**1. Volatility Experiments:**

**(a)** I choose the date from 2020-01-01 to 2021-7-30. Here are the brief view of the data of SPY and VIX:

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**(b)** I use the regression approach to compute the auto-correlations SPY and VIX and here are the summaries of both data:

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The T values in both regression result show that both of these lists have autocorrelation. And since the t-value in VIX is much more larger, which means the autocorrelation is more significant, VIX may has more evidence of autocorrelation.

From my point of view, I think VIX would have stronger autocorrelation before I do the regression. Because people’s action would be influenced by historical atomsphere and their mood also continues to the next period. Therefore, the result is reasonable.

**(c)** The correlation are shown below:

|  |  |  |
| --- | --- | --- |
|  | **Pearson** | **P-value** |
| **Daily** | ﻿-0.1542359412330939 | ﻿5.712265026710278e-17 |
| **Monthly** | ﻿-0.4091390365506273 | ﻿5.709973045267463e-07 |

The P-value of both Daily and Monthly data are less than 0.05 which can be considered as significant result. But the P-value of monthly data is much more larger than daily one, which is a lip in significance. That means when we use BS model, it’s not wise to use a fixed sigma value for a long time, because the result would be unreliable over time.

**(d)** Here’s the plot of rolling 90 days correlation:

![手机屏幕的截图

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Obviously, the correlation deviated from long-run average most in 2018-02-05, and the deviation is about ﻿-0.517726576238743.

**(e)** The plot is shown below:

![图表

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From the plot, we can conclude that the premium is generally positive. It reach the highest point (0.02840) in 2020-03-12 then drop rapidly later reaching the lowest point (-0.016546) in 2020-06-05. I think that might be the COVID emergency that decreases people’s expectation about the whole market.

**(f)** Here’s a brief view of the prices of the portfolio that computed by BS model where the implied volatility equals to VIX:

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**(g)** the result and the plot of P&L are shown below:

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![图表

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The average of P&L is about ﻿-1.6920794754009632.

**(h)** Here’s the plot of this P&L against the premium between implied and realized volatility:

![图表, 散点图

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The plot looks like circular scatter, and that means there’s no relation between P&L and premium. I think this result is reasonable and I don’t expect a strong relation because if there’s any relationship, we may use that connection to predict the market, which is counterintuitive since nobody has succeeded before.