Evaluation of Portfolio selection methods
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Introduction
In these last few years international biography has offered many examples of portfolio selection methods, amply adopted by big financial institutes, international operators and by investment funds. Indicators used for Ex-Post valuation of selected portfolios are less in number but equally variegated.

This poster describes the technical solutions adopted in implementing with SAS System various generalised methods of portfolio selection, integrated into a huge SAS software package for the Stock Market investment support. It then considers the statistical indicators for evaluating the selected portfolios and comparison of the implemented selection methods with mass simulations.

All this is described with examples applied to the Italian Stock Exchange: 18 different portfolio selection methods were evaluated considering hundreds of portfolios generated in three different periods in the last four years.

Finally, the poster presents the last innovations of PORTFOLIO EXCHANGE as for example, activation of thousands of Hot Spots in all generated graphs. Up-Tecno group has many clients of the Italian financial and banking market and partnership with important banking associations. PORTFOLIO EXCHANGE handles a financial data warehouse with historical series, Portfolio Selection and Technical Analysis methods, which support the decision process of the trader and portfolio manager.

Portfolio Exchange
Successful national and international financial trading means giving primary importance to disposal of timely and complete information, but it’s equally necessary to have an always more sophisticated and integrated software and an always-greater technical and statistical know-how.
PORTFOLIO EXCHANGE contains all this expertise in implemented, automated, generalised trading and portfolio-selecting methods verified by time series simulations on an adequate number of markets and listed stock.

Operators of big and small companies usually have software instruments directly connected to information sources, and often capable of local technical analysis and evaluation. In absence of the most common standardisation and integration of methodologies, operators have to work with their own personal approach and sensibility, usually not supported by simulations on the past of trading techniques and portfolio selection methods, especially when these are particularly difficult to describe and test.

Statistical forecasting in the financial field is even poorer. This is often due to diffidence, computational problems, poor knowledge on the argument, and absence of adequate support software.

The SAS software package (PORTFOLIO EXCHANGE) for generating and evaluating portfolios suggests another way, particularly refined and personalised for the required functions. PORTFOLIO EXCHANGE has the ambition of presenting an integrated solution for management of financial trading and stock portfolio selection.

Technology and know-how contained in the statistical procedures, in the specialised products and in books on the subject distributed by SAS Institute have been widely exploited.
PORTFOLIO EXCHANGE groups descriptive, technical, and fundamental analysis, risk management, portfolio selection, forecasting, and tick-by-tick trading. A set of centralised automatic steps offers to all users valid trading indications, supported by complete control graphs.
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Portfolio Exchange: strong points.

SAS System in this field is particularly useful. Points of strength in order of importance are:

- Due to the structure of programs, adopted solutions and to the flexibility of SAS System it’s really easy to associate and integrate trading and portfolio selecting methodologies, standard or custom, automatic reports, interactive control graphs, forecasting models, risk management algorithms, mass simulation methods, special statistical algorithms, mechanisms of analytical book-keeping of effected operations, portfolio and fund current value estimations, and other still. Portfolio Exchange offers therefore a real possibility to face with a single instrument the wide spectre of arguments necessary to a complete financial system for institutes that invest in the markets. RAD (Rapid Application Development) Technology, available statistical procedures, and 4GL languages of SAS System make it a quick work to build very effective interactive object-oriented applications, besides allowing an easy maintenance and updating, required by such big vertical systems. Above all, this allows a timely customisation of great part of the programs for single Investment Institutes according to specific market demands.


- Possibility of integrating different hardware and software platforms, Client/Server, support to external relational database access and new multiprocessor SAS versions, allow to face problems independently from platforms, without scalar limits of power. Moreover, this allows reducing redundancy of programs implemented for single institutes/users.

- The examples show how easy it is to create very complicated graphs, pre-building them at a centralised level and then giving them to end-users. In particular the last SAS versions allow associating with every single graph object a hotspot that recalls all data regarding the selected point. Until two years ago, hardware wasn’t fast enough to support such graphical applications that are directly interpreted and not compiled in machine language. New processors and the steady drop in prices remove performance problems and realistically allow facing most elaboration with a simple PC.

- Thanks to SAS STEP programming and to the particular design of Portfolio Exchange, it’s easy to insert new trading and portfolio selection methods, without having to re-compile the existing programs. Various time series and statistical simulations manage testing of methods and comparison with those already implemented.

- Portfolio Exchange is easily linked to SAS products like Insight, EIS interfaces or various solutions proposed by SAS Institute for the financial world.

- The more recent Internet/Intranet Web Exploitation possibilities of SAS System transform the Portfolio Exchange system into a powerful tool that can be easily distributed to a large number of potential users with a strong cutting of the TCO (Total Cost of Ownership) per each user.

Initial frame

Figure n.1 shows the starting window and the main menu. Big icons (32x32 pixels) are used and customised to obtain a better representation and good graphic imagines.

Access to the application is protected by a different password for every user; each one encrypted with an original algorithm and stored in an SAS encrypted data set protected by application passwords.

Portfolio selection menu

The menu for management of portfolio selecting methods (upper part of figure n.2) is activated by selecting the first icon in the upper right corner.
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Figure 1

Main Menu: Financial DW, trading, Signals, Administration, Portfolio selection, descriptive analysis, fundamental analysis, technical analysis, forecasting and simulation.
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Figure 2

Typical frame for Portfolio generation: it asks Portfolio code and description and various optional parameters.

Risk control.
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The menu shows six different icons represented by the same image. Each of these icons activates frames that execute programs for generating portfolios with a single base method.

The lower part of figure n.2 shows one of these frames. It requires keying an unambiguous identifier of the generated portfolio, a portfolio description and a note field 200 letters long.

What’s more the frame expects indication of the categories in which to select the portfolio and the selection of a time period in which to analyse the state of stocks after their selection. Alternatively, it’s possible to use the predefined categories in each selection method.

Finally, every frame of this kind presents several fields and options for viewing the analysis and the generated portfolio details or for modifying some of the fundamental parameters of the methods. For example, in the frame in figure n.2 it’s possible to exclude the intercept in elaborating the beta for single stocks, to assign interactively with sliders a beta for the portfolio been generated, to select constraints (equal or less than) for the linear programming algorithm (Proc LP in SAS/OR), to view in the output window graphs of the beta, regressions, or detailed analysis like the sensitivity analysis and the dual solution.

New portfolio selection methods

Portfolio Exchange allows you to fit in new portfolio selection methods. To do this you may copy a similar existing method, modify its SAS step program and then add it interactively to the application using Portfolio Exchange’s frames. The SAS step program must be contained in a macro procedure with the following structure:

```sas
%MACRO MET1;
  TITCAT1=, /* Up to 4 categories */
  TITCAT2=, TITCAT3=, TITCAT4=,
  DATINI=, DATFIN=, /* Period of analysis */
  DSPORT=, /* SAS data set and portfolio code */
  DESPOR=, /* Generated portfolio description */
  NOTE= /*Generated portfolio's note */
); %MEND MET1;
```

The macro name is always %MET followed by the selection method identifying number (The same of the MET macro), the description of the method algorithm, the stock market categories to be applied. The lower part of figure n.3 shows the structure of the output data set describing each produced portfolio. It has to contain the selected stock codes and the percentages of each stock. This technical solution allows adding new selection methods without having to re-compile any program. A program so created is ready to select interactively any number of portfolios with different stock market categories and in different periods.

It’s possible to evaluate the method results with the frame showed in the upper part of figure n.4. This frame presents the portfolio’s distribution in several different graphical ways, it allows a numerical analysis for evaluating the single portfolio (see bottom part of figure n.5) or the comparison with all other portfolios that refer to the same date (bottom part of figure n.4). Indicators used in this analysis will be described later. For each single portfolio, the same frame may produce the graph represented in the top part of figure n.5. It traces the state in percentage (100 is the initial capital) of the portfolio from the selected date (top red line), comparing it to the state of the market (lower pink dashed line), the state of an investment in short period government securities or in current accounts (bottom blue line) and the state of the same portfolio using the trading methods automatically proposed by PORTFOLIO EXCHANGE (green line, second from the top). In this example, the automatic methods obtain a bit less than those of the selected portfolio.

So the system allows:

- The implementation of new method procedure with a very strong and easy to use fourth generation language;
- An easy testing of programs constructed with data steps;
- The use of all the ready to use statistical algorithms implemented in SAS System procedures.

Figure n.3 shows the fields to be filled in to identify a portfolio selection method: the
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Figure 3

Implemented portfolio selection methods

PORTFOLIO EXCHANGE already contains several methods based on:

- CAPM and Security Market Line.
- Regressions with P/E or other fundamental indicators.
- Discount Cash Flow Analysis.
- Cluster analysis to represent and divide the market.
- CAPM Beta and linear programming (using SAS Proc LP)

- Markowitz model and research of the efficient frontier with non-linear programming (Proc NLP).
- Single Index Model (Elton/Gruber).

The selection methods are used operating interactively with the program and checking the statistical analysis data. They are stored in the table of portfolio selection methods that can be updated as seen in the preceding paragraph.

Due to lack of space, in this poster we only shortly describe each single method.
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A graphical example of a produced portfolio: stock code and percentage, analysis period, data of creation, method, notes.

Statistical comparison with all other portfolios that refer to the same date. Several portfolio evaluation indicators are available.
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Figure 5

Statistical comparison with all other portfolios that refer to the same date. Several portfolio evaluation indicators are available.

Portfolio
Portfolio with technical trading
Stock market index
Risk-free
Past
Forecast

Single portfolio
Statistical evaluation.
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1. CAPM and Security Market Line.

The CAPM (Capital Asset Pricing Model) is used to predict investment return on assets. The CAPM method relates each portfolio or stock returns to the returns of the whole stock market portfolio. Harry Markowitz (1952-1959) was the first pioneer of this model, which was independently formulated by Sharpe, Linter and Mossin. The base equation of the model is the following:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i \cdot (R_{m,t} - R_{f,t}) + \epsilon_{i,t}$$

With:

- $R_{i,t}$: the return on asset $i$ in the $t$th period.
- $R_{f,t}$: the return on a risk-free asset ($f$=free) for the $t$th period.
- $\alpha_i$: the intercept parameter to be estimated, often called Alpha, identified by regression. On average it is expected to be 0.
- $\beta_i$: the slope parameter to be estimated, often called Beta, normally identified by regression. It identifies systematic, nondiversifiable risk.
- $R_{m,t}$: the return of the global investment in the market index (M=market) for the $t$th period.
- $\epsilon_{i,t}$: the random error term for the asset $i$th in the $t$th period. It identifies the non-systematic risk that can be reduced increasing the portfolio diversified assets.

This method supposes that expected returns are linearly correlated to the betas obtained by the regression that estimates the model (supposition tested in an analysis viewed in the output). In practice, once found the betas, the linear correlation is estimated by a second regression. Then chosen investments are those with the greatest residual, in other words those with the big returns for its beta.

2. Regressions based on P/E and other fundamental indicators.

This method elaborates several indicators like dividends in percentage, betas, risk indicators, profits, price/earnings (P/E) ratio, average monthly growth, profit and return projection, etc. Then it applies regression between P/E and indicators or between stock and indicators to find under-estimated stocks using regression residuals.


The method selects the investments with the highest Discount Cash Flow (DCF). The DCFs are calculated by different methodologies that estimate the stock quotation based on its dividends or earnings related to the risk-free market returns or to the current discount rate.


The market is divided in homogeneous clusters according to yields, returns, dividends, and the stock’s indexes of volatility. Then a few stocks of every cluster are selected proportionally to the volume of negotiations and all stocks considered dangerous are discarded (for example very small stocks without dividend). This method simply aims to get a selection of few stocks that represent the whole market, trying to stay as near as possible to the average of the market.

5. Beta CAPM and linear programming (Proc LP)

This method re-uses the CAPM model and selects a group of stocks using the Proc LP (SAS/OR) to maximise the portfolio’s returns, minimising risk and remaining bound to precise limits in quantity (for example at most 20% of investment in a single stock). Returns are estimated by arithmetic average of past periods, while risk is found from the beta of CAPM. Implemented programs accept as input the linear model’s beta target and the alternative coercion between less or equal to the target or exactly equal. Greater the beta target more portfolios are risky but profitable.

6. Markowitz Model and efficient frontier research.

This method locates the efficient frontier of investments by means of non-linear programming (Proc NLP in SAS/OR). The efficient frontier is made by all portfolios that obtain maximum return with a desired risk level. The basic idea in the Markowitz model is that the association of not much correlated stocks reduces the portfolio total risk (Beta). The implemented programs at present don’t exactly search for the best portfolio according to the Markowitz theory, which means the portfolio obtained from the tangent between return at zero risk and the efficient frontier. The programs just show graphically the frontier letting the user choose the desired level of risk.
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The portfolio is produced according to the selected risk level.

7. Single Index Model (Elton/Gruber).

The model described by Elton and Gruber (Elton/Gruber 1995) is quite simple in its basic idea, but it’s difficult to apply and especially to find the percentage of investment for single stocks. The whole method is based on maximising a single index called “Excess Return to Beta”:

\[
\text{(MA}(R_i) - \text{MA}(R_f))/\beta_i
\]

with MA=arithmetic average, \( R_i \) return in i asset, \( R_f \) return in risk-free asset, \( \beta_i \) =expected variation of returns in the i asset associated with a 1% variation of market returns.

The betas are obtained by regression, while selection of stocks and their percentages of investment, are obtained by a complex calculation that considers betas, average returns and non-systematic risk (variance of \((\text{MA}(R_i)-\text{MA}(R_f)))\).

Portfolio evaluation indicators

Many risk and profit indicators are always disposable to permit single portfolio evaluation:

- **R.geom.%**: geometrical growth of monthly returns in percentage.
- **R.arit.%**: arithmetical growth of monthly returns in percentage.
- **Growth**: total capital growth in the period considering an initial capital of one (for example: 1.35=+35% in the period).
- **Alfa**: Intercept obtained by regression that associates monthly returns reduced by monthly yields of a risk-free bond investment, with those of the considered stock market obtained in the same way. A greater than zero intercept is considered very positive.
- **Beta**: (or systematic risk) dependence of the portfolio from market average obtained by regression that associates the portfolio’s monthly returns reduced by monthly returns of a risk-free bond investment, with those of the stock market of reference obtained in the same way. Portfolios with a high beta are more speculative and risky. Vice versa those with a low beta are usually preferred because more insensible to changes in market returns. A negative beta indicates returns opposite to the market.
- **Total risk**: total risk according to CAPM is the standard deviation of the difference between the portfolio’s monthly returns and monthly yields of a risk-free bond investment. This indicator is similar to beta, but it has a completely different sensibility. Like in the preceding case, portfolios with a high total risk are more speculative, and vice versa, those with a low total risk are generally preferred because they are nearer to risk-free returns. It’s possible to have a portfolio with a greater beta than another has, but with a lower total risk and vice versa.
- **Non syst. Risk**: non-systematic risk according to the CAPM is the variance of the difference between the portfolio monthly returns and the considered market monthly returns in percentage. This indicator is equally similar to the two preceding ones, but again it has a completely different sensibility. In this case, like in the preceding ones, portfolios with the highest not systematic risk are more speculative. Vice versa, those with low risk are generally preferred because nearer to average market returns. It’s possible to have a portfolio with a greater beta (or total risk) than another has, but with a lower non-systematic risk and vice versa.
- **Treynor**: the Treynor index is the ratio between the portfolio arithmetic average of monthly returns (in percentage) reduced by that of a risk-free asset obtained in the same way, and the average systematic risk: \((\text{MA}(R_p)-\text{MA}(R_f))/\beta_p\) with MA = arithmetic average. This index rewards a high monthly return compared to risk-free investments, but without being too far from the market of reference.
- **Sharpe**: the Sharpe index is the ratio of the arithmetic average of portfolio monthly returns (in percentage) reduced by that of a risk-free investment computed in the same way, per unit of total risk: \((\text{MA}(R_p)-\text{MA}(R_f))/\sigma_p\) with MA = arithmetic average and \( \sigma_p = \) standard deviation of the difference between portfolio monthly returns and risk-free monthly returns. This index rewards a
Evaluation of portfolio selection methods

We compared eighteen different selection methods applied to the Italian Stock Exchange, reduced to about twenty stocks among Blue Chips and minor stocks. The eighteen methods were obtained by variations in the parameters of the seven basic methods described in the preceding pages. The reduction of Italian Stock Exchange to only twenty stocks, is a simple trick to reduce elaboration and analysis time. Anyhow it’s generally not convenient to analyse the whole market, but it’s better to pre-select the stocks with better hopes according to expert’s suggestions. The presented programs are equally valid on any market, as seen in figure n.5. Valuation of portfolio selection methods is founded on historical market simulations and on indicators based on market variability or on total systematic risk like the Treynor and Sharpe indexes seen above.

Thanks to the frame in the top part of figure n.6, PORTFOLIO EXCHANGE allows users to generate many portfolios. In this frame, users can select up to six different methods to produce six different portfolios on the same date and with the same stock categories. To evaluate the portfolio selection methods we generated about a hundred portfolios in five different periods in the last four years. With the frame in the bottom part of figure n.6 it’s possible to select one of the portfolios, to evaluate it separately, or to ask for the complete list of the simulation test portfolios, with the evaluation of the adopted selection methods.

Figure n.7 shows a part of the list with the 100 portfolios used in analysis. In all these kind of frames it’s possible to sort the list (Pop-Up Menu), in ascending or descending order, by any of the presented variables. It’s then possible to print the list graphically.

Figure n.8 shows instead the result of simulation. To evaluate the eighteen selection methods, we generated for every portfolio the previously listed indicators, then we built a simple arithmetic average, and a new indicator was generated building and adding the ascending ranks for every variable in the list with the Proc Rank in SAS/STAT (the bigger the rank, the better). The top of figure n.8 shows the first part of the indicators; the bottom shows the second half of the indicators. The last column is obtained adding all ranks from the worst to the best.

The best methods are those founded on the application of linear programming (Proc LP in SAS/OR) to the CAPM with the highest beta target (more risk) and on the application of non-linear programming (Proc NLP in SAS/OR) to the Markowitz Model with medium-high risk parameters.
Evaluation of portfolio selection methods

Figure 6

Application of several portfolio selection methods to the same historical period.
**Evaluation of portfolio selection methods**

Figure 7

Comparison of one hundred portfolios to test the statistical selection methods.

The User can easily sort the portfolio respect to a single indicator.
The best method obtained a monthly growth with an average of 4.62% per month, 4.04% per month more than BOT. Considering reinvestments, in three years this method would have obtained a growth of more than 180%.

Figure n.9 shows graphs plotted with the simulation’s data. A special application allows creating and filing of very kind of Business Graphics similar to those presented. In the examples, the graphs show some of the indicators, like the average alpha of portfolios of every method and the non-systematic risk.

Portfolio Exchange Innovations.

Some of the novelties are:

- The bottom part of figure n.10 shows a graph with a different hot spot for every object. In practice, every graph has hundreds of hot spots that can be activated to obtain information on the object (clicking the mouse on the object). Moreover, the graphs are viewed by a new browser that loads data of hot spots in independent SCL lists and allows to zoom, magnifying the graph up to 300%.
Figure 9

Graphical comparison of the portfolio selection methods respect to an indicator: Alfa.

Graphical comparison of the portfolio selection methods respect to an indicator: non-systematic risk.
A frame for generating and controlling numerically and graphically STATESPACE forecasting models obtained by the proc STATESPACE of SAS/ETS. Figure n.11 shows the interactive frame for STATESPACE model execution and an example of graph, which shows Hi-Lo with actual values (blue) and predicted values (grey) enclosed between bands of confidence. STATESPACE models have the feature of making forecasts of stocks with a strong correlation with other stocks or with historical series important for the market (like inflation or discount rates). The program has several important options like automatic location of the best historical series differentiation level.

Figure n.12 shows the new program that carries out regressions to locate ties between historical series and very under or over estimated stocks due to market erraticity, speculation, or to factors not considered by regression. The frame allows regressions up to nine historical series, files the parameters for estimated models, allows quadratic or non-linear regressions, tests the stability of the model by analysing the period split in two, allows the exclusion of a period, etc.

Essential bibliography:
- Portfolio Selection (1952) Harry Markowitz Journal of Finance, Vol. 7 pp77-91
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Figure 11

New Statespace models

Hi-Lo of Statespace forecasting and historical data with confidence limits
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Figure 12

A new frame to study correlation and regression of market stocks

The dependence between Italian market index and other foreign or internal indexes obtained by the regression.