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**Roman** ， 字号三号，加粗，居中， 段后**8** 磅， 多倍行距**1.08**）

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**ABSTRACT**（**ABSTRACT**字体**Times New Roman** ， 字号**10** ，加粗， 最小值**13** 磅）

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***Keywords:*** *Market probability distribution, Lasso,*

*（关键词字体Times New Roman，字号11，倾斜，段前12磅，* *段后22磅，最小值13磅*

1. **Introduction**

这里写文献综述和我们干了什么

第一段：文献综述，风险中性概率的提出，Breeden-Litzenberger (1978) method[[[1]](#endnote-0)]，The Minneapolis Fed的数据准备和工作。其他人谁用风险中性概率做了什么工作。

第二段：本文的组织结构

第一章干了什么，第二章干了什么等。。。

1. **MPD的有效性**

Minneapolis Fed通过Breeden-Litzenberger (1978) method算出了market probability distribution of the underlying asset，然后通过Shimko (1993)的方法算出了market probability density functions (MPDs) for a variety of different asset classes[[[2]](#endnote-1)]。但是这些文章都没有评估这样计算出来的估计值预测准确性，或者说没有评估MPD有效性。这里我们介绍评估它们预测有效与否的方式和思路，并且在5.2中进行实证检验。

Minneapolis Fed通过期权价格算出了期权对应的底层资产的未来六个月的预期回报率的分布。我们一方面通过假设检验来检验这个分布预测的是否准确；另一方面通过Brier Score、ROC AUC、Log Loss等指标和方法评估标的资产大幅涨跌预测的准确性。

* 1. ***通过假设检验来查看预测的是否准确***

Minneapolis Fed每周给出一个未来六个月的资产的log return的概率分布的预测。一般来说，我们验证一个分布是否很好的描述了数据特征，等价于探究数据服从特定分布的程度。用于解决这种问题的统计方法都需要一组样本来检验它们是否来自这个分布。但是对于我们需要分析的目标数据来说，每个分布的预测只对应一个可以验证的真实数据，就不能用这种验证分布的统计方法。

我们采用的方法是，对于一段时间，来说，每个时间点上有一个对（[[3]](#footnote-0)时刻底层资产log return的分布的预测，我们记为. 时刻预测的底层资产的log return的真实值记为.

对于每个预测的分布，我们有它的10分位数和90分位数，分别记为和。我们就可以构造这个分布对应的80%置信区间[]。现在我们去比较真实值是否落入这个80%置信区间，如果落入我们记为1，没有落入我们记为0.如果这个分布的预测是很准确的，那么最后落入80%置信区间的比例应该近似于80%，也就是说

(1)

其中是指示函数，如果落入[]内则值为1，否则为0。

这样我们通过检验总共有多少比例的点落入置信区间，就能够判断分布预测的合理与否。

* 1. ***判断大幅涨跌预测的是否准确***

Minneapolis Fed给出的预测中还包含了底层资产收益率产生大幅涨跌[[4]](#footnote-1)的概率。为了验证这个概率预测的准确性，计算底层资产真实的收益率，判断是否达到大幅涨跌的标准。在时刻，如果真实的收益率达到了上涨阈值，我们令，反之我们令其等于零，这样就构造出了一个分类变量，用于标记真实的收益率是否有大幅上涨。公式整理如下：

(2)

类似的我们可以构造分类变量，用来表示真实的收益率是否有大幅下跌，公式如下：

(3)

那么我们需要分析的数据是事件是否发生的概率和事件是否发生的分类变量，接下来我们可以用一些评估分类模型性能的常用指标来评估这个预测的准确性。我们选用Brier Score[[[5]](#endnote-2)]、ROC[[[6]](#endnote-3)]、 AUC[4]

The Brier Score is a measure of the accuracy of probabilistic predictions. It is used when predictions must assign probabilities to a set of mutually exclusive outcomes. The score is calculated as the mean squared difference between the predicted probabilities and the actual outcomes, where the outcomes are coded as 1 for the event happening and 0 for it not happening. The formula for the Brier Score is:

(4)

Here, n is the number of forecasting instances, is the forecasted probability for the event at instance , and is the actual outcome of the event at instance . Brier Score的值应该在[0, 1]之间，且Brier Score的值越小证明模型拟合的越好。[[[7]](#endnote-4)]

Typically, the ROC, AUC as a performance metric for classification models 经常应用于 adopted in machine learning for evaluating binary classifiers[[[8]](#endnote-5)]. The Receiver Operating Characteristic (ROC) curve is a graphical plot. The ROC curve is created by plotting the True Positive Rate (TPR)[[9]](#footnote-2) against the False Positive Rate (FPR)[[10]](#footnote-3) at various threshold settings.

To construct an ROC curve, you vary the decision threshold of the classifier and calculate the TPR and FPR for each threshold. Then, plot these rates on a graph with FPR on the x-axis and TPR on the y-axis.

The Area Under the ROC Curve (AUC) is then used as a summary measure to evaluate the overall performance of the classifier. An AUC of 1 represents a perfect classifier, while an AUC of 0.5 represents a no-skill classifier, which means it has no discrimination capacity to distinguish between positive and negative classes.

1. **基于MPD的预测**

在检验MPD的有效性之后，我们希望通过MPD预测标的资产的returns，volatilities，reversals。为了达成这个目标，我们选用的模型为lasso。下面3.1将对lasso的原理做简单的介绍，3.2介绍我们针对不同的回归目标是怎么具体建立模型的。

* 1. ***lasso介绍***

Lasso[[[11]](#endnote-6)] (The Least Absolute Shrinkage and Selection Operator) is an effective method for variable selection in many application scenarios. 它在本质上是添加了使用L1正则化作为惩罚项的线性回归。Lasso在模型训练的时候会通过惩罚项把对因变量影响较小的自变量系数压缩到零，通过这种方式lasso在拟合过程中自然的就进行了一次变量选择。lasso的通用公式如下：

+λ (5)

where:

Y represents the dependent variable.

represents the matrix of independent variables.

β is the vector of coefficients.

n is the number of observations.

λ is the regularization parameter controlling the strength of the penalty.

***3.2预测returns，volatilities，reversals***

这些估计量反映了市场对未来的预期，由于时间序列数据的特性，一般来说数据越临近，数据之间的相关性越大，所以使用估计量和标的资产的lag后的数据来进行预测。并且我们只预测一周后资产的变化情况。

具体来说，对于returns的预测，我们记全部estimates数据为矩阵（i.e. 表示矩阵E的第i行第j个元素，后面所有矩阵数据都按照类似方式表示矩阵和元素），标的资产数据记为矩阵。这里n和p不一定相等，因为数据产生的频率不同，导致产生的数据量也不一样。如果没有特殊注明，本文的数据结构为：每一行数据为一个时间点上不同特征的观测。

仿照时间序列的构造方式，我们对所有用作自变量的数据取lag，把所有lag后的数据作为自变量，把需要预测的目标作为因变量，构建一个lasso的回归模型。其中被用作自变量的估计量只有与这个标的资产相关的预测。举例来说就是，当我们希望预测标普500的returns，我们选择Options on the S&P 500 that expire in 6 months and 12 months的预测数据作为自变量。

首先把自变量的数据频率调整一致，我们把调整为纬的，记为。然后我们把和拼接起来构成新矩阵[,]，对这个矩阵取lag，拼接成最终需要的自变量矩阵X，即：

其中[,]进行了次lag，即。

然后我们使用lasso对进行回归建模。

对于return和volatilities，只有Y取值不同，其余建模方法完全一致

1. **基于预测的策略**

***4.1 策略一***

***4.2策略二***

1. **实证分析**

上述部分已经介绍完了我们使用的解决问题的方法，下面我们介绍我们是如何在实际数据上使用上述方法对我们的想法进行检验的。

***5.1数据介绍***

我们首先介绍我们使用到的数据。我们需要评估的估计量来源于Federal Reserve Bank of Minneapolis[[12]](#footnote-4)，它们提供了基于六种[[13]](#footnote-5)资产类别的五十二种不同期权或远期价格计算出的对应标的资产的Statistics for Market-Based Probability Densities (MPDs)。原始数据有12249条观测数据，14个自变量，这些Statistics的数据字典如下：

**Table 1.** Statistics for Market-Based Probability Densities (MPDs)的数据字典

|  |  |
| --- | --- |
| 统计量 | 统计量描述 |
| market | 表示了期权或远期的类别，共有52种 |
| idt | 表示做出预测的日期，包含年月日 |
| maturity\_target | The time-to-expiry target for options selection |
| mu | The mean of the MPD;  mu = sum(probability at ln-return x \* ln-return x) |
| sd | The standard deviation of the MPD;  sd = sqrt(sum(probability at ln-return x \* (ln-return x - mu)^2)) |
| skew | The skew of the MPD;  skew = sum(probability at ln-return x \* (ln-return x - mu)^3)/(sd^3) |
| kurt | The kurtosis of the MPD;  kurt = sum(probability at ln-return x \* (ln-return x - mu)^4)/(sd^4)-3 |
| p10 | The 10th percentile of the MPD |
| p50 | The 50th percentile of the MPD |
| p90 | The 90th percentile of the MPD |
| lg\_change\_prob | The change in the expected return in percentage terms defined as "large" |
| prDec | The probability of a "large decline" in return as defined by "lg\_change\_prob" |
| prInc | The probability of a "large increase" in return as defined by "lg\_change\_prob" |

对于不同的标的资产，Federal Reserve Bank of Minneapolis每周或者每两周给出预测。不同市场上的数据覆盖的时间不同。我们选择在2013-01-10到2024-02-07时间内都有完整数据的市场，之后删除2013-01-10之前的数据。2014-09-04之前，Federal Reserve Bank of Minneapolis每两周给出一次数据预测，为了保证数据间隔的频率一致，我们用前向填充填充缺失的数据，填充后的数据频率是每周一次。经过这样的筛选，处理后的数据包含对14个市场上从2013-01-10到2024-02-07这段时间上8080个预测，数据间隔的频率为一周一次。我们记处理后的数据为mpd\_stats\_cleaned。

在预测returns，volatilities，reversals时，我们主要对标普500数据进行分析，所以我们从雅虎财经上获取了在目标时间段内的标普500[[14]](#footnote-6)和VIX[[15]](#footnote-7)的全部价格信息。

理论上应该说一下标普500和VIX滚动平均的处理，我再看看。

B-S model假设的底层资产是log normal的，但是给出的估计量都是偏态的（肥尾），那么分析波动性是很有意义的。[[[16]](#endnote-7)]

这里其实最好再有一个数据预测的时间对应的图，不然语言总是说不清楚。

***5.2实证分析***

基于之前的数据处理以及方法介绍，我们现在详细的说明前面方法在实际数据上的表现。

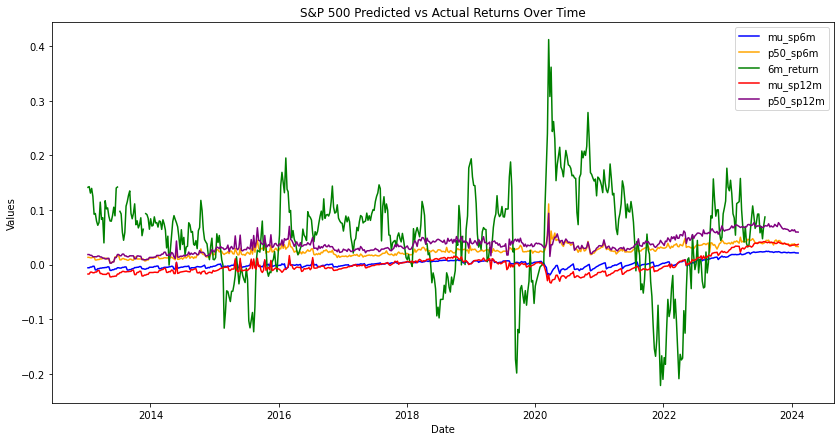
由于Federal Reserve Bank of Minneapolis分别通过6个月到期和12个月到期的以标普500指数为标的资产的期权进行了MPD计算，并且数据已经调整成了每个观测日期六个月后期望值的分布。所以下面的分析我们会同时用到6个月到期的期权数据和12个月到期的期权数据，分别记为sp6m和sp12m。

*5.2.1. 通过标普500数据验证MPD的有效性*

我们参考2.1节的方法，在整个时间段上sp6m和sp12m各有有578个观测，由于它们对应的底层资产相同，我们对这两个市场上的数据都进行分析。经过计算，sp6m预测within\_interval\_accuracy为0.8616，sp12m预测的within\_interval\_accuracy为0.9446。可以看出sp6m预测的结果还是比较接近80%的，产生误差的原因可能有：首先，总共能够用于检测的数据比较少，只有578个，并不能完全说明预测的准确性不够准，可能存在数据的偏差；另外可以看出这是个偏保守的预测，因为有比预测更多的实际数据落入了区间，那么犯第一类错误的概率减少，犯第二类错误的概率增加，总体来说认为这个估计仍然可以使用，只是方差的可能会偏小。

下图（回头改成图片名字）可以看出大多数数据都被覆盖进了80%的置信区间。

**这张图重画，要包含10到90的置信区间的线，然后还要有阴影部分。然后这个图要放大。占半页**



接下来我们用标普500在2013年到2023年的数据对大幅涨跌的预测进行分析。首先我们计算出实际的6个月内的涨跌幅，然后查看有没有达到 upward threshold或者downward threshold，这里我们的阈值都设置成20%。如果有我们标记为1，没有标记为0，之后分别计算sp6m和sp12m预测的Brier Score和 AUC，结果如下表（改成具体的表名所示。

**Table 2.** sp6m和sp12m对大幅涨跌预测的Brier Score和 AUC

|  |  |  |
| --- | --- | --- |
|  | Brier Score | AUC |
| sp6m涨 | 0.0124 | 0.9888 |
| sp6m跌 | 0.0138 | 0.6867 |
| sp12m涨 | 0.0192 | 0.9560 |
| sp12m跌 | 0.0240 | 0.6841 |

通过数据可以看出sp6m和sp12m在预测大幅上涨问题上表现的非常好，其中sp6m预测的结果更好一些，AUC已经达到了0.9888，原因在于本身预测结果就是

这里看能不能再画两个ROC图。

*5.2.2. 通过MPD预测*

分别写对returns，volatilities，reversals的预测。

*5.2.3. 策略的实施*

1. **Conclusions and discussions**
2. **FIRST LEVEL HEADING (HEAD 1)**

（一级标题字体**TIMES NEW ROMAN**， 字号**11.5** ，加粗，段后**9** 磅， 最小值**12.05** 磅）

The body text starts with a standard first-level heading like INTRODUCTION or any other heading suitable to the content and context. First level headings are in all caps. Copy the content and replace it for other first-level headings in remaining text. Reference citations should be within square bracket [ 1]. Headings should always be followed by text.

（正文内容字体Times New Roman， 字号10， 首 行缩进0.51 厘米， 段后6 磅， 最小值12 磅）

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***1.1. Second Level Heading (Head 2)****（二级* *标题字体****Times New Roman****，字号****11.5****，加*

*粗，倾斜，段前****12*** *磅，段后****9*** *磅，最小值* ***12.05*** *磅）*

First, confirm that you have the correct template for your paper size. This template has been tailored for output on the A4 paper size.

In this template, the “Styles” menu should be used to format your text if needed. Highlight the text you want to designate with a certain style, and then select the appropriate name on the Style menu. The style will adjust your fonts and line spacing. Use italics for emphasis; do not underline. To insert images in Word, position the cursor at the insertion point and either use Insert | Picture | From File or copy the image to the Windows clipboard.

*1.1.1. Third Level Heading (Head 3)（三级标* *题字体Times New Roman，字号11.5，倾斜* *,* *段前12 磅，段后9 磅）*

Headings may be numbered or unnumbered (“ 1 Introduction” and “ 1.2 Numbered level 2 head”), with no ending punctuation. As demonstrated in this document, the initial paragraph after a heading is not indented.

*<1.1.1.2>. Fourth Level Heading （四级标题字体*

*Times New Roman，字号五号，倾斜，加横线，* *段前12 磅，段后9磅）*

This is a fourth level heading. You can replicate it where suitable.

**2. STYLE PALETTE**

Styles can be applied using the style palette available within the template. To activate it the press Ctrl+Shift+s. Apply the style as required based on the content and context. (Please don’t highlight your text in yellow.)

**3. MATH AND EQUATIONS**

Scalar *variables* and *physical constants* should be italicized, and a bold (non-italics) font should be used for **vectors** and **matrices**. Do not italicize subscripts unless they are variables. Equations should be either display (with a number in parentheses) or inline. Use the built-in Equation Editor or MathType to insert complex equations.

Display equations should be flush left and numbered consecutively, with equation numbers in parentheses and flush right. First, use the equation editor to create the equation. Then, select the equation, and set the “Equation” Style. Press the tab key and type the equation number in parentheses.

( 1)

(2)

Be sure the symbols in your equation have been defined before the equation appears or immediately following. Please refer to “Equation ( 1),” not “Eq. ( 1)” or “equation ( 1).”

**4. FIGURES AND TABLES**

Figures and tables should be placed either at the top or bottom of the page and close to the text referring to them ifpossible.

**Figure 1** Caption content. The title “Figure” and the label should be in **bold**.（ 图片标题字体Times New

Roman， 字号10， 居中， 段后8 磅， 多倍行距1.08 )

For small tables, please place it within a column and bigger table be placed in a text frame spanning to both columns. Use the Table facility available within the MSWord. The font in the row header should be bold and you can use the style available from the style palette.

**Table 1.** Short cut keys for the template（ 表格标题

字体Times New Roman， 字号10， 居中， 段后6 磅 , 多倍行距1.08）

|  |  |  |  |
| --- | --- | --- | --- |
| Styles | Shortcuts | Styles | Shortcuts |
| Article-Title | Alt+A | Head 2 | Ctl+2 |
| Author-Name | Alt+N | Head 3 | Ctl+3 |
| Affiliation | Alt+L | Head 4 | Ctl+4 |
| Corresponding | Alt+C | ListBullet | Alt+U |
| Abstract | Alt+B | ListNumber ed | Alt+Ctl+N |
| Keywords | Alt+K | Table foot | Alt+Ctl+F |
| Equation | Alt+E | Fig caption | Alt+G |
| Para | Alt+P | Acknowledg ment | Alt+W |
| Head 1 | Ctl+1 | Reference title | Alt+T |
| Referenc e item | Alt+R |  |  |

表格里面的内容字体：Arial Unicode MS， 字 号小五

**AUTHORS’ CONTRIBUTIONS**（ 字体 **Times New Roman** ， 字号**11.5** ，加粗，段 前**12** 磅，段后**8**磅）

The title "AUTHORS ’ CONTRIBUTIONS" should be in all caps.

**ACKNOWLEDGMENTS**（ 字体**Times**

**New Roman** ， 字号**11.5** ，加粗，段前**12**磅 , 段后**8**磅）

The title "ACKNOWLEDGMENTS" should be in all caps and should be placed above the references. The references should be consistent within the article and follow the same style. List all the references with full details.

**REFERENCES**（ 字体**Times New Roman** , 字号**11.5** ，加粗，段前**12**磅，段后**8**磅）

[ 1] E.M. Clarke, E.A. Emerson, Design and synthesis of synchronization skeletons using branching time

temporal logic, in: D. Kozen (Eds.),

1. [] Breeden, D. T., & Litzenberger, R. H. (1978). Prices of State-Contingent Claims Implicit in Option Prices. The Journal of Business, 51(4), 621–651. http://www.jstor.org/stable/2352653 [↑](#endnote-ref-0)
2. [] Federal Reserve Bank of Minneapolis. (2024). Methodology for current and historical market-based probabilities. Retrieved from [https://www.minneapolisfed.org/-/media/assets/banking/current-and-historical-market-based-probabilities/methodology.pdf](https://www.minneapolisfed.org/-/media/assets/banking/current-and-historical-market-based-probabilities/methodology.pdf" \t "/Users/apple/Documents\\x/_new) [↑](#endnote-ref-1)
3. 本文全都认为T = 1为一个周期，也就是说T = 0.5表示半年。 [↑](#footnote-ref-0)
4. 6个月内上涨或下跌20%被认为是产生了大幅涨跌。 [↑](#footnote-ref-1)
5. [] BRIER, G. W. (1950). VERIFICATION OF FORECASTS EXPRESSED IN TERMS OF PROBABILITY. Monthly Weather Review, 78(1), 1-3. [https://doi.org/10.1175/1520-0493(1950)078<0001:VOFEIT>2.0.CO;2](https://doi.org/10.1175/1520-0493(1950)078<0001:VOFEIT>2.0.CO;2" \t "/Users/apple/Documents\\x/_blank) [↑](#endnote-ref-2)
6. [] Zou, K.H., O'Malley, A.J., Mauri, L. (2007). Receiver-operating characteristic analysis for evaluating diagnostic tests and predictive models. Circulation, 6;115(5):654–7. [↑](#endnote-ref-3)
7. [] Wikipedia contributors. (2024, February

   25). Brier score. In Wikipedia, The Free Encyclopedia. Retrieved from [https://en.wikipedia.org/wiki/Brier\_score](https://en.wikipedia.org/wiki/Brier_score" \t "/Users/apple/Documents\\x/_new) [↑](#endnote-ref-4)
8. [] Wikipedia contributors. (2024, February

   25). Receiver operating characteristic. In Wikipedia, The Free Encyclopedia. Retrieved [Your Date of Access], from [https://en.wikipedia.org/wiki/Receiver\_operating\_characteristic#Curves\_in\_ROC\_space](https://en.wikipedia.org/wiki/Receiver_operating_characteristic" \l "Curves_in_ROC_space" \t "/Users/apple/Documents\\x/_new) [↑](#endnote-ref-5)
9. True Positive Rate (TPR): It measures the proportion of actual positives that are correctly identified by the classifier. It is calculated as:

   where TP is the number of true positives, and FN is the number of false negatives. [↑](#footnote-ref-2)
10. False Positive Rate (FPR): It measures the proportion of actual negatives that are incorrectly classified as positives. It is calculated as:

    Where FP is the number of false positives, and TN is the number of true negatives. [↑](#footnote-ref-3)
11. [] Tibshirani, R. (1996). Regression Shrinkage and Selection via the Lasso. Journal of the Royal Statistical Society. Series B (Methodological), 58(1), 267–288. http://www.jstor.org/stable/2346178 [↑](#endnote-ref-6)
12. 数据来源于：https://www.minneapolisfed.org/banking/current-and-historical-market--based-probabilities [↑](#footnote-ref-4)
13. 六种资产类别分别是：Rates、Inflation、Equity、Currency、Commodity、Bank。 [↑](#footnote-ref-5)
14. 数据来源于：https://finance.yahoo.com/quote/%5EGSPC [↑](#footnote-ref-6)
15. 数据来源于：https://finance.yahoo.com/quote/%5EVIX?.tsrc=fin-srch [↑](#footnote-ref-7)
16. [] Figlewski, Stephen, Estimating the Implied Risk Neutral Density for the U.S. Market Portfolio (July 30, 2008). VOLATILITY AND TIME SERIES ECONOMETRICS: ESSAYS IN HONOR OF ROBERT F. ENGLE, Tim Bollerslev, Jeffrey R. Russell and Mark Watson, eds., Oxford, UK: Oxford University Press, 2008, Available at SSRN: [https://ssrn.com/abstract=1256783](https://ssrn.com/abstract=1256783" \t "/Users/apple/Documents\\x/_blank) [↑](#endnote-ref-7)