Chapter 2
Measuring Social Responsibility: A Multicriteria Approach

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Abstract In this chapter we present a portfolio selection model for Socially Responsible Investment. The model, following the spirit of Socially Responsible Investment, consists of two different steps. Firstly, a social screening is applied in order to obtain the feasible set of assets accomplishing the socially responsible investment policy of the assets' manager. In this step, an indicator is obtained for the measurement of the social responsibility degree of an asset. Assets are then ranked using this indicator from the most socially responsible to the less socially responsible. In a second step, once the feasible set is obtained, composed of those socially responsible assets verifying the screens and standards imposed by the assets' manager, a portfolio selection model is proposed based on the classical Markowitz mean-variance model to determine efficient portfolios.

2.1 Introduction

Nowadays, and especially after the 2008 financial crisis, more and more stakeholders are interested in the positive actions of business. Therefore, companies have, now more than ever, to integrate social and environmental concerns into their activities and into their relationships with their stakeholders.

Socially Responsible Investing (SRI) is an investment process that integrates not only financial but also social, environmental, and ethical concerns into investment decision making. The most common socially responsible investment strategy is screening. This investment strategy consists of checking companies for the presence or absence of certain social, environmental, ethical and/or good corporate governance characteristics. Negative screening avoids investing in companies whose products and business practices are harmful to individuals, communities, or the

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environment whereas positive screening implies investing in profitable companies that make positive contributions to society, for example, that have good employer-employee relations, strong environmental practices, products that are safe and useful, and operations that respect human rights around the world [24].

When reviewing the academic literature on Socially Responsible Investing we can observe how it evolves around two main research questions [18]. The first one is concerned with whether a relationship between corporate social performance and corporate financial performance exists or not and its direction, if any exists. On the other hand, the second main research question is concerned with whether social screening has an impact on portfolio performance and its diversification where social screening is implemented through exclusion rules such as operating in a specific sector of industry; for example, gambling [22], through additional constraints; say on the minimum acceptable score on social responsibility as measured, for example, by an index [9], or by using a classification made available by some authority in the field [5].

In this work, we will first address the problem of the measurement of the social responsibility degree of an asset. This is usually done through the screening intensity of the asset defined as the number of applied social screens (see for example, [1–4, 6, 10, 13, 14, 16, 20, 21, 23]). However, measurement of social responsibility requires taking into account other factors. Several rating agencies rate firms based on their social responsibility performance taking into account not only the screening intensity but also questions related with the impact and results of the firms in social terms. Although representing an advance with respect to only taking into account the screening intensity, the measures used by rating agencies still lack of several weaknesses. One of them is the problem of the aggregation of the scores obtained for the different social dimensions into an overall score.

In this chapter we will propose an aggregating method which overcomes the later problem. The method is based on Induced Ordered Weighted Averaging (IOWA) and will allow us to rank firms based on an overall measure of their social responsibility taking into account the specific nature of the data and without the necessity of relying on the manager's preferences.

Once an overall social score is obtained we will address the portfolio selection problem from a multicriteria decision making perspective. The proposed approach will take into account the two main characteristics of Socially Responsible Investment. First, social responsibility is usually approached passively. Assets' managers apply social screens in order to determine the set of possible investments (feasible set). They decide to include or exclude investments from their portfolio based on their socially responsible investment policy and using information from their own research teams or from well-known social rating agencies as EIRIS, Vigeo or KLD. Second, once screens are applied the main objective is to maximize the financial return while minimizing financial risk.

The remaining of this chapter is as follows: in the next section we will present a proposal for the measurement of the social responsibility degree of an asset which overcomes some limitations of the social responsibility scores used in practice. In this section the first step of the model will be addressed, i.e. the application of social screens for the obtaining of the feasible set of socially responsible assets.

In the following section, once assets have been evaluated with regards to their social responsibility and they have been selected and ranked, the second step of the approach will be presented, i.e. a portfolio selection model based on the classical mean-variance model. In this second step the spotlight will be on the financial aspects of the portfolio (return and risk objectives).

All the steps will be illustrated with a real numerical example. Finally, in the last section the main conclusions will be discussed.

2.2 Measuring the Social Responsibility of an Investment

Nowadays, several independent agencies try to supply transparent and credible information about the Environmental, Social and Governance (ESG) performance of companies throughout the world. Some examples are the MSCI ESG STATS (known under the name of KLD Research & Analytics Inc.) database (http://www.msci.com), Ethibel (http://forumethibel.org), Vigeo (http://www.vigeo.com), Oekom Research, SAM (Sustainable Asset Management) or EIRIS (http://www.eiris.org).

In this chapter we will focus on a real example based on data provided by Vigeo. Vigeo is a leading European expert in the assessment of companies and organizations with regards to their practices and performance on ESG issues. Vigeo has developed Equitics®, a model based on internationally recognized standards to assess to which degree companies take into account social responsibility objectives in the definition and deployment of their strategy.

Vigeo offers access to scores in six dimensions, which are commonly used by the rating agencies: Human Rights; Human Resources; Environment; Business Behavior; Corporate Governance and Community Involvement. A description of these dimensions is presented in Table 2.1. Vigeo's database provides scores rated from 0–100, for each firm in each social dimension. It also provides an overall score for each firm calculated as an equally weighted geometric mean. Information about sectors' performance is also provided. Sectors are rated from 0–100 in each dimension.

In order to illustrate our approach we will use a real example with data provided by Vigeo and Morningstar Ltd. Our initial sample is composed of 1081 firms with social scores provided by Vigeo for 2012. We have first ranked companies based on Vigeo's overall scores (see Table 2.2). Then, and in order to take into account performance with respect to the sector of the firms, we have calculated the discrepancy (difference between the overall score and the overall average sector score) and we have ranked companies based on this discrepancy (see Table 2.2).

We have then applied a first filter and we have considered only those companies outperforming their sector, i.e. those with a positive discrepancy. This filter reduced our sample to 492 firms.

Table 2.1 List of Vigeo's evaluation criteria

Goal	Treatment
CG	Corporate Governance: Effectiveness and integrity, guarantee of independence and efficiency of the Board of Directors, effectiveness and efficiency of auditing and control mechanisms, in particular the inclusion of social responsibility risks, respect for the rights of shareholders, particularly minority shareholders
C&S	Business Behaviour: Consideration of the rights and interests of clients, integration of social and environmental standards in the selection of suppliers and in the entire supply chain, effective prevention of corruption and respect for competitive practices
ENV	Environment: Protection, safeguarding, prevention of damage to the environment, implementation of an adequate management strategy, eco-design, protection of biodiversity and coordinated management of environmental impacts on the entire lifecycle of products or services
HR	Human Resources: Continuous improvement of professional relations, labor relations and working conditions
HRts	Human Rights at the Workplace: Respect of freedom of association, the right to collective bargaining, non-discrimination and promotion of equally, elimination of illegal working practices such as child or forced labor, prevention of inhumane or degrading treatment such as sexual harassment, protection of privacy and personal data
CIN	Community Involvement: Effectiveness, managerial commitment to community involvement, contribution to the economic and social development of territories/societies within which the company operates, positive commitment to manage the social impacts linked to products or services and overt contribution and participation in causes of public or general interest

Source: www.vigeo.com

Table 2.2 Ranking based on overall discrepancy with the sector

Rank	Firm	Sector	OSS	OSF	D
F25	Danone	Food	30(6)	60(1)	30
F3	ADIDAS	Specialized Retail	25(9)	54(4)	29
F4	ADP	Transport & Logistics	27(7)	52(5)	25
F19	CGG Veritas	Oil Equipment & Services	26(8)	50(6)	24
F20	Coca-Cola Hellenic	Beverage	30(6)	54(4)	24
F47	L'Oreal	Luxury Goods & Cosmetics	37(3)	60(1)	23
F17	BNP Paribas	Banks	40(2)	60(1)	20
F60	Sanofi-Aventis	Pharmac. & Biotechnology	32(5)	52(5)	20
F62	Schneider Electric	Electric Comp. & Equipment	36(4)	55(3)	19
F52	PSA Peugeot Citroën	Automobiles	44(1)	59(2)	15

A second filter has been applied in the next step. This second filter consisted of selecting only those companies in the Advanced Sustainability Performance Eurozone Index ("ASPI Eurozone®") which is based on Vigeo's sector peers' comparison.

From that comparison companies are classified in four groups: leaders, advanced, average, below average and unconcerned. Our final sample is composed of 73 firms, the leaders and advanced firms in terms of their social responsibility compared with

Fig. 2.1 Steps in the social screening process

their sector. Figure 2.1 summarizes the screening process conducted in the first phase of the portfolio selection model.

Table 2.2 displays firms ranked in the first ten positions taking into account the discrepancy (D) between the overall sector score (OSS) and the overall score of the firm (OSF). In the fifth column (OSF) we have indicated into parenthesis the corresponding position of the firms in terms of Vigeo's overall sector. Comparison with sector scores is a key question, as sectors tend to perform better in certain social responsibility dimensions depending on their type of activities. Observing the ranking of sectors in the fourth column, we can see how best sectors in terms of their overall social responsibility are Automobiles, banks and Luxury Goods & Cosmetics. The worse are Specialized Retails, Oil Equipment & Services, Transport, and Logistics.

We can observe how Danone doubles the overall score obtained in average by its sector, Food. This is the only company ranking in the same position concerning its overall score and taking into account discrepancy with its sector (it is the firm outperforming more its sector). However, its sector, Food, ranks in the sixth position.

If we now pay attention to the performance of the firms in each dimension we can observe how the ranking changes depending on the firms and their sectors. Table 2.3 displays within parenthesis the position of the firm in the ranking considering individually each dimension. As we can observe, position changes depending on the considered dimension. For example, ADIDAS performs the best in Environment and the worst in Human Resources. L'Oreal is the best performer of the sample in Business Behavior and it performs badly in Community Involvement.

We can also observe how there are firms performing worse than the average of their sectors in certain dimensions whereas being classified as leaders when taking into account the overall score aggregating all the dimensions (e.g. ADP, Schneider Electric, PSA Peugeot Citröen and Sanofi Aventis perform worse than they sectors in the Corporate Governance, CG, dimension).

Table 2.3 Ranking based on discrepancies of firms with respect to their sector in each dimension

Firm	*Sector*	*HR*	*ENV*	*C&S*	*CG*	*CIN*	*HRts*
F3	Specialized Retail	24 (6)	**33 (1)**	7 (8)	9 (2)	23 (8)	**8 (10)**
F4	Transport & Logistics	**20 (9)**	27 (4)	12 (7)	**−1 (8)**	29 (4)	**14 (9)**
F17	Banks	24 (5)	20 (8)	15 (5)	19 (1)	25 (6)	22 (5)
F19	Oil Equipment & Services	28 (4)	**11 (10)**	16 (4)	1 (6)	31 (3)	17 (7)
F20	Beverage	24 (7)	27 (5)	5 (10)	5 (4)	13 (10)	23 (4)
F25	Food	**39 (1)**	32 (2)	20 (2)	1 (5)	27 (5)	**38 (1)**
F47	Luxury Goods & Cosmetics	32 (3)	27 (3)	**23 (1)**	5 (3)	**19 (9)**	24 (3)
F52	Automobiles	36 (2)	21 (7)	16 (3)	**−8 (10)**	25 (7)	33 (2)
F60	Pharmaceuticals & Biotechnology	**18 (10)**	24 (6)	13 (6)	**−7 (9)**	34 (2)	21 (6)
F62	Electric Comp. & Equipment	20 (8)	20 (9)	5 (9)	**−1 (7)**	**49 (1)**	15 (8)

Table 2.4 Objectives of our approach for the measurement of the social responsibility of a firm

Goal	Treatment
Take into account the performance of the firm with respect to its sector.	We first calculate the discrepancies of the firms with respect to their sector.
Take into account that certain sectors perform best in certain social dimensions due to the characteristics of their activities.	We then rank the firms based on this discrepancy.
	We select the best firms with positive discrepancy (ASPI index).
Obtain an aggregated weighted score that takes into account the specific nature of the data overcoming the problems associated with an a priori assignment of weighs, i.e. linear behaviors that are difficult to explain specially in the case of the geometric mean.	We obtain weights for each dimension based on the variability given by the variance of the scores in each social dimension.
	We apply IOWGA to obtain an aggregated weighted score for each firm.

In sum, and looking at the results displayed in Table 2.3, it seems that the geometric mean with equal weights does not reflect all the information from the firms' scores. Not being a bad choice, other measures can be proposed that based on the Geometric Mean enrich the information provided by Vigeo's overall scores. It seems convenient to take into account the specific nature of each of the social dimensions. Bold values in Table 2.3 reflect peculiar behaviour of the firms in different dimensions. For example, firm F3 behaves the best with respect to the environmental dimension but the worst with respect the Human Rights at the Workplace.

In what follows we will propose an aggregated measure of the social responsibility of the firms based on the scores obtained for each dimension taking into account the variability of these scores in each dimension. Table 2.4 summarizes the main objectives of our proposal.

Ordered weighted averaging (OWA) operators provide a parameterized family of mean type aggregation operators that includes the minimum, the maximum, and the average [29]. As an important feature of these operators, the arguments to be aggregated are ordered according to their value, and the aggregation weights are associated with a particular position in such reordering instead of being associated with a specific argument. In what follows, we will give some basic definitions.

Definition 1 A vector $\mathbf{w} = (w_1, \ldots, w_n)$ is called a weighting vector if the following two conditions are verified:

1. $w_d \in [0, 1], d = 1, \ldots, n,$
2. $w_1 + w_2 + \ldots + w_n = 1.$

OWA operators assign weights that are based on the magnitude of the arguments to be aggregated:

Definition 2 Given a weighting vector **w**, the OWA operator OWAw is defined to aggregate a list of values $\{a_1, \ldots, a_n\}$ according to the following expression:

$$OWA_w(a_1, \ldots, a_n) = \sum_{d=1}^{n} w_d a_{\sigma(d)}$$

where $a_{\sigma(d)}$ is the dth largest element in the collection $\{a_1, \ldots, a_n\}$, i.e., $a_{\sigma(1)} \geq \cdots \geq a_{\sigma(n)}$.

In particular, for $\mathbf{w}_1 = (1, 0, \ldots, 0)$ and $\mathbf{w}_2 = (0, 0, \ldots, 1)$, we obtain, respectively, $OWA_{w_1}(a_1, \ldots, a_n) = \max\{a_1, \ldots, a_n\}$ and $OWA_{w_2}(a_1, \ldots, a_n) = \min\{a_1, \ldots, a_n\}$. In order to measure the similarity of other weighting vectors with the extreme weighting vectors we will introduce the concept of orness as follows:

Definition 3 The level of orness associated with the operator OWA_w is defined as

$$\alpha = \frac{1}{n-1} \sum_{d=1}^{n} (n-d) w_d$$

The level of orness belongs to [0,1] and measures the degree to which the aggregation behaves as the maximum operator or the minimum operator. Thus, degree 1 means that the operator is the maximum, degree 0 means that the operator is the minimum and in between all the other possibilities are allowed.

Yager and Filev [31] proposed a general class of OWA operators in which the ordering of the arguments is induced by another variable called the order-inducing variable. The authors named this class, IOWA operators. Thus, IOWA operators allow us to order the arguments to be aggregated with different criteria, not only that of the order of magnitude used by OWA operators (more details on IOWA operators can be found in [15, 30, 31]).

Researchers searching for operators that allow aggregation of information, soon realized that similar reasoning to the one done with the weighted sums were also valid for products weighted with powers [28]. Therefore, some new induced aggregation operators have also been developed, including the induced ordered weighted geometric (IOWG) operator [12, 27, 28].

The ASPI index based on Vigeo's database uses the geometric mean for the aggregation of the six social dimensions. In this work, and in order to respect as much as possible their aggregation proposal, we will do the final aggregation using the Ordered Weighted Geometric operator.

Definition 4 Given a weighting vector **w**, the OWG operator OWG_w is defined to aggregate a list of values $\{a_1, \ldots, a_n\}$ according to the following expression:

$$OWG_{w,z}(a_1, \ldots, a_n) = \prod_{d=1}^{n} a_{\sigma(d)}^{w_d}$$

where $a_{\sigma(d)}$ is the dth largest element in the collection $\{a_1, \ldots, a_n\}$, i.e., $a_{\sigma(1)} \geq \cdots \geq a_{\sigma(n)}$

In particular, for the weights $w_1 = (1, 0, \ldots, 0)$, $w_2 = (0, 0, \ldots, 1)$ and $w_3 = (1/n, 1/n, \ldots, 1/n)$, we have $OWG_{w_1}(a_1, \ldots, a_n) = \max\{a_1, \ldots, a_n\}$, $OWG_{w_2}(a_1, \ldots, a_n) = \min\{a_1, \ldots, a_n\}$ and $OWG_{w_3}(a_1, \ldots, a_n) = \sqrt[n]{a_1 a_2 \cdots a_n}$.

The operator OGW can be generalized to an Induced Ordered Weighted Geometric (IOWG) operator, in which the arguments are not rearranged according to their magnitude but rather using a function of the arguments, i.e., by using an inducing variable, which is denoted by **z** here (see, for instance, [12, 28]).

Definition 5 Given a weighting vector $\mathbf{w} = (w_1, w_2, \ldots, w_n)$ and a vector of order inducing variables $\mathbf{z} = (z_1, z_2, \ldots, z_n)$, the IOWG operator $IOWG_{w,z}$ is defined to aggregate the second arguments of a list of 2-tuples $\{(z_1, a_1), \ldots, (z_n, a_n)\}$ according to the following expression:

$$IOWG_{w,z}(< z_1, a_1 >, \ldots, < z_n, a_n >) = \prod_{n=1}^{n} a_{\eta(d)}^{w_d}$$

where the arguments $< z_d, a_d >$ are rearranged in such a way that $z_{\eta(d)} \geq z_{\eta(d+1)}$, $d = 1, \ldots, n-1$.

Example Let us consider variables $a_1 = 1.6$, $a_2 = 3.2$, $a_3 = 2.2$, with inducing variables $\mathbf{z} = (z_1, z_2, z_3) = (0.2, 0.9, 0.5)$. Let us calculate the IOWG operators for two different vectors of weights:

(a) With weights $\mathbf{w}_1 = (0.6, 0.1, 0.3)$,
IOWG $(< 0.2, 1.6 >, < 0.9, 3.2 >, < 0.5, 2.2 >) = 3.2^{0.6} \times 2.2^{0.1} \times 1.6^{0.3} = 2.5036$.

(b) With weights $\mathbf{w}_2 = (1/3, 1/3, 1/3)$,
$\text{IOWG}_{\mathbf{w}_2}(< 0.2, 1.6 >, < 0.9, 3.2 >, < 0.5, 2.2 >) = 3.2^{1/3} \times 2.2^{1/3} \times 1.6^{1/3} = \sqrt[3]{3.2 \times 2.2 \times 1.6}$ =Geometric Mean{1.6, 3.2, 2.2} = 2.242.

The use of IOWG allows determining the weights describing the different importance to be attached to the scores in each dimension obtained by a firm and facilitates the aggregation into an overall score.

We will follow the three-step procedure described in León et al. [15]. We will first consider an $n \times n$ matrix **M** composed of the scores of each firm in each dimension. Then, the idea is to use the same IOWG operator n times, once for the aggregation of the scores in each of the columns of **M**.

The inducing order variable is chosen to quantify a certain property of the scores in each dimension; therefore, its definition will be made in terms of the columns of **M**. In our case, we are highly concerned about the variability of the scores within each social dimension. Therefore, our induced variable will be the variance.

Step 1: Rearranging the columns of **M** according to the inducing variable (variance) from the most preferred to the less preferred. In our case, we seek for high variability.

Step 2: Determining the aggregation weights. We cannot only set an order of preference for the scores (and, consequently, for their aggregation weights) but also we can adjust the degree of such preference by means of the orness level [15]. To calculate the weights we use the method proposed by Wang and Parkan [26] in which they solve the so-called minimax disparity problem:

$$
\begin{aligned}
&\min d \\
&\text{s.t.}\quad \frac{1}{(n-1)}\left[(n-1)\,w_1 + (n-2)\,w_2 + \ldots + 2w_{n-2} + 1w_{n-1}\right] = \alpha \\
&\qquad w_1 + w_2 + \ldots + w_n = 1 \\
&\qquad w_k - w_{k+1} - d \le 0 \quad k = 1, \ldots, n-1 \\
&\qquad w_k - w_{k+1} + d \ge 0 \quad k = 1, \ldots, n-1 \\
&\qquad w_k \ge 0
\end{aligned}
$$

where $\alpha \in [0, 1]$ is the orness degree specified by the assets' manager.

Step 3: Calculating the overall scores for each firm. The overall score for each firm is the result of applying the IOWG operator to each element in a row with the aggregation weights obtained in the previous step.

Table 2.5 displays the rearranging of columns (social responsibility dimensions) according to our inducing variable (variance).

Table 2.5 Rearranging of social dimensions based on their variance

Firm	HR score	ENV score	C&S score	CG score	CIN score	HRts score
F1	29	60	35	36	62	44
F2	42	46	67	57	40	58
F3	49	75	43	63	54	47
F4	47	68	45	43	65	49
...	...	...	...	...	...	...
F73	56	49	40	43	45	56
Variance	128.74	94.83	73.69	102.27	142.69	115.49

Table 2.6 Aggregating weights for different orness levels

Weights	$\alpha = 0$	$\alpha = 0.25$	$\alpha = 0.5$	$\alpha = 0.75$	$\alpha = 1$
w_1	0	0.083333	0.166667	0.350	1
w_2	0	0.083333	0.166667	0.275	0
w_3	0	0.083333	0.166667	0.200	0
w_4	0	0.083333	0.166667	0.125	0
w_5	0	0.083333	0.166667	0.050	0
w_6	1	0.583333	0.166667	0.000	0

Table 2.7 IOWG overall scores

Firm	$\alpha = 0$	$\alpha = 0.25$	$\alpha = 0.5$	$\alpha = 0.75$	$\alpha = 1$
F1	35	38.62	42.61	43.82	62
F2	67	58.32	50.77	45.96	40
F3	43	48.26	54.17	52.99	54
F4	45	48.36	51.97	53.48	65
F5	57	55.44	53.93	50.74	67
F6	50	49.99	49.98	50.88	64
...	...	...	...	...	...
F73	40	43.72	47.78	49.85	45

Table 2.8 Ranks of the firms based on IOWG

Position	$\alpha = 0$	$\alpha = 0.25$	$\alpha = 0.5$	$\alpha = 0.75$	$\alpha = 1$
1	F2	F47	F25	F31	F62
2	F66	F66	F47	F52	F67
3	F47	F54	F17	F25	F70
4	F54	F2	F31	F67	F54
5	F71	F67	F52	F17	F19
6	F67	F17	F67	F62	F77
...	...	...	...	...	...
73	F38	F38	F50	F50	F50
# Coincidences	3	5	73	3	1

Once columns have been rearranged we obtain the aggregation weights for different orness levels, α. Table 2.6 displays the obtained aggregating weights.

Finally, we calculate the overall scores for each firm applying the IOWG operator to each element in a row (obtained scores of the firm in each dimension) with the aggregation weights obtained in the previous step. Results are displayed in Table 2.7 for the different orness levels.

In Table 2.8, we rank firms based on the IOWG overall scores and we compare the number of coincidences on the position of the firms when compared to Vigeo's ranking.

Last row in Table 2.8 shows the number of coincidences in the ranking when comparing to the rank from Vigeo's overall scores obtained using the geometric mean and equal weights for all the social dimensions. As expected, the orness level for which the number of coincidences in the position of the firm is higher is 0.5.

2.3 Portfolio Selection Model for Socially Responsible Investment

Making an investment decision involves solving, explicitly or not, a multiple criteria problem because it intends to balance between the conflicting objectives of minimizing risk and maximizing the financial return of the portfolio. Multiple Criteria Decision Making is a branch of Operational Research which has developed numerous methods for solving such financial multicriteria problems.

Zopounidis et al. [32] present an updated review of the literature on the application of Multiple Criteria Decision Making (MCDM) techniques to financial problems as, for instance, portfolio selection. Most of the portfolio selection models solved by MCDM methods are based on the classical mean-variance model. The classical portfolio analysis assumes that investors are interested only in returns attached to specific levels of risk when selecting their portfolios.

However, despite the wide-spread use of the Markowitz framework [17], there is an increasing acknowledgment among academics and practitioners of the necessity of incorporating social criteria in the portfolio selection decision process, in order to better reflect the individual preferences of investors. Some recent examples can be found in [1, 2, 4, 6–8, 11, 19, 20, 25].

Most of those authors simultaneously proposed the optimization of financial and non-financial objectives. However, SRI is characterized by the passive attitude of the asset managers in terms of social criteria. Managers usually apply negative and/or positive screens to determine the set of possible investments and then optimize financial criteria. In this chapter, once the social screening of the assets is done and their social overall scores are obtained, we propose a classical mean-variance portfolio selection model in order to obtain socially responsible investment portfolios.

2.3.1 Methodology

We use modern portfolio theory and the efficient frontier approach. To be more specific, we use the basic Markowitz's model where the criteria set consists of conventional criteria only, namely, return and risk. The investor's objective is to minimize only risk under the constraint that a specific level of return is required:

$$\begin{aligned} \text{Minimize} \; & \sum_{i=1}^{N} \sigma_i^2 x_i^2 + \sum_{i=1}^{N} \sum_{\substack{k=1 \\ k \neq i}}^{N} \sigma_{ik} x_i x_k \\ \text{s.t.} \; & \sum_{i=1}^{N} \hat{R}_i x_i \geq R_P^{\min} \\ & \sum_{i=1}^{N} x_i = 1 \\ & x_i \geq 0 \end{aligned}$$

where

$N =$ cardinality of opportunity set
$R_{i,t} =$ return on asset i at time t
$\hat{R}_i =$ expected return of asset $i = \frac{1}{T} \sum_{t=1}^{T} R_{i,t}$
$\sigma_i =$ std. dev. of asset i return $= \sqrt{\frac{1}{T-1} \sum_{t=1}^{T} (R_{i,t} - \hat{R}_i)^2}$
$\sigma_{ij} =$ covariance of assets i and $j = \frac{1}{T-1} \sum_{t=1}^{T} (R_{i,t} - \hat{R}_i)(R_{j,t} - \hat{R}_j)$
$R_P^{\min} =$ minimum expected return generated by portfolio
$x_i =$ proportion of budget allocated to asset i

Our portfolio selection model does not include among its objectives a social responsibility objective but the sample of firms is composed of the "best" companies in terms of social responsibility (companies outperforming their sectors, i.e. leaders and advanced).

2.3.2 Results

The portfolio selection problem has been solved using LINGO. Table 2.9 shows some examples of the obtained portfolios for different return targets. First column displays the portfolio number; second column shows the composition and weights of each portfolio and finally, in last column we have included the obtained return and risk for each portfolio.

We have also computed the overall social score of the portfolio, OPS, using the overall score obtained with IOWG for $\alpha = 0.5$.

Table 2.9 Some examples of portfolios

	Description of portfolios	
1	*Composition and weights:* **F4**: 0.004137. **F14**: 0.001957. **F15**: 0.046198. **F20**: 0.081607 **F34**: 0.209789. **F64**: 0.028674. **F66**: 0.015262. **F63**: 0.1979 **F67**: 0.054078. **F75:** 0.360397	*Return:* 0.2063 *Risk:* 1.8667 *OPS:* 36.2606
2	*Composition and weights:* **F14**: 0.047373. **F15**: 0.059271. **F20**: 0.072242. **F34**: 0.249584 **F63**: 0.169091. **F64**: 0.017898. **F66**: 0.000610. **F67**: 0.018202 **F75**: 0.365728	*Return:* 0.2501 *Risk:* 1.9053 *OPS:* 44.9700
3	*Composition and weights:* **F14:** 0.0954693. **F15:** 0.0750050. **F20**: 0.0563700. **F34:** 0.2910707. **F63:** 0.1268149. **F75:** 0.3552702	*Return:* 0.3001 *Risk:* 2.0205 *OPS:* 65.9891
4	*Composition and weights:* **F14**: 0.1401843. **F15**: 0.0901143. **F20**: 0.0285395 **F30**: 0.0156617. **F34**: 0.3370393. **F63**: 0.0666574 **F75**: 0.3216319. **F79**: 0.0001716	*Return:* 0.3500 *Risk:* 2.2850 *OPS:* 71.5686
5	*Composition and weights:* **F14**: 0.1763333. **F15**: 0.1017072. **F20**: 0.0013029 **F30**: 0.0414511. **F34**: 0.3778154. **F63**: 0.0100176 **F75**: 0.2873400. **F79**: 0.0040325	*Return:* 0.3999 *Risk:* 2.7016 *OPS:* 35.8386
6	*Composition and weights:* **F14**: 0.234878. **F15**: 0.111753. **F30**: 0.089682 **F34**: 0.410546. **F60**: 0.065551. **F75**: 0.082626 **F79**: 0.004963	*Return:* 0.4499 *Risk:* 3.3782 *OPS:* 77.1147
7	*Composition and weights:* **F14**: 0.168204. **F30**: 0.282336. **F34**: 0.415570 **F60**: 0.091378. **F79**: 0.042512	*Return:* 0.4999 *Risk:* 4.9569 *OPS:* 255.4497
8	*Composition and weights:* **F30**: 0.608525. **F34**: 0.284320. **F60**: 0.000000 **F79**: 0.107155	*Return:* 0.5498 *Risk:* 9.7072 *OPS:* 360.6655

As we can observe in Fig. 2.2, firm F34 (Essilor International, Healthcare equipment) appears in all the portfolios followed in frequency by firms F14 (Beiersdorf, Luxury goods & cosmetics), F15 (BIC, Specialized retail) and F75 (Unilever, Food). These firms rank in positions 71, 60, 45 and 58 respectively, with regards to their overall firm score, OFS, for an orness degree, $\alpha = 0.5$.

It is interesting to observe how the higher the return the higher the risk, as expected. However, when calculating the associated overall IOWA score for each portfolio we find out how portfolio #5 decreases social responsibility with respect to portfolio #4 for a higher return and a higher risk. It is also surprising how the levels of social responsibility of portfolios #7 and #8 are considerably higher when compared to the other portfolios.

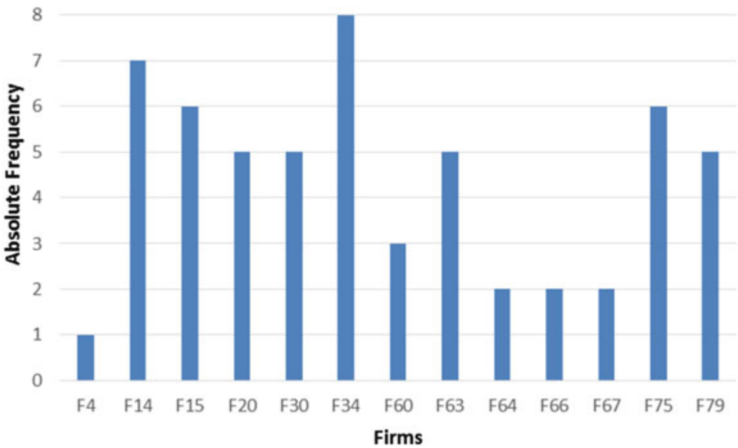

Fig. 2.2 Frequency of firms in portfolios

2.4 Conclusions

In this chapter we have solved a socially responsible portfolio selection problem. The investment strategy of Socially Responsible Investment mainly consists of the application of negative and positive screening. In this chapter we have solved the portfolio selection problem in two main steps. In the first one, we have applied both, negative and positive screenings to the sample of firms rated by a social rating agency, Vigeo. First, we have calculated a measure of the social performance of the firm with respect to its sector. Based on this measure, we have excluded from the sample those firms underperforming their sectors. Then, we have ranked firms outperforming their sectors and we have selected only the leaders and advanced firms.

When analyzing the social scores provided by the rating agency for the firms we have realized that the geometric mean with equal weights used by Vigeo to obtain an overall social score has some important limitations. In order to overcome these limitations we have proposed an aggregating method that allows establishing different objective weights for the different social dimensions based on the nature of the data, in our case, scores in the different dimensions. IOWG has been applied using as inducing variable the variability of the scores in each dimension measured by the sample relative variance. Dimensions have been ordered based on their variance and weights have been determined for each dimension using an objective method. The obtained results are quite different from the results obtained by Vigeo using for the aggregation the geometric mean and using equal unitary weights. This shows how the ranking is sensitive to the weights of the dimensions.

Once a suitable measure has been obtained, a classical portfolio selection model has been solved. Several portfolios have been obtained in this second step with different levels of return-risk and the associated overall social score has been calculated for each of them.

References

1. Ballestero, E., Bravo, M., Pérez-Gladish, B., Arenas-Parra, M., Plà-Santamaria, D.: Socially responsible investment: a multicriteria approach to portfolio selection combining ethical and financial objectives. Eur. J. Oper. Res. **216**(2), 487–494 (2012)
2. Ballestero, E., Pérez-Gladish, B., Garcia-Bernabeu, A. (eds.): Socially Responsible Investment. A Multi-Criteria Decision Making Approach. International Series in Operations Research & Management Science, vol. 219. Springer, Heidelberg (2015)
3. Barnett, M.L., Salomon, R.M.: Beyond dichotomy: the curvilinear relationship between social responsibility and financial performance. Strateg. Manag. J. **27**(11), 1101–1122 (2006)
4. Bilbao-Terol, A., Arenas-Parra, M., Cañal-Fernández, V.: Selection of socially responsible portfolios using goal programming and fuzzy technology. Inf. Sci. **189**, 110–125 (2012)
5. Brammer, S., Brooks, C., Pavelin, S.: Corporate social performance and stock returns: UK evidence from disaggregate measures. Financ. Manag. **35**, 97–116 (2006)
6. Cabello, J.M., Ruiz, F., Pérez-Gladish, B., Méndez-Rodríguez, P.: Synthetic indicators of mutual funds' environmental responsibility: an application of the reference point method. Eur. J. Oper. Res. **236**(1), 313–325 (2014)
7. Calvo, C., Ivorra, C., Liern, V.: Fuzzy portfolio selection with non-financial goals: exploring the efficient frontier. Ann. Oper. Res. (2014). doi:10.1007/S10479-014-1561-2 [published online 26 February 2014]
8. Dorfleitner, G., Utz, S.: Safety first portfolio choice based on financial and sustainability returns. Eur. J. Oper. Res. **221**(1), 155–164 (2012)
9. Dupré, D., Girerd-Potin, I., Kassoua, R.: Adding an ethical dimension to portfolio management. Financ. India **18**, 625–642 (2004)
10. Gupta, P., Mehlawat, M.K., Saxena, A.: Hybrid optimization models of portfolio selection involving financial and ethical considerations. Knowl. Based Syst. **37**, 318–337 (2013)
11. Hallerbach, W., Ning, H., Soppe, A., Spronk, J.: A framework for managing a portfolio of socially responsible investments. Eur. J. Oper. Res. **153**(2), 517–529 (2004)
12. Herrera, F., Herrera-Viedma, E., Chiclana, F.: A study of the origin and uses of the ordered weighted geometric operator in multicriteria decision making. Int. J. Intell. Syst. **18**(6), 689–707 (2003)
13. Hirschberger, M., Steuer, R.E., Utz, S., Wimmer, M.: Is socially responsible investing just screening? Evidence from mutual funds. Tech. rep., SFB 649 discussion paper (2012)
14. Jegourel, Y., Maveyraud, S.: A reassessment of the European SRI funds 'underperformance': does the intensity of extra-financial negative screening matter? Econ. Bull. **30**(1), 913–923 (2010)
15. León, T., Ramón, N., Ruiz, J.L., Sirvent, I.: Using induced ordered weighted averaging (IOWA) operators for aggregation in cross-efficiency evaluations. Int. J. Intell. Syst. **29**(12), 1100–1116 (2014)
16. Liern, V., Méndez-Rodrıguez, P., Pérez-Gladish, B.: A soft computing approach for ranking firms based on experts' valuation of corporate social responsibility. Appl. Math. Inf. Sci. **9**(3), 1113–1122 (2015)
17. Markowitz, H.: Portfolio selection. J. Financ. **7**(1), 77–91 (1952)
18. Ouenniche, A., Ouenniche, J., M'Zali, B., Pérez-Gladish, B.: A portfolio analysis approach to assist socially responsible investors in making decisions. Int. J. Oper. Res. (2015, in press)
19. Perez-Gladish, B., M'Zali, B.: An AHP-based approach to mutual funds' social performance measurement. Int. J. Multicrit. Decis. Mak. **1**(1), 103–127 (2010)
20. Pérez-Gladish, B., Rodríguez, P.M., M'zali, B., Lang, P.: Mutual funds efficiency measurement under financial and social responsibility criteria. J. Multicrit. Decis. Anal. **20**(3–4), 109–125 (2013)
21. Renneboog, L., Ter Horst, J., Zhang, C.: Socially responsible investments: institutional aspects, performance, and investor behavior. J. Bank. Financ. **32**(9), 1723–1742 (2008)

22. Sauer, D.A.: The impact of social-responsibility screens on investment performance: evidence from the Domini 400 social index and Domini equity mutual fund. Rev. Financ. Econ. **6**(2), 137–149 (1997)
23. Scholtens, B.: Financial and social performance of socially responsible investments in the Netherlands. Corp. Gov. Int. Rev. **15**(6), 1090–1105 (2007)
24. SIF: Report on socially responsible investing trends in the United States. In: Social Investment Forum, Washington, DC (2012)
25. Utz, S., Wimmer, M., Hirschberger, M., Steuer, R.E.: Tri-criterion inverse portfolio optimization with application to socially responsible mutual funds. Eur. J. Oper. Res. **234**(2), 491–498 (2014)
26. Wang, Y.M., Parkan, C.: A minimax disparity approach for obtaining OWA operator weights. Inf. Sci. **175**(1), 20–29 (2005)
27. Xu, Z.: On generalized induced linguistic aggregation operators. Int. J. Gen. Syst. **35**(1), 17–28 (2006)
28. Xu, Z., Da, Q.: The ordered weighted geometric averaging operators. Int. J. Intell. Syst. **17**(7), 709–716 (2002)
29. Yager, R.R.: On ordered weighted averaging aggregation operators in multicriteria decision-making. IEEE Trans. Syst. Man Cybern. **18**(1), 183–190 (1988)
30. Yager, R.R.: Induced aggregation operators. Fuzzy Sets and Syst. **137**(1), 59–69 (2003)
31. Yager, R.R., Filev, D.P.: Induced ordered weighted averaging operators. IEEE Trans. Syst. Man Cybern. B Cybern. **29**(2), 141–150 (1999)
32. Zopounidis, C., Galariotis, E., Doumpos, M., Sarri, S., Andriosopoulos, K.: Multiple criteria decision aiding for finance: an updated bibliographic survey. Eur. J. Oper. Res. **247**(2), 339–348 (2015)