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JEL Classifications: G11, G15

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CEB Working Paper N° 09/014
November 2009

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This version: November 2009

**Abstract**

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**Acknowledgements**
The author thanks Ariane Szafarz, Marie Brière, Ombretta Signori, Valérie Mignon, Kim Oosterlinck, Luc Renneboog, Kokou Topeglo and all the participants of the 2nd PRI Academic Conference for their helpful comments. The author specially thanks the extra-financial rating agency Vigeo for supplying its Sustainability Country Ratings and Vigeo's employees for their availability.

# 1. Introduction

Little attention has been paid to the link between sovereign bond returns and the performance of states in terms of environmental, social and governance (ESG) issues. This is striking, considering the considerable share of the sovereign bond market in the global capital markets and the boom of the Socially Responsible Investment (SRI)[1] segment. This is all the more striking since governments have the power to improve regulations related to ESG criteria. However, as many asset managers have signed up to the Principles for Responsible Investment (PRI)[2], there is a crucial need to investigate the link between the financial performance of sovereign bonds and extra-financial SRI factors. The objective of this paper is to assess the possibility to increase the socially responsible value of a sovereign bond portfolio without a significant loss of diversification in the mean-variance plan.

A lively and ongoing debate takes place about the financial performances of SRI. Do SRI investments differ significantly from conventional investments? Do investors pay an additional price for SRI? In practice, there are two main ways to investigate this question: to fund and to asset level. Bauer *et al.* (2005) find that ethical funds do not underperform conventional funds while Renneboog *et al.* (2008,b) show that SRI funds strongly underperform their domestic benchmarks. If these two studies agree on the fact that screening activities do not add value, results about the potential cost of SRI are mixed, leaving the basic question unresolved. In the particular case of fixed-income funds, Derwall and Koedijk (2009) show that SRI funds performances are not significantly different of conventional funds. Another vein in the literature studies SRI performances at asset level: for instance, Derwall *et al.* (2005) link stock returns to environmental performance based on scores produced by Innovest Strategic Value Advisors[3], an extra-financial rating agency. They show that companies with good environmental performances have significantly higher returns.

Kempf and Osthoff (2007) and Statman and Glushkov (2009) extend this analysis to other dimensions of SRI, using ratings from KLD Research & Analytics, Inc.[4]. They find that socially responsible portfolios obtain significantly higher returns than conventional ones. However, to our best knowledge, this type of analysis has not been applied yet to sovereign bond portfolios.

Few papers explore the link between sovereign bond returns and qualitative factors. Erb *et al.* (1996) exhibit a link between sovereign bond returns and country risk measured according to the International Country Risk Guide (ICRG)[5]. Portfolios invested in countries with upgraded ICRG ratings perform significantly better than portfolios of countries with downgraded ICRG ratings. Unfortunately, the study by Erb *et al.* (1996) suffers from a lack of data for several countries, due to the heterogeneous starting dates of the ICRG ratings, making it impossible to draw firm conclusion. Connolly (2007) puts forward a link between sovereign credit ratings and the corruption index measured by Transparency International's Corruption Perceptions Index[6]. While these two studies focus on governance characteristics, Scholtens (2009) assesses the environmental performances of sovereign bond funds in Netherlands and shows that they differ according to the environmental indicator. However, despite the production of country ratings according to ESG factors for several years, no academic research has yet assessed the financial performances of responsible sovereign bond investments. Our paper aims to fill this gap. To do so, we consider the Sustainability Country Ratings (SCR) produced by Vigeo[7], which are indices meant to represent the countries' socially responsible performances; and we investigate the impact of taking them into account in a portfolio process.

This paper bridges two blocks of portfolio management research: one concerning SRI, the other concerning sovereign bond diversification within a group of developed countries. The benefits of diversification in the government bond market is discussed, for example, by Levy and Lerman (1988), who find very high correlations between developed countries' government bond returns, with the notable exception of Japan. Hunter and Simon (2004) show that the diversification benefits to US investors from investing in international government bonds are significant on a currency-hedged basis, even during periods of market weakness. Though, Hanson *et al.* (2009) provide new evidence contradicting these observations, both papers share the spanning test methodology proposed by DeRoon and Nijman (2001) and De Roon *et al.* (2001).

In this paper, we first compute the efficient frontier of portfolios including sovereign bonds from twenty developed countries[8] over the period 1995-2008. We then add a linear constraint imposing the portfolio average SCR to be above a minimum threshold. We make these minimum thresholds grow and we observe the induced deformation of the efficient frontier. In theory, the stronger the constraint, the weaker the potential diversification becomes. However, in practice, the loss of mean-variance efficiency might be insignificant. To test whether SRI leads to significant losses we use the test proposed by Basak *et al.* (2002). The results show that sovereign bond portfolios with a high socially responsible component are reachable without any significant loss of diversification. This is good news for investors in the socially responsible bond market.

Our contribution is twofold. First, this paper opens the way to analyzing sovereign bond markets in the SRI framework. Second, it explores an original dataset because, to our

knowledge, the Vigeo Sustainability Country Ratings (SCR) are being used for the first time in a financial perspective.

The remainder of the paper is structured as follows. Section 2 presents the data and describes the SCR construction. In Section 3, we present the methodology used to determine the impact of successive SCR constraints on the bond efficient frontier. The results are exposed in Section 4. Section 5 concludes.

## 2. Data

The data on sovereign bond monthly returns come from Citigroup[9] World Government Bond Index (WGBI) "All maturities"[10], downloaded from Datastream, from 31st December 1994 to 31st December 2008. We use total returns in US dollars hedged for exchange rate risk.

The SCR data are taken at the end of 2008. The rating system is based on universally opposable social responsibility criteria. Vigeo selected criteria approved by the international community including: the Millennium Development Goals[11], Agenda 21[12], the International Labour Organization (ILO) conventions, the United Nations Charters and Treaties, and the OECD Guiding Principles.

For transparency reasons, Vigeo gathers only official data from international institutions and non-governmental organizations: the World Bank, the United Nations Development Program, the United Nations Environment Program, the United Nations Office on Drugs and Crime, the United Nations Children's Emergency Fund, the Food and Agriculture Organization, the United Nations Conference on Trade and Development, the

United Nations Department for Disarmament Affairs, the International Labour Institute, the Organisation for Economic Co-operation and Development, the Office of the High Commissioner for Human Rights, Coface, Amnesty International, Transparency International, Freedom House and Reporters Without Borders.

Three separate ratings are available as well as a composite index. The specific indexes are the Environmental Responsibility Rating (ERR), Social Responsibility and Solidarity Rating (SRSR), and the Institutional Responsibility Rating (IRR). They correspond to the three classical SRI dimensions (see Table 5 of the Appendix for a comprehensive list). For each rating, Vigeo has selected several criteria representing either commitments or quantitative realisations. For each criterion, the countries are rated on a scale ranging from 0 to 100 (the best grade).

For the commitment criteria, i.e. the signature and ratification of treaties and conventions, the grade is: 0 if the country did not sign, 50 if the country signed but did not ratify, and 100 if the country signed and ratified. For the quantitative criteria, a score is computed following the decile method: the 10 percent of worst-performing countries obtain a score of 10, and so on. Vigeo ranks not only levels but also trends computed as variation rates between the first and the last available values. More precisely, if a country's trend lies in the top 20 percent, then it benefits from a premium of ten points for the criterion at stake; if the country exhibits a negative trend, it gets a ten-point penalty.

The three specific ratings (ERR, SRSR, IRR) are weighted averages of scores. The SCR global index is an equally-weighted average of these three ratings. The advantage of using these Vigeo ratings comes from the wide spectrum of criteria taken into account. The

main drawback is that, contrary to credit ratings, no historical data are available, which makes it impossible to run a dynamic analysis.

## 3. Methodology

Our purpose is to determine to what extent constraints on country ratings lead to a significant loss of diversification in sovereign bond portfolios. Consider a financial market including $n$ sovereign bonds, each from a different country ($i = 1, \ldots, n$). A portfolio $p$ of securities is defined by the vector of portfolio weights $\omega_p = \begin{bmatrix} \omega_{p1} & \omega_{p2} & \ldots & \omega_{pn} \end{bmatrix}'$, where $\omega_{pi} \geq 0$, $\omega' \iota = 1$ and $\iota = \begin{bmatrix} 1 & \ldots & 1 \end{bmatrix}'$. Denote by $\mu$ the vector of expected returns and $\sum$ the return covariance matrix of the sovereign bonds. Denote also by $\phi = \begin{bmatrix} \phi_1 & \phi_2 & \ldots & \phi_n \end{bmatrix}'$ the vector of country ratings. Similarly to Barracchini (2007) and Scholtens (2009), we define the portfolio rating $\phi_p$ as the weighted average rating of the corresponding countries:

$$\phi_p = \omega_p' . \phi$$

The same computation applies for all indexes in use (specific ratings EER, SRSR, IRR, or global index, SCR). The portfolio's ratings are thus directly linked to its shares in well-rated countries.

First, we compute the true efficient frontier without any constraint on the portfolio rating, by applying the standard mean-variance optimization:

$$\begin{aligned} \min_{\{\omega\}} \quad & \frac{1}{2} \omega' \sum \omega \\ \textit{subject to} \quad & \mu_p = \omega' \mu \\ & \omega' \iota = 1 \\ & \omega \geq 0 \end{aligned}$$

Then, we compute efficient frontiers with a constraint requiring the portfolio rating to be above a minimum threshold $\phi_0$ :

$$\begin{aligned} \min_{\{\omega\}} \quad & \frac{1}{2}\omega' \sum \omega \\ \textit{subject to} \quad & \mu_p = \omega' \mu \\ & \omega' \iota = 1 \\ & \omega \geq 0 \\ & \phi_p = \omega' \phi \geq \phi_0 \end{aligned}$$

Opting for a higher SRI constraint restricts the set of possible combinations of sovereign bonds. This implies a move of the efficient frontier to the south-east of the mean-variance plan. In order to measure the significance of the efficient frontier move, we apply the Ehling & Ramos (2006) procedure that uses the test proposed by Basak, Jagannathan and Sun (2002), referred to as the BJS test.

The BJS test is meant for testing the mean-variance efficiency of a given benchmark portfolio. It is based on an efficiency measure $\lambda$ defined as the difference between the variance of the efficient portfolio with the same expected return as the benchmark and the variance of the benchmark. Under the null, the benchmark is mean-variance efficient and $\lambda = 0$ . BJS (2002) derive the asymptotic distribution of the sample measure of efficiency $\lambda_T$ :

$$\sqrt{T}(\lambda_T - \lambda) \rightarrow N(0, \sigma^2)$$

where $\sigma^2$ is the variance of the efficiency measure and T is the sample size.

To compare two efficient frontiers, Ehling & Ramos (2006) use one of them as the reference efficient frontier and take two points of the other one as benchmark portfolios: the minimum variance portfolio and the tangency portfolio. Given that the mean-variance efficiency statistics of these portfolios have no reason to be equal, Ehling & Ramos (2006)

consider that the second efficient frontier is mean-variance inefficient compared to the first if one of the two benchmark portfolios is significantly inefficient according to the BJS test. We follow the same procedure here.

The WGBI index returns hedged for FX variations are used as proxies for the sovereign bond returns. At each date, the reference efficient frontier is built from portfolios that are fully invested in the twenty WGBI indexes, excluding short sales. Then, we compute the efficient frontier with a constraint "portfolio rating above a given threshold". We successively consider increasing thresholds, starting from the lowest rating[13]. For each of these "constrained" efficient frontiers, we run the BJS test for the two portfolios suggested by Ehling & Ramos (2006). In this way, we sequentially obtain the rating thresholds leading to the rejection of the null hypothesis of mean-variance efficiency at the respective probability levels of 10%, 5%, and 1%.

# 4. Empirical results

## *4.1. Descriptive statistics of the WGBI indexes*

Table 1 in Appendix reports the descriptive statistics of the WGBI indexes in US dollars hedged for FX variations for the period January 1995-December 2008 for the twenty study countries. Table 1 shows that the WGBI indexes offer annualized returns from 5.07%/year to 8.16%/year and volatilities from 3.35%/year to 4.77%/year for the period January 1995 - December 2008. We notice that the distribution of the returns is close to those of a normal distribution: skewness is close to 0 (except for the Australian and New Zealand indexes with skewness superior to 0.5) and that kurtosis is close to 3 (except for Japan with kurtosis of 8.97). In addition, the descriptive statistics of the returns are very close for the Eurozone[14] countries, due to common monetary policy. For the European countries, the

annualized volatility of the WGBI indexes is very low, around 3.5%/year. The annualized volatility of the US and UK WGBI indexes is much higher than those of the other indexes. This has to be related to maximal monthly gains that are the highest for these two countries and should be interpreted as a particularly strong flight-to-quality phenomenon.

Table 2 in Appendix reports the correlation matrix of the monthly returns. All correlation pairs are positive. We notice that correlations are higher between geographically or culturally close countries. We roughly distinguish two homogeneous zones, a European zone and a dollar zone[15], and we find the well-known result that Japan is very uncorrelated with other countries. For example, the correlations are very high within the ten countries of the Eurozone. Even within this set of similar assets, good diversification possibilities emerge. For example, the Japanese index return exhibits low correlations with all other indexes (the highest correlation of the Japanese index is 0.36 with Australia). Except with the Australian index, the New Zealand index is quite weakly correlated with the others (correlation of 0.67 at most). In Europe, Norway and Switzerland also offers diversification possibilities: their correlations with the other WGBI indexes do not exceed 0.73.

### *4.2. Descriptive statistics of the Sustainability Country Ratings*

For the twenty countries under study, the Vigeo ratings available at the end of December 2008 appear in the Table 3.

**Table 3 Vigeo ratings at the end of December 2008**

| | Environmental Responsibility Rating (ERR) | Social Responsibility and Solidarity Rating (SRSR) | Institutional Responsibility Rating (IRR) | Sustainability Country Rating (SCR) |
|---|---|---|---|---|
| **AUS** | 57.74 | 72.93 | 91.67 | 74.11 |
| **AUT** | 67.14 | 77.60 | 97.40 | 80.71 |
| **BEL** | 52.44 | 85.54 | 89.39 | 75.79 |
| **CAN** | 48.91 | 78.95 | 83.92 | 70.60 |
| **CHE** | 74.24 | 79.48 | 91.58 | 81.77 |
| **DEU** | 61.71 | 76.65 | 94.56 | 77.64 |
| **DNK** | 60.94 | 84.86 | 97.80 | 81.20 |
| **ESP** | 52.84 | 77.91 | 92.95 | 74.57 |
| **FIN** | 65.18 | 84.68 | 97.67 | 82.51 |
| **FRA** | 60.29 | 80.27 | 91.58 | 77.38 |
| **GBR** | 64.94 | 81.98 | 94.98 | 80.63 |
| **IRL** | 51.25 | 82.84 | 92.89 | 75.66 |
| **ITA** | 54.14 | 77.09 | 85.76 | 72.33 |
| **JPN** | 52.69 | 72.20 | 77.34 | 67.41 |
| **NLD** | 56.80 | 87.71 | 97.18 | 80.56 |
| **NOR** | 68.30 | 92.89 | 97.64 | 86.27 |
| **NZL** | 54.20 | 80.46 | 86.00 | 73.55 |
| **PRT** | 51.67 | 68.54 | 93.60 | 71.27 |
| **SWE** | 71.05 | 91.18 | 98.45 | 86.89 |
| **USA** | 47.75 | 67.89 | 62.83 | 59.46 |
| **Average** | 58.71 | 80.08 | 90.76 | 76.52 |
| **Std. Dev.** | 7.71 | 6.72 | 8.58 | 6.55 |

AUS stands for Australia, AUT Austria, BEL Belgium, CAN Canada, CHE Switzerland, DEU Germany, DNK Denmark, ESP Spain, FIN Finland, FRA France, GBR United Kingdom, IRL Ireland, ITA Italy, JPN Japan, NLD Netherlands, NOR Norway, NZL New Zealand, PRT Portugal, SWE Sweden and USA United States.

Globally, all twenty countries are well-rated for the SRSR and for IRR but obtain poor ratings for ERR. The dispersion of the ratings score is quite similar among the three SCR components, except IRR for which Japan and United States are well below the other countries. This dispersion shows that even if the sample countries are developed and homogeneous from a wealth point of view, there is discrimination between good and bad performers regarding ESG criteria. The Spearman's rank correlation in Appendix 2 indicates that the three SCR components are certainly not perfectly correlated (the correlation ranking goes from 43.3% between ERR and SRSR to 68.9% between ERR and IRR).

The analysis of the SCR confirms certain popular views: the Scandinavian countries (Denmark, Finland, Norway, Sweden) obtain the best scores for each area, with Norway and Sweden far above the other countries for the global rating (these countries are the only ones with a rating superior to the mean of the rating plus one standard deviation). The SCR also puts Japan and the United States at the bottom of the ranking. In particular, the United States is the worst-rated for each area. This position is due to the non-signature of several international conventions, to a high energy-consuming economy and also to weak development aid. We also notice that South European countries (Italy, Portugal, Spain) globally obtain poor performances, especially for ERR.

Some of the ratings go against popular views. Canada is often cited as an example of a sustainable country but is ranked only 18$^{th}$ with the SCR. Actually, Canada is badly rated for the same reasons as the United States: non-signature of international conventions, high energy-consuming economy and weak development aid. The IRR score is also diminished by the fact that Canada, like the United States, has no minimum employment age. Another surprise is the poor ERR rating of the Netherlands, often presented as a green country. This could be explained by the fact that the agriculture in the Netherlands intensively uses pesticides, fertilizers and water.

Because of the dispersion of the SCR, the question of how a constraint on the ratings affects diversification power is obviously relevant.

### *4.3. BJS test on SRI constraints portfolios*

We first compute the static efficient frontier given by the historical returns of the twenty WGBI indexes currency-hedged without restriction on the portfolio rating. Then, we compute the efficient frontiers given by portfolios of WGBI indexes with a constraint of the type "portfolio ratings superior to a threshold". For each threshold, we run the BJS (2002) test by considering the unconstrained efficient frontier as the reference and two points of the constrained efficient frontier (minimum variance and tangency portfolios) as benchmarks. To compute the tangency portfolio of the unconstrained frontier, we use the average on the sample study of the US 1 month interbank rate as risk free. The null hypothesis is the following:

H0: *"The portfolio constrained on the SCR is mean-variance efficient with reference to the unconstrained efficient frontier"*

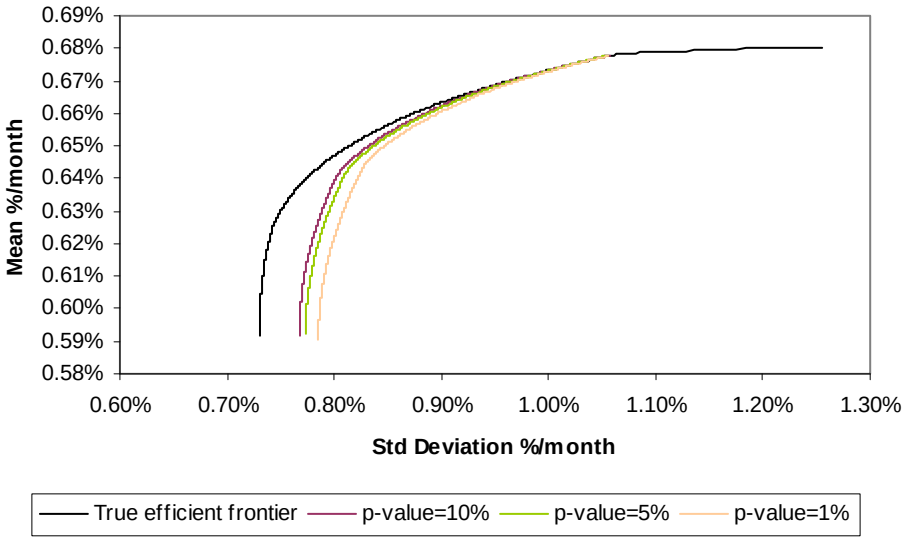
The rejection of H0 means that the constrained portfolio is not mean-variance efficient and that the constraint on the rating implies a significant loss of diversification. If H0 is not significantly rejected, it means that the mean-variance efficiency is not rejected and that socially responsible portfolios can be built without a significant diversification cost. In Table 4, we report the thresholds on portfolio ratings for which the mean-variance efficiency of the portfolios is rejected with a probability level of 10%, 5% and 1%.

**Table 4 Thresholds of the portfolio rating corresponding to the rejection of H0 at the probabilities 10%, 5% and 10%**

| | Portfolio rating | | |
|---|---|---|---|
| **Minimum variance portfolio** | | | |
| | Null hypothesis rejection probability | | |
| | *10%* | *5%* | *1%* |
| Sustainable Country Rating (SCR) | 79.56 | 80.01 | 80.73 |
| Environmental Responsability Rating (ERR) | 66.51 | 67.08 | 68.01 |
| Social Responsability and Solidarity Rating (SRSR) | 83.35 | 83.92 | 84.82 |
| Institutional Responsability Rating (IRR) | 90.84 | 91.23 | 91.95 |
| **Tangency portfolio** | | | |
| | Null hypothesis rejection probability | | |
| | *10%* | *5%* | *1%* |
| Sustainable Country Rating (SCR) | 79.47 | 79.86 | 80.55 |
| Environmental Responsability Rating (ERR) | 67.08 | 67.65 | 68.58 |
| Social Responsability and Solidarity Rating (SRSR) | 82.72 | 83.23 | 84.10 |
| Institutional Responsability Rating (IRR) | 90.99 | 91.38 | 92.10 |

For each Vigeo rating, the thresholds of the portfolio rating corresponding to the rejection of H0 differ slightly between the minimum variance and the tangency portfolios: we keep the less mean-variance efficient portfolio according to the BJS (2002) test. For the SCR, we plot in Figure 1 the constrained efficient frontiers corresponding to these rejections of mean-variance efficiency against the unconstrained efficient frontier.

**Figure 1 Efficient frontiers defined by the WGBI indexes hedged for FX in US dollars with restrictions on the Vigeo Sustainability Ratings, period January 1995-December 2008**




For each rating type, we also notice that the thresholds of the portfolio rating corresponding to the rejection at 10%, 5% and 1% of mean-variance efficiency are very close. The efficiency measures all have a negative sign, which is expected by construction: by imposing a linear constraint on the weights of the WGBI indexes, the efficient frontier moves to the south-east in accordance with modern portfolio theory.

For each rating, we report the Vigeo ratings and the threshold on the portfolio rating corresponding to the rejection of the mean-variance efficiency at the 5% significance level (Figures 2 to 5 of the Appendix). We notice that the portfolio rating thresholds corresponding to the rejection of the null hypothesis of mean-variance efficiency are all above the mean of the ratings of the twenty countries. Concerning the SCR, i.e. our global proxy of countries' socially responsible behaviour, only portfolios with a rating superior to 79.86 (which corresponds to the mean of the SCR of the study's countries plus 0.51 standard deviation) significantly displace the efficient frontier with a probability of 5%. This means that one can

significantly improve the average rating of the portfolio without significant loss of diversification power. It is thus possible to create socially responsible portfolios of sovereign bonds without a significant diversification cost.

This being said, the possibility of improving the portfolio rating differs depending on the rating types: while it is possible to substantially increase the portfolio rating without significantly moving away from the efficient frontier for the SCR, ERR and SRSR, this is not the case for IRR. Indeed, for IRR, the portfolio rating corresponding to a rejection at a probability of 5% of the mean-variance efficiency is very close to the mean of the ratings of the sample countries. Actually, the ability to improve the average rating of the portfolio without losing diversification power depends heavily on the ratings of the countries whose sovereign bonds are the least correlated with others, that is to say Japan or New Zealand for our sample.

**Table 7 Weights of the WGBI indexes in the minimum variance and tangency portfolios corresponding to the rejection of the BJS (2002) test at a probability level of 10%, 5% and 1%**

| | Minimum variance portfolio | | | | Tangency portfolio | | | |
|---|---|---|---|---|---|---|---|---|
| | | Null hypothesis rejection probability | | | | Null hypothesis rejection probability | | |
| | True Frontier | 10% | 5% | 1% | True Frontier | 10% | 5% | 1% |
| AUS | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| AUT | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| BEL | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| CAN | 0.00% | 0.00% | 0.00% | 0.00% | 5.62% | 0.00% | 0.00% | 0.00% |
| CHE | 15.28% | 25.14% | 25.46% | 25.72% | 18.21% | 25.49% | 25.63% | 25.88% |
| DEU | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| DNK | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| ESP | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| FIN | 0.00% | 5.96% | 5.09% | 3.82% | 0.00% | 12.91% | 12.23% | 11.02% |
| FRA | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| GBR | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| IRL | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| ITA | 1.14% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| JPN | 39.36% | 28.29% | 26.50% | 22.98% | 41.04% | 28.24% | 26.33% | 22.95% |
| NLD | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| NOR | 12.03% | 29.03% | 30.75% | 32.17% | 0.00% | 7.84% | 8.61% | 9.97% |
| NZL | 6.89% | 0.68% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| PRT | 25.30% | 0.00% | 0.00% | 0.00% | 27.66% | 0.00% | 0.00% | 0.00% |
| SWE | 0.00% | 10.90% | 12.20% | 15.31% | 7.47% | 25.52% | 27.20% | 30.18% |
| USA | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

For the global SCR, we report in Table 7 the composition of the minimum variance and tangency portfolios corresponding to the rejection of mean-variance efficiency at the 10%, 5% and 1% probability level and those of the unconstrained frontier. We observe that either limit portfolios or unconstrained portfolios exclude many countries including the United States. Concerning the portfolios of the unconstrained frontier, it has to be noticed that investment is concentrated in countries (Canada, Japan, New Zealand, Norway, Portugal, Sweden, Switzerland) whose WGBI indexes are low uncorrelated. There are few differences in the composition of the minimum variance and tangency portfolios. With regard to the constrained portfolios, the proportion of highly rated countries is closely linked to the constraint on the portfolio's SCR: the stronger the constraint, the higher the proportion of

well-rated countries (mainly Sweden and Switzerland) and the lower the proportion of badly rated countries. Some countries included in portfolios of the unconstrained frontier are absent from the constrained portfolios (Italy, Portugal, Canada) and, on the contrary, some countries absent from the unconstrained frontier are included in the constrained portfolios (Finland in the minimum variance and the tangency portfolios and Sweden in the tangency portfolio). For Eurozone countries, it can be noticed that Portugal has a positive weight in the unconstrained portfolios, the other countries being absent, while only Finland appears in the constrained portfolios. The impact of the constraint on SCR is to concentrate the investment on Finland which is the best rated country of the Eurozone. This illustrates the importance of taking into account the link between the level of socially responsible indicators and sovereign bond correlations when building a socially responsible portfolio.

**Table 8 Descriptive Statistics of the minimum variance and tangency portfolios corresponding to the rejection of the BJS (2002) test at a probability level of 10%, 5% and 1%, period January 1995-December 2008**

| | Minimum variance portfolio | | | | Tangency portfolio | | | |
|---|---|---|---|---|---|---|---|---|
| | | Null hypothesis rejection probability | | | | Null hypothesis rejection probability | | |
| | **True Frontier** | **10%** | **5%** | **1%** | **True Frontier** | **10%** | **5%** | **1%** |
| Ann. Mean | 7.10% | 7.10% | 7.10% | 7.10% | 7.52% | 7.52% | 7.52% | 7.52% |
| Ann. Std. Dev. | 2.53% | 2.66% | 2.69% | 2.73% | 2.58% | 2.72% | 2.74% | 2.79% |
| Max. | 2.60% | 2.56% | 2.53% | 2.48% | 2.76% | 2.76% | 2.73% | 2.68% |
| Min. | -1.86% | -1.85% | -1.85% | -1.85% | -1.85% | -1.88% | -1.87% | -1.87% |
| Skewness | -0.13 | -0.11 | -0.11 | -0.11 | -0.17 | -0.12 | -0.12 | -0.12 |
| Kurtosis | 3.57 | 3.01 | 2.95 | 2.87 | 3.44 | 3.08 | 3.03 | 2.96 |
| Sharpe Ratio | 0.33 | 0.31 | 0.31 | 0.31 | 0.37 | 0.35 | 0.35 | 0.34 |
| Vigeo SCR | 73.33 | 79.56 | 80.01 | 80.73 | 72.73 | 79.47 | 79.86 | 80.55 |

In addition, descriptive statistics of portfolios' returns are available in Table 8. While the average SCR of the constrained portfolios are well improved compared to the unconstrained portfolios, their Sharpe ratios are relatively undamaged. For example, the Sharpe ratio of the tangency portfolio of the true efficient frontier is 0.37 with an average

SCR equal to 72.73 while those corresponding to the rejection of mean-variance efficiency at a probability level of 1% is 0.34 with an average SCR equal to 80.55. As we compare portfolios with equal mean returns, we observe the impact on other moments of the constraint on the average SCR: while volatility increases only slightly with the strength of the constraint (from 2.58% per year to 2.79% per year with the previous example), skewness and kurtosis decrease (respectively from -0.17 to -0.12 and from 3.44 to 2.96), making the extreme risks lower.

In the case of IRR, the difficulty of sensibly improving the portfolio rating with no undue loss of diversification power could be explained by the particularly poor performance of Japan (more than one standard deviation below the average of the countries of the sample) and the weak performance of other countries whose sovereign bonds are not closely correlated with the others, e.g. New Zealand, Canada.

As far as ERR is concerned, the possibility of substantially increasing the average SRI rating of the sovereign bond portfolio compared to the average rating of the sample countries without significantly losing diversification benefits likely comes from the not-so-bad ratings of Japan ($15^{th}$ country) and New Zealand ($12^{th}$). It may also come from the particularly good performance of Switzerland (more than one standard deviation above the average rating of the countries of the sample), whose sovereign bonds returns are moderately correlated with the others.

As regards SRSR and SCR, the results are intermediate with the very high ratings of Norway and Sweden (more than one standard deviation above the mean rating of the study's countries in both cases) and the very low ratings of Japan. The rejection of H0 at the 5%

probability level occurs for portfolio ratings respectively equal to 83.23 (corresponding to the mean plus 0.47 standard deviation) and 79.86 (corresponding to the mean plus 0.51 standard deviation).

## 5. Conclusion

In the current context of financial turmoil, the sovereign bond market is in the spotlight, notably because of the huge increase of public debt. Besides, the considerable size of the sovereign bond market and the growing interest for SRI are strong arguments in favour of developing financial research that joins the two themes. Indeed, it is very likely that investors searching for responsible investments in the stock market would act likewise in the sovereign bond market. However, countries and companies are obviously not judged on the same criteria. For this reason, the first challenge of our study was to find appropriate country ratings that make it possible to define SRI in sovereign bonds. We have chosen the Vigeo Sustainable Country Ratings because they take into account a large set of criteria referring to environmental, social and governance issues. Moreover, we find them to be a good indicator of countries' socially responsible performance. And they are highly reliable because they use only data from international organisations such as the World Bank and various United Nations bodies.

Restricting the set of possible investments reduces the diversification possibilities and displaces the efficient frontier to the south-east. Thus, in principle, requiring higher global socially responsible performances reduces the possibility of diversification. However, our results show that portfolio ratings may be improved at a very low cost, that is, without significantly displacing the efficient frontier. The consequence is that asset managers can create sovereign bond portfolios with a higher than average socially responsible rating without significantly losing diversification possibilities.

This positive result differs across the three sub-ratings of the Sustainability Country Ratings. In sum, requiring better average ratings costs more in terms of diversification for the Institutional Responsibility rating than for the Environmental Responsibility and Social Responsibility and Solidarity ratings. This shows that the investors' decisions to favour some ESG criteria rather than others may have dramatic consequences for the composition and diversification of his/her portfolio. This point is particularly important in an industry with bespoke products.

This work is in line with existing literature focusing on the potential cost associated with SRI (Adler and Kritzman, 2008; Renneboog *et al.*, 2008,b) but it brings the discussion into the sovereign bond market. As we worked here only on developed countries, one interesting direction for further research would be to focus on emerging and developing countries. Indeed, the process of building sovereign bond portfolios is very different for emerging markets. We expect that the socially responsible indicators for emerging countries would be much more scattered than for developed countries and also that ESG criteria play a very different role. Another topic would be to study how to build a socially responsible portfolio containing sovereign bonds and other asset classes, for example corporate bonds, and the financial consequences of this mix. Finally, because of the relativity of individual ethics, another possible area of research is the way in which investors weight different criteria and the implications of those weightings.

## Notes

[1] SRI is defined by the European Social Investment Forum (2008) as "a generic term covering ethical investments, responsible investments, sustainable investments, and any other investment process that combines investors' financial objectives with their concerns about environmental, social and governance (ESG) issues". In practice, SRI has taken various forms, including negative screening, positive screening, and shareholder activism. See Renneboog *et al.*, (2008,a) for a concise description of the successive generations of SRI.

[2] PRI is a joint initiative of the United Nations Environment Programme Finance Initiative (UNEPFI) and the United Nations Global Compact (2005). According to the PRI, investors "will incorporate ESG issues into investment analysis and decision-making process", "support development of ESG-related tools, metrics and analyses", and "encourage academic and other research on this theme".

[3] Innovest Strategic Value Advisors is an extra-financial rating agency. Among other things, it evaluates companies' environmental performances along 60 variables and gives them a score between 1 and 10.

[4] KLD Research & Analytics, Inc. is an extra-financial rating agency. It rates companies on different themes: corporate governance, community, diversity, employee relations, environment, human rights, products.

[5] The ICRG rating is published by the PRS Group. It rates more than 140 countries and comprises 22 variables in three subcategories of risk: political, financial and economic.

[6] Transparency International is an international non-governmental organization addressing corruption. Each year, it publishes the Corruption Perceptions Index that uses different surveys to evaluate perceptions of the degree of corruption in 180 countries.

[7] Vigeo is an extra-financial agency that evaluates the ESG performances of companies and countries.

[8] The same sample as Erb et al. (1996), that is to say: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

[9] Formerly from Salomon Brothers

[10] We use the "All Maturities" indexes rather than comparable maturity indexes because there was no common maturity with sufficiently long series of observations.

[11] These eight goals were established in 2000 by 189 countries as targets to be achieved by 2015.

[12] Agenda 21 on sustainable development was adopted by 179 countries in 1992 at the UN Earth Summit in Rio de Janeiro.

[13] The lowest threshold corresponds to the reference efficient frontier.

[14] Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain belong to the Eurozone since the 1st of January 1999.

[15] That is to say: Australia, Canada, New Zealand and United States.

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## Appendix - Tables

### Table 1 Descriptive statistics of the WGBI indexes in US dollars hedged for FX variations, period January 1995-December 2008

| | Ann. Mean | Ann. Std. Dev. | Max. | Min. | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| **AUS** | 6.67% | 4.38% | 4.84% | -2.11% | 0.50 | 3.39 |
| **AUT** | 7.09% | 3.47% | 4.61% | -2.05% | -0.03 | 3.74 |
| **BEL** | 7.53% | 3.48% | 3.50% | -1.76% | -0.16 | 2.92 |
| **CAN** | 8.16% | 4.35% | 4.45% | -2.15% | 0.43 | 3.59 |
| **CHE** | 7.46% | 3.48% | 3.19% | -1.68% | -0.11 | 2.72 |
| **DEU** | 7.20% | 3.35% | 3.83% | -1.60% | -0.14 | 3.00 |
| **DNK** | 7.45% | 3.44% | 4.33% | -1.46% | 0.07 | 3.42 |
| **ESP** | 7.70% | 3.63% | 4.04% | -1.66% | 0.14 | 3.23 |
| **FIN** | 7.68% | 3.37% | 3.62% | -1.69% | -0.05 | 3.08 |
| **FRA** | 7.47% | 3.59% | 4.28% | -1.75% | -0.01 | 3.05 |
| **GBR** | 6.64% | 4.77% | 5.10% | -2.56% | 0.11 | 3.20 |
| **IRL** | 7.32% | 4.27% | 4.97% | -2.03% | 0.21 | 3.46 |
| **ITA** | 7.29% | 3.72% | 3.72% | -1.78% | 0.07 | 2.83 |
| **JPN** | 7.39% | 3.50% | 4.80% | -4.65% | -0.18 | 8.97 |
| **NLD** | 7.42% | 3.51% | 4.40% | -2.00% | -0.02 | 3.48 |
| **NOR** | 6.06% | 3.61% | 3.84% | -3.03% | 0.03 | 4.01 |
| **NZL** | 5.07% | 3.84% | 4.54% | -2.84% | 0.55 | 4.46 |
| **PRT** | 7.48% | 3.36% | 3.97% | -1.86% | -0.05 | 3.28 |
| **SWE** | 8.11% | 3.91% | 3.81% | -2.27% | 0.03 | 3.10 |
| **USA** | 7.21% | 4.65% | 5.41% | -4.38% | -0.15 | 4.48 |

AUS stands for Australia, AUT Austria, BEL Belgium, CAN Canada, CHE Switzerland, DEU Germany, DNK Denmark, ESP Spain, FIN Finland, FRA France, GBR United Kingdom, IRL Ireland, ITA Italy, JPN Japan, NLD Netherlands, NOR Norway, NZL New Zealand, PRT Portugal, SWE Sweden and USA United States.

**Table 2 Correlation matrix of the monthly returns of the WGBI indexes in US dollars hedged for FX variations, period January 1995-December 2008**

| | AUS | AUT | BEL | CAN | CHE | DEU | DNK | ESP | FIN | FRA | GBR | IRL | ITA | JPN | NLD | NOR | NZL | PRT | SWE | USA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AUS** | 1.00 | 0.65 | 0.66 | 0.75 | 0.53 | 0.66 | 0.66 | 0.61 | 0.66 | 0.63 | 0.65 | 0.62 | 0.58 | 0.36 | 0.65 | 0.59 | 0.73 | 0.63 | 0.65 | 0.68 |
| **AUT** | | 1.00 | 0.97 | 0.62 | 0.74 | 0.97 | 0.90 | 0.88 | 0.91 | 0.96 | 0.77 | 0.91 | 0.85 | 0.28 | 0.97 | 0.72 | 0.59 | 0.91 | 0.79 | 0.74 |
| **BEL** | | | 1.00 | 0.64 | 0.72 | 0.98 | 0.91 | 0.90 | 0.93 | 0.97 | 0.79 | 0.92 | 0.87 | 0.31 | 0.98 | 0.71 | 0.58 | 0.91 | 0.82 | 0.74 |
| **CAN** | | | | 1.00 | 0.47 | 0.63 | 0.65 | 0.60 | 0.65 | 0.63 | 0.65 | 0.60 | 0.57 | 0.29 | 0.63 | 0.55 | 0.64 | 0.60 | 0.58 | 0.78 |
| **CHE** | | | | | 1.00 | 0.73 | 0.71 | 0.66 | 0.70 | 0.71 | 0.58 | 0.68 | 0.60 | 0.24 | 0.72 | 0.56 | 0.52 | 0.67 | 0.62 | 0.56 |
| **DEU** | | | | | | 1.00 | 0.90 | 0.88 | 0.91 | 0.97 | 0.81 | 0.89 | 0.83 | 0.30 | 0.99 | 0.71 | 0.59 | 0.89 | 0.80 | 0.76 |
| **DNK** | | | | | | | 1.00 | 0.86 | 0.90 | 0.91 | 0.80 | 0.87 | 0.84 | 0.22 | 0.91 | 0.73 | 0.56 | 0.86 | 0.86 | 0.72 |
| **ESP** | | | | | | | | 1.00 | 0.87 | 0.90 | 0.76 | 0.91 | 0.94 | 0.13 | 0.88 | 0.68 | 0.49 | 0.97 | 0.83 | 0.68 |
| **FIN** | | | | | | | | | 1.00 | 0.90 | 0.75 | 0.89 | 0.82 | 0.28 | 0.93 | 0.72 | 0.54 | 0.87 | 0.83 | 0.69 |
| **FRA** | | | | | | | | | | 1.00 | 0.80 | 0.91 | 0.87 | 0.22 | 0.97 | 0.69 | 0.56 | 0.91 | 0.81 | 0.75 |
| **GBR** | | | | | | | | | | | 1.00 | 0.77 | 0.73 | 0.19 | 0.81 | 0.62 | 0.57 | 0.74 | 0.71 | 0.71 |
| **IRL** | | | | | | | | | | | | 1.00 | 0.90 | 0.17 | 0.92 | 0.71 | 0.51 | 0.90 | 0.80 | 0.70 |
| **ITA** | | | | | | | | | | | | | 1.00 | 0.12 | 0.84 | 0.65 | 0.48 | 0.92 | 0.78 | 0.66 |
| **JPN** | | | | | | | | | | | | | | 1.00 | 0.30 | 0.22 | 0.32 | 0.16 | 0.19 | 0.28 |
| **NLD** | | | | | | | | | | | | | | | 1.00 | 0.71 | 0.59 | 0.89 | 0.80 | 0.75 |
| **NOR** | | | | | | | | | | | | | | | | 1.00 | 0.49 | 0.68 | 0.69 | 0.52 |
| **NZL** | | | | | | | | | | | | | | | | | 1.00 | 0.53 | 0.51 | 0.67 |
| **PRT** | | | | | | | | | | | | | | | | | | 1.00 | 0.81 | 0.69 |
| **SWE** | | | | | | | | | | | | | | | | | | | 1.00 | 0.60 |
| **USA** | | | | | | | | | | | | | | | | | | | | 1.00 |

**Table 5 Themes taken into account in the Vigeo Sustainability Country Ratings and their weights**

| | |
|---|---|
| **Environmental Responsability** | |
| **Participation in International environmental conventions** | Air<br>Biodiversity<br>Water<br>Land<br>Information systems |
| **Air emissions** | Climate change<br>Ozone layer protection<br>Local and regional air quality |
| **Water** | Water |
| **Biodiversity** | Threatened species<br>Sensitive areas |
| **Land use** | Land use |
| **Environmental pressures** | Waste<br>Energy consumption |
| **Institutional responsability** | |
| **Respect, protection and promotion of civil rights** | Respect, protection and promotion of human rights<br>Respect, protection and promotion of labour rights |
| **Democratic institutions** | Political freedom and stability<br>Control of corruption<br>Independance of justice<br>Market regulation<br>Press freedom |
| **Society Responsability and Solidarity** | |
| **Social protection** | Poverty<br>Employment |
| **Education** | Educational policy<br>Primary school education<br>Secundary school education |
| **Health** | Health policy<br>Mortality<br>HIV/Aids<br>Tuberculosis |
| **Gender equality** | Gender equality |
| **Development aid** | Development aid |
| **Safety** | Safety policy |

**Table 6 Spearman's rank correlation of the Vigeo ratings**

| | SCR | ERR | IRR | SRSR |
|---|---|---|---|---|
| **SCR** | 100.0% | 88.3% | 84.6% | 72.9% |
| **ERR** | | 100.0% | 68.9% | 43.3% |
| **IRR** | | | 100.0% | 58.1% |
| **SRSR** | | | | 100.0% |

SCR stands for Sustainability Country Rating, ERR for Environmental Responsibility Rating, IRR for Institutional Responsibility Rating and SRSR for Social Responsibility and Solidarity Rating.

## Appendix - Figures

**Figure 2 Sustainability Country Ratings and threshold on the SRI portfolio rating for the rejection of the BJS (2002) test at 5%**

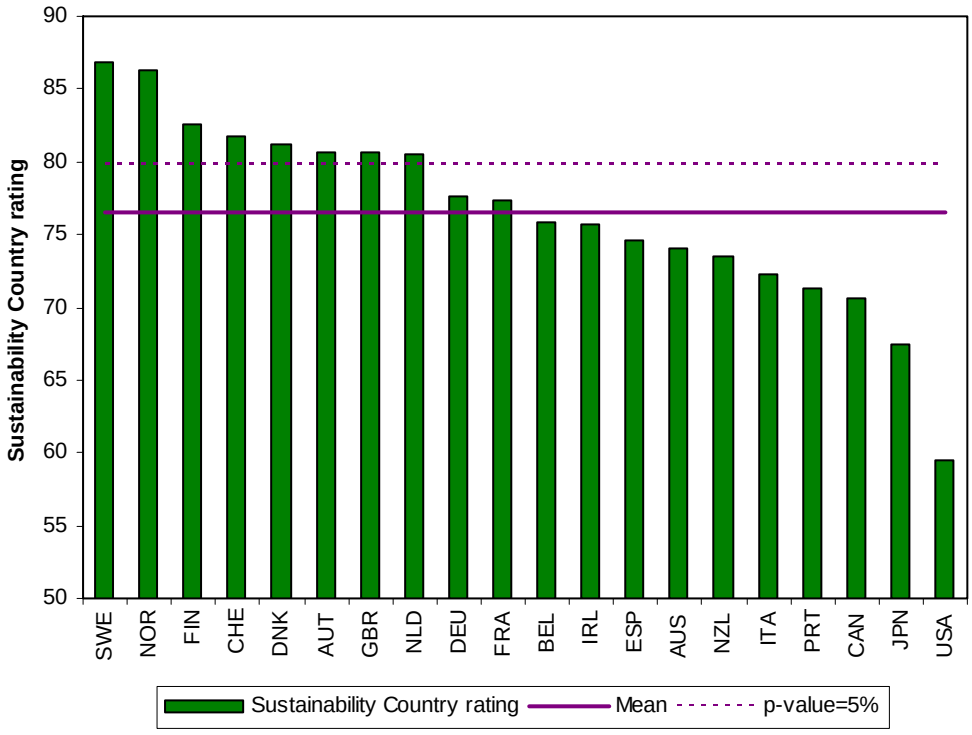


**Figure 3 Environmental Responsibility Ratings and threshold on the SRI portfolio rating for the rejection of the BJS (2002) test at 5%**

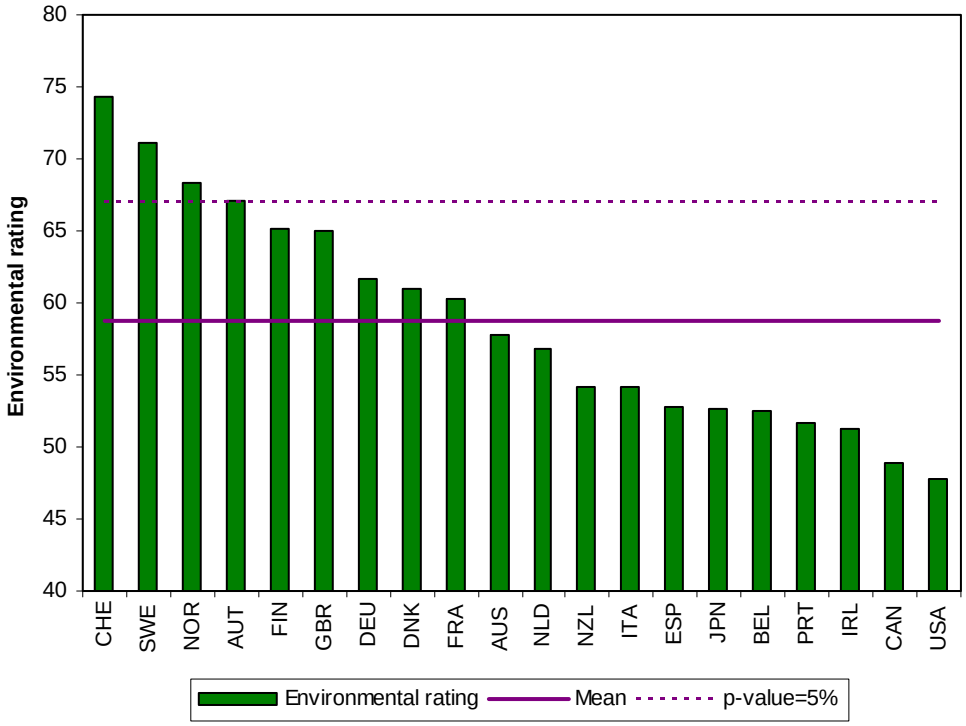

**Figure 4 Institutional Responsibility Ratings and threshold on the SRI portfolio rating for the rejection of the BJS (2002) test at 5%**


**Figure 5 Social Responsibility and Solidarity Ratings and threshold on the SRI portfolio rating for the rejection of the BJS (2002) test at 5%**