty risk. Precisely, the clearing house in transactions carried out with derivatives requires, for positions that are kept open for more than one day, the payment of an initial margin (quantified on the basis of the official closing price recorded on the day on which the contract was opened) to a special account. At the end of each day positions that have been taken in the futures market are valued against the daily settlement price. This price is established in the closing minutes of trading. If the position has earned a profit, funds will be transferred into the position holder's margin account. If the position has recorded a loss, then there may be a call for additional funds to be deposited in the margin account. Specifically in fixed income, these instruments are used for hedging purposes on bond positions held in the portfolio, in fact, if there is a fear of an increase in interest rates the investor in order to protect against the loss of bond value could proceed to sell an interest rate futures, for which there would be a similar reduction in market value.

Forward Rate Agreements (FRAs)

FRAs are derivative contracts with which the parties agree to exchange, at contract's maturity, the difference between a fixed rate and a variable market rate, multiplied by the contract term and principal amount. These contracts can be traded either in regulated markets or over-the-counter; they usually have a life of 3 months and are generally traded with standardized maturities. FRAs appear to be constructed to hedge against the future level of short-term interest rates. Specifically, they can be used during periods of high uncertainty about interest rates to hedge against a decline in interest rates.

We note that FRAs are different from IRSs, which are also used for hedging purposes in fixed income, specifically here we simply point out that in the case of the former, there is a single payment, while in the case of interest rate swaps the exchange of a plurality of payments periodically takes place.

Options on Interest Rates and Swaptions

Interest rate Options are a particular category of options that do not have a financial instrument as the underlying asset, but an interest rate. These financial derivatives allow the subscriber to benefit from a change in the level of interest rates. Specifically, we recognize three main types of interest rate options:

- Interest rate Cap: this derivative contract gives the purchaser the right to receive from the seller, for a certain period and on set dates, an amount equal to the positive difference between a market rate and the rate set by the contract on the date of detection, a notional principal and the length of the period expressed in the same rate base.
- Interest Rate Floor: this derivative has a structure similar to that of the interest rate cap, the only difference being that in this case, the buyer has the right to receive a cash flow determined from the difference between the rate set by the contract and the market rate at the date of recognition, and not the other way around as is the case with the cap.
- Interest Rate Collars: this long position (buy) derivative contract is equivalent to the purchase of an interest rate cap and the sale of an interest rate floor by the same dealer.

As can be easily understood on the basis of the description of these instruments they turn out to be usually used as a hedge against interest rate fluctuations, in fact, they allow banks to limit the potential downside risk in case there turns out to be a reduction in the interest rates on which the cash flows of financial instruments held in the portfolio are determined. However, in addition to this hedging purpose, interest rate options are also used for speculative purposes, in fact, traders can bet on the direction in which interest rates will move without having to resort to underwriting bonds, but rather through the less expensive underwriting of an interest rate option.

In conclusion, a further use that can be made of interest rate options is to implement volatility trading strategies. These strategies are based on the observation of how the value of options turns out to be affected by the volatility of the underlying, specifically an option turns out to be the more sensitive to changes in the volatility of the underlying (which in the case in question turns out to be an interest rate) the more it is at the money. These trading strategies are usually aimed to speculate on a situation of potential instability of interest rates, however, they can be used to neutralize by means of the resulting revenues, the unpleasant effects that can be determined on the profitability of a fixed-income portfolio. The main strategy by which one can speculate on increases in interest rate volatility is to pursue a Long Straddle, which involves the purchase of an interest rate call and an interest rate put (usually both ATM) with the same strike price. Such an overall position realizes a positive payoff whenever at option expiration the interest rate deviates from the reference rate of the two options in an amount sufficient to cover the price of the options. We can see how this strategy can thus achieve a positive payoff regardless of the direction that turns out to be taken by interest rates, thus providing a hedge in situations where there is uncertainty about the direction that will be taken by interest rates.

Market Scenario and Outlook

To date, the global economy appears to be characterized by great instability in the interest rate market; in fact, over the past several months all the world's major central banks have revised their interest rates upward with unprecedented speed. This dramatic change of direction in monetary policy by institutions turns out to be driven by the inflationary levels noted in the immediate past. Following a particularly prolonged period of low inflation, there has been a sharp rise in interest rates across the global landscape since the second half of 2021. Inflation recorded on an annual basis (i.e., on the basis of comparing the consumer price index for the relevant quarter with that of the corresponding quarter of the preceding year) during 2022 reached its highest level in 30 years for some of the world's major monetary powers (Euro area, U.S., U.K.).

Rising inflation rates have led to the achievement of almost unprecedented levels of profitability in fixed income. As of today, however, due to the pressure on global economies realized by the continuous rate hikes and the collapse of high-profile banks recorded over the past few weeks, the position among others of the Fed and ECB seems more uncertain than ever. Since the beginning of 2023, it can be said that a real countdown towards the end of this season of rate hikes has now begun, although the central bankers' leadership continues to hint that the path taken will continue to be beaten as long as it proves necessary. Given this evidence, one can therefore assume an increase in the use of derivatives in fixed income, in fact, as pointed out they are particularly efficient to be able to deal with situations characterized by instability in interest rate movements.

The instruments previously presented would make it possible to pursue an efficient hedge against possible changes in direction by financial institutions while not jeopardising all institutions, while at the same time not going to jeopardize the profitability of the fixed-income divisions in case the bullish path persists over time. Specifically, it is possible to expect an increased use of interest rate options by asset managers, as these instruments have been shown to be particularly versatile and suitable for facing different scenarios.

Among the various uses of these derivative instruments, a particular focus can be given to volatility trading strategies. These strategies can allow portfolio managers to deal with possible changes in interest rates and pursue a positive return in what is expected to be a period characterized by high levels of volatility in these markets. Through these strategies, whether implemented through the exemplified straddle or through strategies such as strangle or strep (strategies with a similar underlying logic to the presented straddle, but with small structural differences), one could benefit from both an expected reduction in interest rates and a continued bullish trend. This could enable the increase of revenues in fixed income portfolios or mitigate potential losses that may arise. Conversely, it is more difficult to imagine the use of directional trading

strategies, given the difficulty in identifying a direction with a degree of certainty sufficient to bet on it in the interest rate market.

A Quantitative Analysis

In this section, we will be exploring the relationship between the VIX and MOVE indexes, where we will use correlation analysis to determine if they are in fact correlated, or if their values move independently of each other. The VIX ticker is a calculation made by the Chicago Board Options Exchange or CBOE to calculate the expectations of future volatility. For example, times of greater uncertainty such as during the COVID-19 pandemic lead to a higher VIX value, while calmer times result in a lower VIX value. The MOVE (Merrill Lynch Option Volatility Estimate) Index calculates the implied volatility of U.S. Treasury markets. Both the VIX and MOVE indices are financial metrics that provide insights into the level of market volatility. The VIX quantifies the expected level of market volatility over a 30-day time horizon, derived from analysing options on the S&P 500 index. It comprises two distinct components, anticipated realized volatility, which is a measure of risk, and the variance risk premium, which reflects investors' level of risk aversion. Similarly, the MOVE index normalizes the implied volatility on 1-month US Treasury options and weighs them by the yield curve on the 2, 5, 10, and 30-year contracts over the ensuing 30-day period. This yields information on the level of US market volatility, similar to the VIX. The MOVE is even often considered the “VIX for bonds” because of its accuracy in predicting bond market volatility. An important aspect is that these indices are mostly coincident indicators as opposed to forward looking, because they tend to track realized volatility. There's a very tight correlation between the realized movement, the day-to-day market activity of liquid instruments, and options on them.

Historically, the price changes of bond and equity markets have been interlinked. The most common reason is that any change in the level of interest rates highly affects both markets. When interest rates rise, bond prices tend to fall as investors become less attracted to the lower yields offered by existing bonds. Conversely, when interest rates fall, bond prices tend to rise due to increased demand for fixed-income securities. Changes in interest rates can also have an impact on equity prices. When interest rates rise, the cost of borrowing increases which can reduce the profitability of companies that rely heavily on debt financing. As a result, stock prices of these companies may decrease. An increase in interest rates can also make bonds more attractive, leading to a shift out of equities and into bonds. In summary, the relationship between prices of equities and bonds is highly complex.

With both the VIX and MOVE being risk metrics, and with the assumption that bond and equity markets are conversely correlated, we are going to use correlation analysis to determine whether the indices are correlated, or if their values move relatively independently. The last 5 years of financial data (See exhibit 1) were selected as a more thorough test of correlation due to significant factors such as the COVID 19 pandemic and recent interest rate hikes. The numerical output and a key graph (See Exhibit 2.2) are shown below¹:

Call:				
lm(formula = V ~ M)				
Residuals:				
Min	1Q	Median	3Q	Max
-8.725	-4.992	-2.644	4.427	29.289
Coefficients:				
	Estimate	Std. Error	T Value	Pr(> t)
(Intercept)	16.87747	2.59812	6.496	2.05e08***
M	0.06699	0.03161	2.120	0.0383*

¹ The tables shown are taken from our results on R Studio

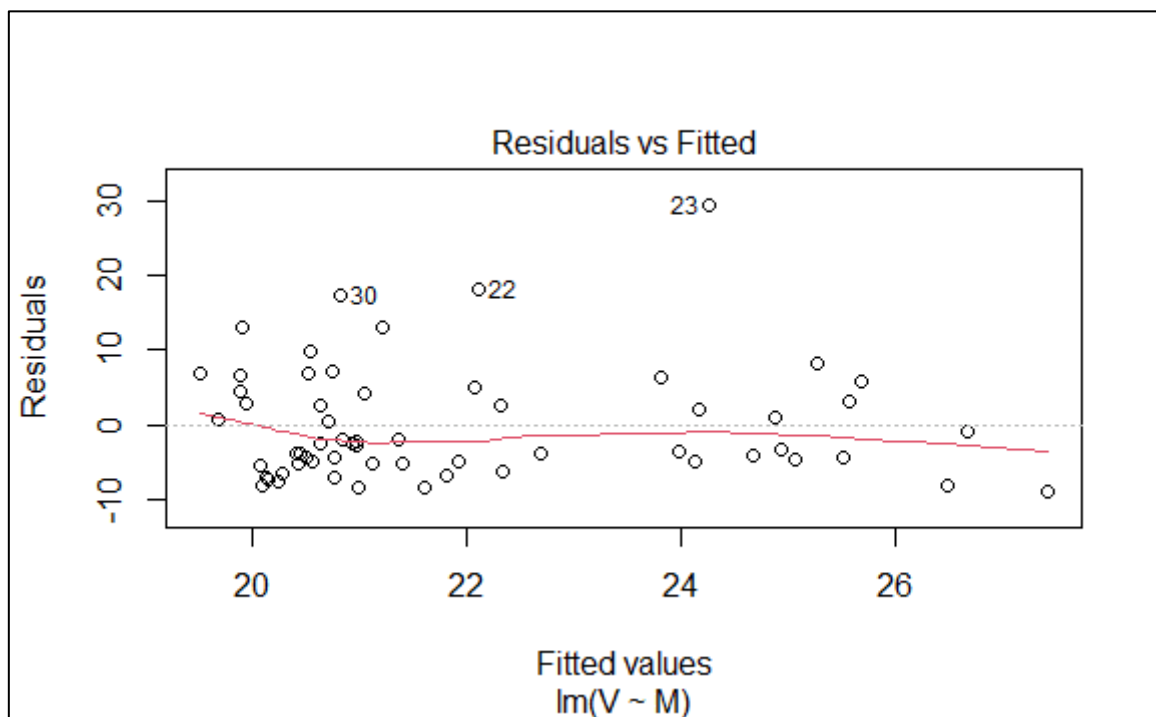
Significance codes:

0 = '***'	0.001 = '**'	0.01 = '*'	0.05 = '.'	0.1 = ''
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Residual standard error: 7.644 on 58 degrees of freedom

Multiple R-squared: 0.07189, Adjusted R-squared: 0.05589

F-statistic: 4.493 on 1 and 58 DF, p-value: 0.03833



After inputting the data, the software calculates the coefficient and the intercept of the regression model built off the equation:

$$VIX = \text{Intercept} + \text{Coefficient} \times \text{MOVE} + \varepsilon$$

The output provided by the software gives us the coefficient and intercept, and the significance of both: from a statistical point of view, both parameters are significant, and that is confirmed by the low p-value associated with both (<0.01). The coefficient associated with the MOVE index is positive and small (0.06699), which implies a slight positive correlation between the VIX index and the MOVE index.

Since the VIX and MOVE indexes have been found to be correlated, it provides important information about the state of the financial markets. A positive correlation between the VIX and MOVE suggests that market volatility is increasing across the board, and more specifically indicates that investors are becoming more risk-averse and uncertain about future market movements. However, the relationship between the VIX and MOVE is not limited to economic uncertainty. There are several other factors that can contribute to this phenomenon. For example, broader economic and geopolitical factors such as political tensions between countries can cause markets to react in a seemingly "uneconomic" fashion. The ongoing war in Ukraine and political tensions

between China and the United States and Taiwan are some examples of geopolitical factors that can impact markets.

Interestingly, the correlation between the VIX and MOVE can contradict economic theory. According to traditional economic theory, when interest rates rise, bonds should decrease in value, while equities should increase. However, in a scenario where the VIX and MOVE indexes are positively correlated, both bonds and equities can change in value in the same direction, which defies economic theory. This could be due to speculators becoming more stressed about the future state of the market and reacting among all asset classes.

Investors and portfolio managers use these measures of implied volatility to maximize profit in times of uncertainty. Many of these investment strategies use derivatives to create another layer of risk management aside from speculation.

Investment Strategies

Derivative instruments contribute to market efficiency and liquidity by giving market participants the ability to hedge positions and to trade in and out of markets at any time. Other benefits consist of continuous price updates and algorithmic predictions. In the current market environment, certain investment managers have implemented fixed income derivative strategies to withstand higher inflation and rising interest rates.

One strategy is creating a High Yield bond fund, hedged by fixed income derivatives. Investing in high yield floating rate notes can shield the investor from the effects of inflation due to the higher income from the bonds, as well as reducing the interest rate risk due to their floating rate coupon payments. The derivative contracts aim to increase the fund's return in case of volatility in the prices of the underlying assets. Moreover, they allow the fund to generate profits from the leverage of the derivatives higher than the cash flows from the bonds. As a result, the extent of losses and gains are larger, leading to greater fluctuations in the fund's value. Investment managers will exercise HY FRN (High Yield Floating Rate Notes) derivatives when they are willing to take on higher risk for higher potential returns due to favourable speculations. The current credit spread on the BofA index for HY FRNs is 4.48 (ICE BofA US High Yield Index Option-Adjust Spread), while the current investment grade credit spread is 1.39. Currently, probability of loan default is low due to the rising corporate profitability that has led to strong interest coverage ratios- enabling debtors to pay off their debts with the profits. Accordingly, HY FRNs have a higher likelihood of producing income that can outperform annual inflation than investment-grade companies.

Investment managers also have a strategy for managing risk in equity portfolios, which involves using options. Specifically, put options can be purchased to protect equity portfolios against potential declines in value. These options give investors the right to sell the underlying asset at a specific price, even if the market price falls below that level. By doing so, investors can limit their potential losses if the market were to experience a downturn. Options also offer investors the opportunity to leverage their exposure to stocks they believe will rise in value. However, this leverage can amplify gains as well as losses, emphasizing the importance of careful risk management when using derivatives. Given the current risk of inflation and rising interest rates, investment managers may find it wise to hedge their equity portfolios with options. Inflation can lead to higher interest rates, which could have a negative impact on equity prices. By hedging with options, investment managers can mitigate this risk and protect their portfolios against potential losses.

Overall, derivatives like options can be valuable in investment strategies by allowing for hedging positions, trading at any time, and generating profits through leverage and speculative opportunities. However, the potential for losses due to leverage highlights the importance of strategic planning and careful risk management. Overall, derivative strategies offer investment managers a range of tools to protect against market risks and generate returns in a volatile market environment. However, the use of derivatives can

increase the complexity of an investment portfolio, so careful consideration and risk management are crucial in ensuring successful implementation of these strategies. It is also important to consider the costs associated with using derivatives, as well as the potential risks of counterparty default and market illiquidity. By utilizing these tools responsibly, investment managers can optimize their portfolios and provide better returns for their investors.

Conclusion

After a period of great uncertainty and high volatility, the fixed-income market seems to be returning to its standards of stable income generation. However, the first part of 2023 brought us destabilizing events such as those in the banking sector which increased volatility again and cast worries on the market.

We analyzed more in detail some of the derivatives on fixed income and we examined their uses and investment strategies inside the industry. We saw how we can use these instruments for, for example, hedging portfolios or trading strategies like volatility trading. These instruments are of fundamental importance for many asset managers and play a crucial role especially in banks who need to manage interest rate risk on a daily basis.

This gives us important insights on recent developments in the banking sector, especially for what concerns Silicon Valley Bank who failed to hedge its long-term bonds portfolio.

Subsequently, we went through a quantitative analysis of the VIX and MOVE indexes which are very important tools when it comes to analyzing volatility. We found a positive correlation between the indexes signaling rising risk-aversion and uncertainty. This is the effect of the disrupted political and economic environment to which we assisted in the last few years. This unexpected positive correlation goes partly against traditional financial knowledge that wants stocks and bonds to move in opposite directions. We could make a leap further and note that this correlation in volatilities is given by the general high volatility caused by distressed markets; but this assertion requires further economic analysis and testing and could be a suggestive idea for future developments of this topic.

Finally, we presented in detail some investment strategies with fixed-income derivatives which are very effective for hedging. For example, the hedged High Yield Bond fund is a way to pursue higher returns while being protected by volatility risks.

Appendix

Exhibit 1: Yahoo Finance, 2023

Source: Yahoo Finance https://finance.yahoo.com/quote/%5EVIX?p=%5EVIX&tsrc=fin-srch								https://finance.yahoo.com/quote/%5EMOVE/							
VIX	Date	Open	High	Low	Close	VIX Adj	Close	MOVE	Date	Open	High	Low	Close	MOVE Adj	Close
	5/1/18	16.00	18.78	10.91	15.43	15.43			5/1/18	53.11	55.40	51.13	52.84	52.84	
	6/1/18	14.92	19.61	11.22	16.09	16.09			6/1/18	54.38	55.89	52.47	54.21	54.21	
	7/1/18	17.70	18.08	11.44	12.83	12.83			7/1/18	49.73	50.38	47.69	48.79	48.79	
	8/1/18	13.09	16.86	10.17	12.86	12.86			8/1/18	49.50	50.96	48.73	50.30	50.30	
	9/1/18	13.13	15.63	11.10	12.12	12.12			9/1/18	48.10	49.07	46.75	47.97	47.97	
	10/1/18	11.99	28.84	11.34	21.23	21.23			10/1/18	52.12	57.68	51.42	57.14	57.14	
	11/1/18	20.96	23.81	16.09	18.07	18.07			11/1/18	55.78	58.06	52.97	55.93	55.93	
	12/1/18	16.04	36.20	15.94	25.42	25.42			12/1/18	59.72	63.51	57.63	62.19	62.19	
	1/1/19	27.54	28.53	16.54	16.57	16.57			1/1/19	55.45	55.45	52.18	52.75	52.75	
	2/1/19	16.63	17.89	13.44	14.78	14.78			2/1/19	47.10	48.44	45.97	47.62	47.62	
	3/1/19	14.57	18.33	12.37	13.71	13.71			3/1/19	48.41	51.51	47.31	50.67	50.67	
	4/1/19	13.90	14.39	11.03	13.12	13.12			4/1/19	49.01	50.45	47.66	48.50	48.50	
	5/1/19	12.86	23.38	12.74	18.71	18.71			5/1/19	56.01	61.59	54.97	60.92	60.92	
	6/1/19	19.41	19.75	13.19	15.08	15.08			6/1/19	72.46	77.39	68.73	73.64	73.64	
	7/1/19	13.85	16.55	11.69	16.12	16.12			7/1/19	62.23	66.60	60.62	63.39	63.39	
	8/1/19	15.41	24.81	13.73	18.98	18.98			8/1/19	83.32	87.85	80.41	86.80	86.80	
	9/1/19	20.96	21.15	13.31	16.24	16.24			9/1/19	81.17	85.84	78.09	81.51	81.51	
	10/1/19	16.02	21.46	12.27	13.22	13.22			10/1/19	77.40	77.45	70.32	70.64	70.64	
	11/1/19	12.50	14.17	11.42	12.62	12.62			11/1/19	62.57	66.01	60.07	61.22	61.22	
	12/1/19	12.69	17.99	11.71	13.78	13.78			12/1/19	59.56	61.30	56.35	58.02	58.02	
	1/1/20	13.46	19.99	11.75	18.84	18.84			1/1/20	58.12	62.25	54.56	58.98	58.98	
	2/1/20	18.64	49.48	13.38	40.11	40.11			2/1/20	73.88	81.29	69.55	78.04	78.04	
	3/1/20	38.54	85.47	24.93	53.54	53.54			3/1/20	123.84	131.22	95.06	110.06	110.06	
	4/1/20	57.38	60.59	30.54	34.15	34.15			4/1/20	68.86	72.02	62.50	64.61	64.61	
	5/1/20	38.17	40.32	25.92	27.51	27.51			5/1/20	55.30	58.02	52.00	54.29	54.29	
	6/1/20	28.94	44.44	23.54	30.43	30.43			6/1/20	56.21	58.88	53.30	54.68	54.68	
	7/1/20	30.96	33.67	23.55	24.46	24.46			7/1/20	47.11	48.07	44.50	44.83	44.83	
	8/1/20	25.75	27.09	20.28	26.41	26.41			8/1/20	44.35	46.58	43.24	44.98	44.98	
	9/1/20	25.86	38.28	24.84	26.37	26.37			9/1/20	41.09	43.55	38.49	39.33	39.33	
	10/1/20	25.78	41.16	24.03	38.02	38.02			10/1/20	53.30	59.59	51.92	58.78	58.78	
	11/1/20	38.57	38.78	19.51	20.57	20.57			11/1/20	45.34	48.23	40.27	41.73	41.73	
	12/1/20	20.21	31.46	19.97	22.75	22.75			12/1/20	44.54	48.63	43.07	45.81	45.81	
	1/1/21	23.04	37.51	21.09	33.09	33.09			1/1/21	45.51	48.09	43.77	45.11	45.11	
	2/1/21	31.45	33.96	19.69	27.95	27.95			2/1/21	50.51	57.99	49.82	57.58	57.58	
	3/1/21	25.20	31.90	18.68	19.40	19.40			3/1/21	69.23	71.64	61.73	66.84	66.84	
	4/1/21	18.60	19.90	15.38	18.61	18.61			4/1/21	61.87	63.13	59.22	60.47	60.47	
	5/1/21	18.65	28.93	15.90	16.76	16.76			5/1/21	54.78	57.14	52.93	53.11	53.11	
	6/1/21	17.24	21.82	14.10	15.83	15.83			6/1/21	52.99	58.45	50.94	54.82	54.82	
	7/1/21	15.62	25.09	14.25	18.24	18.24			7/1/21	59.01	65.68	56.89	61.16	61.16	
	8/1/21	18.16	24.74	15.19	16.48	16.48			8/1/21	60.78	64.03	56.84	57.86	57.86	
	9/1/21	16.06	28.79	15.68	23.14	23.14			9/1/21	54.68	58.85	54.04	55.91	55.91	
	10/1/21	24.78	24.89	14.84	16.26	16.26			10/1/21	62.37	68.32	61.26	67.46	67.46	
	11/1/21	16.85	28.99	14.73	27.19	27.19			11/1/21	74.51	83.48	71.25	77.50	77.50	
	12/1/21	24.92	35.32	16.62	17.22	17.22			12/1/21	77.12	81.83	72.41	75.30	75.30	
	1/1/22	17.60	38.94	16.34	24.83	24.83			1/1/22	79.70	84.05	77.93	81.06	81.06	
	2/1/22	24.57	37.79	19.93	30.15	30.15			2/1/22	92.34	107.22	91.00	103.39	103.39	
	3/1/22	29.45	37.52	18.67	20.56	20.56			3/1/22	104.78	124.91	97.36	106.10	106.10	
	4/1/22	20.62	34.34	18.45	33.40	33.40			4/1/22	119.98	129.26	117.82	125.26	125.26	
	5/1/22	33.35	36.64	24.94	26.19	26.19			5/1/22	116.74	121.16	108.67	108.67	108.67	
	6/1/22	26.05	35.05	23.74	28.71	28.71			6/1/22	118.31	135.35	116.37	129.79	129.79	
	7/1/22	29.53	29.82	21.21	21.33	21.33			7/1/22	138.20	143.05	127.88	128.79	128.79	
	8/1/22	22.41	27.69	19.12	25.87	25.87			8/1/22	119.64	128.84	115.66	119.27	119.27	
	9/1/22	26.88	34.88	22.64	31.62	31.62			9/1/22	125.21	139.67	124.95	131.41	131.41	
	10/1/22	33.00	34.53	25.75	25.88	25.88			10/1/22	150.01	155.00	142.21	146.27	146.27	
	11/1/22	25.96	26.87	20.31	20.58	20.58			11/1/22	128.80	134.10	119.91	122.31	122.31	
	12/1/22	20.83	25.84	18.95	21.67	21.67			12/1/22	119.56	129.88	113.78	120.30	120.30	
	1/1/23	23.09	23.76	17.97	19.40	19.40			1/1/23	112.90	118.06	107.37	108.37	108.37	
	2/1/23	19.62	23.63	17.06	20.70	20.70			2/1/23	110.39	116.90	109.44	116.27	116.27	
	3/1/23	20.39	30.81	18.16	18.70	18.70			3/1/23	154.09	173.77	135.34	157.44	157.44	
	4/1/23	19.79	20.08	18.35	18.40	18.40			4/1/23	141.83	150.81	137.56	143.46	143.46	

Exhibit 2: R Studio Generated Graphs

Exhibit 2.1

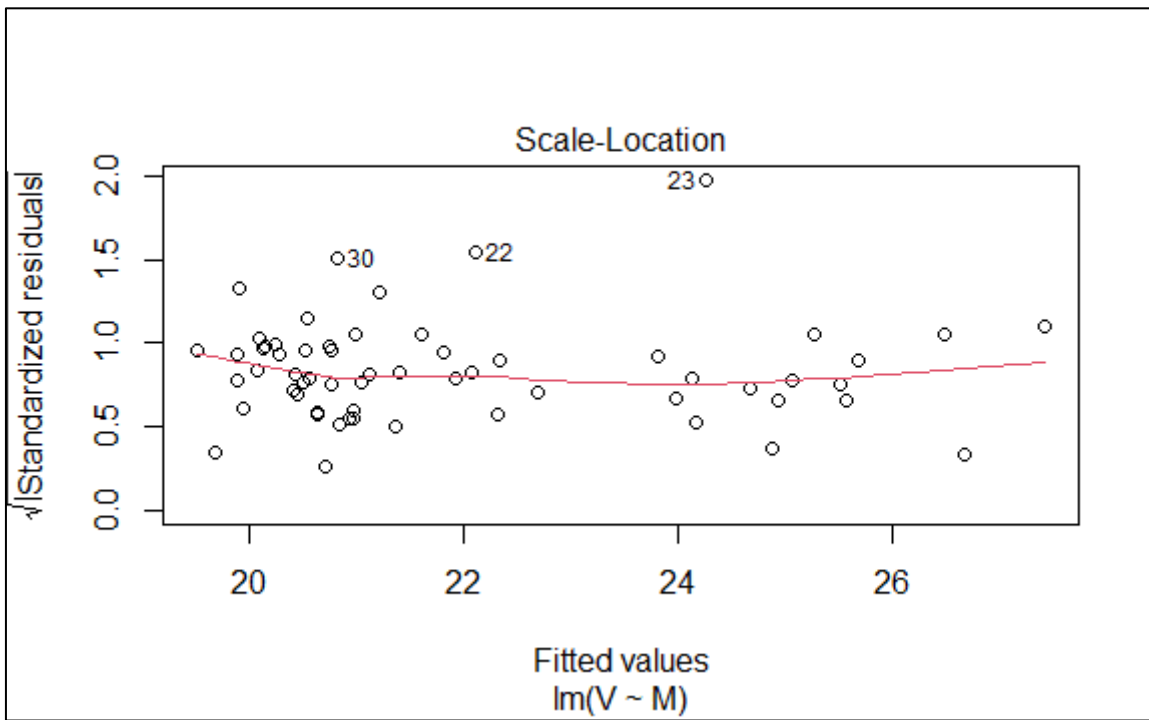
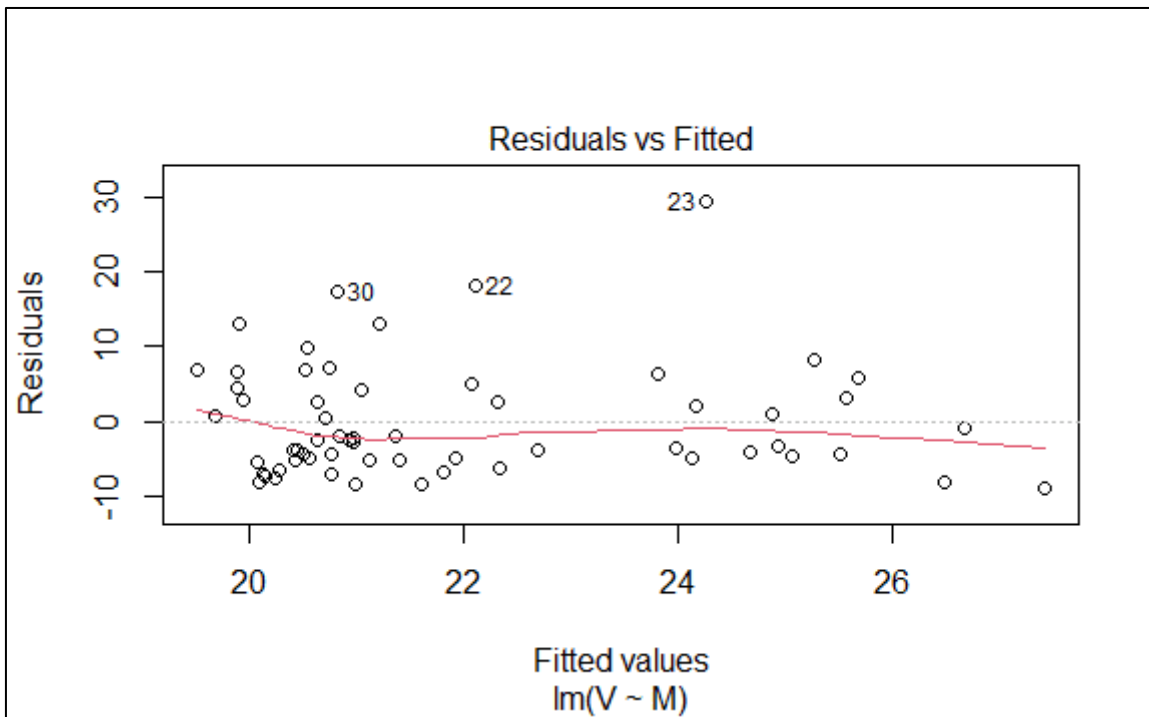


Exhibit 2.2



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