

Mathematical Modeling and Consulting



Sponsor

Jabre Capital

Progress Report

Portfolio Optimization based on PCA analysis

Team Members

Tianyu Luo (Project Manager), Engineering Management Department
tluo3@jhu.edu

Zichan Wang (Report Coordinator), Engineering Management Department
zichan.wang@gmail.com

Yixuan Da (Report Coordinator), Financial Mathematics Department
dayixuan2010@gmail.com

Academic Mentor

Dr. N. .H. Lee, Applied Mathematics and Statistics
nhlee@jhu.edu

Date: Last Compiled on November 4, 2012

Abstract

Acknowledgments

Contents

Abstract	2
Acknowledgments	3
1 Introduction	7
2 Technical Background	8
3 Problem Statement	9
4 Analysis	10
5 Results	11
6 Conclusion	13
A Lemmas	14
B Glossary	15
C Abbreviations	16
REFERENCES	
Selected Bibliography Including Cited Works	17

List of Figures

3.1	Jabre Capital’s Portfolio Selection in 2011	9
5.1	Optional caption for list of figures	11
5.2	Jabre Capital’s Portfolio Selection in 2011	12

List of Tables

Chapter 1

Introduction

Jabre Capital Partners is an alternative asset management platform founded in 2006. The Group offers a diversified range of investment management services and products, including Cayman-based collective investment schemes, UCITS IV regulated strategies, and individually managed accounts, to a broad network of institutional and high net worth clients. In addition, the Group provides discretionary investment management and advisory services to private clients.

As of December 31st 2010, Jabre Capital had portfolio value of \$4,133,365,000. A year later, the portfolio value was only \$793,966,000. In one year, the hedge fund's value was down by around 80%, which made it among the 10 worst hedge funds 2011.

Chapter 2

Technical Background

The stock market is a financial game of winners and losers. Is there a method to predict the stock market? Using the multivariate statistical methods of principal component analysis (PCA), we aim to find out the problem of Jabre Capital Partners stock investment portfolio and choice.

Diversifiable risk (also known as unsystematic risk) represents the portion of an assets risk that is associated with random causes that can be eliminated through diversification. While the non-diversifiable risk (also known as systematic risk) is the relevant portion of an assets risk attributable to market factors that affect all firms such as war, inflation, international incidents, and political events. In the other word systematic risk is beyond the control of investors and cannot be mitigated to a large extent. In contrast to this, the unsystematic risk can be mitigated through portfolio diversification. Since the unsystematic risk is a risk that can be avoided and the market does not compensate for taking such risks, our work focuses on the evaluation of the unsystematic risk of Jabre Capital Partners.

Principal component analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. Using PCA, we will combine related factor, which is weekly return performance of the stocks, into a smaller number of key components largely responsible for the variations observed. Since PCA can find structure in the covariance or correlation matrix and uses this structure to locate low-dimensional subspaces containing most of the variation in the data, we can tell whether the stock portfolio is diversified or not, that is whether the unsystematic risk is low or not.

Chapter 3

Problem Statement

According to a talk with the company fund manager, Philippe Jabre, it was known that the company implemented a conservative investment strategy in year 2011 in order to reduce unsystematic risk by improving the portfolio diversification. This strategy has been confirmed by Figure 1 which implies that the fund manager had changed the stock portfolio from quarter to quarter. However, this change did not prevent the portfolio value and investment return from skyfalling. In addition, due to the low portfolio value and the low return of investment, the company was limited to invest in a large numbers of stocks to increase diversification which deteriorated the situation even more.



Figure 3.1: Jabre Capital's Portfolio Selection in 2011

First, Mr. Jabre did not truly grab the essence of the diversification of the stock. Diversification is aimed to decrease the unsystematic risk of a portfolio by introducing diversified stocks. However, investing in a large number of different stocks cannot guarantee the diversification of the portfolio. In addition, if the stocks performances are positively related to each other, the portfolio risk can be increased rather than decreased.

Second, apart from the stock number and diversification from a general aspect, the company has problem in stock selection in different industries as well. For example, the stocks in bank industry tend to be positively correlated to each other since they usually depend on the monetary policy. As a result, we can decrease the stock number held in bank industry since they have limited diversification and a specific stock can explain a certain pattern of stock performance. However, it is different in IT industry since the stocks performances have less correlation to each other. Based on this reason, we need to maximize the diversification of the stock holdings in this industry. As a result, the selection of the stocks in different industries has great impact on the investment performance.

Chapter 4

Analysis

In order to analyze these problems, we categorize the risk into systematic risk and unsystematic risk. The systematic risk does not depend on individual companies and industry. Thus, it is independent (exogenous). The unsystematic risk depends on the financial position of the individual company, the industry the company is in, and so on. Thus, it is dependent (endogenous).

After we went through the stock holdings of the company from Yahoo Finance, it has been known that the company invested 418 stocks throughout year 2011 in total. Since this is a huge database, we then divided our work into two stages: first is to analyze the diversification and unsystematic risk of the 21 stocks that company held for entire year, second is to analyze the stock portfolio changes from quarter to quarter in order to observe the diversification improved or not.

Chapter 5

Results

```
[1] 12.13010053  1.74525479  1.37552811  0.92864613  0.84215313  0.57205350
[7]  0.51705529  0.46615511  0.40400355  0.37596636  0.34386097  0.29725966
[13]  0.20593959  0.16113721  0.13836054  0.12433864  0.09973491  0.09002862
[19]  0.08035446  0.05844796  0.04362094
```

(a) Eigenvalue of the correlation matrix

```
      [,1]      [,2]      [,3]      [,4]      [,5]
[1,] 0.25739222 -0.083824295  6.390649e-02 -0.154887827 -0.128907784
[2,] 0.25055818 -0.108192799  6.193188e-02 -0.113600233 -0.050284747
[3,] -0.23831702 -0.091323953 -2.720312e-01  0.024958456 -0.044034840
[4,] 0.12365464 -0.417137160 -2.430918e-01  0.216325051  0.519129132
[5,] 0.23716171 -0.019078344  3.670934e-02  0.022325359  0.086798150
[6,] 0.24403207  0.152268310 -3.020318e-02 -0.088783741  0.115286247
[7,] 0.22182294 -0.113967138  3.257406e-01 -0.206622730 -0.223010313
[8,] 0.20019255  0.036948384 -4.368381e-02 -0.535502483  0.122149801
[9,] 0.24757623 -0.240507413  1.482732e-01  0.149099024 -0.170244469
[10,] 0.22495868  0.068066899 -6.243494e-05  0.195610655  0.331875512
[11,] 0.23268546  0.062753159 -1.023223e-01 -0.006421951  0.039770147
[12,] 0.23493060 -0.129124013  2.766632e-01 -0.031794646 -0.004861505
[13,] 0.26405292 -0.075636027 -5.080867e-03  0.047840801 -0.116978062
[14,] 0.07923047 -0.290577602 -6.155392e-01  0.025434950 -0.433212948
[15,] 0.22367753 -0.066410025 -2.064976e-01  0.027247613 -0.345560003
[16,] 0.10604025  0.402520360  1.355602e-01  0.611034259 -0.294184024
[17,] 0.23925801  0.070918512 -9.360436e-02  0.247110674  0.247376234
[18,] -0.26274959 -0.004808317 -6.574092e-02 -0.080790712  0.051853502
[19,] 0.16487304  0.465054742 -1.987298e-01 -0.217797236  0.028110742
[20,] 0.25238148 -0.062053213 -1.723540e-01  0.115273474  0.095726441
[21,] -0.13464920 -0.442905156  3.427802e-01  0.104627237 -0.045391925
```

(b) Eigenvector of the correlation matrix(some columns are excluded due to limited space)

Figure 5.1: Engenvalue and eigenvector of the correlation matrix

We conducted the PCA analysis in the following steps:

1. We standardized the return matrix using R and got the standardized return matrix(51*22),
2. we calculated the correlation matrix,
3. we linearized the correlation matrix into independent eigenvectors and corresponding eigenvalues as shown above, and the plot accordingly.

Because the space is limited, we don't provide the complete eigenvector matrix here. We don't provide the standardized matrix and correlation matrix, either. This information will be provided upon request.

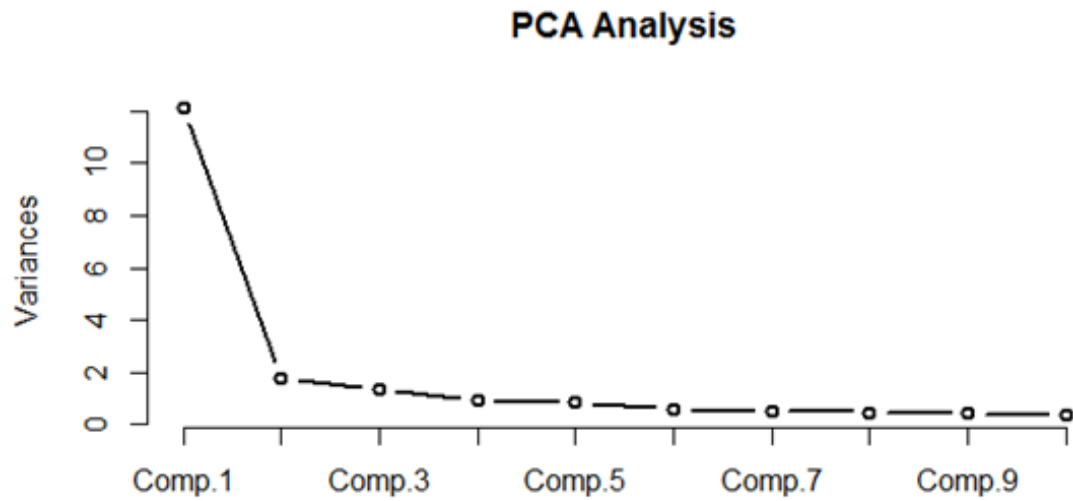


Figure 5.2: Jabre Capital's Portfolio Selection in 2011

Chapter 6

Conclusion

The PCA analysis result shows that the first three eigenvectors can explain appoxiamately 72.62% of the variance of the portforlio. So we believe that the correlation among the 21 stocks is relatively high and the portforlio is not well diversified. In this case, the portfolio is more risky than the other well diversified portfolios.

In the future reseach, we will mainly look into if adding more stocks from different industries, asset classes and commodities will improve the result.

Appendix A

Lemmas

Appendix B

Glossary

Ascending node. The point where the satellite crosses through the equatorial plane in a northerly direction.

Earth-centered inertial frame. A frame of reference whose origin is the center of the earth and which does not rotate with respect to inertial space.

Earth-centered rotating frame. A frame of reference whose origin is the center of the earth but which rotates with the earth.

Footprint. The intersection of a visibility cone with the surface of the earth.

Great circle of arc. The shortest path between two points on the surface of the earth.

Groundtrack. The location of the center of a visibility cone footprint on the surface of the earth.

Inclination. The angle between the normal to the orbit plane and the normal to the equatorial plane.

LEO. An orbit with an altitude approximately below 2,000 km.

Molniya orbit. A highly elliptical orbit with an orbital period of half a day.

Projection distance. The distance between the center of the visibility cone footprint and a point of interest projected onto the plane orthogonal to the vector defining the visibility cone center and tangent to the earth surface.

Right ascension of the ascending node. The angle between the unit vector \mathbf{X} and the point where the satellite crosses the ascending node, measured counterclockwise when viewed from the north side of the equatorial plane.

Appendix C

Abbreviations

ECI. Earth-centered inertial frame

ECR. Earth-centered rotating frame

LEO. Low Earth Orbit

RAAN. Right ascension of the ascending node

Selected Bibliography Including Cited Works

- [1] American Mathematical Society. *MathSciNet: Mathematical Reviews on the Web*. <http://www.ams.org/mathscinet/>. Accessed June 17, 2009.

Because an online reference may be changed at any time, it is conventional to tie the reference to the date when the resource was accessed.

- [2] Roger R. Bate, Donald D. Mueller, and Jeremy E. While. *Fundamentals of Astrodynamics*. Dover, 1971.

A standard textbook on astrodynamics. It provided a reference for orbital mechanics and satellite propagation.

- [3] Ingrid Carlbom and Joseph Paciorek. Planar Geometric Projections and Viewing Transformations. *Computing Surveys*, 1978.

Gives a thorough background to projective geometry and vertical perspective projection. This includes details about calculating projections using homogeneous coordinates and projection matrices.

- [4] Gelfand and Fomin. *Calculus of Variations*. Prentice-Hall, 1963.

Discusses the essential principle of variational method for optimal path problems.

- [5] George Grätzer. *More Math Into L^AT_EX*. Birkhäuser, Boston, MA, fourth edition, 2007.

- [6] Jacob Kogan. *Introduction to Clustering Large and High-Dimensional Data*. Cambridge, 2007.

Focuses on a few of the most important clustering algorithms, providing also some useful optimization techniques for high-dimensional objective functions.

- [7] David A. Vallado. *Fundamentals of Astrodynamics and Applications*. Space Technology, 2007.

A professional astrodynamics reference. It emphasizes the practical use of astrodynamics in space missions.

- [8] Emo Welzl. Smallest Enclosing Disks (Balls and Ellipsoids). *New Results and New Trends in Computer Science*, 1991.

Outlines a smallest circle algorithm that runs in linear time using recursion.