Project-2 Memo

DATE: April 10th, 2018
TO: Zhixin Wu, Professor of Mathematics
FROM: Bijay Ranabhat, Hengyi Zhou, Bingyun Chen
RE: Futures Hedging of a Portfolio Based on Historical Data

Background:

As per the given scenario, the market is expected to fall and an increase in volatility is forecasted. As a result, there is a chance of short term loss in the market. However, the long run performance of our market holdings is expected to be profitable. To tackle the situation at hand, we plan to mitigate our equity exposure risk by shorting some stock market index futures. Our holdings consists of 1000 shares each of three different tickers: IBM, JPM and AGX. IBM and JPM are large cap stocks and we will use S&P 500 index mini-size Futures (E-mini) and as AGX is a small cap stock, we will use Russell 2000 Index Mini-size Futures. Transaction fees, taxes and other fees are ignored as per the given condition.

Findings:

The project highlighted the significance of hedging in mitigating the risk of equity exposure to the market. Through this project we had the following inferences on hedging stock positions using stock index futures:

1. Using Index Futures to hedge removes the risk arising from market movements in general, leaving the hedger vulnerable to the performance of the portfolio relative to the market.
2. Dynamic Hedging is more effective way of hedging a portfolio compared to Static Hedging as, Dynamic Hedging represents market movement more accurately.

Discussion:

1. **Method:**

As mentioned in the background, our portfolio consists of 1,000,000 shares each three tickers: IBM, JPM and AGX. Based on the historical performance of these tickers in the market, we are predicting Futures hedging strategies. The historical data for all the related securities and market indices was acquired from finance.yahoo.com. The data consists of monthly and daily performance of each security. We used Microsoft Excel to perform all the necessary calculations.

We worked with Capital Asset Pricing Model(CAPM) in this project to calculate the expected return from an asset during a period in terms of the risk of return. CAPM argues that return should depend only on risk related to the return from the market as a whole and this risk is determined by β factor. For an individual asset, the β value is the measure of the sensitivity of its returns to returns from the market.

To calculate these β values for each asset, we started off by calculating the rate of return for each security in our portfolio using both daily(last 30-day, 60-day, 90-day) and monthly(last 24-month, 36-month, 60-month, 120-month) data. Based on the returns for particular period of time, we calculated the covariance between the return on individual assets and their respective index Futures. To obtain β value of an individual asset for a specific period of time, we divided the covariance obtained by the variance of return of the individual asset for that same time period. We also calculated the slope of the return on individual assets against their respective index Futures which is another way of calculating β.

After calculating individual β values for each asset for a specific period of time, we calculated the historic β values using a rolling window for the last 10 years of each security, to measure and analyze the volatility of β values for each asset. We used 30-day rolling window for daily data and 24-month rolling window for monthly data.

To construct a hedge portfolio, we selected the 90-day daily period. Based on that time frame, we calculated our portfolio β value. Based on the β obtained for the portfolio and the calculated rate of return based on risk free interest rates, we performed Static Hedging on the portfolio for a period of 3 weeks and monitored our net asset value which included stock holdings and future positions at the end of this 3 week time frame. We also carried out Dynamic Hedging on the portfolio allowing us to change our futures positions every week based on the changes in asset value at the end of each week.

To calculate the number of futures to be shorted for each stock index futures (E-mini, Russell 2000 Index Mini-size Futures), we calculated the ratio of current value of the portfolio(V_A) to the current value of one future contract(V_F) and multiplied that ratio by the β factor of the entire portfolio.

2. Main Analysis

Using the methods mentioned in the previous section, we calculated the β values for each of the tickers based on the daily and monthly historical data. A β value of less than 1 means that the security is theoretically less volatile than the market. A beta of greater than 1 indicates that the security's price is theoretically more volatile than the market.

The β values calculated from the daily data will allow us to see the short term trends in the market and how an individual stock is performing on a short term basis compared to that of the market. For IBM, the β values obtained from the daily data were close to 1 indicating that IBMs' short term performance is consistent with that of the market. For JPM stocks, the β values dropped from 1.15 to 0.64 when changing the time period from last 90 days to last 30 days. This indicates that, JPMs' stocks performance has been consistently diminishing compared to that of the market. However, unlike JPM, AGXs' performance has been consistently better with time in the short term scenario with its β values increasing from 1.20 to 1.59. The β values for daily data are shown in *Table 1*.

	Beta Values(Daily)		
Time	IBM	JPM	AGX
90 Days	1.003992911	1.153562964	1.20638339
60 Days	1.006543195	1.072648828	1.256355704
30 Days	1.054131218	0.643496202	1.594805053

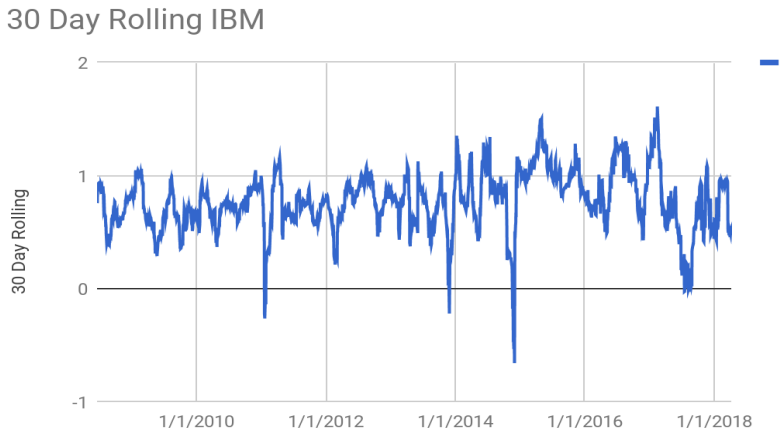
Table 1

From the monthly data, we calculated β values for each of the tickers based on their historical performance in the long term scenario. As we see, IBMs' β value increases as we decrease the time period. This indicates an upward trend in market performance for IBM compared to the performance of the market on the long term, with IBM outperforming the market average for the past 24 and 36 months. For JPM, although the returns is consistently more than that of the market, it has seen a decline in its β value from 1.3 to 1.14. We observe that for the time period of 120 months and 60 months, the β lingers around 1.3 but as we look at the performance for the last 36 and 24 months, the β value resides around the mark of 1.14. Unlike the large cap stocks, the β values of AGX indicate that its' long term performance is consistently lower than that of the market with β values ranging from 0.69 to 0.41. Inferring this, we can expect the long term return for AGX is half of that of the market. The β values for the monthly data are given in *Table 2*.

	Beta Values(Monthly)		
Time	IBM	JPM	AGX
120 months	0.730458809	1.303531888	0.697272981
60 months	0.902794662	1.31443367	0.499904941
36 months	1.086816349	1.134369741	0.413384338
24 months	1.313981293	1.145145489	0.465571696

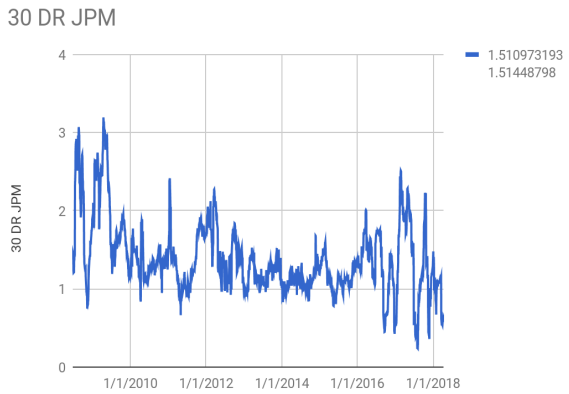
Table 2

Going one step further, we calculated the historical β values using 30-day and 24-month rolling window for both daily and monthly data respectively, for the past 10 years.

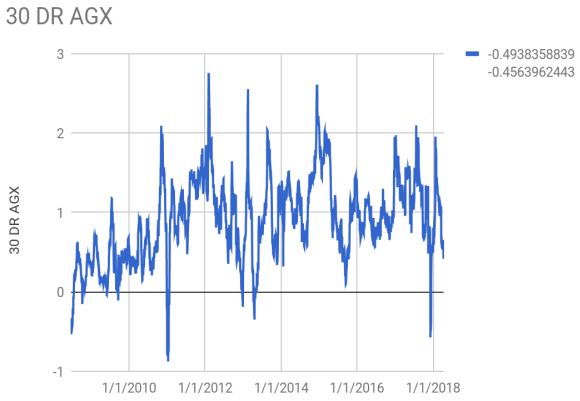


Graph:1

The chart shows that the 30 days rolling window beta of IBM vibrate around 1 which means the expected return on the asset almost equals to the return on the market.

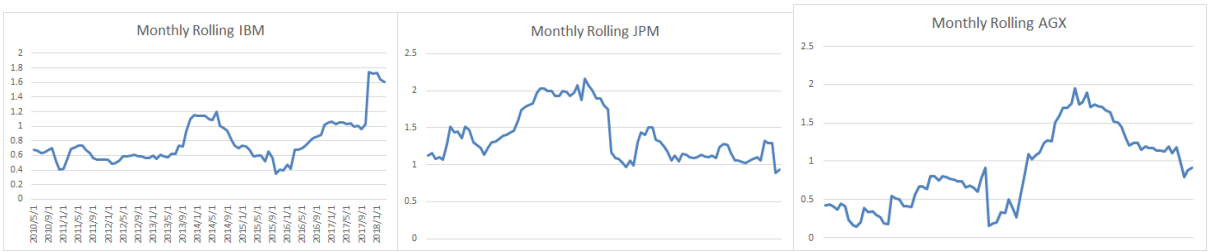


Graph:2



Graph:3

These two graphs(Graph 2 and 3) indicate that the excess return on AGX and JPM over the risk-free rate are 0 to 3 times (mostly above 1) the excess return of the market over the risk-free rate.



These graphs imply that the IBM has lowest risk compare to the JPM and AGX, because it has only half of the excess return of the market over the risk-free rate. The JPM is most sensitive to the

returns from the markets. The excess return on JPM over risk free asset is 1.5 times the the market return excess the risk-free rate.

After observing and analysing the volatility of the β values using the rolling window method, we moved on to construct a hedge portfolio using S&P 500 index mini-size futures for the large cap stocks(IBM, JPM) and Russell 2000 index mini-size futures for the small cap stock(AGX). We chose daily data for the past 30 days to calculate β and picked the start date for 3/23/2018. The β value for the S&P 500 index mini-size futures was calculated to be 1.189 with 58.18% of IBM stocks and 41.82% of JPM stocks in our equity for S&P 500 futures. The β value for the Russell 2000 index mini futures was calculated to be 1.20 and AGX stocks had 100% weight for this index. This implies that the portfolio's excess return is expected to underperform the benchmark by 17% in up markets and outperform the by 17% during down markets.

The total value of the portfolio at this point was calculated to be $293,800,000.00 and the numbers of S&P 500 mini and Russell 2000 mini futures to be shorted were calculated to be 2352 and 605 respectively. The total value of the futures shorted came out to be $7,001,227.00 approximately.

As we had an initial hedge position for the futures, we carried out static hedging on our portfolio for a period of 3 weeks. Based on the market situation after 3 weeks, we calculated the return of our diversified portfolios for S&P 500 mini and Russell 2000 mini index to be 1.82% and 3.097% respectively. We observed the expected return of the portfolio in 3 weeks to be $299,635,868.60 and shorting of futures resulted in a loss of $9,171,974.3, making the expected position of the hedger to be $290,463,894.2. Here we, observe that the difference of the net asset value to be 5,567,148.395 which is a relatively big difference. *Table 3* shows static hedging on the portfolio.

Static Hedging			
Time(In weeks)	Gain on Future:	Expected Portfolio Value	Total Value
0	0	293800000	293800000
3	-9171974.378	297404826	288232851.6
		Difference	5567148.395

Table:3

However, as we perform Dynamic Hedging, we observe that the total values of the portfolio after each week hover around the initial value. *Table 4* shows the details for the change in net asset at the end of each week:

Dynamic Hedging				
Time(In weeks)	Gain on Future:	Expected Portfolio Value	Total Value	Difference
0	0	293800000	293800000	0
1	1302748.716	292925103.8	294227852.5	427852.5115
2	-3814233.846	297404826	293590592.1	209407.8637
3	-5661300.661	297404826	291743525.3	2056474.678

Table:4

Here, we see that the difference in total asset value is not substantial compared to the difference obtained from Static Hedging.

Thus, this clearly indicates that the Dynamic Hedging of a portfolio will provide better and more accurate hedging.

3. Limitations:

Even though we conducted the analysis meticulously, we believe that the project does have some limitations. We used the CAPM to conduct hedging by future contracts, but CAPM is based on the assumption that investors can lend and borrow at a risk free rate which is not possible. Individual

investors are unable to borrow or lend at the same rate as the government. Therefore, the minimum required return might actually be less than what the model calculates. The assumptions that CAPM makes are at best approximately true, which contribute further to the limitations.

Conclusion:

Our objective was to hedge our stock position using stock index futures. Based on the analysis we performed using CAPM, we conclude that the risk of equity exposure can be subdued by shorting stock market index futures, however this can result in a decrease or increase in profits relative to the position it would be in with no hedging.

References:

1. *Investopedia*, https://www.investopedia.com/terms/b/beta.asp. Accessed 4 Apr. 2018.
2. *Investopedia*, https://www.investopedia.com/articles/investing/021015/advantages-and-disadvantages-capm-model.asp. Accessed 7 Apr. 2018.