Ca' Foscari
University
of Venice

Department of Economics

Working Paper

Antonella Basso
and Stefania Funari

Constant and variable returns to scale DEA models for socially responsible investment funds

ISSN: 1827/3580
No. 20/WP/2012

Working Papers
Department of Economics
Ca' Foscari University of Venice
No. 20/WP/2012
ISSN 1827-3580

Constant and variable returns to scale DEA models for socially responsible investment funds

Antonella Basso
Department of Economics – Ca' Foscari University of Venice
Stefania Funari
Department of Management – Ca' Foscari University of Venice

August 24, 2012

Abstract
In order to evaluate the performance of socially responsible investment (SRI) funds, we propose some models which use data envelopment analysis and can be computed in all phases of the business cycle. These models focus on the most crucial elements of an investment in mutual funds.
In the literature both constant and variable returns to scale DEA models have been used to evaluate the performance of mutual funds. An empirical investigation carried out on European SRI equity funds indicates that for the funds analyzed the returns to scale are constant. Another aspect taken into account by the empirical investigation is the measurement of the degree of social responsibility of SRI equity funds in the various European countries. In addition, we have analyzed the performance of the funds considered with the different DEA models proposed, which differ in the way the ethical objective is taken into account. Moreover, the paper focuses on another crucial issue regarding socially responsible investing: the comparison of the performances between SRI and non SRI funds; the empirical study suggests that the ethical objective can be pursued without having to renounce financial rewards.

Keywords: Data envelopment analysis, Finance, Mutual fund performance evaluation, Socially responsible investing
JEL Codes: C65, G1, G23

Address for correspondence:
Antonella Basso
Department of Economics
Ca' Foscari University of Venice
Cannaregio 873, Fondamenta S.Giobbe
30121 Venezia - Italy
Phone: (++39) 041 2346914
Fax: (++39) 041 2347444
e-mail: basso@unive.it

The Working Paper Series is available only on line (http://www.unive.it/nqcontent.cfm?a_id=86302)
For editorial correspondence, please contact: wp.dse@unive.it

Department of Economics
Ca' Foscari University of Venice
Cannaregio 873, Fondamenta San Giobbe
30121 Venice Italy
Fax: ++39 041 2349210

1. Introduction

The data envelopment analysis (DEA) methodology can be used to define mutual fund performance measures that allow to take into consideration several input variables, such as different risk measures and the initial and exit fees of the investment, as well as several output variables, such as a return indicator but also indicators related to other objectives of the investors (see e.g. Murthi et al. (1997) and Basso and Funari (2001), but also more recent contributions such as Chen and Lin (2006), Kerstens et al. (2011) and Lamb and Tee (2012)).

DEA models can also easily integrate non financial objectives that drive the choices of investors who turn their attention to socially responsible investing (SRI). Actually, the market of socially responsible investment funds has seen a marked increase in the last decade both in the US and in Europe, while the traditional indicators used to evaluate the performance of mutual funds do not allow to take account of non financial aspects, such as the ethical level of mutual funds. Along this line, Basso and Funari (2003) presents some DEA models specifically designed to evaluate the performance of SRI funds, which explicitly consider the ethical level of the mutual funds among the outputs.

In order to evaluate the performance of both SRI and non SRI funds, we apply some special models which use the data envelopment analysis technique and can be computed in all phases of the business cycle.

Unlike much of the literature on mutual funds, in this contribution we propose to focus on what can be considered as the most crucial elements of an investment in mutual funds: the capital which is invested at the beginning of the holding period, the risk that has to be sustained and the final value which is withdrawn at the end of the holding period.

Hence, in this paper we propose to include among the inputs of the DEA models the initial capital invested in the mutual fund, assumed equal for all funds analyzed. In the literature the case of a constant input is studied with reference to DEA models with a single input (see Lovell and Pastor (1999) and Soares de Mello et al. (2009)); on the contrary, in our models the initial capital is only one of the inputs taken into consideration, since the volatility of the investment and/or other risk measures are other important features considered.

On the other hand, we include among the outputs the net final value of the investment and a measure of the degree of social responsibility of the investment fund.

In order to compute the net final value of the investment, first of all we have to choose the holding period of the investment considered in the analysis. Then we have to take into account the charges entailed by the investment in the mutual fund (initial and/or exit fees), which lower the overall profitability of the financial investment. In the case of a unit investment, the final value net of fee can be defined as follows

$$M_j = (1 - c_{Ij})(1 + R_j)^T (1 - c_{Ej}) \qquad j = 1, 2, \ldots, n, \tag{1}$$

where R_j denotes the mean return of fund j (with $j = 1, 2, \ldots, n$, n being the number of mutual funds considered) in the holding period of length T consid-

ered and c_{Ij} and c_{Ej} denote the initial and exit charges required by the fund, respectively. Hence, M_j is the net amount obtained at the end of the holding period by investing 1 monetary unit at the beginning.

Let us remark that, by definition of mutual funds, the final value (1) cannot become negative: in the worst case (fortunately rare) we may at most lose all the capital invested. This means that, using the final value as a measure of profitability in place of the mean return, we overcome the computational difficulties encountered in slump periods, in which the mean return is negative for many mutual funds.

This is especially important in periods of financial crises, since in times of crisis the historical mean returns of most mutual funds are negative, and this would force the models that rely on mean returns to resort to one of the devices suggested to deal with the problem of the presence of negative data in DEA models. For example, among the models which can be used in order to tackle the problem of negative output data in the DEA analysis we may cite the additive models, which are translation invariant (see Cooper et al. (2000), Ali and Seiford (1990) and Lovell and Pastor (1995)), the input oriented BCC model (see Chen and Lin (2006)), the range directional model proposed in Silva Portela et al. (2004) and the semi-oriented radial measure recently proposed in Emrouznejad et al. (2010).

In addition to the final value of the investment, when we analyze the performance of SRI funds we introduce among the outputs also a measure of the ethical level of the funds, as suggested by Basso and Funari (2003), and we present a method to evaluate the degree of social responsibility by taking the main ethical features into account.

As for the question of which DEA model is more suitable for the evaluation of the performance of SRI and non SRI funds, we may wonder whether it is better to use a constant or a variable returns to scale model; for a discussion on the issue of returns to scale in data envelopment analysis we refer to Banker et al. (2011).

In the literature both the constant returns to scale CCR and the variable returns to scale BCC models have been used to evaluate the performance of mutual funds, often without an explicit discussion of the motivations. On the one hand, the CCR model has the advantage to allow for a generalization of well known financial performance indexes such as the Sharpe ratio (see the pioneering contributions Murthi et al. (1997) and Basso and Funari (2001)). On the other hand, the BCC models are more flexible and allow to consider also variable returns to scale (see for example Glawischnig and Sommersguter-Reichmann (2010)); an empirical investigation of returns to scale in a mutual fund market is presented in Kerstens et al. (2011).

As for the orientation of the models, the contributions that use a BCC model to evaluate the performance of mutual funds tend to adopt an input orientation, due to the fact that the BCC model with this orientation is translation invariant with respect to output variables, thus allowing to overcome the problem posed by the presence of negative mean returns. However, with our choice of input and output variables, the problem of negative data is bypassed by construction,

so that we are no longer bound in the choice of the model orientation.

In our opinion, the model orientation which is more suitable for evaluating the performance of mutual funds is the output one. Indeed, the presence of a constant input, such as the initial capital, suggests as natural the output orientation, in which the objective is to maximize the value of the output variables (in our case, the final value of the investment and the ethical level of the fund) without increasing the value of the input variables (in our case, the capital initially invested and one or more risk measures). At the same time, the presence of a constant input makes the choice of the input orientation inconsistent, since in an input oriented model the objective is to minimize inputs without decreasing the output levels.

In the empirical investigation carried out for European SRI equity funds we have specifically compared the results of the constant and variable returns to scale models, using the output orientation; interestingly, the results indicate that for all the funds analyzed the returns to scale are constant.

In addition, the empirical analysis carried out, concerning the period June 2006 to June 2009, has investigated both the degree of social responsibility of SRI funds in the various European countries and their performance.

Finally, we have focused the attention on another crucial issue regarding socially responsible investing, long debated in the literature: the comparison of the performances between SRI and non SRI funds. In particular, the empirical study tries to ascertain if the ethical aim has to be reached at the expense of financial rewards.

The paper is organized as follows. In Section 2 we present three DEA models with constant returns to scale that differ in the way the ethical objective is taken into account; in Section 3 we present the corresponding models with variable returns to scale, while in Section 4 we study the relations that exist among the performance measures obtained with the different models. Section 5 defines the ethical measure proposed and Section 6 summarises the specific analysis of the degree of social responsibility of European SRI funds. The empirical results on the performance of the European SRI funds are synthesized in Section 7, while Section 8 compares the performance of SRI and non SRI mutual funds. Finally, Section 9 presents some conclusions.

2. Models with constant returns to scale

In this section we present some models with constant returns to scale which can be adopted to analyse the performance of both SRI and non SRI funds. We begin with a basic model without the ethical measure, which can be used to evaluate the performance of non SRI funds but will be used in Section 8 also to test if the SRI funds require a sacrifice in terms of financial returns.

2.1. DEA-C model

Let us denote by:

$\{1, 2, \ldots, n\}$	the set of mutual funds considered
M_j	the final value for fund $j \in \{1, 2, \ldots, n\}$
σ_j	the historical volatility of fund j, i.e. the standard deviation of the returns of fund j
u	the weight assigned to the final value M_j
v_1	the weight assigned to the unit initial investment
v_2	the weight assigned to the standard deviation σ_j
ε	a non-archimedean constant that prevents the weights from vanishing (see for example Cooper et al. (2000))

A CCR basic DEA model for the computation of the performance measure of mutual funds can be written as follows:

$$\max_{\{u,v_i\}} \quad \frac{uM_{j_0}}{v_1 + v_2\sigma_{j_0}} \tag{2}$$

subject to

$$\frac{uM_j}{v_1 + v_2\sigma_j} \leq 1 \qquad j = 1, 2, \ldots, n \tag{3}$$

$$u \geq \varepsilon, \tag{4}$$

$$v_i \geq \varepsilon \qquad i = 1, 2 \tag{5}$$

The DEA performance measure for fund j_0, $I_{j_0,DEA-C}$, is the optimal value obtained for the objective function:

$$I_{j_0,DEA-C} = \frac{u^* M_{j_0}}{v_1^* + v_2^*\sigma_{j_0}}. \tag{6}$$

Let us observe that in model (2)–(5) we have used (and included among the inputs) the historical volatility σ_j as a risk measure of the investment in fund j, but we could also use one or more different risk measures without changing the structure of the model; for different risk measures that can be used in DEA models see for example Basso and Funari (2001) and Chen and Lin (2006).

As it is well known, from a computational point of view the solution of problem (2)–(5) can be more conveniently computed by solving the following equivalent linear programming problem (see for example Cooper et al. (2000)):

$$\min_{\{u,v_i\}} \quad v_1 + v_2\sigma_{j_0} \tag{7}$$

subject to

$$uM_{j_0} = 1 \tag{8}$$

$$-uM_j + v_1 + v_2\sigma_j \geq 0 \quad j = 1, 2, \ldots, n \tag{9}$$

$$u \geq \varepsilon \tag{10}$$

$$v_i \geq \varepsilon \qquad i = 1, 2. \tag{11}$$

2.2. DEA-CE model for SRI funds

Model (2)–(5) can be applied to evaluate the performance of all mutual funds, but it does not explicitly take into consideration a socially responsible objective. It is immediate to generalise this model so that we can take into account also the ethical objective of investors in SRI funds:

$$\max_{\{u_r, v_i\}} \quad \frac{u_1 M_{j_0} + u_2 e_{j_0}}{v_1 + v_2 \sigma_{j_0}} \tag{12}$$

subject to

$$\frac{u_1 M_j + u_2 e_j}{v_1 + v_2 \sigma_j} \leq 1 \qquad j = 1, 2, \ldots, n \tag{13}$$

$$u_r \geq \varepsilon \qquad r = 1, 2 \tag{14}$$

$$v_i \geq \varepsilon \qquad i = 1, 2, \tag{15}$$

where e_j denotes the ethical measure used to rate SRI funds according to their ethical profile; a suitable ethical measure will be proposed in Section 5.

Therefore, a DEA performance measure for fund j_0 which gives social responsibility an additional premium is given by the optimal value of the objective function (12):

$$I_{j_0, DEA-CE} = \frac{u_1^* M_{j_0} + u_2^* e_{j_0}}{v_1^* + v_2^* \sigma_{j_0}}. \tag{16}$$

Again, model (12)–(15) is equivalent to a linear programming problem which can be easily solved; it is also useful to consider the dual program:

$$\max \quad z_0 + \varepsilon s_1^+ + \varepsilon s_2^+ + \varepsilon s_1^- + \varepsilon s_2^- \tag{17}$$

subject to

$$M_{j_0} z_0 - \sum_{j=1}^{n} M_j \lambda_j + s_1^+ = 0 \tag{18}$$

$$e_{j_0} z_0 - \sum_{j=1}^{n} e_j \lambda_j + s_2^+ = 0 \tag{19}$$

$$\sum_{j=1}^{n} \lambda_j + s_1^- = 1 \tag{20}$$

$$\sum_{j=1}^{n} \sigma_j \lambda_j + s_2^- = \sigma_{j_0} \tag{21}$$

$$\lambda_j \geq 0 \qquad j = 1, 2, \ldots, n \tag{22}$$

$$s_r^+ \geq 0 \qquad r = 1, 2 \tag{23}$$

$$s_i^- \geq 0 \qquad i = 1, 2 \tag{24}$$

$$z_0 \qquad \text{unconstrained}, \tag{25}$$

where z_0 is the dual variable associated with the equality constraint $u_1 M_{j_0} + u_2 e_{j_0} = 1$, λ_j are the dual variables associated with the mutual funds constraints $-u_1 M_j - u_2 e_j + v_1 + v_2 \sigma_j \geq 0$ and s_i^- and s_r^+ are the dual variables connected with the input and output weight constraints $v_i \geq \varepsilon$ and $u_r \geq \varepsilon$, respectively.

We may observe that due to the presence of a constant input (the initial capital) we have

$$\sum_{j=1}^{n} \lambda_j \leq 1 \tag{26}$$

so that, following Banker et al. (2011), the sum of the dual variables λ_j cannot identify any situation of decreasing returns to scale.

2.3. DEA-CEef model for SRI funds

Model (12)–(15) is fairly straightforward and is effective in measuring the performance of SRI and non SRI funds under the assumption that investors choose their investment in mutual funds by trying to maximise their satisfaction which depends, among other things, on both the return of the investment and its ethical level.

On the other hand, when investing in a socially responsible manner, some investors fix the value of the ethical level they prefer in advance, and try to maximise their satisfaction by choosing among the funds with at least this value. In such a case, a constraint is actually imposed on the fund chosen; indeed, investors that choose a given ethical level discard the funds with lower ethical levels and try to maximize their satisfaction among all the funds that satisfy the required ethical level.

Formally, this entails that the ethical level has to be considered as an exogenously fixed output; on DEA models for exogenously fixed inputs or outputs see Banker and Morey Banker and Morey (1986). It can be proved that this constraint leads to the following model in the case of constant returns to scale:

$$\max \quad z_0 + \varepsilon s_1^+ + \varepsilon s_1^- + \varepsilon s_2^- \tag{27}$$

subject to

$$M_{j_0} z_0 - \sum_{j=1}^{n} M_j \lambda_j + s_1^+ = 0 \tag{28}$$

$$\sum_{j=1}^{n} e_j \lambda_j - s_2^+ = e_{j_0} \tag{29}$$

$$\sum_{j=1}^{n} \lambda_j + s_1^- = 1 \tag{30}$$

$$\sum_{j=1}^{n} \sigma_j \lambda_j + s_2^- = \sigma_{j_0} \tag{31}$$

$$\lambda_j \geq 0 \qquad j = 1, 2, \ldots, n \tag{32}$$

$$s_r^+ \geq 0 \qquad r = 1, 2 \tag{33}$$
$$s_i^- \geq 0 \qquad i = 1, 2 \tag{34}$$
$$z_0 \qquad \text{unconstrained,} \tag{35}$$

As a matter of fact, it is well known that the solution of a dual problem such as (17)–(25) enables to identify a virtual unit made up of a linear combination of efficient funds, with coefficients given by the optimal values of the dual variables λ_j $(j = 1, 2, \ldots, n)$, that uses a level of inputs which is not greater than that employed by fund j_0 and obtains a level of outputs that is not lower than that obtained by fund j_0.

When the ethical level is considered as an exogenously fixed output, the virtual unit is required to have an ethical level not lower than that of fund j_0

$$\sum_{j=1}^{n} e_j \lambda_j^* \geq e_{j_0} \tag{36}$$

and constraint (19) of the dual problem has to be substituted by the following constraint

$$\sum_{j=1}^{n} e_j \lambda_j - s_2^+ = e_{j_0}. \tag{37}$$

Moreover, following the suggestion of Banker and Morey (1986), we relax the constraint on the weight u_2 in the primal problem to a pure non negativity constraint; this entails that the coefficient of the slack variable s_2^+ in the objective function of the dual problem vanishes. With these modifications we obtain the dual program (27)–(35).

By construction, the performance index when the ethical level is exogenously fixed, $I_{j_0,DEA-CEef}$, is the reciprocal of the optimal value of z_0.

3. Variable returns to scale models

Models analogous to the three models presented in the previous section for the case of constant returns to scale can be written also for the case of variable returns to scale. We will denote these BCC models - with an output orientation, as discussed in the introduction - by DEA-V, DEA-VE and DEA-VEef, respectively.

In the following subsection we present the DEA-VE model for SRI funds; the variable returns to scale version of the exogenously fixed output model is similar, as is that of the model without the ethical level.

3.1. DEA-VE model for SRI funds

From the dual model (17)–(25) it is straightforward to write the output oriented BCC model with variable returns to scale, DEA-VE. It suffices to

observe that the additional constraint which characterises the BCC model in dual form,

$$\sum_{j=1}^{n} \lambda_j = 1, \tag{38}$$

together with with constraint (20), entails that the dual variable s_1^- is equal to zero.

The variable returns to scale DEA-VE model can therefore be written as follows:

$$\max \quad z_0 + \varepsilon s_1^+ + \varepsilon s_2^+ + \varepsilon s_2^- \tag{39}$$

subject to

$$M_{j_0} z_0 - \sum_{j=1}^{n} M_j \lambda_j + s_1^+ = 0 \tag{40}$$

$$e_{j_0} z_0 - \sum_{j=1}^{n} e_j \lambda_j + s_2^+ = 0 \tag{41}$$

$$\sum_{j=1}^{n} \sigma_j \lambda_j + s_2^- = \sigma_{j_0} \tag{42}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{43}$$

$$\lambda_j \geq 0 \qquad j = 1, 2, \ldots, n \tag{44}$$

$$s_r^+ \geq 0 \qquad r = 1, 2 \tag{45}$$

$$s_2^- \geq 0 \tag{46}$$

$$z_0 \qquad \text{unconstrained}, \tag{47}$$

where constraint (20) is replaced by constraint (38) and the dual variable s_1 is omitted.

It can be noticed that all optimal solutions of the DEA-CE model (17)–(25) with $s_1^- = 0$, i.e. for which constraint (26) is satisfied as equality, are also optimal solutions of the DEA-VE model.

4. Relations between the performance indexes

It can be proved that among the performance indexes obtained with the constant returns to scale models *DEA-C*, *DEA-CE* and *DEA-CEef* there exist some useful relations.

Theorem 1. *Let $I_{j_0,DEA-C}$, $I_{j_0,DEA-CEef}$ and $I_{j_0,DEA-CE}$ be the DEA performance measures for fund j_0 defined in Section 2. The following inequalities hold:*

$$I_{j_0,DEA-C} \leq I_{j_0,DEA-CEef} \leq I_{j_0,DEA-CE}. \tag{48}$$

PROOF. Let us first prove the inequality $I_{j_0,DEA-CEef} \leq I_{j_0,DEA-CE}$. Since in both problems (17)–(25) and (27)–(35) the optimal value of the dual variable z_0 is not lower than 1, if we cut the feasible regions of both problems by introducing the additional constraint $z_0 \geq 1$ we do not cut out the optimal solution. In the remaining part of the feasible region, we have $\sum_{j=1}^{n} e_j \lambda_j \geq e_{j_0} z_0 \geq e_{j_0}$ and therefore constraint (19) is more restrictive than constraint (29). As all the other constraints of the feasible regions of problems (17)–(25) and (27)–(35) are equal, we conclude that the feasible region of problem (17)–(25) is a subset of that of problem (27)–(35). Since the difference between the objective functions of the two dual problems is given by εs_2^+ which is lower than any positive real number, given the nature of non-Archimedean infinitesimal of ε, the optimal solution of problem (17)–(25) is lower than or equal to the optimal solution of problem (27)–(35). Hence, for their reciprocal values, which give the DEA performance measures $I_{j_0,DEA-CE}$ and $I_{j_0,DEA-CEef}$, respectively, the reverse inequality holds.

Let us now demonstrate the inequality $I_{j_0,DEA-C} \leq I_{j_0,DEA-CEef}$. Let us compare the dual programs associated to the DEA-C and DEA-CEef models. We may observe that the dual program connected to the DEA-C model (the dual of problem (7)–(11)) can be obtained from the dual program (27)–(35) connected to the DEA-CEef model by omitting constraint (29) and the variable s_2^+, the remaining constraints and the objective function being the same. The optimal solution of the second program, with the more restricted feasible region, cannot be higher than the optimal solution of the first one; therefore, for their reciprocal values, which give the DEA performance measures $I_{j_0,DEA-CEef}$ and $I_{j_0,DEA-C}$, respectively, the reverse inequality holds.

Another useful relation concerns the efficiency measures of the non SRI funds obtained with the models for ethical funds.

Theorem 2 shows that for a mutual fund j_0 with ethical measure equal to 0 (i.e. a non SRI fund) the use of either the DEA-CE or DEA-CEef models does not improve the fund efficiency score.

Theorem 2. *Let j_0 be a mutual fund with ethical measure $e_{j_0} = 0$ and let $I_{j_0,DEA-C}$, $I_{j_0,DEA-CEef}$ and $I_{j_0,DEA-CE}$ be the DEA performance measures defined in Section 2. The following equalities hold:*

$$I_{j_0,DEA-C} = I_{j_0,DEA-CEef} = I_{j_0,DEA-CE}. \tag{49}$$

PROOF. By Theorem 1 it is sufficient to prove that $I_{j_0,DEA-C} = I_{j_0,DEA-CE}$. Let us observe that when $e_{j_0} = 0$ the dual problem (17)–(25) can be written by eliciting the variable s_2^+ from the equality constraint (19) and substituting its formula

$$s_2^+ = \sum_{j=1}^{n} e_j \lambda_j \tag{50}$$

in the objective function; the non negativity constraint $s_2^+ \geq 0$ is redundant in this case, since $\sum_{j=1}^{n} e_j \lambda_j \geq 0$ as both e_j and λ_j are non negative. With this

substitution we obtain an equivalent program with the same feasible region as the dual program connected to the DEA-C model (the dual of problem (7)–(11)), while the difference between the objective functions of the two dual problems is given by the term $\varepsilon \sum_{j=1}^{n} e_j \lambda_j$. This term is the product of a non-Archimedean infinitesimal and a limited quantity (notice that the dual variables λ_j cannot be greater than 1 for all j by constraint (20)), so that the performance indicators $I_{j_0,DEA-C}$ and $I_{j_0,DEA-CE}$ coincide.

Analogous relations hold for the performance indexes obtained with the variable returns to scale models *DEA-V*, *DEA-VE* and *DEA-VEef*.

Theorem 3. *Let $I_{j_0,DEA-V}$, $I_{j_0,DEA-VEef}$ and $I_{j_0,DEA-VE}$ be the DEA performance measures for fund j_0 defined in Section 3. The following inequalities hold:*

$$I_{j_0,DEA-V} \leq I_{j_0,DEA-VEef} \leq I_{j_0,DEA-VE}. \tag{51}$$

Proof. Theorem 3 can be proved similarly to Theorem 1.

Theorem 4. *Let j_0 be a mutual fund with ethical measure $e_{j_0} = 0$ and let $I_{j_0,DEA-V}$, $I_{j_0,DEA-VEef}$ and $I_{j_0,DEA-VE}$ be the DEA performance measures defined in Section 3. The following equalities hold:*

$$I_{j_0,DEA-V} = I_{j_0,DEA-VEef} = I_{j_0,DEA-VE}. \tag{52}$$

Proof. Theorem 4 can be proved similarly to Theorem 2.

In addition, we have:

$$I_{j_0,DEA-C} \leq I_{j_0,DEA-V} \tag{53}$$

$$I_{j_0,DEA-CE} \leq I_{j_0,DEA-VE} \tag{54}$$

$$I_{j_0,DEA-CEef} \leq I_{j_0,DEA-VEef} \tag{55}$$

due to the fact that the BCC model differs from the CCR model only for the additional constraint $\sum_{j=1}^{n} \lambda_j = 1$.

5. A measure of the degree of social responsibility

The models for SRI funds presented in Sections 2 and 3 use as an output variable an ethical measure e_j. In this section we define a suitable ethical measure that can be computed from the data inferred from the ethical profile of mutual fund j.

In particular, in order to assess the degree of the socially responsible behaviour of the funds stated as SRI funds, we have focused our attention on a number of questions which define this behaviour and are related to either ethical, social or green issues. These questions can be grouped into issues used to exclude from the portfolios the assets of the companies with a profile that is bad for socially responsible criteria (negative screening), and issues used to include

in the portfolio investments in companies which are selected on the ground of their SRI behaviour (positive screening).

More in detail, the questions considered are taken from the 'SRI Funds Service'[1] and can be summarized as follows:

- ***Negative screening issues**: 1. firearms; 2. weapons and military contracting; 3. nuclear energy; 4. tobacco; 5. gambling; 6. human rights violations; 7. Labour right violations; 8. oppressive regimes; 9. pornography; 10. alcohol; 11. animal testing; 12. factory farming; 13. furs; 14. excessive environmental impact and natural resources c.; 15. GMO; 16. products dangerous to health/environment; 17. other.*

- ***Positive screening issues**: 1. innovative and beneficial products and services for the environment; 2. innovative and beneficial products and services for the quality of life (e.g. health care, social housing); 3. responsible management of relations with customers; 4. environmental protection; 5. responsible management of employees; 6. human rights protection & supply chain; 7. promotion of economic and social development of local communities; 8. corporate governance; 9. fund investing according to the Islamic religion principles; 10. fund investing according to the Christian religion principles; 11. other.*

Another important information on the behaviour of SRI funds is the (eventual) presence of an ethical or environmental committee which has the function of defining the guidelines of the socially responsible investments and controlling the actions of the fund management in this respect.

We propose to measure the degree of the socially responsible behaviour as follows. Let n_j^N and n_j^P be the number of negative and positive screening features presented by fund j, respectively, and let L be the maximum value assigned to the ethical measure, so that it will be defined in the real interval $[0, L]$. The ethical measure is defined as follows:

$$e_j = \omega^N \frac{n_j^N}{n^N} + \omega^P \frac{n_j^P}{n^P} + \omega^C C_j \tag{56}$$

where n^N and n^P are the total number of negative and positive screening issues taken into account, respectively, C_j is a variable which takes value 1 if fund j has an ethical or environmental committee and 0 otherwise and ω^N, ω^P and ω^C are positive weights such that $L = \omega^N + \omega^P + \omega^C$.

For example, in the empirical analysis carried out we have chosen $\omega^N = \omega^P = 2$ and $\omega^C = 1$, so that

$$e_j = 2\,\frac{n_j^N}{17} + 2\,\frac{n_j^P}{11} + C_j \tag{57}$$

[1]The 'SRI Funds Service' is a database of European SRI funds, offered since 1999 by the corporate social responsibility rating agency Vigeo Italia (formerly Avanzi SRI Research); financial data are added to the socially responsible database through a partnership with Morningstar. We thank Vigeo Italia for allowing us to use their database.

and $0 \leq e_j \leq 5$; with such a choice we give the same importance to the negative and positive screening and less relevance to the presence of the ethical committee. Notice that $e_j > 0$ denotes a socially responsible fund, while non SRI funds have $e_j = 0$.

6. SRI funds in Europe: how much responsible?

The fraction of overall total asset under management referred to SRI funds domiciled in Europe may seem not much significant (1.11 % of total UCITS[2] on 30/06/2009, see Vigeo (2009)); it is nevertheless a question of more than 50 billion euros (53276 million euros on 30/06/2009). Moreover, the SRI phenomenon is rapidly expanding; see figure 1 for the growth of the total asset under management since 1999. In the triennium June 2006–June 2009 the total asset under management increased from 34009 to 53276 million euros, with a growth of +57 % (+381 % in ten years).

On 30/06/2006, at the beginning of the triennium considered in our analysis, the number of European SRI funds was equal to 388, spread over 15 countries (Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Norway, Poland, Spain, Sweden, Switzerland, Netherlands, United Kingdom; see Vigeo (2009)). Three years later, on 30/06/2009, this number has increased to 683 (+76 %). We may observe that the per cent increase in the number of funds is higher than the per cent increase in the total asset under management, meaning that the average asset under management per fund has slightly decreased.

All the three typologies of funds (equity, balanced, fixed income) are represented; however, the breakdown varies in time: it changes from equity funds 61 %, fixed income funds 22 % and balanced funds 17 % in June 2006 to 55 %, 33 %, 12 %, respectively, in June 2009. In this paper we turn our attention to the typology of equity funds.

For a more detailed presentation of the main features of socially responsible investing in Europe we refer to the Eurosif report Eurosif (2010) which analyses their presence in each European country. The analysis presented in this contribution considers the European socially responsible funds which use ethical, social and/or environmental screening to select the assets in their portfolios. Moreover the funds considered are retail funds available to the public, advertised as socially responsible investments.

In the analysis carried out we have included all the SRI European equity funds for which the data in the 'SRI Funds Service' database were available for the period 30/06/2006 to 30/06/2009.

The number of SRI equity funds considered is equal to 190; their distribution for the various European countries is reported in table 1, where they are grouped by country of domicile. As we can see, in the period considered the SRI funds

[2]Publicly offered open-end funds investing in transferable securities and money market funds.

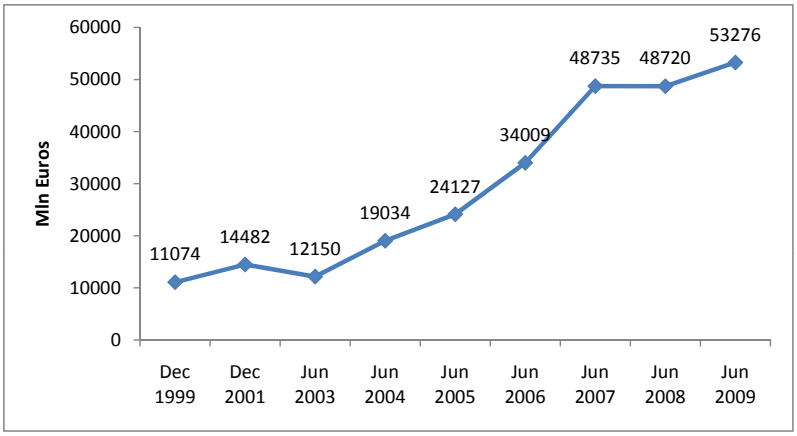


Figure 1: Trend of total asset under management of European SRI funds in the period December 1999-June 2009.

are mainly concentrated in few countries, namely France, Luxembourg, Sweden and United Kingdom.

Table 1 shows the average value of the ethical measure (57) for each country. As it can be seen, the mean ethical level is not the same in all countries; for example, the ethical level of UK funds is on average almost twice the ethical level of Spanish, Swedish and French funds, while the mean level is even higher in Norway, Belgium, Switzerland and Austria.

Figure 2 shows the frequency distribution of European SRI equity funds by ethical rating; as can be seen, the ethical level is not uniformly distributed and only few funds exhibit an ethical level lower than 0.5 or higher than 4.

Table 1: Average features of European SRI funds by country.

Country	No. of funds	Ethical level	Mean return %	St. Dev. %	Excess return %	Initial charges %	Exit charges %	Final value
Austria	10	2.69	-9.74	22.00	-13.23	4.45	0.00	0.705
Belgium	10	2.95	-8.72	21.08	-12.19	3.20	0.00	0.738
Switzerland	5	2.92	-4.06	19.98	-5.86	3.40	0.01	0.857
Germany	4	1.76	-7.89	18.96	-11.40	3.63	0.00	0.753
Spain	2	1.15	-11.40	18.47	-14.89	0.00	3.00	0.678
France	36	1.29	-6.96	20.36	-10.50	2.64	0.15	0.783
Irland	3	2.06	-8.09	20.54	-11.61	2.67	0.00	0.759
Italy	3	1.62	-10.68	19.05	-14.15	1.00	0.00	0.708
Luxembourg	38	2.10	-6.46	20.46	-10.05	4.34	0.24	0.784
The Netherlands	7	2.17	-6.33	20.09	-9.83	0.33	0.26	0.819
Norway	1	3.81	-12.00	22.13	-16.60	0.20	0.30	0.678
Sweden	32	1.27	-1.36	21.41	-4.77	0.31	0.36	0.958
United Kingdom	39	2.26	-3.58	19.64	-8.19	4.22	0.00	0.867
Europe	190	1.92	-5.53	20.45	-9.23	2.93	0.18	0.823

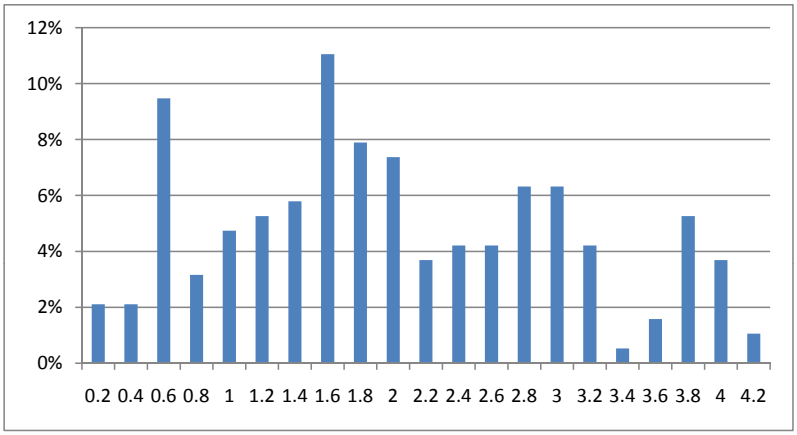


Figure 2: Frequency distribution of the ethical rating of European SRI funds.

Table 1 reports also for all countries the average values of the relevant data which have been used in the performance analysis of mutual funds, namely the annual mean return and standard deviation (the return data taken into account are the monthly returns achieved by the mutual funds in the triennium 30/06/2006–30/06/2009; source: Morningstar Europe), the excess return, the initial and exit charges.

The financial load due to the initial and exit charges differs substantially among the countries; we may notice that it is definitely heavy for some countries. On the other hand, while the average value of standard deviation is fairly similar for the different countries, the same cannot be said for the mean return, which shows great differences among the countries. In particular mutual funds domiciled in some countries seem to have suffered the negative trend of the financial markets in the triennium considered more than others.

Anyhow, due to the hardship of the financial crisis, most of the mutual funds considered exhibit a negative value for both the excess return and the mean return. Table 1 shows that the average value of both quantities is negative for all countries, and only 4 out of 190 funds exhibit a positive excess return in the period analyzed, with the consequence that the Sharpe ratio is negative for almost all the funds analysed.

In our opinion, this is an exemplary case in which it is better to avoid using the Sharpe ratio to evaluate the performance of mutual funds. Indeed, the Sharpe ratio would cause us to choose funds with higher standard deviations; for example, between two mutual funds with the same (negative) value of the excess return, the fund with the highest value of the Sharpe ratio is the one

with the highest value of the standard deviation; this problem is known in the literature (see McLeod and van Vuuren (2004)) and severely affects the ability of Sharpe ratio to measure the performance of mutual funds in slump periods.

7. The performance of the European SRI funds: empirical results

In this section we present the results of the empirical analysis carried out to assess the performance of SRI equity funds in Europe.

To this aim, in order to compare the performance obtained by SRI and non SRI equity funds, we have also analysed a set of non socially responsible funds. More precisely, we have included in the set of funds considered some non SRI equity funds with features analogous to those of the European SRI funds: for each SRI fund considered, a non SRI fund with similar features and a similar investment style was selected among those offered by the same fund company, whenever one such fund was available in the Morningstar Europe database. In this way the number of non SRI funds considered is lower than the number of SRI funds, but the comparison of the performance achievements takes place among SRI and non SRI funds with a similar management.

The main features of the non SRI funds considered are summarised in table 2, which exhibits the average values by country. The last row also reports the average value of SRI European funds, by comparison. On the whole, the average values for the SRI and non SRI funds are fairly close, although we may observe that the SRI funds exhibit a slightly higher mean return as well as a slightly higher standard deviation. The appropriate statistical test for equality of the means (Welch's t test) and that for equality of the variances (F-test), however, indicate that the differences are not statistically significant, thus confirming the conclusions of many empirical studies.

We have computed the performance indexes with the DEA models presented in Sections 2 and 3, both with the basic model for all mutual funds and the DEA models devised specifically for SRI funds. The analysis has been carried out for the European mutual funds considered on the whole (281 mutual funds, 190 SRI funds and 91 non SRI funds).

A first objective of the empirical analysis was to determine if the mutual funds analyzed exhibit constant or variable returns to scale, so that we could use the most appropriate models in the subsequent analysis. It is interesting to notice that the returns to scale turn out to be constant for all the mutual funds considered. Actually, the results obtained with the constant and variable returns to scale models are identical, namely we have

$$I_{j_0,DEA-C} = I_{j_0,DEA-V} \tag{58}$$

$$I_{j_0,DEA-CE} = I_{j_0,DEA-VE} \tag{59}$$

$$I_{j_0,DEA-CEef} = I_{j_0,DEA-VEef} \tag{60}$$

for all funds.

At a first sight this may seem surprising; for example, Kerstens et al. (2011) finds different results for the constant and variable returns to scale version of a

Table 2: Average features of European non SRI funds by country.

Country	No. of funds	Mean return %	St. Dev. %	Excess return %	Initial charges %	Exit charges %	Final value
Austria	6	-11,66	20,63	-15,16	3,33	0,00	0,669
Belgium	4	-9,27	18,64	-12,72	3,25	0,00	0,723
Switzerland	3	-5,60	18,11	-7,44	4,33	0,33	0,802
Germany	2	-5,82	17,09	-9,29	4,00	0,00	0,802
Spain	2	-13,56	18,39	-16,97	0,00	1,00	0,649
France	21	-7,38	19,77	-10,88	3,05	0,05	0,771
Italy	3	-8,32	18,86	-11,82	2,33	0,00	0,754
Luxembourg	16	-7,13	19,43	-10,69	3,45	0,00	0,775
The Netherlands	4	-4,41	18,18	-7,93	0,35	0,35	0,869
Sweden	10	-1,87	21,51	-5,29	0,10	0,00	0,948
United Kingdom	20	-1,48	20,36	-6,10	4,15	0,00	0,926
Europe non SRI	91	-5,74	19,79	-9,43	2,92	0,06	0,819
Europe SRI	190	-5,53	20,45	-9,23	2,93	0,18	0,823

basic non-parametric frontier model called MV-Loads, for a large sample of US and European mutual funds in the period January 2004 to February 2009.

It can easily be seen that the identical results obtained with our models are connected to the presence among the inputs of a constant initial investment. As a matter of fact, we have seen in Section 3 that all optimal solutions of the DEA-CE model (17)–(25) with $s_1^- = 0$, i.e. for which constraint (26) is satisfied as equality, are also optimal solutions of the DEA-VE model. An analogous property holds also for the pairs of models DEA-C/DEA-V and DEA-CEef/DEA-VEef. In our empirical investigation this turns out to be the case for all the mutual funds considered.

The main results of the analysis carried out are summarized in table 3, which reports the mean value of the performance indexes and the average ranking for each country, separately for SRI and non SRI funds (only the results of the constant returns to scale models are reported, since those of the variable returns to scale models are identical).

Of course, as pointed out in the previous section, the values of the three performance indexes computed coincide for the non SRI funds, while for the socially responsible funds we have $I_{DEA-CE} \geq I_{DEA-CEef} \geq I_{DEA-C}$. Hence, the funds which are efficient with the *DEA-C* model (for which $I_{DEA-C} = 1$) remain efficient also with the other two models. Moreover, despite the fact that the two DEA models devised for the socially responsible behaviour raise the value of the performance index of the SRI funds while keeping it constant for the non SRI funds, the overall ranking does change, even for the non SRI funds.

We have computed the matrix of the correlation coefficients for the values of the indexes I_{DEA-C}, I_{DEA-CE} and $I_{DEA-CEef}$, both for the whole set of funds (matrix Σ_1) and for the SRI funds (matrix Σ_2):

$$\Sigma_1 = \begin{pmatrix} 1.00 & 0.48 & 0.77 \\ 0.48 & 1.00 & 0.87 \\ 0.77 & 0.87 & 1.00 \end{pmatrix} \qquad \Sigma_2 = \begin{pmatrix} 1.00 & 0.37 & 0.71 \\ 0.37 & 1.00 & 0.85 \\ 0.71 & 0.85 & 1.00 \end{pmatrix} \tag{61}$$

The empirical results indicate that the inclusion of the ethical level in the analysis does raise the results of the SRI funds considerably. This effect is stronger

Table 3: Mean performance results of the European SRI funds by country.

Country	No. funds	I_{DEA-C}	I_{DEA-CE}	$I_{DEA-CEef}$
SRI funds				
Austria	10	0,470 *(234)*	0,734 *(98)*	0,578 *(176)*
Belgium	10	0,500 *(209)*	0,796 *(69)*	0,640 *(118)*
Switzerland	5	0,621 *(113)*	0,830 *(40)*	0,733 *(62)*
Germany	4	0,517 *(183)*	0,607 *(151)*	0,523 *(203)*
Spain	2	0,471 *(220)*	0,501 *(228)*	0,473 *(237)*
France	36	0,528 *(168)*	0,589 *(176)*	0,542 *(182)*
Irland	3	0,503 *(200)*	0,638 *(138)*	0,528 *(204)*
Italy	3	0,488 *(215)*	0,571 *(191)*	0,500 *(221)*
Luxembourg	38	0,535 *(167)*	0,700 *(112)*	0,609 *(135)*
The Netherlands	7	0,558 *(133)*	0,718 *(92)*	0,625 *(106)*
Norway	1	0,449 *(263)*	0,915 *(20)*	0,637 *(87)*
Sweden	32	0,658 *(51)*	0,695 *(100)*	0,668 *(73)*
United Kingdom	39	0,590 *(118)*	0,735 *(90)*	0,660 *(103)*
Europe	190	0,561 *(143)*	0,691 *(115)*	0,615 *(130)*
Non SRI funds				
Austria	6	0,469 *(223)*	0,469 *(258)*	0,469 *(243)*
Belgium	4	0,501 *(199)*	0,501 *(246)*	0,501 *(224)*
Switzerland	3	0,563 *(116)*	0,563 *(198)*	0,563 *(153)*
Germany	2	0,581 *(103)*	0,581 *(176)*	0,581 *(140)*
Spain	2	0,466 *(183)*	0,466 *(223)*	0,466 *(200)*
France	21	0,525 *(175)*	0,525 *(230)*	0,525 *(203)*
Italy	3	0,529 *(181)*	0,529 *(225)*	0,529 *(205)*
Luxembourg	16	0,537 *(157)*	0,537 *(217)*	0,537 *(187)*
The Netherlands	4	0,665 *(97)*	0,665 *(155)*	0,665 *(125)*
Sweden	10	0,655 *(53)*	0,655 *(121)*	0,655 *(82)*
United Kingdom	20	0,632 *(83)*	0,632 *(149)*	0,632 *(113)*
Europe	91	0,568 *(136)*	0,568 *(195)*	0,568 *(164)*

for I_{DEA-CE} (much less correlated with I_{DEA-C}), while the $I_{DEA-CEef}$ is – as expected – comprised between the values of the other two indexes. Notice that the value of the correlation coefficients for the SRI funds are even lower, since the value of the performance indexes of non SRI funds coincide for all the three models.

As regards the I_{DEA-C} performance index, at first glance the differences among the SRI and non SRI funds seem negligible for most countries; in next section we will explicitly test if these differences are statistically significant. On the contrary, the differences do seem sensible for the $I_{DEA-CEef}$ index, and even more for I_{DEA-CE}.

As for the differences among the various countries, we may observe that the best SRI funds can be found on average in Sweden if we do not take the ethical level into account, and in Switzerland if, in a more appropriate way, we use one of the models – DEA-CEef or DEA-CE – that do take it into consideration.

8. SRI vs non SRI

From a financial point of view, investing in SRI funds raises the interesting question as to whether the social aim has to be pursued at the expense of the financial performance of the investment. This question has been widely

discussed in the literature, with sometimes opposite and surprising conclusions (for a review see for example Renneboog et al. (2008) and Cortez et al. (2009)).

Of course, at least in theory, we would generally expect that the non SRI funds outperform SRI funds, since they may select their portfolio of assets without any restrictions. However, the empirical results presented in the literature do not always support the conclusion that non SRI funds obtain better financial performances; rather, most empirical studies suggest that the differences in the performance obtained by SRI and non SRI funds are not statistically significant.

In next subsection we briefly discuss the results of the main empirical studies, whereas in Subsection 8.2 we will investigate which indications come out from the analysis of the European SRI funds using a DEA methodology.

8.1. SRI vs non SRI: the literature

For more than two decades the literature have tried to compare the performance of socially responsible and non socially responsible investments; actually, several empirical studies on the comparison of mutual funds regard the nineties. For example, in 1993 Hamilton et al. (1993) compares the performance of 17 U.S. SRI equity funds with that of 170 randomly selected conventional mutual funds in the period from January 1981 through December 1990 and finds that the performance of socially responsible funds is not statistically different from the performance of conventional mutual funds. For the successive period May 1990–September 1998, Statman (2000) compares the performance of 31 U.S. SRI equity funds with that of 62 conventional funds near to them in asset size; the conclusion is that SRI funds performed better than conventional funds of equal asset size, although the difference is not statistically significant.

As regards Europe, Kreander et al. (2002) investigates the financial performance of 40 ethical funds from 7 European countries for the period 1996–1998 and finds that investors in ethical funds suffer no appreciable loss in return per unit of market risk with respect to a benchmark portfolio. Analogously, Bauer et al. (2005) finds no evidence of significance differences in risk-adjusted returns between 103 German, UK and U.S. ethical mutual funds and 309 conventional funds of similar age and size in the period from January 1990 through March 2001. In addition, Kreander et al. (2005) studies the performance of 30 ethical European mutual funds from UK, Sweden, Germany and the Netherlands in the period January 1995–December 2001. Their performance is compared with that of 30 non ethical mutual funds with similar age, size, country and investment universe; in this case, too, the findings suggest that there is no difference between ethical and non ethical mutual funds in terms of performance.

To the same conclusion comes Bello (2005) for the period January 1994 to March 2001 for 42 U.S. socially responsible domestic equity funds, compared with 84 randomly selected conventional funds of similar net assets. As for Australian ethical funds, Bauer et al. (2006) studies 25 ethical open-ended equity mutual funds and 281 conventional funds in the period November 1992–April 2003 and, again, concludes that ethical funds do not underperform relative to conventional funds. An analogous conclusion is obtained by Bauer et al. (2007)

Table 4: Summary statistics of the empirical results of the analysis of the performance for DEA-C, DEA-CE and DEA-CEef models.

	DEA-C	DEA-CE	DEA-CEef
Percentage number of efficient funds	0.7%	2.5%	2.5%
Percentage of SRI efficient funds	0.0%	2.6%	2.6%
Percentage of non SRI efficient funds	2.2%	2.2%	2.2%
Average performance	0.563	0.651	0.599
Average SRI performance of SRI funds	0.561	0.691	0.615
Average SRI performance of non SRI funds	0.568	0.568	0.568
Median of the performance score	0.540	0.614	0.575
Percentage no. of SRI funds above the median	48.9%	64.7%	55.3%
Percentage no. of non SRI funds above the median	52.7%	19.8%	39.6%

for 8 Canadian ethical mutual funds, in an analysis that concerns the domestic equity funds in the period January 1995-January 2003.

In the last decade, an analysis carried out by Cortez et al. (2009) on 88 SRI funds from 7 European countries during the period August 1996–February 2007 suggests that "investors who wish to hold European funds can add social screens to their investment choices without compromising financial performance".

Even, some empirical studies on the performance of socially responsible investments show evidence that SRI portfolios exhibit a better performance than unscreened conventional investments. Along this line, we may cite Derwall et al. (2005) for U.S. stock portfolios in the period July 1995-December 2003, Kempf and Osthoff (2007) for U.S. stock portfolios in the years 1992-2004 and Fernandez-Izquierdo and Matallin-Saez (2008) for Spanish mutual funds in the period from June 1998 through June 2001.

On the other hand, there exists also some empirical results supporting the opposite conclusion that SRI funds exhibit an inferior reward-to-risk performance; see the analysis of U.S. mutual funds in the period 1993-2008 presented in Chang and Witte (2010).

8.2. SRI vs non SRI: empirical comparisons

Let us now examine the empirical results on the comparison between the performances of the SRI and non SRI funds considered in our analysis, and see if they are in accordance with the results of most empirical studies.

Table 4 reports some synthetic indicators which give some initial clues. As we can see, the number of efficient funds is small with the basic DEA-C model (only 2 funds turn out to be efficient, both non SRI) while it grows with the two models that reward social responsibility (the number of efficient funds increases to 7: 5 SRI and 2 non SRI). The proportion of SRI funds with a performance score higher than the overall median, too, is much higher with the DEA-CEef and DEA-CE models: with these models the proportion is well over 50 %, while it is slightly below this level with the DEA-C model. Analogously, if we compare the average value of the performance for SRI and non SRI funds, we notice that the SRI funds exhibit a markedly higher value with DEA-CEef and DEA-CE, while they show a slightly lower average value with DEA-C.

The situation is highlighted in more detail in figure 3, which compares the empirical cumulative distribution functions of the DEA efficiency measures of SRI and non SRI funds obtained with the three models adopted. We can observe that the SRI funds obtain a sensibly higher performance score when the ethical indicator is included in the set of outputs, while the behaviour is very close when the only output variable taken into consideration is the final value of the investment. It is also evident that the gain obtained by SRI funds using the $I_{DEA-CEef}$ indicator is on average around half the gain assigned by the I_{DEA-CE} indicator.

To verify if the differences in the performance scores are statistically significant or not, we have carried out some statistical tests specifically designed to compare DEA efficiency scores between two groups of decision making units; for the description of the tests adopted we refer to Banker and Natarajan (2011), that presents a number of different tests that can be used to this aim. The various tests are based on different assumptions on the distribution of the "true" inefficiency measure, and can be clustered into two groups: three tests which assume that the deviations of the actual output from the production frontier arise only from a stochastic inefficiency term (see Banker and Natarajan (2011), par. 11.2.2, and Banker et al. (2010)) and five tests that can be used when the data generating process involves both an inefficiency term and a noise term independent of the inefficiency (see Banker and Natarajan (2011), par. 11.4.1), as it seems more appropriate in the case of mutual funds.

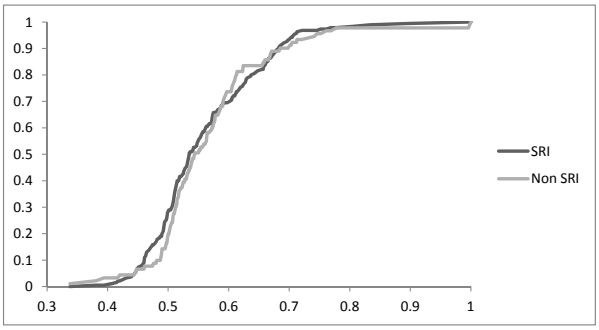
All the 8 tests applied to the two groups of SRI and non SRI funds give the same results. In agreement with most of the empirical studies - though the result is obtained using a different approach - with a 0.05 significance level all the tests carried out lead to accept the null hypothesis of no differences in the performance scores with the DEA-C model: hence, the differences are too light to be significant.

On the contrary, when applied to the performance indicator I_{DEA-CE}, which considers also the ethical level, with a 0.05 significance level we reject the null hypothesis and accept the alternative hypothesis of different distributions: with this model, the SRI funds outperform their non SRI counterparties, which accounts for the fact that investors in SRI funds do care for the ethical profile.

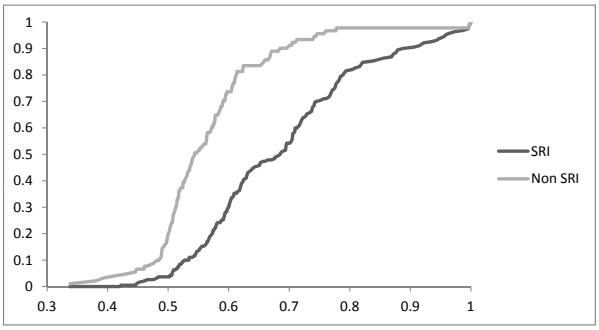
9. Conclusions

In this contribution we have presented some models, in a DEA framework, to evaluate the performance of both socially responsible and traditional mutual funds. The input and output variables of these models are focused on the capital initially invested and its final value obtained at the end of the investment horizon, in addition to a measure of the investment risk and a measure of the ethical degree of the fund.

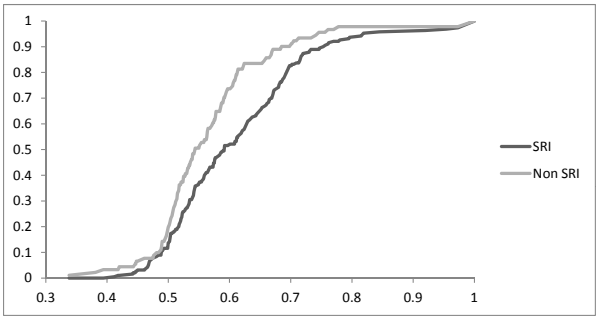
A convenient property of the models proposed is that they do not suffer from the problem of the presence of negative data, not even in periods of heavy economic recession such as the one we are facing at present.



(a) I_{DEA-C}



(b) I_{DEA-CE}



(c) $I_{DEA-CEef}$

Figure 3: Cumulative distribution functions of I_{DEA-C}, I_{DEA-CE} and $I_{DEA-CEef}$ performance measures for SRI and non SRI European funds.

These models are used to analyze the performance of European socially responsible investment funds in the period June 2006 to June 2009. An interesting result of the empirical investigation is that the returns to scale related to such models turn out to be constant for all the mutual funds analysed.

The empirical study carried out have also focused on the comparison of the performance scores between the SRI and non SRI funds, to see if the ethical objectives of the socially responsible investment funds require a sacrifice from a financial point of view. The answer to this issue is negative, in accordance with the results reported by most of the literature on the subject, though obtained with different methodologies. Therefore, it is possible to invest in a socially responsible manner without having to renounce financial reward.

References

Ali, A.I., Seiford, L.M., 1990. Translation invariance in data envelopment analysis. Operations Research Letters 9, 403-405.

Banker, R.D., Cooper, W.W., Seiford, L.M., Zhu, J., 2011. Returns to scale in DEA. In: Cooper, W.W., Seiford, L.M., Zhu, J. (eds) Handbook on Data Envelopment Analysis, 2nd edn. Springer, New York, 41-70.

Banker, R.D., Morey, R.C., 1986. Efficiency analysis for exogenously fixed inputs and outputs. Operations Research 34, 513-521.

Banker, R.D., Natarajan, R., 2011. Statistical tests based on DEA efficiency scores. In: Cooper, W.W., Seiford, L.M., Zhu, J. (eds) Handbook on Data Envelopment Analysis, 2nd edn. Springer, New York, 273-295.

Banker, R.D., Zheng, Z.E., Natarajan, R., 2010. DEA-based hypothesis tests for comparing two groups of decision making units. European Journal of Operational Research 206, 231-238.

Basso, A., Funari, S., 2001. A data envelopment analysis approach to measure the mutual fund performance. European Journal of Operational Research 135, 477-492.

Basso, A., Funari, S., 2003. Measuring the performance of ethical mutual funds: A DEA approach. Journal of the Operational Research Society 54, 521-531.

Bauer, R., Derwall, J., Otten, R., 2007. The ethical mutual fund performance debate: New evidence from Canada. Journal of Business Ethics 70, 111-124.

Bauer, R., Koedijk, K., Otten, R., 2005. International evidence on ethical mutual fund performance and investment style. Journal of Banking & Finance 29, 1751-1767.

Bauer, R., Otten, R., Tourani Rad, A., 2006. Ethical investing in Australia: Is there a financial penalty? Pacific-Basin Finance Journal 14, 33-48.

Bello, Z.Y., 2005. Socially responsible investing and portfolio diversification. The Journal of Financial Research XXVIII, 41-57.

Chang, C.E., Witte, H.D., 2010. Performance evaluation of U.S. socially responsible mutual funds: Revisiting doing good and doing well. American Journal of Business 25, 9-20.

Chen, Z., Lin, R., 2006. Mutual fund performance evaluation using data envelopment analysis with new risk measures. OR Spectrum 28, 375-398.

Choi, Y.K., Murthi, B.P.S., 2001. Relative performance evaluation of mutual funds: A non-parametric approach. Journal of Business Finance & Accounting 28, 853-876.

Cooper, W.W., Seiford, L.M., Tone, K., 2000. Data envelopment analysis: A comprehensive text with models, applications, references and DEA-Colver Software. Kluwer Academic Publishers, Boston.

Cooper, W.W., Seiford, L.M., Zhu, J. (eds) 2011. Handbook on Data Envelopment Analysis, 2nd edn. Springer, New York.

Cortez, M.C., Silva, F., Areal, N., 2009. The performance of European socially responsible funds. Journal of Business Ethics 87, 573-588.

Derwall, J., Guenster, N., Bauer, R., Koedijk, K. (2005) The eco-efficiency premium puzzle. Financial Analysts Journal 61, 51-63.

Emrouznejad, A., Anouze, A.L., Thanassoulis, E., 2010. A semi-oriented radial measure for measuring the efficiency of decision making units with negative data, using DEA. European Journal of Operational Research 200, 297-304.

European Sustainable and Responsible Investment Forum (Eurosif) 2010. European SRI Study 2010. Eurosif report.

Fernandez-Izquierdo, A., Matallin-Saez, J.C., 2008. Performance of ethical mutual funds in Spain: Sacrifice or premium? Journal of Business Ethics 81, 247-260.

Glawischnig, M., Sommersguter-Reichmann, M., 2010. Assessing the performance of alternative investments using non-parametric efficiency measurement approaches: Is it convincing? Journal of Banking & Finance 34, 295303.

Hamilton, S., Jo, H., Statman, M., 1993. Doing well while doing good? The investment performance of socially responsible mutual funds. Financial Analysts Journal 49, 62-66.

Kempf, A., Osthoff, P., 2007. The effect of socially responsible investing on portfolio performance. European Financial Management 13, 908-922.

Kerstens, K., Mounir, A., Van de Woestyne, I., 2011. Non-parametric frontier estimates of mutual fund performance using C- and L-moments: Some specification tests. Journal of Banking & Finance 35, 1190-1201.

Kerstens, K., Van de Woestyne, I., 2011. Negative data in DEA: a simple proportional distance function approach. Journal of the Operational Research Society 62, 1413-1419.

Kreander, N., Gray, R.H., Power, D.M., Sinclair, C.D., 2002. The financial performance of European ethical funds 1996-1998. Journal of Accounting and Finance 1, 3-22.

Kreander, N., Gray, R.H., Power, D.M., Sinclair, C.D., 2005. Evaluating the performance of ethical and non-ethical funds: a matched pair analysis. Journal of Business Finance & Accounting 32, 1465-1493.

Lamb, J.D., Tee, K.H., 2012. Data envelopment analysis models of investment funds. European Journal of Operational Research 216, 687-696.

Lovell, C.A.K., Pastor, J.T., 1995. Units invariant and translation invariant DEA models. Operations Research Letters 18, 147-151.

Lovell, C.A.K., Pastor, J.T., 1999. Radial DEA models without inputs or without outputs. European Journal of Operational Research 118, 46-51.

McLeod, W., van Vuuren, G., 2004. Interpreting the Sharpe ratio when excess returns are negative. Investment Analysts Journal 59, 15-20.

Morey, M.R., Morey, R.C., 1999. Mutual fund performance appraisals: a multi-horizon perspective with endogenous benchmarking. Omega 27, 241-258.

Murthi, B.P.S., Choi, Y.K., Desai, P., 1997. Efficiency of mutual funds and portfolio performance measurement: A non-parametric approach. European Journal of Operational Research 98, 408-418.

Renneboog, L., Ter Horst, J., Zhang, C., 2008. Socially responsible investments: Institutional aspects, performance, and investor behavior. Journal of Banking & Finance 32, 1723-1742.

Silva Portela, M.C.A., Thanassoulis, E., Simpson, G., 2004. Negative data in DEA: a directional distance approach applied to bank branches. Journal of the Operational Research Society 55, 1111-1121.

Soares de Mello, J.C.C.B., Angulo-Meza, L., Branco da Silva, B.P., 2009. A ranking for the Olympic Games with unitary input DEA models. IMA Journal of Management Mathematics 20, 201-211.

Statman, M., 2000. Socially responsible mutual funds. Financial Analysts Journal 56, 30-39.

Vigeo SRI Research 2009. Green, social and ethical funds in Europe-2009 Review. Vigeo report.