SELECTING PORTFOLIOS GIVEN MULTIPLE EUROSTOXX-BASED UNCERTAINTY SCENARIOS: A STOCHASTIC GOAL PROGRAMMING APPROACH FROM FUZZY BETAS

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Abstract

We deal with the 'satisficing' choice of portfolios of funds for buy-and-hold strategies by considering fifteen goals defined from fifteen future (uncertain) states of the world. Each state is a scenario specified from historical values of the Eurostoxx market index. These values are a pair of potential events characterizing profitability and risk, in this case, the expected value and variance of returns to be received from the market index if the scenario under consideration was the true state. Potential returns on each fund are related to each scenario by using betas, which are elicited by fuzzy logic taking into account their various measures (weekly, monthly, etc.). For this purpose, triangular membership functions are used as an appropriate tool from which expected values (Heilpern, 1992) are computed. As an opportunity set of assets, we use a large set of funds. A frontier of portfolios is then derived by stochastic goal programming (SGP) as a recent uncertainty multiobjective model characterized by the following aspects: (a) it is built from Eu(R) principles in a framework of bounded rationality; (b) under some assumptions, it leads to efficient frontiers of portfolios; and (c) its moderate computational burden allows easy application to large scale problems. In SGP, the variability matrices of goals are aggregated by Arrow's risk aversion coefficients. Concerning the case study, numerical tables are developed to highlight the computational process and results, including sensitivity analysis and comparisons. Our approach is new in the sense of combining SGP and fuzzy tools. It also seems relevant because: (i) the beta treatment by fuzzy measures improves the use of betas as they are affected by uncertainty; (ii) SGP appears more appropriate than deterministic goal programming for

problems involving uncertainty; (iii) the computational burden of SGP only reasonably exceeds the burden of deterministic goal programming approaches; and (iv) our approach can be extended to financial goals other than profitability and risk, which is also appealing in portfolio selection.

1. Introduction

In Modern Portfolio Theory, analysis and choice are usually undertaken from historical information on returns. Explicitly or implicitly, this information is assumed to be sufficient to predict (in comparative terms) the performance of funds in the near future. More precisely, if portfolio *X* has outperformed *Y* in the recent past, then the investor can sensibly expect that *X* will also outperform *Y* in the close future (Sharpe, 1997, p. 170). However, many investors are interested in portfolio selection models where future scenarios of market performance are considered (Ballestero et al., 2007). This line of research will be addressed hereafter.

Therefore, our objective in this paper is portfolio choice when the investor faces multiple future scenarios of market uncertainty. These states of the world are related to potential values of the market index, so that the linkage relies on either historical information, or subjective predictions, or both. For this purpose, SGP (Ballestero, 2001, 2005) will be used combined with fuzzy logic. A large-scale problem with real world information on 80 funds (opportunity set) will be developed as case study.

Our proposal is motivated by comparing SGP with:

(a) *Classic mean-variance (E-V) model*. If the number of goals/future scenarios is limited to only one, then both E-V and SGP statements coincide. Therefore, E-V is a special case of SGP with a single scenario defined as follows: "the future random returns on each stock are assumed to be governed by the same probability distribution that has governed the respective returns in the historical period of observation (i.e., the 4-5 year period immediately prior to the date of analysis)." As this E-V assumption seems to be quite strong, it should be mitigated by considering the E-V scenario as a particular potential state of the world together with other potential states. This is what SGP can do in fact.

(b) *Other classic methods in Modern Portfolio Theory*. These methods rely on the same E-V assumption commented above, and therefore, comments in (a) can be extended to them. Moreover, the most sophisticated methods such as stochastic dominance (Copeland and Weston, 1988) and direct utility maximization (Kroll et al., 1984) are too cumbersome to apply.

(c) *Approaches that use either historical or subjective data*. As SGP can combine past data with beliefs, it proves in a sense superior to other approaches subjectively constructed or historically supported. Since historical information has “some predictive ability” (as Sharpe contends) and fuzzy logic provides flexibility, our proposal will likely work more effectively than its separate components.

(d) *Heuristic and metaheuristic techniques which do not ensure efficiency*. As SGP leads to efficient solutions, it proves superior to those techniques whose solutions are not always efficient.

(e) *Decision tables under uncertainty which do not use a consistent weighting*. Some decision rules under strict uncertainty such as Wald’s (1950) maximin and Hurwicz’s (1951) optimism-pessimism criteria are less appropriate for portfolio selection purposes due to the following shortcomings: (i) they only use a part of the available information; (ii) they evaluate the portfolios by a measurement system that changes from one portfolio to another, which involves inconsistency; and (iii) the portfolios at the top of the ranking are often dominated by other portfolios or by their convex combinations.

In sum, our proposal appears new and relevant, namely, an approach ensuring efficiency, addressing future scenarios, and combining both fuzzy and historical information.

Unrelated to the SGP approach, there is literature on GP given uncertainty that is partially rooted in chance constrained programming (CCP, Charnes and Cooper, 1959). On certain necessary conditions, some simple problems are solved by CCP, but the treatment of most problems by CCP turn out to be quite cumbersome for this method. There is another technique (expected value model, EVM) with a special version adapted to goal programming (EVM-GP), also named stochastic goal programming with recourse. This is based on minimizing the sum of a cost function and an extra cost function (recourse). However, EVM is often inappropriate (Liu, 2002, ch. 5, pp. 62, 75). The model to be used in this paper (SGP) aggregates variability from multiple goals, taking into account the decision maker's preferences and risk aversion attitudes. Critical advantages of this model are soundness –as based on Eu(R) maximization– and easy application. References to this model are, e.g., Tozer and Stokes (2002), Bordley and Kirkwood (2004), Sahoo and Biswal (2005). If probability distributions are not explicitly known, they can be treated by fuzzy techniques (Ben Abdelaziz and Masri, 2005). In another recent paper dealing with GP under uncertainty (Aouni et al, 2005), satisfaction functions are introduced to explicitly integrate the decision preferences into the model.

Recent literature (papers in high impact journals from 2000) on multicriteria decision approaches to portfolio management and other techniques includes topics such as: (a) combining goal programming and fuzzy techniques (Arenas et al., 2001); (b) approximating the optimum portfolio between compromise-utility bounds on the efficient frontier (Ballestero and Plà-Santamaria, 2003; 2004, 2005); (c) managing socially responsible investments (Hallerbach et al., 2004); (d) using multi-objective programming (Steuer et al., 2005); (e) deriving downside risk efficient frontiers (Ballestero, 2005); and (f) using hybrid models, neural networks and algorithms (Huang et al., 2005; Huang et al., 2006; Lin et al., 2005).

2. Empirical information and future scenarios

Herein, the opportunity set of assets is a large universe of mutual funds managed by a brokers' company on the Frankfurt market. Daily prices of these funds, 80 funds, have been provided by DWS Investment GMBH Dachfondsmanagement, Frankfurt (portfolio managers: Christian Schwehm and Arnulf Metzger), including time series over 4 years immediately prior to the date of analysis. From these prices, weekly and monthly returns are computed to obtain mean values, covariance matrices of returns, and beta coefficients.

In practice, the number of future scenarios ranges between 5 and 25; however, in theory, no such limitation is indeed required. This paper deals with 15 future scenarios of the Eurostoxx Market Index. These scenarios are objectively determined from historical information. Each is defined by a pair of potential events characterizing profitability and risk, in this case, the expected value and variance of returns to be received from the market index if the scenario under consideration was the true state of the world. Tables with this information have been included in the appendix at the end of the paper.

3. Methodology

As noted, portfolio choice is here undertaken by SGP. In our statement, the j^{th} goal refers to the j^{th} future scenario, so that each goal pursues the achievement of a certain target relative to a state of the world. Like other models of risk, the objective function to be minimized is quadratic. More precisely, the weighted sum of deviations characterizing the GP achievement function (or objective function) is a weighted sum of portfolio variances. This is accomplished by aggregating a number *n* of covariance matrices corresponding to the *n* goals (scenarios). The aggregate matrix is called variability matrix. The minimization of this achievement function is subject to the goal constraints, the portfolio percentage constraint (saying that the sum of investment percentage is equal to 1) and the nonnegativity conditions. Once the targets are fixed, a solution is obtained, while the parameterization of targets leads to an efficient frontier of solutions.

3.1 *The model: A review*. The essential difference between deterministic GP and SGP is that goals in SGP contain random coefficients, their mean values and standard deviations being at least known. For simplicity, it is assumed that all the goals behave in such a way that "the more the better". This does not imply a loss of generality because each "the more the worse" goal can be transformed into "the more the better" by suitable changes in the variables.

As noted above, SGP is rooted in Eu(R) maximization theory, which is narrowly related to Von Neumann's and Morgenstern's (1947) utility theory under uncertainty. This is a common feature to Markowitz's (1952) mean-variance (E-V), which ensures efficient solutions under plausible conditions. The analytical statement of SGP is as follows.

$$Eu\left(\sum_{i=1}^{m} \xi_{ij} x_i\right) \rightarrow u(t_j) \quad \text{for } j = 1, 2, \ldots, n \tag{1}$$

where

u and *Eu* are utility and expected utility, respectively.

ξ_{ij} is random return on the *i*th asset related to the *j*th future scenario. Its probability distribution is obtained from historical series of returns.

x_i is the *i*th weight of the portfolio, namely, the *i*th decision variable $(0 \le x_i \le 1)$.

t_j is the investor's target for the *j*th goal.

Symbol $\rightarrow$ means that the target utility should be covered as much as possible by the expected utility of the goal.

As proven in the Ballestero (2001, 2005), the deterministic equivalent of (1) is the following parametric quadratic programming model:

$$\min XVX^T \tag{2}$$

subject to

$$\sum_{i=1}^{m} E(\xi_{ij})x_i \ge t_j \quad \text{for } j = 1, 2, \ldots, n \tag{3}$$

$$\sum_{i=1}^{m} x_i = 1 \tag{4}$$

where,

V is the variability matrix

X is the row vector of decision variable, namely, $X=(x_1, x_2, \ldots x_m)$

X^T is the transposed vector of X

$E(\xi_{ij})$ is the ξ_{ij} mean value.

Variability matrix V is the weighted sum of covariance matrices V_j relative to the *j*th goal, namely,

$$V = \sum_{j=1}^{n} w_j V_j = \sum_{j=1}^{n} \alpha_j A_j V_j \tag{5}$$

where w_j are composite weights whose components have the following meaning:

α_j expresses the investor's preferences for the *j*th goal.

A_j expresses Arrow's (1965, p. 94) absolute risk aversion coefficient for the *j*th goal. This means that the investor fears a possible error affecting the *j*th goal, this error differing from possible errors in other goals. These Arrow's coefficients will be estimated below (see subsection 3.3).

3.2 *Methodological insights*. Therefore, in SGP the achievement function is constructed not with linear deviations from the targets (as usual in deterministic weighted GP) but with quadratic deviations. This can be intuitively explained by noting that SGP uses the variance (namely, the square of the standard deviation) as an appropriate measure of risk concerning the random goals. Therefore, the portfolio variance should be minimized, which means minimizing the squared deviations from the mean value. Moreover, constraints should be imposed to ensure that each mean value is greater than (or equal to) the respective target. Because each random variable has been previously converted into "the more the better", the mean value plays an effective role of reward higher than (or equal to) the target set by the investor. Concerning the SGP weights to aggregate covariance matrices from goals (thus obtaining the variability matrix), notice that the GP decision maker (investor) is not only worried about preferences for the goals but also about risk from random goals. Accordingly, the weights attached to the random deviation measures are composite coefficients of preference weights and risk aversion estimates.

3.3 *Preferences and risk aversion coefficients*. As to preferences, they are assumed to be proportional to the probability of each scenario. To estimate the absolute risk aversion coefficient A_j, we assume the following quadratic utility function:

$$u = a + 2cR_j - cR_j^2 \tag{6}$$

where R_j is random return on the market index for the jth scenario, while parameter c is greater than zero. Utility (6) meets desirable properties such as: (i) it is an increasing function for $R_j < 1$; and (ii) it is marginally decreasing, namely, its second derivative is less than zero. From Arrow's (1965, p. 94) definition, absolute risk aversion coefficient A_j is given by:

$$A_j = (-1)u'' / u' \tag{7}$$

where u' and u'' are the first and second derivatives of utility u, respectively. From (6), equation (7) yields:

$$A_j(R_j) = (-1)(-2c)/(2c - 2cR_j) = 1/(1 - R_j) \tag{8}$$

If equation (8) is specified for the mean value ER_j, we obtain:

$$A_j(E(R_j)) = 1/(1 - E(R_j)) \quad (9)$$

Thus, each risk aversion coefficient is straightforwardly estimated.

4. Step-by-step process

In our statement, the computational process is developed as follows.

First step. *Betas*. For each fund i we have obtained 6 Betas. Each Beta for mutual fund i represents sensitivity of mutual fund's return to changes in the market index, Eurostoxx's return. We have considered three different periods (2, 3 and 4 years) and monthly and weekly returns for each fund, F_{it} and for the Eurostoxx, R_t. Therefore, six regression equations have been proposed from which the different Betas have been obtained:

Four Years-Monthly Returns: $F_{it}^{4m} = \alpha_i^{4m} + \beta_i^{4m} R_t^{4m}, \quad i = 1,...,80 \quad t = 1,...,48$ (10)

Four Years-Weekly Returns: $F_{it}^{4w} = \alpha_i^{4w} + \beta_i^{4w} R_t^{4w}, \quad i = 1,...,80 \quad t = 1,...,208$ (11)

Three Years-Monthly Returns: $F_{it}^{3m} = \alpha_i^{3m} + \beta_i^{3m} R_t^{3m}, \quad i = 1,...,80 \quad t = 1,...,36$ (12)

Three Years-Weekly Returns: $F_{it}^{3w} = \alpha_i^{3w} + \beta_i^{3w} R_t^{3w}, \quad i = 1,...,80 \quad t = 1,...,156$ (13)

Two Years-Monthly Returns: $F_{it}^{2m} = \alpha_i^{2m} + \beta_i^{2m} R_t^{2m}, \quad i = 1,...,80 \quad t = 1,...,24$ (14)

Two Years-Weekly Returns: $F_{it}^{2w} = \alpha_i^{2w} + \beta_i^{2w} R_t^{2w}, \quad i = 1,...,80 \quad t = 1,...,104$ (15)

Then, for each mutual fund i we have six different Betas: $\left(\beta_i^{4m}, \beta_i^{4w}, \beta_i^{3m}, \beta_i^{3w}, \beta_i^{2m}, \beta_i^{2w}\right)$.

Using this information we have constructed a fuzzy triangular Beta for each fund and we have handled them through their expected value, $EV\left(\tilde{\beta}_i\right)$, (Heilper, 1992). Heilpern defines the expected value, *EV*, of a fuzzy triangular number $\tilde{a} = \left(a^L, a^C, a^R\right)$ as follows:

$$EV\left(\tilde{a}\right) = \frac{a^L + 2a^C + a^R}{4} \quad (16)$$

As central value of the fuzzy number (value with the highest possibility of occurrence) we have choose β_i^{2w}, that is, Beta from the two year regression (2002-2004) and weekly returns. Lateral values in the fuzzy Beta have been obtained in the following way:

First. Calculate the mean Beta among the six Betas available for each fund.

Second. Calculate the absolute difference between the highest Beta and the mean Beta for each fund, d_1.

Third. Calculate the absolute difference between the lowest Beta and the mean Beta for each fund, d_2.

Fuzzy triangular Betas for each fund are denoted as $\tilde{\beta}_i = \left(\beta_i^L, \beta_i^C, \beta_i^R\right)$ where:

$\beta_i^C = \beta_i^{2w}$

$\beta_i^L = \beta_i^{2w} - d_1$

$\beta_i^R = \beta_i^{2w} + d_2$

Second step. *Future scenarios*. 15 future scenarios have been defined (j=1,2,…,15) each of them representing a historical year of the Eurostoxx (from 1990 to 2004) in terms of its mean and variance, i.e. E(Rj) representing Eurostoxx returns' mean and var(Rj) representing Eurostoxx returns' variance both of them for each scenario j.

Third step. *Achievement (objective) function*. Minimize a quadratic function which is formally analogous to the classical one from the mean-variance model. The only difference is that the proposed matrix in this work is not the classical covariance matrix but a variability matrix, V, defined in section 3. We will assume the investor has the same preferences for all goals ($\alpha_j = 1, \quad j = 1,...,15$):

$$V = \sum_{j=1}^{15} A_j V_j \tag{17}$$

Where each coefficient A_j estimates risk aversion for scenario j. This risk aversion is calculated in the following way:

$$A_j = \frac{\left| E\left[\left(R_j\right)^2\right] - \left[E\left(R_j\right)\right]^2 \right|}{\left(1 - E\left(R_j\right)\right) \operatorname{var}\left(R_j\right)} = \frac{1}{1 - E\left(R_j\right)} \tag{18}$$

Each matrix V_j $(j = 1, \ldots, 15)$ has 80 row and 80 columns. Its expression is the following:

$$V_j = \left[EV\left(\tilde{\beta}_i\right) EV\left(\tilde{\beta}_k\right) \operatorname{var}\left(R_j\right) \right] \quad i, k = 1, \ldots, 80 \tag{19}$$

Fourth step. *Constraints*. 15 constraints of the type goal, one for each scenario, have been considered with the budget constraint (the sum of the weights of the portfolio equal to one). The expression of goal for scenario j is:

$$\sum_{i=1}^{80} E_j\left(F_i\right) x_i \geq t_j \tag{20}$$

Where $E_j\left(F_i\right)$ is the expected value in scenario j of the mutual fund $i's$ return obtained from the regression equation particularized for the mean annual return of the Eurostoxx in scenario j, that is, particularized for $E\left(R_j\right)$; x_i is the weight of fund i in the portfolio and t_j is the target assigned to goal in the *jth* scenario (see table in the appendix):

$$E_j\left(F_i\right) = \alpha^{2w}{}_i + EV\left(\tilde{\beta}_i\right) E\left(R_j\right) \tag{21}$$

Each target, t_j, is elicited by the decision maker, by ensuring that it is compatible with the left hand side of the constraint.

Fifth. *Solution by Matlab*. The problem, which is a quadratic problem similar to Markowitz's, has been solved using MATLAB but it could be also easily solved using LINGO which has a special model for Markowitz's problem:

$$
\begin{aligned}
&Min\sum_{j=1}^{15} X\left\{A_j V_j\right\}X^t \\
&s.t. \quad \sum_{i=1}^{80} E_j\left(F_i\right)X \geq h_j \quad \forall j=1,...,15 \\
&\sum_{i=1}^{80} x_i = 1 \\
&x_i \geq 0 \quad i=1,...,80
\end{aligned}
\tag{22}
$$

Where $X=\left(x_1,...,x_{80}\right)$ represents the vector of weights in the portfolio.

The following table displays 16 sets of targets, h_j, fixed by the Decision Maker:

Tabla 5.1 Aspiration levels h_j.

	Portf 1	Portf 2	Portf 3	Portf 4	Portf 5	Portf 6	Portf 7	Portf 8
j	h_j	h_j	h_j	h_j	h_j	h_j	h_j	h_j
1	-0.0043078	-0.003877	-0.0034893	-0.0031404	-0.0028263	-0.0018544	-0.00178	-0.0043078
2	0.0029574	0.0026617	0.0032531	0.0032531	0.0032531	0.0035785	0.0044	0.0032531
3	0.00080202	0.00072182	0.00088222	0.00088222	0.00088222	0.00097044	0.0025	0.00088222
4	0.0063142	0.0056828	0.0069456	0.0069456	0.0069456	0.0072929	0.00729	0.0069456
5	-0.0015548	-0.0013993	-0.0013993	-0.0013993	-0.0013993	-0.0013993	0.00057	-0.0015548
6	0.003062	0.0027558	0.003062	0.0033682	0.0033682	0.0033682	0.0045	0.0033682
7	0.0037374	0.0033637	0.0037374	0.0041111	0.0041111	0.0041111	0.005	0.0041111
8	0.0068163	0.0061347	0.0068163	0.0074979	0.0074979	0.0074979	0.0077	0.0074979
9	0.0070963	0.0063867	0.0070963	0.0070963	0.0078059	0.0078059	0.0079	0.0078059
10	0.0052304	0.0047074	0.0052304	0.0052304	0.0052304	0.0057534	0.0063	0.0057534
11	0.00072362	0.00065126	0.00072362	0.00072362	0.00072362	0.00079598	0.0025	0.00079598
12	-0.0033012	-0.0029711	-0.0029711	-0.0029711	-0.0029711	-0.0029711	-0.00092	-0.0033012
13	-0.0073322	-0.006599	-0.006599	-0.006599	-0.006599	-0.006599	-0.0044	-0.0073322
14	0.0026413	0.0023772	0.0026413	0.0026413	0.0026413	0.0029054	0.0041	0.0029054
15	0.0011719	0.0010547	0.0011719	0.0011719	0.0011719	0.0012891	0.0029	0.0012891

Tabla 5.2 Aspiration levels h_j.

	Portf 9	Portf 10	Portf 11	Portf 12	Portf 13	Portf 14	Portf 15	Portf 16
j	h_j	h_j	h_j	h_j	h_j	h_j	h_j	h_j
1	-0.0043078	-0.0043078	-0.0043078	-0.0043078	-0.0043078	-0.0043078	-0.0043078	-0.0043078
2	0.0044361	0.0029574	0.0029574	0.0029574	0.0029574	0.0029574	0.0029574	0.0029574
3	0.00080202	0.0027269	0.00080202	0.00080202	0.00080202	0.00080202	0.00080202	0.00080202
4	0.0063142	0.0063142	0.007577	0.0063142	0.0063142	0.0063142	0.0063142	0.0063142
5	-0.0015548	-0.0015548	-0.0015548	-0.0015548	-0.0015548	-0.0015548	-0.0015548	-0.0015548
6	0.003062	0.003062	0.003062	0.004593	0.003062	0.003062	0.003062	0.003062
7	0.0037374	0.0037374	0.0037374	0.0037374	0.0052324	0.0037374	0.0037374	0.0037374
8	0.0068163	0.0068163	0.0068163	0.0068163	0.0068163	0.0081796	0.0068163	0.0068163
9	0.0070963	0.0070963	0.0070963	0.0070963	0.0070963	0.0070963	0.0085156	0.0070963
10	0.0052304	0.0052304	0.0052304	0.0052304	0.0052304	0.0052304	0.0052304	0.0067995
11	0.00072362	0.00072362	0.00072362	0.00072362	0.00072362	0.00072362	0.00072362	0.00072362
12	-0.0033012	-0.0033012	-0.0033012	-0.0033012	-0.0033012	-0.0033012	-0.0033012	-0.0033012
13	-0.0073322	-0.0073322	-0.0073322	-0.0073322	-0.0073322	-0.0073322	-0.0073322	-0.0073322
14	0.0026413	0.0026413	0.0026413	0.0026413	0.0026413	0.0026413	0.0026413	0.0026413
15	0.0011719	0.0011719	0.0011719	0.0011719	0.0011719	0.0011719	0.0011719	0.0011719

5. Numerical results.

As explained in section 4, we have worked with both, weekly and monthly returns, considering three different periods: 2 years period (from 2003 to 2004), 3 years period (from 2002 to 2004) and three years period (from 2001 to 2004).

In order to obtain sensitivity of each asset to changes in the Eurostoxx index six simple linear regressions have been proposed (see equations (10)-(15)) from which we have obtained six different Beta values for each fund (see table 6):

Table 6. Betas.

Fund	*4 years regression*		*3 years regression*		*2 years regression*	
i	β_i^{4m}	β_i^{4w}	β_i^{3m}	β_i^{3w}	β_i^{2m}	β_i^{2w}
1	0,939	0,7507	0,9387	0,7388	0,869	0,6691
2	0,7978	0,8336	0,8111	0,8105	0,8396	0,8492
3	0,9361	0,771	0,9412	0,7168	0,8741	0,6165
4	0,771	0,6069	0,7384	0,5485	0,5908	0,3616
5	0,7647	0,7495	0,7573	0,7372	0,7554	0,7068
6	0,8685	0,7181	0,8646	0,7031	0,7608	0,6201
7	0,6431	0,6785	0,5814	0,6136	0,5612	0,5791
8	0,6531	0,6656	0,6253	0,6291	0,6724	0,6014
9	0,853	0,7355	0,8771	0,7336	0,9116	0,7024
10	0,8206	0,7462	0,8478	0,7392	0,9027	0,7025
11	0,9991	0,8383	1,0211	0,8169	1,1038	0,7794
12	0,9627	0,8257	1,0199	0,7688	1,1442	0,7526
13	0,8644	0,7387	0,88	0,6781	0,8345	0,6097
14	0,8319	0,7681	0,8263	0,6905	0,8095	0,6441
15	0,7807	0,7389	0,7874	0,6536	0,7259	0,5437
16	0,8613	0,799	0,8705	0,7296	0,8287	0,6693
17	0,7259	0,6131	0,7247	0,6116	0,7276	0,621
18	0,8114	0,8499	0,815	0,8116	0,8273	0,8272
19	0,823	0,6753	0,8379	0,6892	0,8353	0,7056
20	0,7685	0,6156	0,7651	0,5976	0,754	0,6463
21	0,773	0,7143	0,7746	0,672	0,7266	0,628
22	0,7819	0,7258	0,7885	0,6924	0,7457	0,6473
23	0,755	0,6779	0,7418	0,6658	0,7058	0,6661
24	1,0434	0,8927	1,0653	0,8262	1,0148	0,7264
25	0,8659	0,7784	0,8723	0,7127	0,8281	0,6371
26	0,9615	0,7902	0,9299	0,7852	0,9055	0,7012
27	0,7587	0,6558	0,7407	0,6374	0,6412	0,5734
28	0,7703	0,7519	0,7627	0,7395	0,7603	0,7074
29	0,8059	0,6768	0,7594	0,6556	0,68	0,6294
30	1,0018	0,8227	1,0478	0,8286	1,1517	0,8419
31	0,8873	0,8208	0,8917	0,7696	0,835	0,7502
32	0,8773	0,7672	0,9184	0,7563	0,9955	0,734
33	0,8021	0,7437	0,8354	0,7322	0,8631	0,6891
34	0,7764	0,7542	0,7668	0,7153	0,7475	0,6936
35	0,8333	0,7735	0,8599	0,7478	0,8848	0,7602
36	0,7736	0,7353	0,7752	0,708	0,7485	0,6238
37	0,8102	0,8324	0,8106	0,7877	0,7673	0,7584
38	0,8146	0,7569	0,7931	0,7235	0,7954	0,7051
39	0,7638	0,7453	0,7628	0,7393	0,7618	0,7096
40	0,7543	0,7819	0,7439	0,7125	0,7277	0,7158
41	0,8081	0,7503	0,8211	0,7143	0,8854	0,7262
42	0,8314	0,6826	0,8409	0,676	0,7562	0,6381
43	0,788	0,7137	0,7097	0,6666	0,6359	0,618
44	0,7521	0,7269	0,7523	0,7044	0,7507	0,6484

45	0,8088	0,7445	0,7779	0,6981	0,7746	0,6364
46	0,7945	0,7319	0,7833	0,6975	0,7778	0,6438
47	0,677	0,5881	0,6994	0,6009	0,7099	0,5507
48	0,7642	0,8503	0,7707	0,8294	0,749	0,8375
49	0,6832	0,5978	0,6542	0,5383	0,6653	0,5838
50	0,7531	0,768	0,7597	0,7359	0,7417	0,7663
51	0,7312	0,7521	0,7597	0,7306	0,722	0,7514
52	0,8381	0,8236	0,8466	0,8042	0,8061	0,8214
53	0,7644	0,847	0,762	0,8337	0,7411	0,8567
54	0,631	0,679	0,6332	0,6421	0,7002	0,7003
55	0,7489	0,7806	0,7602	0,7421	0,7022	0,7509
56	0,8141	0,8408	0,8124	0,8184	0,8235	0,8313
57	0,766	0,7739	0,7938	0,7208	0,8152	0,7262
58	0,819	0,7446	0,791	0,7141	0,8263	0,7308
59	0,6255	0,8156	0,511	0,7998	0,389	0,821
60	0,7758	0,827	0,7979	0,8127	0,7342	0,7956
61	0,8003	0,6693	0,8056	0,6316	0,8061	0,7042
62	0,7733	0,8111	0,7744	0,8083	0,7834	0,839
63	0,728	0,7062	0,7428	0,6448	0,7588	0,6976
64	0,8012	0,9001	0,7998	0,8776	0,7823	0,8658
65	0,767	0,7467	0,7672	0,7272	0,7903	0,6739
66	0,7869	0,7667	0,7641	0,6914	0,7884	0,6916
67	0,7731	0,8267	0,7707	0,8221	0,8685	0,9099
68	0,814	0,7775	0,8072	0,7195	0,8216	0,771
69	0,7585	0,7813	0,7779	0,7441	0,8038	0,7785
70	0,6229	0,6608	0,6892	0,678	0,7475	0,7331
71	0,811	0,7156	0,8133	0,6705	0,7259	0,6076
72	0,7791	0,8044	0,7796	0,7709	0,7886	0,8002
73	0,7811	0,824	0,7922	0,818	0,8088	0,8345
74	0,8893	0,7886	0,9336	0,7739	1,0412	0,8236
75	0,6863	0,7611	0,7032	0,7488	0,7061	0,7607
76	0,783	0,7217	0,7796	0,6699	0,7487	0,6629
77	0,7405	0,7026	0,7511	0,6823	0,7275	0,6079
78	0,7538	0,8585	0,7542	0,8438	0,7439	0,8579
79	0,7825	0,795	0,7791	0,7434	0,7757	0,7198
80	0,7526	0,6102	0,7807	0,6115	0,7153	0,5854

Following indications given in the first step of the step-by-step process (section 4) fuzzy triangular Betas have been obtained for each fund. We will handle fuzzy Betas by means of their expected value (Heilpern, 1992).

In table 7 fuzzy Betas and their expected value are displayed.

Table 7. Fuzzy triangular Betas and Expected Value.

Fund	β_i^L	β_i^C	β_i^R	$EV\left(\tilde{\beta}_i\right)$
1	0,72085	0,8693	0,99075	0,86255
2	0,821267	0,8471	0,872667	0,847033
3	0,642017	0,8348	0,966717	0,819583
4	0,261933	0,5032	0,671333	0,484917
5	0,80495	0,8433	0,86285	0,8386
6	0,673233	0,809	0,921633	0,803217
7	0,660317	0,7086	0,777617	0,713783
8	0,69125	0,731	0,76225	0,728875
9	0,7767	0,8765	0,9859	0,8789
10	0,778533	0,8692	0,978733	0,873917

11	0,848167	0,9952	1,172567	1,002783
12	0,820183	0,9799	1,211783	0,997942
13	0,615033	0,7729	0,885333	0,761542
14	0,681967	0,7996	0,869767	0,787733
15	0,498067	0,6594	0,741767	0,639658
16	0,720033	0,8438	0,921233	0,832217
17	0,67445	0,7335	0,79045	0,732975
18	0,855067	0,8674	0,893567	0,870858
19	0,74965	0,8354	0,91225	0,833175
20	0,726617	0,8202	0,897517	0,816133
21	0,69295	0,7797	0,83955	0,772975
22	0,717933	0,8009	0,859133	0,794717
23	0,752333	0,7886	0,841533	0,792767
24	0,740067	0,9418	1,078967	0,925658
25	0,654583	0,7999	0,889783	0,786042
26	0,721017	0,8654	0,981317	0,858283
27	0,653133	0,7476	0,838433	0,746692
28	0,803717	0,845	0,866617	0,840083
29	0,712517	0,7843	0,889017	0,792533
30	0,905617	1,032	1,234617	1,051058
31	0,810033	0,8856	0,951533	0,883192
32	0,81325	0,9207	1,07475	0,93235
33	0,7564	0,8449	0,9304	0,84415
34	0,7918	0,8405	0,8746	0,83685
35	0,862983	0,9251	0,999983	0,928292
36	0,6772	0,7808	0,8286	0,76685
37	0,810867	0,8469	0,884867	0,847383
38	0,783333	0,843	0,892833	0,840542
39	0,8099	0,8474	0,8641	0,8422
40	0,79125	0,8181	0,86065	0,822025
41	0,798867	0,8688	0,969967	0,876608
42	0,736167	0,8356	0,938967	0,836583
43	0,69045	0,7611	0,86045	0,768275
44	0,722133	0,7962	0,826033	0,785142
45	0,67975	0,7834	0,85215	0,774675
46	0,695767	0,7901	0,846467	0,780608
47	0,591233	0,6782	0,750433	0,674517
48	0,778817	0,83	0,880117	0,829733
49	0,604667	0,6868	0,749567	0,681958
50	0,747483	0,7657	0,779583	0,764617
51	0,751633	0,7708	0,789333	0,770642

52	0,799167	0,8183	0,841567	0,819333
53	0,777683	0,8374	0,893283	0,836442
54	0,6814	0,7147	0,7507	0,715375
55	0,712217	0,7575	0,790617	0,754458
56	0,834883	0,8459	0,863283	0,847492
57	0,777817	0,823	0,872217	0,824008
58	0,820433	0,8773	0,932633	0,876917
59	0,536083	0,8074	0,968083	0,779742
60	0,758667	0,815	0,851467	0,810033
61	0,664117	0,7687	0,838617	0,760033
62	0,83425	0,8592	0,89995	0,86315
63	0,730967	0,7992	0,844967	0,793583
64	0,7847	0,8402	0,9025	0,8419
65	0,746317	0,8178	0,862717	0,811158
66	0,723617	0,7804	0,820617	0,776258
67	0,8692	0,927	1,0084	0,9329
68	0,778967	0,8446	0,881067	0,837308
69	0,841583	0,8715	0,901283	0,871467
70	0,704617	0,7703	0,829217	0,768608
71	0,556917	0,6733	0,762617	0,666533
72	0,815367	0,8316	0,848867	0,831858
73	0,810533	0,8392	0,863933	0,838217
74	0,861367	0,9625	1,128667	0,978758
75	0,7242	0,7656	0,799	0,7636
76	0,688467	0,7532	0,808567	0,750858
77	0,659017	0,7531	0,802217	0,741858
78	0,783883	0,842	0,898483	0,841592
79	0,780583	0,8267	0,855783	0,822442
80	0,65655	0,7471	0,85185	0,75065

Above information has been used with information displayed in table 8 in order to construct our variability matrix defined in (17):

Table 8. Eurostoxx's annual mean, variance and coefficients A_j for each scenario over the period (1990-2004).

Scenario *j*	$E(R_j)$	$E\left[(R_j)^2\right]$	$\left[E(R_j)\right]^2$	$Var(R_j)$	A_j
1	-0.00431	0.00063566	1.85571E-05	0.000617	0.995710448
2	0.002957	0.000260605	8.7461E-06	0.000252	1.002967038

3	0.000802	0.000382616	6.43236E-07	0.000382	1.00080317
4	0.006314	0.000284924	3.98692E-05	0.000245	1.00635408
5	-0.00155	0.000355664	2.41734E-06	0.000353	0.99844845
6	0.003062	0.000211547	9.37609E-06	0.000202	1.003073964
7	0.003737	0.000207034	1.39684E-05	0.000193	1.003751027
8	0.006816	0.000829729	4.64626E-05	0.000783	1.006863194
9	0.007096	0.001398125	5.03569E-05	0.001348	1.007146854
10	0.00523	0.000809169	2.7357E-05	0.000782	1.005257601
11	0.000724	0.000749388	5.23626E-07	0.000749	1.000724134
12	-0.0033	0.00165229	1.08981E-05	0.001641	0.996709627
13	-0.00733	0.001594564	5.37607E-05	0.001541	0.992720914
14	0.002641	0.00098814	6.97668E-06	0.000981	1.002648284
15	0.001172	0.000286591	1.37344E-06	0.000285	1.00117303

Once the quadratic objective function has been defined and the parameters of the goals determined (see details in the appendix) we have solved problem (22) obtaining the following results:

Table 9.1 Obtained solutions

i	**Portfolio 1**	**Portfolio 2**	**Portfolio 3**	**Portfolio 4**	**Portfolio 5**	**Portfolio 6**
Fund 4	0.2558	0.7130	0	0	0	0
Fund 12	0	0	0.0465	0.1937	0.2630	0.3930
Fund 61	0.7442	0.2870	0.9535	0.8063	0.7370	0.6070

Table 9.2 Obtained solutions

i	**Portfolio 7**	**Portfolio 8**	**Portfolio 9**	**Portfolio 10**	**Portfolio 11**	**Portfolio 12**
Fund 4	0	0	0	0.2558	0	0
Fund 12	0.3901	0.2630	0.4342	0	0.6765	0.7254
Fund 61	0.6099	0.7370	0.5658	0.7442	0.3235	0.2746

Table 9.3 Obtained solutions

i	**Portfolio 13**	**Portfolio 14**	**Portfolio 15**	**Portfolio 16**
Fund 12	0.7498	0.8014	0.8602	0.9730
Fund 61	0.2502	0.1986	0.1398	0.0270

As it can be observed we have obtained sixteen different portfolios corresponding to different targets sets elicited by the Decision Maker (see tables 5.1 and 5.2).

In the following tables results corresponding to variability in each obtained portfolio are displayed. We have also included the reached targets for each solution.

Table 10. Results.

Portfolio	V
1	0.0049802
2	0.0033823
3	0.0061836
4	0.0067536
5	0.0070308
6	0.0075656
7	0.0075534
8	0.0070308
9	0.0077389
10	0.0049802
11	0.0087998
12	0.0090221
13	0.0091339
14	0.009373
15	0.0096493
16	0.01019

Table 11.1 Reached targets.

	Port 1	**Port 2**	**Port 3**	**Port 4**	**Port 5**	**Port 6**	**Port 7**	**Port 8**
j	h_j^*	h_j^*	h_j^*	h_j^*	h_j^*	h_j^*	h_j^*	h_j^*
1	-0.000768	-0.439220	-0.001245	-0.0014694	-0.0015751	-0.0017734	-0.001769	-0.0015751
2	0.0042419	0.0040528	0.0043572	0.0043871	0.0044013	0.0044277	0.0044271	0.0044013
3	0.0027554	0.0028374	0.0026952	0.0026497	0.0026282	0.002588	0.0025889	0.0026282
4	0.006557	0.0059457	0.0069456	0.0070931	0.0071626	0.0072929	0.00729	0.0071626
5	0.0011301	0.0015085	0.00087786	0.00074981	0.00068952	0.00057642	0.00057894	0.00068952
6	0.0043141	0.0041118	0.0044379	0.0044715	0.0044873	0.0045171	0.0045164	0.0044873
7	0.0047799	0.0044927	0.0049587	0.005016	0.0050429	0.0050935	0.0050924	0.0050429
8	0.0069033	0.0062288	0.0073328	0.0074979	0.0075757	0.0077215	0.0077182	0.0075757
9	0.0070963	0.0063867	0.0075487	0.0077236	0.0078059	0.0079604	0.007957	0.0078059
10	0.0058095	0.0053345	0.0061099	0.0062195	0.0062711	0.0063678	0.0063657	0.0062711
11	0.0027014	0.0027932	0.0026347	0.0025865	0.0025637	0.0025211	0.0025221	0.0025637
12	-0.743810	0.00052367	-0.0004688	-0.000658	-0.0007471	-0.0009142	-0.0009105	-0.0007471
13	-0.002854	-0.0017493	-0.0035771	-0.0039075	-0.004063	-0.0043548	-0.0043483	-0.004063
14	0.0040239	0.0038746	0.0041135	0.0041324	0.0041413	0.004158	0.0041576	0.0041413
15	0.0030106	0.003046	0.0029804	0.0029479	0.0029325	0.0029038	0.0029044	0.0029325

Table 11.2 Reached targets.

	Port 9	**Port 10**	**Port 11**	**Port 12**	**Port 13**	**Port 14**	**Port 15**	**Port 16**
j	h_j^*	h_j^*	h_j^*	h_j^*	h_j^*	h_j^*	h_j^*	h_j^*
1	-0.0018361	-0.000768	-0.002205	-0.0022802	-0.0023174	-0.0023961	-0.0024858	-0.002657
2	0.0044361	0.0042419	0.0044854	0.0044954	0.0045004	0.0045109	0.0045228	0.0045458
3	0.0025753	0.0027554	0.0025004	0.0024853	0.0024777	0.0024618	0.0024436	0.0024087
4	0.0073341	0.006557	0.007577	0.007626	0.0076504	0.0077022	0.0077611	0.0078741
5	0.00054062	0.0011301	0.0003298	0.00028728	0.00026609	0.00022118	0.00017001	0.719150
6	0.0045265	0.0043141	0.0045818	0.004593	0.0045986	0.0046104	0.0046238	0.0046496
7	0.0051095	0.0047799	0.0052039	0.0052229	0.0052324	0.0052524	0.0052753	0.0053192
8	0.0077677	0.0069033	0.0080395	0.0080943	0.0081217	0.0081796	0.0082455	0.008372
9	0.0080093	0.0070963	0.0082973	0.0083554	0.0083843	0.0084457	0.0085156	0.0086496
10	0.0063985	0.0058095	0.0065789	0.0066152	0.0066334	0.0066718	0.0067156	0.0067995
11	0.0025076	0.0027014	0.0024282	0.0024122	0.0024042	0.0023872	0.002368	0.002331
12	-0.0009671	-0.74381	-0.001278	-0.0013415	-0.0013728	-0.0014392	-0.0015148	-0.001659
13	-0.004447	-0.002854	-0.004991	-0.0051008	-0.0051555	-0.0052713	-0.0054034	-0.005656
14	0.0041633	0.0040239	0.0041944	0.0042006	0.0042038	0.0042104	0.004218	0.0042324
15	0.0028947	0.0030106	0.0028411	0.0028303	0.0028249	0.0028135	0.0028004	0.0027755

6. Conclusions.

As a contribution to theory, the method in this paper has proven capable of conciliating two opposite philosophies in investment management, namely, the use of historical price information to construct efficient portfolios of securities and the use of conjectures on prices/returns for the same purpose. It is worth recalling that in Modern Portfolio literature, the first philosophy is associated with consistently-built models, while the second philosophy (suggestive and popular enough) is rather associated with heuristic approaches. Our method is advantageous in the sense of combining both perspectives. Indeed, we have considered multiple future scenarios (uncertain states of the world defined by observations of the market index historical positions) instead of considering a single scenario of simulated returns computed from time series over the recent past. This means a significant advance. In fact, each scenario can be then treated as an SGP goal, a sound treatment since SGP stems from Arrow-Pratt Eu(R) theory under uncertainty, namely, SGP is rooted in the classic paradigm. Linkages between assets and scenarios are beta linkages, but uncertainty involving betas has been treated by fuzzy logic, which is another critical contribution of the paper. In sum, the proposed method allows us to relax Sharpe's principle of historical information ("if fund X outperforms fund Y in the past, then fund X will also outperform fund Y in the future") since new elements in the model (the future scenarios) play their role together with the historical performance of each fund.

As a contribution to practice, a large scale numerical problem has been solved by Matlab without significant computational burden. This proves that portfolio selection by SGP is easy for practitioners. Application can be carried out by parametric quadratic optimization either using a general format or more easily by using the special E-V format often available in software programs. This is because the SGP computational structure is like the E-V structure, although both models are analytically different.

Future research can be conducted to strengthen the use of fuzzy betas versus historical betas.

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Appendix

Table 1. Mutual Funds.

i	*Mutual Fund (ISIN)*	*i*	*Mutual Fund (ISIN)*	*i*	*Mutual Fund (ISIN)*	*i*	*Mutual Fund (ISIN)*
1	AT00092588	21	DE0009756957	41	DE0009779751	61	LU009842692
2	BE0126161612	22	DE0009757310	42	DE0009780569	62	LU0053334230
3	DE0008485111	23	DE0009757468	43	DE0009781799	63	LU0053685029
4	DE0008485343	24	DE0009757609	44	DE0009786152	64	LU0062625115
5	DE0008486234	25	DE0009757849	45	DE0009786186	65	LU0058891119
6	DE0008488024	26	DE0009761312	46	DE0009786194	66	LU0062647606
7	DE0008490210	27	DE0009765404	47	DE0009786202	67	LU0066549592
8	DE0008490319	28	DE0009765511	48	IE0003859786	68	LU0068894848
9	DE0008490822	29	DE0009766261	49	IE0005060581	69	LU0070215420
10	DE0008490848	30	DE0009766865	50	IE0005388354	70	LU0073375403
11	DE0008493370	31	DE0009769679	51	IE0008365730	71	LU0081952268
12	DE0009750018	32	DE0009769729	52	IE0008367116	72	LU0073234501
13	DE0009750216	33	DE0009769992	53	IE0008470928	73	LU0082087510
14	DE0009750232	34	DE0009770255	54	IE0008505517	74	LU0082769356
15	DE0009750554	35	DE0009770289	55	LU0006391097	75	LU0085424579
16	DE0009750562	36	DE0009772582	56	LU0010012721	76	LU0086349049
17	DE0009751826	37	DE0009772996	57	LU0011846440	77	LU0088122097
18	DE0009752220	38	DE0009775643	58	LU0011889846	78	LU0090145607
19	DE0009753707	39	DE0009778506	59	LU0048669088	79	LU0090717413
20	DE0009754333	40	DE0009779546	60	LU0049810905	80	LU0090968255

Table 2. Scenario definition based on the mean, $E\left(R_j\right)$, and variance, $Var\left(R_j\right)$, of the returns of the market index Eurostoxx, R_j.

Scenario ***j***	$E\left(R_j\right)$	$Var\left(R_j\right)$
1	-0.00431	0.000617
2	0.002957	0.000252
3	0.000802	0.000382
4	0.006314	0.000245
5	-0.00155	0.000353
6	0.003062	0.000202
7	0.003737	0.000193
8	0.006816	0.000783
9	0.007096	0.001348
10	0.00523	0.000782
11	0.000724	0.000749
12	-0.0033	0.001641
13	-0.00733	0.001541
14	0.002641	0.000981
15	0.001172	0.000285

Table 3. Expected returns for each scenario $E_j\left(F_i\right)$ obtained from equation $Ej\left(F_i\right)=\alpha_i^{2w}+EV\left(\tilde{\beta}_i\right)E\left(R_j\right)$.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	-0,0033	0,00295	0,00109	0,00585	-0,00094	0,00304	0,00362	0,00628	0,00652	0,00491	0,00102	-0,00245	-0,00592	0,00268	0,00141
2	-0,0030	0,00310	0,00128	0,00595	-0,00072	0,00319	0,00377	0,00637	0,00661	0,00503	0,00121	-0,00220	-0,00561	0,00284	0,00159
3	-0,0021	0,00382	0,00206	0,00658	0,00013	0,00391	0,00446	0,00699	0,00722	0,00569	0,00199	-0,00131	-0,00461	0,00356	0,00236
4	0,0004	0,00393	0,00289	0,00556	0,00175	0,00398	0,00431	0,00581	0,00594	0,00504	0,00285	0,00090	-0,00106	0,00378	0,00307
5	-0,0038	0,00228	0,00047	0,00510	-0,00150	0,00237	0,00293	0,00552	0,00575	0,00419	0,00041	-0,00297	-0,00635	0,00202	0,00078
6	-0,0032	0,00268	0,00094	0,00537	-0,00095	0,00276	0,00330	0,00578	0,00600	0,00450	0,00088	-0,00235	-0,00559	0,00242	0,00124
7	-0,0039	0,00131	-0,00023	0,00371	-0,00191	0,00139	0,00187	0,00407	0,00427	0,00293	-0,00028	-0,00316	-0,00603	0,00109	0,00004
8	-0,0039	0,00136	-0,00022	0,00380	-0,00193	0,00143	0,00192	0,00417	0,00437	0,00301	-0,00027	-0,00321	-0,00614	0,00113	0,00005
9	-0,0030	0,00340	0,00150	0,00635	-0,00057	0,00349	0,00408	0,00679	0,00704	0,00540	0,00144	-0,00210	-0,00564	0,00312	0,00183
10	-0,0034	0,00298	0,00110	0,00592	-0,00096	0,00308	0,00367	0,00636	0,00660	0,00497	0,00103	-0,00248	-0,00601	0,00271	0,00142
11	-0,0034	0,00387	0,00170	0,00723	-0,00066	0,00397	0,00465	0,00774	0,00802	0,00614	0,00163	-0,00241	-0,00645	0,00355	0,00208
12	-0,0027	0,00455	0,00240	0,00790	0,00005	0,00466	0,00533	0,00840	0,00868	0,00682	0,00232	-0,00169	-0,00572	0,00424	0,00277
13	-0,0024	0,00315	0,00151	0,00571	-0,00028	0,00323	0,00375	0,00609	0,00630	0,00488	0,00145	-0,00161	-0,00468	0,00291	0,00179
14	-0,0030	0,00273	0,00103	0,00537	-0,00082	0,00281	0,00334	0,00577	0,00599	0,00452	0,00097	-0,00220	-0,00538	0,00248	0,00132
15	-0,0010	0,00369	0,00231	0,00584	0,00081	0,00376	0,00419	0,00616	0,00634	0,00515	0,00226	-0,00031	-0,00289	0,00349	0,00255
16	-0,0034	0,00266	0,00087	0,00545	-0,00109	0,00275	0,00331	0,00587	0,00611	0,00455	0,00080	-0,00255	-0,00590	0,00240	0,00118
17	-0,0027	0,00267	0,00109	0,00513	-0,00064	0,00274	0,00324	0,00550	0,00570	0,00433	0,00103	-0,00192	-0,00487	0,00244	0,00136
18	-0,0045	0,00188	0,00000	0,00480	-0,00205	0,00197	0,00255	0,00524	0,00548	0,00385	-0,00007	-0,00357	-0,00709	0,00160	0,00032
19	-0,0027	0,00336	0,00157	0,00616	-0,00040	0,00345	0,00401	0,00658	0,00681	0,00526	0,00150	-0,00185	-0,00521	0,00310	0,00188
20	-0,0017	0,00421	0,00245	0,00695	0,00053	0,00430	0,00485	0,00736	0,00759	0,00607	0,00239	-0,00089	-0,00418	0,00396	0,00276

21	-0,0032	0,00239	0,00072	0,00498	-0,00110	0,00247	0,00299	0,00537	0,00559	0,00414	0,00066	-0,00245	-0,00557	0,00214	0,00101
22	-0,0034	0,00238	0,00067	0,00505	-0,00121	0,00246	0,00300	0,00545	0,00567	0,00419	0,00061	-0,00259	-0,00580	0,00213	0,00096
23	-0,0035	0,00225	0,00055	0,00492	-0,00132	0,00234	0,00287	0,00531	0,00554	0,00406	0,00048	-0,00271	-0,00590	0,00200	0,00084
24	-0,0031	0,00364	0,00164	0,00674	-0,00054	0,00373	0,00436	0,00721	0,00747	0,00574	0,00157	-0,00216	-0,00589	0,00334	0,00198
25	-0,0029	0,00282	0,00113	0,00546	-0,00072	0,00291	0,00344	0,00586	0,00608	0,00461	0,00107	-0,00209	-0,00526	0,00258	0,00142
26	-0,0036	0,00259	0,00074	0,00547	-0,00128	0,00268	0,00326	0,00590	0,00614	0,00454	0,00067	-0,00278	-0,00624	0,00232	0,00106
27	-0,0033	0,00212	0,00051	0,00462	-0,00125	0,00220	0,00270	0,00500	0,00521	0,00382	0,00045	-0,00255	-0,00556	0,00188	0,00079
28	-0,0037	0,00238	0,00057	0,00520	-0,00141	0,00247	0,00304	0,00563	0,00586	0,00429	0,00051	-0,00287	-0,00626	0,00212	0,00088
29	-0,0032	0,00254	0,00084	0,00520	-0,00103	0,00263	0,00316	0,00560	0,00582	0,00435	0,00077	-0,00242	-0,00561	0,00229	0,00113
30	-0,0034	0,00421	0,00194	0,00774	-0,00053	0,00432	0,00503	0,00826	0,00856	0,00660	0,00186	-0,00237	-0,00661	0,00388	0,00233
31	-0,0032	0,00321	0,00131	0,00618	-0,00077	0,00330	0,00390	0,00662	0,00687	0,00522	0,00124	-0,00232	-0,00588	0,00293	0,00164
32	-0,0031	0,00366	0,00165	0,00679	-0,00055	0,00375	0,00438	0,00726	0,00752	0,00578	0,00157	-0,00218	-0,00594	0,00336	0,00199
33	-0,0027	0,00340	0,00158	0,00623	-0,00041	0,00348	0,00405	0,00665	0,00689	0,00532	0,00151	-0,00189	-0,00529	0,00313	0,00189
34	-0,0037	0,00241	0,00061	0,00522	-0,00136	0,00250	0,00307	0,00564	0,00588	0,00432	0,00055	-0,00282	-0,00620	0,00215	0,00092
35	-0,0041	0,00269	0,00068	0,00580	-0,00150	0,00278	0,00341	0,00627	0,00653	0,00480	0,00061	-0,00312	-0,00687	0,00239	0,00103
36	-0,0026	0,00297	0,00132	0,00554	-0,00049	0,00305	0,00357	0,00593	0,00614	0,00471	0,00125	-0,00183	-0,00492	0,00273	0,00160
37	-0,0039	0,00231	0,00048	0,00515	-0,00152	0,00239	0,00297	0,00558	0,00581	0,00423	0,00041	-0,00300	-0,00641	0,00204	0,00079
38	-0,0029	0,00319	0,00137	0,00601	-0,00061	0,00327	0,00384	0,00643	0,00666	0,00510	0,00131	-0,00207	-0,00546	0,00292	0,00169
39	-0,0038	0,00229	0,00048	0,00512	-0,00151	0,00238	0,00295	0,00554	0,00578	0,00421	0,00041	-0,00298	-0,00638	0,00202	0,00079
40	-0,0035	0,00250	0,00073	0,00526	-0,00121	0,00259	0,00314	0,00567	0,00590	0,00437	0,00066	-0,00264	-0,00596	0,00224	0,00103
41	-0,0029	0,00349	0,00160	0,00644	-0,00046	0,00358	0,00418	0,00688	0,00712	0,00549	0,00153	-0,00199	-0,00553	0,00322	0,00193
42	-0,0036	0,00248	0,00067	0,00529	-0,00130	0,00256	0,00313	0,00571	0,00594	0,00438	0,00061	-0,00276	-0,00613	0,00221	0,00098
43	-0,0034	0,00217	0,00052	0,00475	-0,00129	0,00225	0,00277	0,00514	0,00535	0,00392	0,00046	-0,00264	-0,00573	0,00193	0,00080

44	-0,0036	0,00212	0,00043	0,00476	-0,00142	0,00220	0,00273	0,00515	0,00537	0,00391	0,00037	-0,00279	-0,00596	0,00187	0,00072
45	-0,0036	0,00199	0,00032	0,00459	-0,00150	0,00207	0,00260	0,00498	0,00520	0,00375	0,00026	-0,00286	-0,00598	0,00175	0,00061
46	-0,0038	0,00191	0,00023	0,00453	-0,00161	0,00199	0,00252	0,00492	0,00514	0,00368	0,00016	-0,00298	-0,00612	0,00166	0,00051
47	-0,0026	0,00229	0,00084	0,00456	-0,00075	0,00237	0,00282	0,00490	0,00509	0,00383	0,00079	-0,00193	-0,00465	0,00208	0,00109
48	-0,0034	0,00265	0,00087	0,00544	-0,00109	0,00274	0,00330	0,00586	0,00609	0,00454	0,00080	-0,00254	-0,00588	0,00239	0,00117
49	-0,0023	0,00262	0,00115	0,00491	-0,00046	0,00269	0,00315	0,00525	0,00544	0,00417	0,00109	-0,00165	-0,00440	0,00240	0,00140
50	-0,0030	0,00256	0,00091	0,00513	-0,00089	0,00264	0,00316	0,00551	0,00573	0,00430	0,00085	-0,00222	-0,00531	0,00232	0,00120
51	-0,0024	0,00318	0,00152	0,00577	-0,00030	0,00326	0,00378	0,00615	0,00637	0,00493	0,00146	-0,00164	-0,00475	0,00294	0,00180
52	-0,0025	0,00342	0,00166	0,00617	-0,00027	0,00351	0,00406	0,00658	0,00681	0,00529	0,00159	-0,00170	-0,00501	0,00316	0,00196
53	-0,0035	0,00257	0,00077	0,00538	-0,00120	0,00266	0,00323	0,00580	0,00604	0,00447	0,00071	-0,00266	-0,00603	0,00231	0,00108
54	-0,0021	0,00312	0,00157	0,00552	-0,00011	0,00319	0,00367	0,00588	0,00608	0,00474	0,00152	-0,00136	-0,00425	0,00289	0,00184
55	-0,0024	0,00313	0,00151	0,00566	-0,00027	0,00321	0,00372	0,00604	0,00625	0,00485	0,00145	-0,00159	-0,00463	0,00289	0,00178
56	-0,0036	0,00261	0,00078	0,00545	-0,00122	0,00270	0,00327	0,00588	0,00611	0,00453	0,00071	-0,00270	-0,00611	0,00234	0,00109
57	-0,0031	0,00284	0,00106	0,00560	-0,00088	0,00292	0,00348	0,00602	0,00625	0,00471	0,00100	-0,00232	-0,00564	0,00258	0,00137
58	-0,0028	0,00359	0,00170	0,00654	-0,00036	0,00369	0,00428	0,00698	0,00722	0,00559	0,00163	-0,00189	-0,00543	0,00332	0,00203
59	-0,0039	0,00181	0,00013	0,00442	-0,00171	0,00189	0,00241	0,00481	0,00503	0,00358	0,00006	-0,00307	-0,00622	0,00156	0,00041
60	-0,0035	0,00238	0,00063	0,00509	-0,00128	0,00246	0,00301	0,00550	0,00573	0,00422	0,00057	-0,00269	-0,00596	0,00212	0,00093
61	-0,0012	0,00435	0,00271	0,00690	0,00092	0,00443	0,00494	0,00728	0,00749	0,00608	0,00265	-0,00041	-0,00347	0,00411	0,00299
62	-0,0041	0,00215	0,00029	0,00505	-0,00174	0,00224	0,00283	0,00548	0,00573	0,00411	0,00022	-0,00325	-0,00673	0,00188	0,00061
63	-0,0023	0,00345	0,00174	0,00611	-0,00013	0,00353	0,00407	0,00651	0,00673	0,00525	0,00167	-0,00152	-0,00472	0,00320	0,00203
64	-0,0037	0,00239	0,00058	0,00522	-0,00141	0,00248	0,00305	0,00564	0,00587	0,00430	0,00051	-0,00288	-0,00627	0,00212	0,00089
65	-0,0038	0,00210	0,00035	0,00482	-0,00156	0,00218	0,00273	0,00523	0,00546	0,00394	0,00029	-0,00298	-0,00625	0,00184	0,00065
66	-0,0028	0,00280	0,00112	0,00540	-0,00071	0,00288	0,00340	0,00579	0,00601	0,00456	0,00106	-0,00206	-0,00519	0,00255	0,00141

67	-0,0039	0,00286	0,00085	0,00599	-0,00135	0,00296	0,00359	0,00646	0,00672	0,00498	0,00078	-0,00298	-0,00674	0,00256	0,00119
68	-0,0032	0,00288	0,00107	0,00569	-0,00090	0,00296	0,00353	0,00611	0,00634	0,00478	0,00101	-0,00236	-0,00574	0,00261	0,00138
69	-0,0040	0,00238	0,00050	0,00530	-0,00155	0,00247	0,00306	0,00574	0,00598	0,00436	0,00043	-0,00308	-0,00659	0,00210	0,00082
70	-0,0031	0,00247	0,00082	0,00505	-0,00100	0,00255	0,00307	0,00544	0,00565	0,00422	0,00076	-0,00234	-0,00544	0,00223	0,00110
71	-0,0016	0,00327	0,00183	0,00551	0,00026	0,00334	0,00379	0,00584	0,00603	0,00479	0,00178	-0,00090	-0,00359	0,00306	0,00208
72	-0,0040	0,00206	0,00027	0,00485	-0,00169	0,00215	0,00271	0,00527	0,00550	0,00395	0,00020	-0,00315	-0,00650	0,00180	0,00057
73	-0,0031	0,00298	0,00117	0,00579	-0,00080	0,00307	0,00363	0,00621	0,00645	0,00488	0,00111	-0,00227	-0,00565	0,00271	0,00148
74	-0,0035	0,00359	0,00148	0,00688	-0,00082	0,00370	0,00436	0,00737	0,00765	0,00582	0,00141	-0,00253	-0,00648	0,00329	0,00185
75	-0,0030	0,00256	0,00091	0,00512	-0,00089	0,00264	0,00315	0,00550	0,00572	0,00429	0,00085	-0,00222	-0,00530	0,00232	0,00119
76	-0,0028	0,00262	0,00100	0,00514	-0,00077	0,00270	0,00321	0,00552	0,00573	0,00433	0,00094	-0,00208	-0,00511	0,00238	0,00128
77	-0,0031	0,00228	0,00068	0,00477	-0,00106	0,00236	0,00286	0,00515	0,00535	0,00397	0,00063	-0,00236	-0,00535	0,00205	0,00096
78	-0,0037	0,00239	0,00057	0,00521	-0,00141	0,00248	0,00305	0,00564	0,00587	0,00430	0,00051	-0,00288	-0,00627	0,00212	0,00089
79	-0,0035	0,00243	0,00065	0,00519	-0,00128	0,00251	0,00307	0,00560	0,00583	0,00430	0,00059	-0,00272	-0,00604	0,00217	0,00096
80	-0,0025	0,00292	0,00130	0,00544	-0,00047	0,00300	0,00351	0,00582	0,00603	0,00463	0,00124	-0,00178	-0,00480	0,00268	0,00158

Table 4. α_i^{2w} **in equation** $Ej\left(F_i\right) = \alpha_i^{2w} + EV\left(\tilde{\beta}_i\right)E\left(R_j\right)$.

Fund	α_i^{2w}	Fund	α_i^{2w}	Fund	α_i^{2w}	Fund	α_i^{2w}
1	0,0004	21	1,00E-04	41	0,0009	61	0,0021
2	0,0006	22	3,00E-05	42	3,00E-06	62	-0,0004
3	0,0014	23	-9,00E-05	43	-0,0001	63	0,0011
4	0,0025	24	0,0009	44	-0,0002	64	-0,0001
5	-0,0002	25	0,0005	45	-0,0003	65	-0,0003
6	0,0003	26	5,00E-05	46	-0,0004	66	0,0005
7	-0,0008	27	-9,00E-05	47	0,0003	67	1,00E-04
8	-0,0008	28	-0,0001	48	0,0002	68	0,0004
9	0,0008	29	0,0002	49	0,0006	69	-0,0002
10	0,0004	30	0,0011	50	0,0003	70	0,0002
11	0,0009	31	0,0006	51	0,0009	71	0,0013
12	0,0016	32	0,0009	52	0,001	72	-0,0004
13	0,0009	33	0,0009	53	0,0001	73	0,0005
14	0,0004	34	-6,00E-05	54	0,001	74	0,0007
15	0,0018	35	-6,00E-05	55	0,0009	75	0,0003
16	0,0002	36	0,0007	56	0,0001	76	0,0004
17	0,0005	37	-0,0002	57	0,0004	77	9,00E-05
18	-0,0007	38	0,0007	58	0,001	78	-0,0001
19	0,0009	39	-0,0002	59	-0,0005	79	-6,00E-06
20	0,0018	40	7,00E-05	60	-2,00E-05	80	0,0007

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