Measures for Sustainable Investment Decision Making - A Triple Bottom Line Approach

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Abstract

Traditionally, most investors have only taken economic variables (profitability and risk) into account when making investment decisions. In this paper we propose two measures, the *Relative Sustainable Performance Measure (RSPM)* and the *Measure of Commitment-failure (MC)*, that permit sustainable investment decision making, which takes environmental and social variables into consideration in addition to the economic variables. This makes a Triple Bottom Line (TBL) approach to investment decision making possible. We apply our measures to the worldwide chemical sector and validate them. Moreover, we propose a *2D Graphical Sustainability Analysis*, which is simple and easy for investors to understand when making investment decisions and can be used if they are concerned about environmental and social matters.

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Key Words

Commitment Measurement, ESG, Investment decisions, Performance Measurement, Sustainable Finance, TBL

Abbreviations

- RSPM: Relative Sustainable Performance Measure
- MC: Measure of Commitment-failure
- TBL: Triple Bottom Line
- ESG: environmental, social and corporate governance
- SRI: socially responsible investment
- GRI: Global Reporting Initiative
- VCR: Value Contribution of the Resource
- USD: United States Dollar
- EBIT: Earnings Before Interests and Taxes
- ROTA: Return on Total Assets
- CO_2: Carbon dioxide
- NO_X: Mono-nitrogen oxides
- SO_X Mono-sulphur oxides
- VOC: Volatile organic compound

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2 Introduction

Traditionally, when making investment decisions, investors take into consideration the classic measures of profitability and risk (Markowitz (1952), Merton (1969), Samuelson (1969), Li and Ng (2000)), which are concerned with the economic aspects of investment. However, in the last few decades, and especially since the first definitions of Sustainability[1] (Ehrenfeld (2008)) and Sustainable Development (contained in WCED (1987)) were drawn up, environmental, social and corporate governance (ESG) issues have become more important for both companies and individuals. This is due to increased awareness of the fact that economic activities also generate externalities (Pigou (1920), Coase (1960), Turvey (1963)) that affect society. However, for a long time this effect was not taken into account by those who carry out the activities in question, because it did not directly affect their private costs. Investors' decisions can force companies to take these externalities into account if ESG variables are considered in the investment decision making process.

[1] Sustainability has three pillars: economic, social and environmental.

By making an investment, investors are financing the activities that a company carries out. If investors consider not only economic factors but also environmental and/or social factors when making investment decisions their analysis will be much more accurate. This is the standpoint of the so-called Triple Bottom Line (TBL) approach, first introduced by Elkington (1997) and also explained by other authors such as Slaper and Hall (2011). In fact, socially responsible investment (SRI) is a promising line of research (Renneboog et al. (2008)).

Nevertheless, for investors to be able to consider these factors, they need data and measures to help them to make sense of those data.

A slow but steady data disclosure process started towards the end of the 20th century (with the creation of the 'Global Reporting Initiative (GRI)' and other systems) and indeed continues today. In the beginning the disclosure of ESG data, for example taking part in the GRI, was voluntary (although reporting is mandatory if companies wish to stay within the initiative). The 'United Nations Global Compact' is another worldwide initiative: it was created in 2001 and has since promoted data disclosure with good results, as Williams (2004) anticipated and Rasche (2011) later confirmed.

Later, legislators started to require companies to publish ESG data. In fact, citing United Nations Global Compact (2014): "Once only a voluntary activity, there is a trend towards mandatory non-financial reporting. For example, in South Africa, China, Denmark, Finland, Indonesia, and most recently the European Union there are requirements in place for companies, be they large, publicly-listed or state-owned companies, to disclose ESG practices". In the case of the European Union, Directive 2013/34/EU of the European Parliament and of the Council of 26 June 2013 on the annual financial statements, consolidated financial statements and related reports of certain types of undertakings[2]

[2] Also taking into account amending Directive 2006/43/EC of the European Parliament

obliges large companies with more than 500 employees, such as listed companies and banks, to disclose information regarding environmental, social and other matters as well as issues concerning human rights and anticorruption measures affecting their company. This has led to what has come to be called "Integrated Reporting" (Jensen and Berg (2012), Abeysekera (2013), Cheng et al. (2014), De Villiers et al. (2014)), the creation of single reports that include both economic and non-economic information about companies. Such initiatives have increased the disclosure of non-economic information by companies, as Ioannou and Serafeim (2011) show. However, ESG data disclosure is not consistent from one country and one sector to another (Peiró-Signes et al. (2012)).

Although increasing data disclosure is very positive, for most investors data are just data: they do not reveal whether one company is more sustainable than another. As Clapp et al. (2016) mention in their report, "investors need clear and tailored information to enable climate-smart financial decisions". The same goes for other environmental and social variables. In fact, as Cohen et al. (2015) state, investors prefer "nonfinancial information that is concise, comprehensive, comparable, [...]". This is where measures have a part to play.

To date, there have been many attempts to create measures for the "integration of economic, social and corporate governance performance and reporting in enterprises" (Hřebíček et al. (2011b)). These same authors proposed a series of environmental indicators in Hřebíček et al. (2011a), but did not really present any integrating measure that made the companies comparable. Kocmanová and Dočekalová (2012) also highlight the importance of creating economic indicators of the environmental, social and governance performance of companies but fail

and of the Council and repealing Council Directives 78/660/EEC and 83/349/EEC (Directive 2013/34/EU) as amended by Directive 2014/95/EU of the European Parliament and of the Council of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups (Directive 2014/95/EU).

to present any formula for simple calculation; their study is also based on a survey rather than objective data. Some authors, such as some researchers belonging to the 'ECRI Ethics in Finance & Social Value' group, have conducted private analyses of the sustainability of some firms. However, such analysis is based on private data, is not necessarily subject of public disclosure and cannot feasibly be carried out by investors. Closer to our objective, Sustainalytics and similar companies have created ESG scores that are included in databases such as Datastream or Morningstar, but the way that scores are calculated is not fully disclosed (they outline the process but do not describe the calculations in detail). Herbohn et al. (2014) also create a sustainability measure, which rates companies according to a modified version of the framework proposed by International Finance Corporation (2001), which is based on indicators scaled in levels and not on continuous variables. Moreover, it does not give a reference of comparison to the sector's performance. The closest measure to the one that we sought can be found in the paper by Hahn and Figge (2011), which presents a formula for calculating the Sustainable Value of a company which, unfortunately, is of no use for comparing one company to another since it is not a size-adjusted measure. All in all, our review of the existing tools for sustainable investment decision making reveals a lack of disclosure of methods of calculation (except Hahn and Figge (2011)) in those cases in which the measures allow for comparison of companies (for example, the ratings by Sustainalytics).

One of the aims of this paper is to fill that gap in the literature and propose a *sustainable performance measure*. In addition to taking into account the environmental and/or the social aspects of the activity carried out, any such measure must use objective public data for its calculations and make it feasible to draw comparisons between companies. We also propose a second measure of the *Commitment-failure* or non-persistence of companies in improving their environmental and/or social performances. The objective is to learn whether the apparent commitment of companies on sustainability issues is real or just coincidental. Finally, with those two measures we propose a *2D Graphical Sustainability Analysis* which enables different companies' sustainability performances and levels of commitment to be compared. The ultimate objective is to provide investors with a simple, visual analysis that can be understood by anyone, regardless of their knowledge of finance or sustainability. Given that "a powerful driver of non-financial reporting is the investment community" (United Nations Global Compact (2014)), we expect the availability of tools that facilitate data analysis to strengthen the already existing virtuous circle between the disclosure of data by companies and their use in analysis by investors.

To show the implementation of our measures and analysis, we have applied them to real data from the chemical sector. We have validated our measures and shown the usefulness of the 2D graphical sustainability analysis.

The rest of this paper is organised as follows. Section 2 presents and discusses the above-mentioned measures. Section 3 presents the data from the chemical sector that are used in the implementation exercise presented in Section 4. The last section presents our conclusions.

3 Measures for sustainable investment decision making

This section presents the measures that we propose for a more complete company analysis: the *Relative Sustainable Performance Measure (RSPM)* and its *Measure of Commitment-failure (MC)*. The ultimate aim of obtaining these measures is to present a *two dimensional (2D) graphical sustainability analysis* (Subsection 4.3) that shows how well a company is performing in certain non-economic issues and its commitment or lack of commitment to those issues.

3.1 Relative Sustainable Performance Measure (RSPM)

The relative sustainable performance measure provides an assessment of how well a company is performing in environmental and social matters[3] that makes it possible to draw comparisons between companies. It is based on the profitability measure proposed by Hahn and Figge (2011), i.e. the Value Contribution of the Resource (VCR).

It is a measure that is calculated relative to the $Market$, defined as the set of companies in a specific industrial sector. Firstly, it is hard to judge whether a company's level of, for example, carbon dioxide (CO_2) emissions is high or low, but comparing its emissions with the emissions of the market gives a clear idea about the company's performance on that issue. Accordingly, Hahn and Figge (2011) argue that environmental and social $Resource$s create value if they are used by companies in a more efficient way than the average in the $Market$. Secondly, it is clear that comparisons only make sense for companies that belong to the same industrial sector.

The measure presented in Hahn and Figge (2011) is the following:

$$VCR_{i,t}^{C} = Profit_{t}^{C} - RU_{i,t}^{C} * RE_{i,t}^{Market} \tag{1}$$

where $VCR_{i,t}^{C}$ is the Value Contribution (to the $Profit$) of the Resource i by *Company C* in year t, $Profit_{t}^{C}$ is the Total Returns of the *Company C* in year t measured, in our case, as the EBIT in millions of USD, $RU_{i,t}^{C}$ is the Use of the Resource i by the *Company C*, measured in the units required in each case, and $RE_{i,t}^{Market} = \frac{Profit_{t}^{Market}}{RU_{i,t}^{Market}} = \frac{\sum_{C=1}^{N} Profit_{t}^{C}}{\sum_{C=1}^{N} RU_{i,t}^{C}}$ is the Efficiency[4] of Use of the Resource i by the *Market* in year t, with N being the total number of

[3]Following the TBL approach, it takes into account the 3 pillars of sustainability.

[4]Using Hahn and Figge (2011)'s terminology.

Companies.

The *Resource*s considered are not the conventional land, labour and capital but range from CO_2 emissions to total donations. They are considered as *Resource*s by Hahn and Figge (2011) in the sense that they are things that the *Company* can manage better or worse in carrying out its activities. In the case of CO_2 emissions, the *Company* should try to obtain the same $Profit$ with lower emissions, whereas in the case of total donations it should try to be able to donate more.

Equation 1 shows that the Profit of *Company C* is corrected by the profit that *Company C* would have obtained if it had performed the same way as the $Market$ in the use of *Resource* i (measured as: $RU_{i,t}^{C} * RE_{i,t}^{Market}$). This gives the positive/negative excess profit that the *Company* has obtained ($VCR_{i,t}^{C}$>0 / $VCR_{i,t}^{C}$<0) by using a certain *Resource* more/less efficiently than the $Market$ ($RE_{i,t}^{Market} < RE_{i,t}^{C}$ / $RE_{i,t}^{Market} > RE_{i,t}^{C} = \frac{Profit_t^C}{RU_{i,t}^C}$).

From Equation 1, given the relative (to the market) nature of the VCR, it can be inferred that any cross-sectional average of the VCR is conceptually equal to zero ($\sum_{C=1}^{N} VCR_{i,t}^{C} = 0$). Additionally, $\sum_{i=1}^{I} VCR_{i,t}^{C} \neq Profit_t^C$, where I is the total number of *Resource*s considered.

On the basis of this first approximation made by Hahn and Figge (2011), and because our aim is to be able to compare different companies regardless of their size, we propose a modification to Hahn and Figge (2011)'s measure that makes every company comparable to every other:

$$RSPM_{i,t}^{C} = \frac{VCR_{i,t}^{C}}{TA_t^C} \tag{2}$$

where $RSPM_{i,t}^{C}$ is the Relative Sustainable Performance Measure of the

Resource i of the *Company C* in *year t* and TA_t^C is the Total Assets of the *Company C* in *year t*.

The difference in the way in which the $RSPM$ and the VCR rank different companies is related to the spread of the TA. The bigger the spread the bigger the difference, and the higher the TA the bigger the change in the ranking for a single company[5]

The value of the $RSPM$ for each company and resource increases with the company's profit ($\frac{\partial RSPM_{i,t}^C}{\partial Profit_t^C} > 0$) and decreases the use of the resource ($\frac{\partial RSPM_{i,t}^C}{\partial RU_{i,t}^C} < 0$).

The higher the total assets (TA) are, *ceteris paribus*, the smaller the $RSPM$ is in absolute terms[6]. When the $RSPM$ is positive, the higher the TA the smaller the $RSPM$ ($\frac{\partial RSPM_{i,t}^C}{\partial TA_t^C} < 0$ when $RSPM > 0$). By contrast, when the $RSPM$ is negative, higher TA make the $RSPM$ less negative, i.e. higher ($\frac{\partial RSPM_{i,t}^C}{\partial TA_t^C} > 0$ when $RSPM < 0$).

Once the $RSPM$s are calculated for every *Resource* considered, they can be grouped into less specific resource combinations by working out an arithmetic average[7] of the $RSPM$s to be grouped. This gives an environmental $RSPM$, a social $RSPM$ and a total $RSPM$, grouping the environmental, social and total

[5]For example, in the implementation in this paper, the largest company had the third worst VCR in 2009, but had 9 companies behind it in the $RSPM$ that same year.

[6]Conceptually, the underlying logic is that when a company is bigger (higher TA) a high (positive) VCR is less praiseworthy than it would be for a smaller company (lower TA), since the bigger company has easier access to, for example, newer and less polluting technologies that can result in lower use of environmental resources. It is that ease of access that also makes a low (negative) VCR less alarming in a bigger company than in a smaller one, because it gives the company a greater ability to improve its performance in environmental, social and economic terms.

[7]This average can be weighted either equally (as it is in this paper) or according to the investor's preferences, or indeed according to objective criteria such as the relative damage (good) caused by the use of the different *Resources*.

resources considered (although any combination is possible).

Moreover, for the ultimate objective of this paper, we calculate the time series average value for each *Company* for each *Resource* and for the environmental, social and total $RSPM$ during the period analysed.

3.2 Measure of Commitment-failure (MC)

The measure of commitment-failure emerged from the idea that since sustainability is a relatively new matter for companies, investors could be interested in having a way to measure how companies are performing environmentally and socially over time.

Like financial downside measures that only take into account the left (negative) side of the distribution of the variable analysed (the downside risk presented in Sortino and Van Der Meer (1991)), we propose a way to detect which companies have decreased their interest in these matters over time. In particular, we need to separate upward and downward movements of the $RSPM$ over time and disregard upward movements, since they are not dangerous in this case. Therefore, we propose a measure, the MC, that works like downside-risk measures and considers only downward $RSPM$ movements:

$$MC_i^C = \left| \frac{\sum_{t=2}^{T} A_{i,t}^C * Z(A_{i,t}^C)}{W} \right| \tag{3}$$

where $A_{i,t}^C = RSPM_{i,t}^C - RSPM_{i,t-1}^C$, $Z(A_{i,t}^C)$ is a function which is 1 if $A_{i,t}^C < 0$ and 0 if $A_{i,t}^C \geq 0$, T is the last year for which data are available and W is the total number of two consecutive year periods for which information is available to compute $A_{i,t}^C$.

The aim of only taking downward movements into account is that we seek to detect companies that start neglecting environmental and social issues, whether their average performance is bad or good, and punish them. Whether a company is a good or bad performer is already shown by the $RSPM$ measure. The MC measures something different and shows a positive value if a company's $RSPM$ has decreased in any of the two-year sub-periods in the period analysed and a level of 0 if its performance has remained constant or improved over the whole period. Thus, the measure has a minimum value of 0, which corresponds to the ideal case of companies that have a constant or improving performance over the whole period, and the higher the MC the worse the trend in the company's performance is over time.

The rationale of punishing a company that has been performing well and better for many years but fails to improve or maintain its performance in one year is open to argument. Our answer is that it makes sense for two reasons. On the one hand the company's time series average $RSPM$ will stay positive anyway. On the other hand, if the downturn in the $RSPM$ is relatively small the MC will not be as big as the MC of a company that has had downward movements in more periods.

Some readers may wonder if the MC in fact adds anything new to conventional standard deviation. We want to emphasise that it is not the same as standard deviation because it only takes downward movements into account and it does not take the mean as a reference. We analyse this further later in this paper.

Lastly, it must be noted that this is a dynamic measure, so the MC of a $Company$ for a specific $Resource$ or combination of resources is affected by changes in the efficiency both the $Company$ and the $Market$ in the use of the $Resource$(s) involved in the calculation.

The changes in the latter are not only a result of the change in the individual *Companies*' *Profit*s and use of the *Resource*s, but also of the way the *Market* is defined. In our case, to make the analysis as comprehensive as possible we define the *complete Market* as the group of *Companies* in a sector that have reported data about the specific *Resource* in the specific *year* analysed, so the *Market* may vary from one *Resource* to another and its composition may change over time either because *Companies* enter or exit the *Market* or because they start (or even stop) reporting environmental and social data. As the last mentioned changes can distort realness, they are unwanted. We expect these changes to diminish in the future with new legislation that obliges *Companies* to report environmental and social data so that only entries into and exits from the *Market* will change the *Market*'s composition.

4 Data

In this section we discuss data availability and sample selection criteria for the empirical implementation of our measures.

4.1 Sample selection

The data used in this study are taken from the ASSET4 database in Datastream. At the time of our data collection in May 2015 there was yearly ESG information[8] available about companies' *Use* of many *Resource*s from the 2002 to 2014 for many sectors[9]. As not all sectors and years had enough data for the set of companies in them to be considered as the *Market*[10], we chose a sector

[8] `https://uvalibraryfeb.files.wordpress.com/2013/09/asset4_esg_data_glossary_april2013.xlsx`

[9] In May 2015, many companies had not yet reported their 2014 data.

[10] ESG reporting is not mandatory in all countries or for all companies, and in those where it is the dates on which it became mandatory differ. For example, as stated in the Directive

that on the one hand is highly affected by environmental and social issues[11] and on the other has a large amount of published ESG data: the chemical sector. According to Datastream, the chemical sector between 2009 and 2013 was made up of 127 companies[12] from all around the world.

Once the sector was chosen, we had to decide what ESG resources and years to include in our study. The selection criteria relied heavily on *Representativity*, which was calculated as follows for each *Resource* i and *year* t:

$$Representativity_{i,t} = \left| \frac{\sum_{C=1}^{N}(TA_t^C * W_{i,t}^C)}{\sum_{C=1}^{N}(TA_t^C)} \right| \quad (4)$$

where TA_t^C is the Total Assets of company C in *year* t and $W_{i,t}^C$ is a function which is valued at 1 if there are data available for the Resource i for company C in year t and at 0 if there are none, with N being the total number of companies in the sector according to Datastream.

For example, as can be seen in Table 1, the *Representativity* of the *Resource* 'CO_2 emissions' in 2002 is 8.04%, meaning that CO_2 emissions data are available for a set of companies that represent 8.04% of the total assets of the chemical sector (according to Datastream). The sampling criterion was to choose those *Resource*s that had a *Representativity* in excess of 40% for more than one year, and the years in which the *Representativity* level for all those *Resource*s was higher than 30%. The average *Representativity* in the sample is 60.5%, which

2014/95/EU of the European Parliament and of the Council of 22 October 2014, in the European Union it will be mandatory from 2017.

[11] This is considered to be one of the most polluting industries (Xing and Kolstad (2002)) and, due to the materials involved in its production processes, one of the industries where most labour risk prevention measures must be taken.

[12] The list of companies includes, among others, Dow Chemical, LG Chem, Lotte Chemical, Hanwha Chemical, Air Liquide, AzkoNobel, Mitshubishi Chemical, LyondellBasell and Formosa Plastics.

we consider representative enough.

As a result, the sample selected[13] consists of the annual data available for 2009 to 2013 for the following resources, classified according to their nature:

1. Environmental resources:
   (a) Carbon dioxide (CO_2) equivalent emissions (CO2Em), measured in thousands of tonnes
   (b) Mono-nitrogen oxide (NO_X) emissions (NOxEm), measured in tonnes
   (c) Mono-sulphur oxide (SO_X) emissions (SOxEm), measured in tonnes
   (d) Volatile organic compound (VOC) emissions (VOCEm), measured in tonnes
   (e) Total Waste (WasteTot), measured in thousands of tonnes
   (f) Hazardous Waste (HazWaste), measured in thousands of tonnes
   (g) Total Energy Use (EnUseTot), measured in terajoules (TJ)
   (h) Water Use (WaterUse)[14], measured in cubic hectometres (hm^3)
2. Social resources:
   (a) Injury Rate (InjuryR)[15], measured as the ratio of the total number

[13] It is noteworthy that the *Representativity* percentages would probably be different (and result in a different sample in terms of resources and years) in other sectors. For example, environmental issues may be less important than social issues in the financial sector, so there would be higher *Representativity* percentages for social resources than for environmental ones.

[14] In this paper we consider that a lower level of water consumption is better than a higher one. However, we are aware of the use of water as one of the least (if not the least) pollutant solvents in the chemical sector, so our consideration of $WaterUse$ as a negative resource is open to argument. As our analysis is flexible in these matters, each analyst or investor can change the sign of the variable (positive *Resource*) or not take it into account at all (neutral *Resource*).

[15] Although TBL literature includes $Safety$ variables in the *Environmental* section, we choose to consider them a *Social* resource, as done by Datastream ASSET4.

Year	CO2Em	NoxEm	SoxEm	VOCEm	WasteTot	HazWaste	EnUseTot	WaterUse	WaterRec	EmplLeav	InjuryR	AvTrainH	DonTot
2002	8.04%	7.71%	7.71%	8.30%	4.97%	8.85%	3.32%	5.34%	0.00%	0.00%	14.08%	8.84%	13.45%
2003	13.77%	4.86%	4.86%	7.93%	7.83%	10.40%	7.57%	4.65%	0.00%	5.69%	16.12%	10.22%	12.66%
2004	29.07%	23.38%	22.74%	12.51%	18.99%	8.37%	20.21%	25.76%	0.54%	3.35%	16.60%	10.33%	11.21%
2005	50.56%	50.36%	43.99%	29.16%	25.72%	8.19%	32.41%	42.26%	0.54%	2.90%	21.79%	14.99%	20.01%
2006	56.94%	55.26%	51.41%	32.63%	31.30%	10.41%	34.99%	51.92%	0.55%	2.05%	23.50%	10.22%	21.38%
2007	62.45%	55.04%	51.47%	40.95%	43.01%	23.84%	59.76%	55.64%	2.85%	12.69%	27.30%	19.70%	23.47%
2008	62.26%	59.08%	56.50%	39.93%	56.31%	34.34%	60.66%	57.05%	5.37%	19.93%	28.28%	25.28%	29.86%
2009	68.66%	62.79%	58.10%	42.44%	61.07%	35.70%	62.82%	65.33%	10.01%	25.72%	32.10%	23.12%	39.25%
2010	76.96%	68.11%	64.69%	51.51%	67.93%	42.97%	72.30%	71.79%	16.36%	30.21%	41.38%	28.54%	40.60%
2011	77.77%	67.40%	63.69%	54.19%	70.79%	44.08%	69.89%	72.35%	18.03%	38.69%	43.17%	30.72%	55.83%
2012	81.70%	70.71%	67.67%	56.65%	74.70%	46.57%	77.62%	75.92%	17.99%	40.04%	45.28%	32.44%	57.83%
2013	74.74%	65.97%	63.67%	55.54%	72.50%	43.40%	75.92%	72.19%	18.55%	38.70%	43.45%	35.04%	57.57%
2014	2.77%	2.20%	2.20%	2.64%	2.72%	2.35%	2.98%	2.87%	2.64%	2.20%	2.90%	0.62%	2.90%

Table 1: Representativity of data

This table shows the *Representativity* of the data available calculated as follows: $Representativity_{i,t} = \left| \frac{\sum_{C=1}^{N}(TA_t^C * W_{i,t}^C)}{\sum_{C=1}^{N}(TA_t^C)} \right|$.

of injuries and fatalities including no-lost-time injuries relative to one million hours worked

(b) Total Donations (DonTot), measured in thousands of USD

The reader should note that $TotalDonations$ are a different kind of resource, because they are not considered negative but positive for society, i.e. the more a company donates the better it is for society. This means that, unlike all the other resources selected, it is good if $RE^C < RE^{Market}$. We have therefore introduced a sign change when calculating the Total Donations $RSPM$.

Regarding *Representativity*, the heterogeneity of the sample is evident in Table 1, as not all companies report all data. Therefore, the number of observations, i.e. the number of companies that have reported data for a specific resource in a specific year (out of the 127 possible companies that comprise the worldwide chemical sector according to Datastream's ASSET4 database) is different for each resource in each year, as Table 2 shows[16].

Year	CO2Em	NoxEm	SoxEm	VOCEm	WasteTot	HazWaste	EnUseTot	WaterUse	InjuryR	DonTot
2009	66	55	51	34	57	34	62	60	31	32
2010	78	57	56	38	65	35	74	69	43	39
2011	85	62	60	44	73	45	78	75	46	54
2012	89	62	61	44	78	48	86	80	51	58
2013	79	57	57	43	75	45	82	76	49	57

Table 2: Number of observations

This table shows the number of companies (out of a total of 127) that have provided data for the different variables and years selected.

In addition, for each company and year we have also used data on the following economic variables for our $RSPM$ calculations:

1. Earnings Before Interests and Taxes (EBIT), measured in millions of USD
2. Total Assets (TA), measured in millions of USD

[16]Exceptionally, there are companies that report ESG values but not EBIT, which prevents their RSPMs from being calculated.

It is important to note that the data obtained are aggregate data for each company, regardless of whether the company operates and uses resources in one or more countries. Therefore, we are unable to disaggregate the data in order to analyse *Resource Use* by country or continent, and nor can we analyse the effect of the different legislations that exist.

4.2 Descriptive Statistics

Table 3 summarises the descriptive statistics of the *Resource*s used in the study. As a general comment, the descriptives are stable throughout the period, with some exceptions that we explain below. It is worth mentioning that the median is always lower than the mean, which shows that the most extreme values are on the right side of the distribution. This is confirmed by the fact that the variables are all positively skewed and leptokurtic.

As Panel A shows, average CO_2 equivalent emissions remained quite stable from 2009 to 2012 but in 2013 they doubled, due to Sumimoto Chemical more than quadrupling its emissions. As the other descriptives show, this resource's distribution has fatter tails than a normal distribution (leptokurtic) and is positively skewed, which means that the extreme events are more extreme on the right side of the distribution (the high emission values). The facts that the median is lower than the mean and the standard deviation is double or more than double the mean and the minimum and maximum values only confirm the description of the distribution given above.

NO_X emissions, shown in Panel B, have a similar distribution to CO_2 equivalent emissions. However, it is to worth noting that there were no big changes in the former during the period analysed and that NO_X emissions are about a thousandth of the CO_2 equivalent emissions. Moreover, the coefficients of variation are about double the values of the same statistic for CO_2 equivalent

Year	Mean	Median	Minimum	Maximum	Standard Deviation	Coefficient of variation	Skewness	Kurtosis
Panel A: CO_2 emissions (CO2Em)								
2009 (n=66)	5,373.06	2,337.50	19.80	71,322.00	10,222.88	1.90	4.63	28.42
2010 (n=78)	5,294.35	2,160.90	26.62	74,976.00	10,328.12	1.95	4.61	28.99
2011 (n=85)	5,061.68	1,844.87	26.81	74,778.00	9,988.64	1.97	4.74	30.70
2012 (n=89)	5,212.09	2,196.00	27.10	75,448.00	9,864.04	1.89	4.77	31.53
2013 (n=79)	10,600.67	2,340.00	27.21	412,400.00	47,039.39	4.44	8.17	70.06
Panel B: NO_X emissions (NOxEm)								
2009 (n=55)	6,224.79	1,363.00	7.00	160,000.00	21,628.89	3.47	6.72	48.20
2010 (n=57)	7,103.75	1,530.00	10.30	165,000.00	22,834.12	3.21	6.12	41.92
2011 (n=62)	6,572.40	1,544.00	10.20	155,000.00	21,036.07	3.20	6.11	42.13
2012 (n=62)	6,859.90	1,965.40	10.50	155,000.00	20,972.13	3.06	6.12	42.30
2013 (n=57)	6,007.37	1,683.60	7.70	158,000.00	20,916.65	3.48	6.91	50.69
Panel C: SO_X emissions (SOxEm)								
2009 (n=51)	7,277.93	730.00	0.70	233,000.00	32,549.61	4.47	6.73	47.18
2010 (n=56)	7,915.59	852.00	0.50	241,000.00	32,742.76	4.14	6.66	47.61
2011 (n=60)	6,897.28	519.00	0.29	208,000.00	27,637.17	4.01	6.67	48.47
2012 (n=61)	6,722.88	899.00	0.26	202,000.00	26,607.04	3.96	6.73	49.34
2013 (n=57)	6,059.67	494.00	0.15	215,000.00	28,455.88	4.70	7.13	52.84
Panel D: VOC emissions (VOCEm)								
2009 (n=34)	3,418.72	767.00	64.80	47,000.00	8,164.55	2.39	4.68	25.39
2010 (n=38)	3,560.36	915.50	25.21	47,700.00	7,924.14	2.23	4.74	26.77
2011 (n=44)	3,200.57	918.00	22.47	46,500.00	7,180.57	2.24	5.17	31.51
2012 (n=44)	3,302.62	1,160.00	21.00	47,200.00	7,318.16	2.22	5.10	30.87
2013 (n=43)	3,327.73	1,049.00	2.00	47,500.00	7,437.71	2.24	5.06	30.38
Panel E: Total Waste (WasteTot)								
2009 (n=57)	1,540.17	93.94	2.99	34,506.00	5,646.03	3.67	4.61	24.37
2010 (n=65)	1,093.07	71.92	2.02	29,089.50	4,507.19	4.12	5.39	31.29
2011 (n=73)	4,463.39	88.70	3.91	218,393.00	26,050.86	5.84	7.78	64.08
2012 (n=78)	4,460.50	84.43	3.05	246,129.06	28,225.92	6.33	8.22	70.72
2013 (n=75)	4,389.52	80.00	3.57	252,974.46	29,449.88	6.71	8.19	69.54
Panel F: Hazardous Waste (HazWaste)								
2009 (n=34)	68.36	18.67	0.20	560.00	121.53	1.78	2.89	11.20
2010 (n=35)	112.99	28.05	0.20	1,199.00	231.47	2.05	3.46	15.57
2011 (n=45)	143.10	23.50	0.15	2,287.51	384.15	2.68	4.46	23.82
2012 (n=48)	131.29	20.16	0.10	2,284.42	369.22	2.81	4.73	26.44
2013 (n=45)	130.56	18.74	0.15	1,877.75	328.49	2.52	4.10	20.53
Panel G: Total Energy Use (EnUseTot)								
2009 (n=62)	66,538.59	24,497.35	396.00	521,000.00	95,964.13	1.44	2.65	11.00
2010 (n=74)	69,610.01	24,737.71	530.00	590,600.00	105,103.96	1.51	2.67	11.21
2011 (n=78)	72,133.60	26,452.23	424.63	606,600.00	108,536.90	1.50	2.56	10.48
2012 (n=86)	72,889.40	30,600.00	452.26	592,900.00	107,042.87	1.47	2.47	9.84
2013 (n=82)	70,633.98	28,049.33	517.83	592,800.00	104,307.64	1.48	2.66	11.25
Panel H: Water Use (WaterUse)								
2009 (n=60)	175.57	51.41	0.28	3,009.00	453.06	2.58	5.04	29.59
2010 (n=69)	155.18	42.26	0.39	2,693.00	378.38	2.44	5.11	32.27
2011 (n=75)	156.19	35.13	0.29	2,830.00	392.71	2.51	5.11	32.21
2012 (n=80)	160.81	38.61	0.30	2,770.00	378.03	2.35	4.91	31.39
2013 (n=76)	153.74	40.25	0.38	3,052.00	403.36	2.62	5.58	38.09
Panel I: Injury Rate (InjuryR)								
2009 (n=31)	3.94	2.70	0.00	13.50	3.44	0.87	1.44	4.53
2010 (n=43)	3.49	2.70	0.00	14.15	3.23	0.92	1.46	5.13
2011 (n=46)	4.25	2.30	0.00	46.91	7.21	1.70	4.79	28.54
2012 (n=51)	3.97	2.48	0.00	38.33	5.77	1.46	4.41	26.35
2013 (n=49)	3.81	2.31	0.07	35.58	5.41	1.42	4.43	26.14
Panel J: Total Donations (DonTot)								
2009 (n=32)	4,691.96	2,546.04	1.10	26,800.00	6,633.03	4.23	4.86	25.75
2010 (n=39)	4,261.18	2,152.07	1.40	40,060.00	7,288.51	3.51	4.44	23.44
2011 (n=54)	5,174.06	1,782.87	0.00	51,400.00	8,920.26	4.20	5.60	35.87
2012 (n=58)	5,364.80	1,626.47	0.00	50,550.00	10,029.00	5.63	7.03	51.68
2013 (n=57)	6,286.90	2,000.00	1.54	73,511.33	12,281.77	5.04	6.28	42.13

Table 3: Descriptives of the *Resource*s year by year

This table shows the descriptive statistics of all the environmental and social resources used in this study, each measured in its respective unit of measure as stated above.

emissions, which means that the tails are fatter. This is confirmed by a much higher level of kurtosis.

As shown in Panel C, SO_X emissions have a similar distribution to those of NO_X.

Panel D shows that VOC emissions have a similar distribution to CO_2 equivalent emissions between 2009 and 2012. The minima in 2012 and especially in 2013 correspond to the company Yara International, which seems to have made a real effort to improve its $Resource\ Efficiency$ over the whole 2009-2013 period.

As Panel E shows, average Total Waste reported by companies quadrupled from 2010 to 2011. This is due, at least in part, to one company, MOSAIC, having approximately sextupled its Total Waste from 2009 to 2011 (in 2010 it did not report any data for this variable).

Panel F shows two significant changes in the Hazardous Waste variable. One happens in the period 2009-2010, when the mean of the variable nearly doubles. This is due to the company Lyondellbasell Inds.Cl.A starting to report its data in 2010 and its value being 2010's maximum. In 2011 the maximum almost doubled again, when the company Incitec Pivot started providing data on this variable.

Panel G shows that Total Energy Use has the least leptokurtic distribution of all the resources used in this study. However, it is positively skewed and leptokurtic, just as all the other variables are.

Panel H shows that the distribution of Water Use looks similar to that of VOC emissions.

In Panel I some interesting facts about the Injury Rate variable can be seen.

First of all, the minimum is really low throughout the period. This means that those companies that have fewer injuries relative to one million hours worked are close to or at zero, which is good news. Secondly, a big increase in the maximum can be seen in 2010-2011. This is due to the company K+S starting to report these data in 2011 and its figures being very high in comparison to those reported by other companies in the years before. This made the distribution more positively skewed and leptokurtic in 2011.

Total Donations, shown in Panel J, show a steady increase, indicating that at least some companies have become more socially aware (especially those that donate most: Dow Chemical, the biggest company in the sample in terms of Total Assets in the first four years, although it decreased its donations in 2013, and Sasol, which shows a steady increase culminating in the maximum for 2013).

Table 4 shows the trend in the average EBIT of the chemical sector in the 2009-2013 period. There is a tendency towards EBIT growth, but some years are not as good as others. One company, Lyondellbasell Inds.Cl.A, is worth mentioning since it started in 2009 and 2010 with the lowest value in the distribution and ended up in 2011 with the highest, with the latter being much higher than any of the other maxima. This value made the distribution more positively skewed and more leptokurtic.

Year	Mean	Median	Minimum	Maximum	Standard Deviation	Coefficient of variation	Skewness	Kurtosis
2009 (n=122)	490.17	267.74	-5,411.81	4,942.40	981.02	2.00	0.01	18.17
2010 (n=123)	363.80	186.80	-2,620.84	2,995.90	664.67	1.83	0.92	9.28
2011 (n=125)	746.46	387.30	-4.15	10,434.17	1,127.78	1.51	5.55	45.30
2012 (n=125)	780.40	443.93	-40.47	4,863.12	866.66	1.11	2.09	7.82
2013 (n=125)	677.96	379.11	-1,574.22	4,648.76	903.60	1.33	2.09	8.54

Table 4: Descriptives of Earnings before Interest and Taxes year by year

This table shows the descriptive statistics for the variable Earnings before Interest and Taxes (EBIT), which is measured in millions of USD.

Table 5 shows a steady increase in the average Total Assets of the companies. The maxima in all the years of the period are those of Dow Chemical, the largest company in our sample.

Year	Mean	Median	Minimum	Maximum	Standard Deviation	Coefficient of variation	Skewness	Kurtosis
2009 (n=122)	6,864.50	4,379.11	0.57	41,574.00	7,858.43	1.14	2.09	7.39
2010 (n=123)	7,116.85	4,200.30	2.54	63,898.00	8,805.62	1.24	3.12	16.83
2011 (n=125)	7,947.85	5,004.22	33.17	67,509.00	9,525.71	1.20	2.95	15.33
2012 (n=125)	8,448.89	5,426.06	37.26	66,665.00	9,596.75	1.14	2.79	14.06
2013 (n=125)	8,797.76	5,539.06	109.09	66,272.00	9,819.35	1.12	2.67	12.92

Table 5: Descriptives of Total Assets year by year

This table shows the descriptive statistics of the variable Total Assets (TA), which is measured in millions of USD.

5 Results

This section presents the main results of applying the measures proposed to data for the companies in the chemical sector worldwide.

5.1 Descriptives and analysis of the RSPM and the MC

With the variables presented in the previous section, we calculated the $RSPM$ for each company, year and resource (and for the Environmental, Social and Total resources) and their associated MCs.

Tables 6 and 8 summarise the main statistical descriptive measures for the $RSPM$ and the MC, respectively, along with some other values, that we consider relevant in each case.

We analyse the $RSPM$ first. To make it easier to interpret, we start by taking an example from Table 6. The mean value of the $RSPM$ which takes into account CO_2 emissions is 0.0316. This means that, on average[17], each company in the sample obtained a profit that exceeded that of the $Market$ by

[17] This is the cross-sectional mean of the time-series means calculated previously for each company.

about 3% of their Total Assets due to their good management of CO_2 emissions in 2009-2013.

Table 6 shows that the mean is statistically zero for 6 out of 13 resources or combinations of resources. The other values are positive for some environmental resources and negative for social resources and their combination, and for the combination of all resources, at different levels of significance. The fact that the Total $RSPM$ is negative (although only at the 10% level of significance) is remarkable, and means that on average for the whole period and all companies the profit obtained was lower than it would have been if they had performed the same way as the market due to the managing of the combination of all the resources considered. Specifically, if they had performed the same way as the market, they would have obtained, on average, a profit higher by an average of about 3% of their Total Assets (the mean of Total $RSPM$ is -0.0317).

Furthermore, it can be seen in Table 6 that the median $RSPM$ (of the time series averages calculated for each company) is positive for all environmental resources and their combination, and negative for all social resources and their combination, which means that more and less than 50% of the companies respectively obtained positive time-series average RSPM values. The percentage of companies with a positive average RSPM confirms that more companies perform better/worse than the $Market$ in the cases where the median is positive/negative. The percentage of positive values (without making time-series averages for the companies) is also similar. These facts show that most companies generally perform better in environmental matters than in social matters, which may imply that the companies that made up the chemical sector between 2009 and 2013 were more aware of environmental concerns than of social concerns. It might be thought that a high percentage of positive values means that the sector is performing fine, and in a way it is, but the somewhat symmetric nature of the VCR, the measure on which the $RSPM$ is built, must not be

	Mean	Median	Minimum	Maximum	Standard Deviation	Coefficient of variation	Skewness	Kurtosis	% of positive values	% of companies with a positive average value	% of companies with at least one positive value
CO2Em	0.0316***	0.0362	-0.2535	0.2491	0.0844	2.6686	-0.6917	5.1010	68.39%	76.47%	94.39%
NoxEm	-0.0423	0.0516	-4.4297	0.1855	0.5762	13.6255	-7.1999	55.1195	75.00%	76.19%	98.84%
SoxEm	-0.0280	0.0566	-3.6731	0.1873	0.5032	17.9847	-6.6199	47.7138	80.36%	81.67%	95.35%
VOCEm	0.0064	0.0222	-0.5486	0.1885	0.1395	21.9263	-2.0216	8.5229	61.11%	64.44%	73.61%
WasteTot	0.0069	0.0651	-2.7736	0.1941	0.3735	54.1826	-6.1167	43.2009	87.54%	90.79%	98.89%
HazWaste	-0.0245	0.0510	-2.1164	0.1780	0.3642	14.8468	-4.6391	25.7971	67.51%	67.39%	70.00%
EnUseTot	0.0244**	0.0312	-0.5941	0.2613	0.1116	4.5803	-2.1189	13.5623	64.69%	69.41%	91.00%
WaterUse	0.0413***	0.0531	-0.2400	0.2529	0.0931	2.2540	-0.5939	3.6139	69.05%	71.43%	89.16%
InjuryR	-0.2239***	-0.0068	-3.3186	0.1618	0.6701	2.9937	-3.4182	14.6102	51.40%	50.00%	69.01%
DonTot	-0.0333***	-0.0340	-0.2867	0.4607	0.1058	3.1759	1.1345	9.9991	32.92%	33.33%	54.55%
Environmental	0.0108	0.0399	-1.3134	0.2613	0.1740	16.0366	-5.2024	38.9016	67.31%	73.33%	92.92%
Social	-0.1421***	-0.0241	-3.3186	0.4979	0.5074	3.5700	-5.1550	30.9043	38.32%	40.00%	56.41%
Total	-0.0317*	0.0142	-1.4361	0.1790	0.1975	6.2312	-4.5911	29.7709	57.36%	58.00%	84.21%

Table 6: Descriptives of the RSPM for the individual and grouped resources

This table shows the descriptive statistics of the Relative Sustainability Performance Measure (RSPM) for each *Resource* and resource combination. Specifically, it shows the mean, the median, the minimum, the maximum, the standard deviation, the coefficient of variation, the skewness, the kurtosis, the percentage of positive values (out of the total values calculated), the percentage of companies with a positive average RSPM during the whole 2009-2013 period (out of all the companies with an RSPM average value for the period, i.e. those for which there are at least 2 yearly values) and the percentage of companies that have a positive RSPM value in at least one of the years from 2009 to 2013 (out of all of the companies that have at least one RSPM value). The symbols ***,** and * denote that the mean value is statistically different from zero, according to the sign test with confidence levels of 1%, 5% and 10%, respectively.

forgotten. This means that the higher the percentage of positive values is, the more probable it is that there are more companies that are performing really badly, with extremely negative $RSPM$ values. For example, NO_x Emissions $RSPM$, with 76.19% of positive values, has a very negative minimum (-4.4297) but the rest of the values are around and especially just above 0. The maximum is 0.1855, very little in absolute terms compared to the minimum. Lastly, the percentage of companies that have at least one positive $RSPM$ value during the period is really high for most of the $Resource$s or combinations of them. This means that almost every company has performed better than the market at least once (though some do not perform this way regularly, as the lower percentages of companies with an average positive value show).

The trend over time in the $RSPM$ for the combinations of environmental, social and all resources over the years analysed is displayed in Figure 1, where each coloured line represents a company. It can be seen that there is heterogeneity between companies and that although there are positive values for some companies the most extreme values are negative[18]. This means that some companies perform really badly in environmental and social issues, which should be a reason for investors not to choose these companies in their investment portfolios. However, most of the companies in question seem to have improved their performance by the end of the period, which may also be a positive sign for investors.

Moreover, the most remarkable point in Figure 1 is the $RSPM$s of many of the companies remain quite stable over time. This can be seen more clearly in the next section, when the MC is added to the analysis.

In order to validate our measure as something new, we need to demonstrate that it provides information that is not included in the classic measures used in

[18] It is evident that there are some companies for which we do not have data for all the years, as expected from Table 2. This is especially evident in the most negative cases.

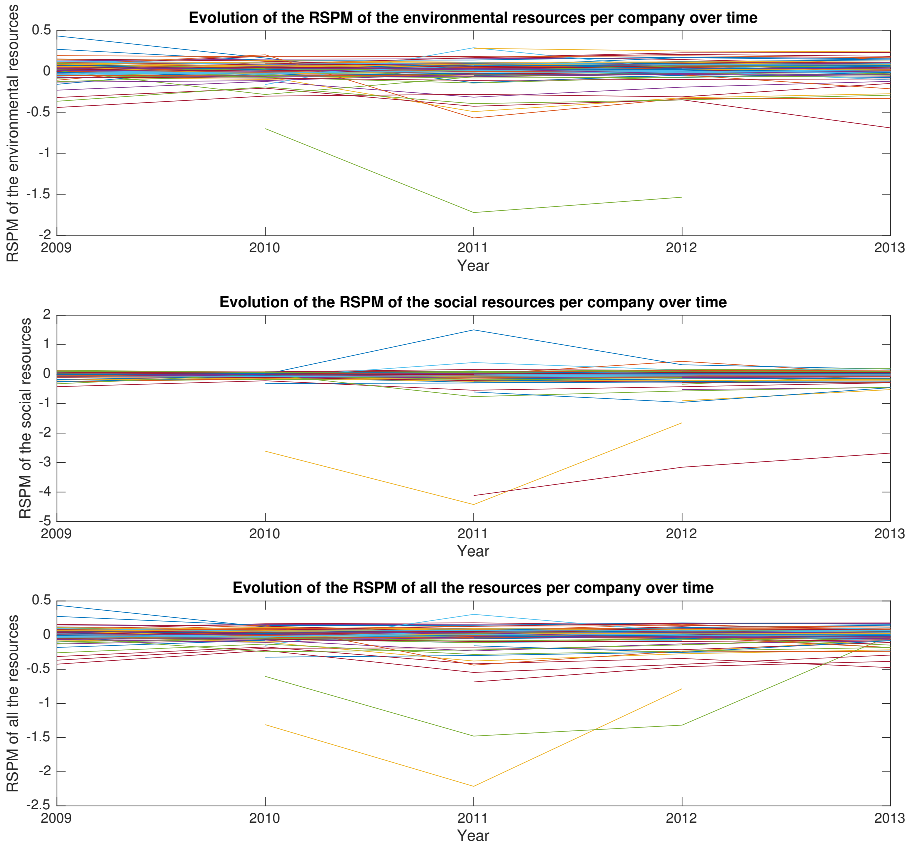

Figure 1: Trend in RSPM over time

This graph shows the trend in the $RSPM$ of the combination of the environmental resources, the combination of the social resources and the combination of all the resources for each company from 2009 to 2013. Each line on the graph corresponds to a company.

investment decision making. We take the Return on Total Assets ($ROTA$) as the classic economic measure with which to compare the $RSPM$.

The $ROTA$ is calculated as follows, using the information available in our database: $ROTA_t^C = \frac{EBIT_t^C}{TA_t^C}$.

Accordingly, we conducted four analyses, one graphic and three analytical. For the graphic analysis the Total $RSPM$ (rescaled for a better graphic representation) has been plotted against the $ROTA$ in Figure 2, both for time series averages per company and for all the company-year observations. In both cases it can be seen that there are companies that perform well financially (high $ROTA$) but not environmentally and socially (low $RSPM$) and viceversa. This evidence seems to confirm that our measure provides new information for investors (although there are also companies that perform well or badly in both financial and environmental/social issues).

We prove this also by calculating the Pearson correlation coefficient for the Total $RSPM$ and $ROTA$, obtaining low values for both average and non-average data (0.1002 and 0.1915, respectively). Although only the first is statistically equal to 0 (p-values for the 2-tailed test are 32.13% and 0% respectively), the value of the correlation is not high enough to make us reject the idea that the $RSPM$ is, indeed, a different measure from the $ROTA$.

In addition, we performed linear regression analysis through Ordinary Least Squares (OLS) to see if the $ROTA$ was capable of explaining the different $RSPM$ calculated. The model tested for each resource i or combination of resources is the following:

$$RSPM_{i,t}^C = \alpha_i + \beta_i * ROTA_t^C \tag{5}$$

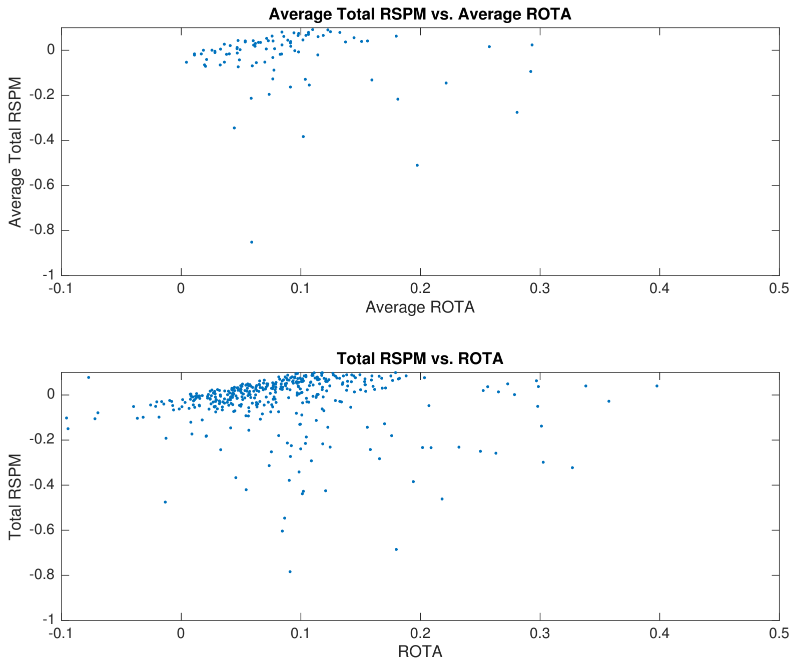

Figure 2: Total RSPM vs. ROTA (Time series average and company-year observations)

This graph shows the Total $RSPM$ plotted against the $ROTA$ for both time series averages per company and all company-year observations.

Table 7 shows the main results obtained. We find that in 8 out of 13 cases they are closely related, with significant betas (at the 5% confidence level). However, except in one case where the adjusted R^2 is nearly 60%, the figures do not exceed 40%, which makes us believe that the $RSPM$ is not only measuring what the $ROTA$ measures.

	Beta	P-value	Adj. R^2
CO2Em	0.8742	0.00%	31.89%
NoxEm	0.7736	6.01%	0.88%
SoxEm	0.4585	20.96%	0.21%
VOCEm	0.6087	0.00%	8.17%
WasteTot	-0.5150	11.11%	0.46%
HazWaste	0.7874	1.71%	2.38%
EnUseTot	0.9934	0.00%	39.60%
WaterUse	1.0972	0.00%	58.42%
InjuryR	-0.0599	92.47%	-0.47%
DonTot	-0.5869	0.00%	10.00%
Environmental	0.7755	0.00%	11.82%
Social	-0.3112	34.07%	-0.03%
Total	0.4957	0.00%	3.46%

Table 7: Results of the linear regressions RSPM vs. ROTA

This table shows the betas, their p-values and the adjusted R^2 for the 13 regressions conducted. The model tested is: $RSPM_{i,t}^C = \alpha_i + \beta_i * ROTA_t^C$.

Lastly, we also calculated the Spearman correlation between the two variables, obtaining high positive and negative[19] values that are significantly different from zero and range from -0.5 to 0.84. This shows that both measures do not rank the same way by definition, since if that had been the case we would have expected to find similar coefficients of correlation between the ROTA and the different implementations of the RSPM (different resources and resource combinations). In fact, we confirmed this by looking at a selection of particular cases selected, which can be seen in Table 10. As an example, it can be seen that there are companies such as MOSAIC or DULUXGROUP that have two of the highest ROTA values of the sample but have negative average Total $RSPM$s.

Altogether, we can confirm that $RSPM$ and ROTA do not measure the same thing and that the contribution of our measure $RSPM$ is relevant.

[19]It is noteworthy that the negative values correspond to total donations and the social factor grouping.

Table 8 contains the descriptive statistics for the MC. 0.0195 is the mean of downward movements of the companies' CO_2 Emission RSPM during the period (taking into account only the years with $RSPM$ data for each company). It can be seen that the median is low compared to the maximum in all cases, which means that some values are far away from the majority (see the maxima and Figures 4, 5 and 6). The fact that the mean is always higher than the median confirms this. The minima are zero in all cases, which is the theoretical minimum of the measure. This shows that there are indeed companies that improve or, at least, do not worsen their performance over time, which is good. However, the percentage of companies that show such behaviour is low, for example 14% for the Total MC as can be seen in the last column of the table. This shows that most companies are not really committed to environmental and social issues. It is also worth noting that although they generally perform worse in social issues, chemical companies do not worsen their performance in social issues as much as in environmental issues (12.22% vs. 18.75% of zero-values).

In order to make sure that the MC is not the same as the standard deviation of the $RSPM$, we again conducted four analyses: one graphic and three analytical. First of all, we plotted the Total MC against the standard deviation of the Total $RSPM$ (see Figure 3). As can be seen, there is a positive link between the two variables when the MC is positive, but no clear pattern exists for companies with an MC value of zero.

In our second analysis, we obtained high significant correlations between MCs for different resources and resource combinations and the standard deviations of their corresponding $RSPM$s. We attribute these high correlations to the low zero-value percentages, because not taking into account (that is, not punishing) upward movements is the most distinctive part of our measure. Since the percentage of companies with MC values of zero is really low, they do not offset the highly correlated MCs and standard deviations of the badly

	Mean	Median	Minimum	Maximum	Standard Deviation	Coefficient of variation	Asymmetry	Kurtosis	% of 0 values
CO2Em	0.0195***	0.0128	0.0000	0.2949	0.0344	1.7630	6.2822	49.9086	10.59%
NoxEm	0.0322***	0.0137	0.0000	0.8253	0.1036	3.2200	7.3020	56.3585	6.35%
SoxEm	0.0321***	0.0127	0.0000	0.6953	0.0913	2.8408	6.5980	48.0668	3.33%
VOCEm	0.0189***	0.0087	0.0000	0.1091	0.0253	1.3386	2.0065	6.6563	11.11%
WasteTot	0.0140***	0.0118	0.0000	0.0644	0.0121	0.8692	1.3212	5.5994	13.16%
HazWaste	0.0139***	0.0048	0.0000	0.0860	0.0198	1.4234	1.8955	6.4542	28.26%
EnUseTot	0.0193***	0.0111	0.0000	0.1220	0.0233	1.2087	2.4349	9.7886	11.76%
WaterUse	0.0177***	0.0132	0.0000	0.0849	0.0171	0.9641	1.7889	6.6942	6.49%
InjuryR	0.0277***	0.0072	0.0000	0.4525	0.0676	2.4434	5.2137	31.9810	23.08%
DonTot	0.0219***	0.0073	0.0000	0.3331	0.0462	2.1114	5.4028	36.0701	20.00%
Environmental	0.0238***	0.0114	0.0000	0.2560	0.0410	1.7208	3.6182	17.3344	12.22%
Social	0.0284***	0.0092	0.0000	0.4525	0.0659	2.3221	4.8455	28.3275	18.75%
Total	0.0238***	0.0156	0.0000	0.2257	0.0375	1.5721	3.6134	17.8775	14.00%

Table 8: Descriptives of the MC for the individual and grouped resources

This table shows the descriptive statistics of the Measure of Commitment-failure (MC) for each of the resources and resource combinations. Specifically, it shows the mean, the median, the minimum, the maximum, the standard deviation, the coefficient of variation, the skewness, the kurtosis and the percentage of zero values (out of all the values calculated, one for each company that has at least 2 RSPM yearly values). The symbol *** denotes that the mean value is statistically different from zero, according to the sign test with a level of confidence of 1%.

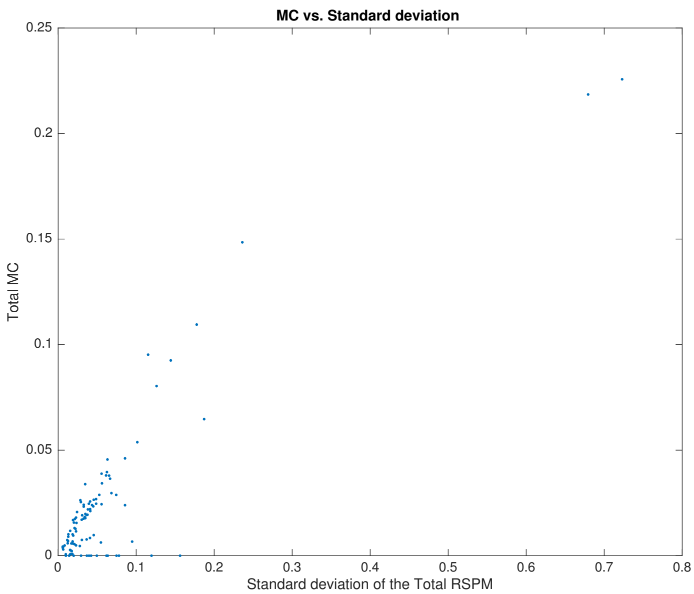

Figure 3: MC vs. Standard deviation

This graph shows the Total MC plotted against the standard deviation of the Total $RSPM$.

performing companies . To prove this, we calculated the correlation between the correlations calculated earlier (of which there were 13, one for each resource or resource combination) and the percentage of MC values of zero. The result was a value of -0.34, which means that the higher the percentage of "zero values" is, the bigger the difference is between the values of the standard deviation of the $RSPM$ and the MC. Although that correlation is not significantly different from zero (probably due to the fact that only 13 data items were used to calculate it), we consider the result enough to corroborate that the MC is not the same as the standard deviation of the $RSPM$.

Moreover, we used OLS to linearly regress the MCs for each resource and resource combination against the standard deviations of the corresponding $RSPM$s, testing the following cross-sectional model:

$$MC_i^C = \alpha_i + \beta_i * \sigma(RSPM_i^C) \tag{6}$$

where $\sigma(RSPM_i^C)$ is the standard deviation of the time series of $RSPM$ for resource or combination of resources i of company C.

The results obtained (see Table 9) show that in 11 of the 13 cases the beta is statistically significant. Furthermore, in most of the cases where the percentage of zero-values of the MC is lower the adjusted R^2 is much higher, almost explaining the whole MC in some cases. Therefore, we continue to attribute the close relationship between the MC and the standard deviation of the $RSPM$ to the low percentage of companies with MC values equal to zero.

	Beta	P-value	Adj. R^2
CO2Em	0.5241	0.00%	84.81%
NoxEm	0.4789	0.00%	98.76%
SoxEm	0.4640	0.00%	98.10%
VOCEm	0.1815	0.07%	21.67%
WasteTot	-0.0006	93.32%	-1.34%
HazWaste	0.0632	5.70%	5.90%
EnUseTot	0.5134	0.00%	65.84%
WaterUse	0.2947	0.00%	42.07%
InjuryR	0.2327	0.00%	62.56%
DonTot	0.4563	0.00%	88.13%
Environmental	0.5154	0.00%	86.62%
Social	0.2887	0.00%	69.43%
Total	0.3324	0.00%	79.73%

Table 9: Results of the linear regressions MC vs.$\sigma(RSPM)$

This table shows the betas, their p-values and the adjusted R^2 for the 13 regressions conducted. The model tested is: $MC_i^C = \alpha_i + \beta_i * \sigma(RSPM_i^C)$.

Finally, we calculated the Spearman correlations between the two variables. Although they are significantly different from zero (as expected), the coefficients are never higher than 0.72. We can thus confirm that the rankings of companies that result from each of the two variables are different.

In short, we have proven that the MC is not the same measure as the standard deviation of the $RSPM$ and that it is therefore a good contribution to the literature.

Finally, we sought to learn whether there was a relationship between the $RSPM$ and the MC. We calculated the Pearson correlation for the 13 resources or resource combinations and, in most cases, obtained negative correlations significantly different from zero. This means that in general those companies that perform better in the different categories presented are also more committed to those issues.

5.2 2D graphical sustainability analysis

This section takes both measures proposed into account at the same time and presents the 2D[20] graphical sustainability analysis: a tool for making *sustainable* investment decisions. By using it investors can choose not only those companies that have positive $RSPM$ values but also those which also work to maintain them or even make them better.

One really valuable aspect of this 2D graphical sustainability analysis is that investors can apply it to whatever resource or set of resources[21] they are concerned about or consider most important, as $RSPM$ and MC are calculated for each of them.

The 2D graphical analysis for the environmental (Figure 4) and social (Figure 5) resources separately and for the above-mentioned different combinations (Figure 6) can all be seen. In each graph we represent the MC on the x-axis and the time series Average $RSPM$ for each company on the y-axis. Therefore,

[20]Referring to the 2-dimensional nature of the graph and not to the number of sustainability pillars taken into account: all 3 are covered: economic, social and environmental.

[21]It is important to note that in the resource combinations (Figure 6) some of the downward movements offset upward ones in other resources, so the same company can have MC=0 in an aggregate measure and MC>0 for some of the individual resources of which it is composed. Therefore, if an investor is concerned, for example, about environmental issues, especially NO_x emissions, he/she should take into account both issues, analysing the two different relevant 2D analyses. He/she could evaluate one company using one analysis and, if it fulfils his/her expectations, go on to evaluate the company using the other to see whether it performs in the range acceptable to him/her. The order of the analysis depends on his/her priorities.

every point on a graph corresponds to a company. For the sake of illustration we have selected some of the most representative companies (see Table 10) and included three of them[22] in the above-mentioned Figures. As mentioned in the previous section, and although it is not very clear graphically, there is a general pattern: the better (higher) the $RSPM$, the better (lower) the MC. However, there are also companies that have better $RSPM$ while having worse MC values and viceversa.

According to our analysis, investors should choose companies with high $RSPM$ and low MC (especially $MC=0$) over those with lower $RSPM$ and/or higher MC. Thus, preferences expand to the top left part of the graph. However, the final investment decision will depend on the investor's specific concerns and his/her threshold of tolerance.

An examination of Table 10 and Figures 4-6 enables us to identify some companies that are always (or almost always) preferable to investors, no matter what their particular concerns may be. For example, Table 10 shows that LG CHEM is a better performer than URALKALI in all the emissions analysed, because its $RSPM$ is higher and its MC lower. This can also be seen in Figure 6, for example, when comparing the performances of LG CHEM and MOSAIC in relation to environmental resources, in which the former is clearly better than the latter. However, there are other cases where the $RSPM$ is higher but the MC is higher too (see Figure 5 for the graph for Total Donations). In those cases, for example when deciding whether to invest in LG CHEM or CLARIANT based on their performance in Total Donations, investors must decide whether they prefer a better performing company or a company that is working on improving its performance (or, at least, not neglecting it as much).

Whatever the investor's specific concerns (and threshold of tolerance) for

[22] LG CHEM, MOSAIC and CLARIANT, which have data for almost all the measures represented.

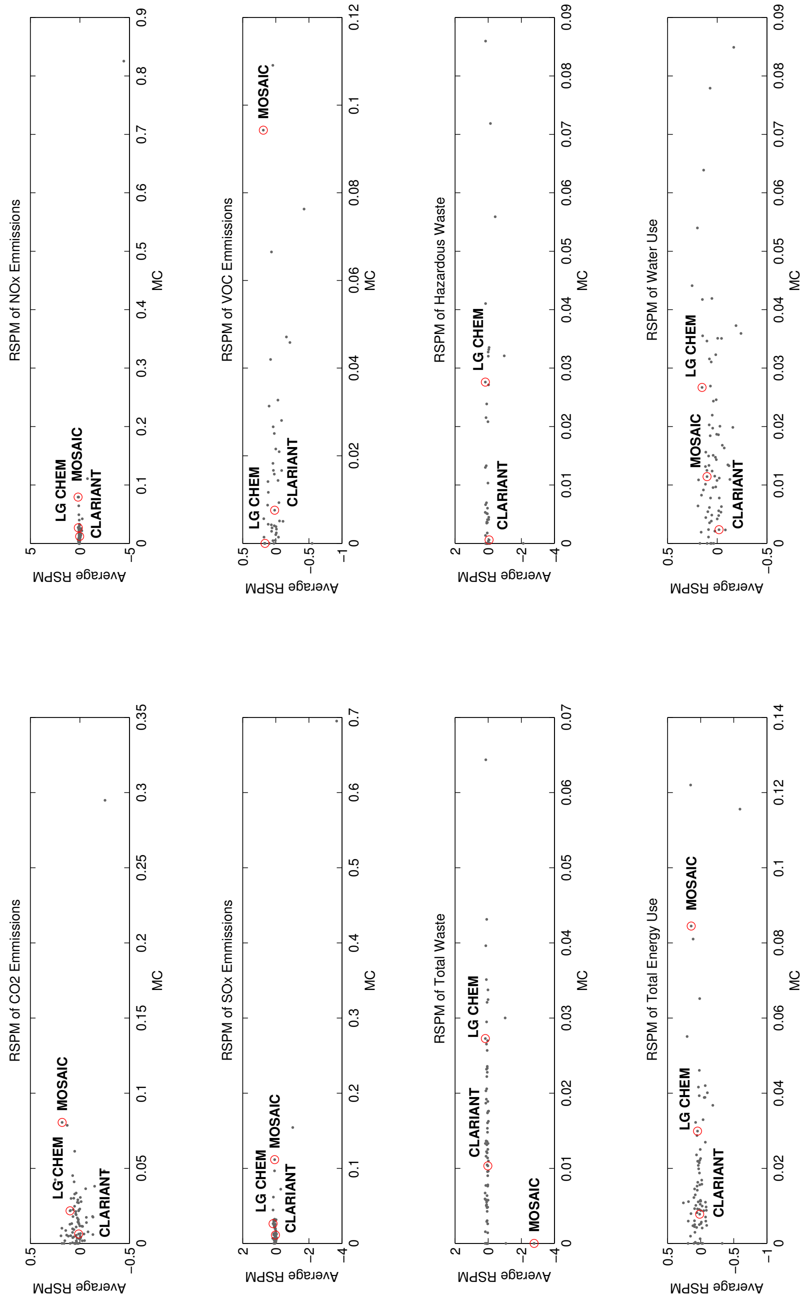

Figure 4: 2D analysis for individual environmental resources

This figure shows the 2D analysis for environmental resources individually. Each point corresponds to a company.

	CLARIANT	LG CHEM	URALKALI	CANEXUS	UPL	DULUXGROUP	MOSAIC	NIPPON KAYAKU
ROTA	0.0329	0.1749	0.2366	0.0385	0.1226	0.1973	0.2214	0.0759
Average RSPM CO2Em	0.0120	0.0994	0.0729	0.0236	No data	0.1908	0.1795	0.0721
MC CO2Em	0.0063	0.0217	0.0451	0.0000	No data	0.0051	0.0806	0.0039
Average RSPM NOxEm	0.0236	0.1613	0.1016	No data	No data	No data	0.1816	0.0749
MC NOxEm	0.0121	0.0269	0.0492	No data	No data	No data	0.0794	0.0049
Average RSPM SOxEm	0.0234	0.1678	0.1626	No data	No data	No data	0.0727	0.0756
MC SOxEm	0.0112	0.0263	0.0445	No data	No data	No data	0.1115	0.0048
Average RSPM VOCEm	0.0178	0.1634	0.0439	No data	No data	No data	0.1885	0.0674
MC VOCEm	0.0076	0.0000	0.1091	No data	No data	No data	0.0943	0.0042
Average RSPM WasteTot	0.0230	0.1689	-1.0616	No data	No data	0.1941	-2.7736	0.0723
MC WasteTot	0.0103	0.0273	0.0000	No data	No data	0.0059	0.0000	0.0048
Average RSPM HazWaste	-0.0514	0.1697	0.1581	No data	No data	No data	No data	0.0512
MC HazWaste	0.0006	0.0276	0.0410	No data	No data	No data	No data	0.0036
Average RSPM EnUseTot	0.0145	0.0477	0.1511	No data	0.0928	0.1881	0.1428	0.0940
MC EnUseTot	0.0078	0.0299	0.1220	No data	0.0093	0.0060	0.0845	0.0045
Average RSPM WaterUse	-0.0183	0.1525	0.1469	No data	No data	0.1939	0.1025	0.0551
MC WaterUse	0.0024	0.0267	0.0355	No data	No data	0.0064	0.0114	0.0049
Average RSPM InjuryR	0.1473	0.0987	-0.1482	-2.8959	No data	-3.3186	0.0415	0.0288
MC InjuryR	0.0256	0.0043	0.0035	0.4525	No data	0.0000	0.0088	0.0031
Average RSPM DonTot	0.0637	0.4607	0.0666	No data	0.0881	No data	-0.0521	No data
MC DonTot	0.0433	0.3331	0.0379	No data	0.0000	No data	0.0072	No data
Average Environmental RSPM	0.0056	0.1397	0.0912	0.0236	0.0928	0.1917	-0.1849	0.0675
MC Environmental	0.0051	0.0251	0.1424	0.0000	0.0093	0.0059	0.1929	0.0043
Average Social RSPM	0.1055	0.4979	0.0827	-2.8959	0.0881	-3.3186	-0.0554	0.0288
MC Social	0.0213	0.3331	0.0179	0.4525	0.0000	0.0000	0.0079	0.0031
Average Total RSPM	0.0051	0.1326	0.1292	-1.4361	0.0904	-0.5103	-0.1453	0.0629
MC Total	0.0049	0.0234	0.1095	0.2257	0.0008	0.0000	0.1485	0.0054

Table 10: ROTA, RSPM and MC for all the individual and grouped resources for different companies

This table shows the values of the ROTA, RSPM and MC for all the individual and grouped resources for 8 selected companies.

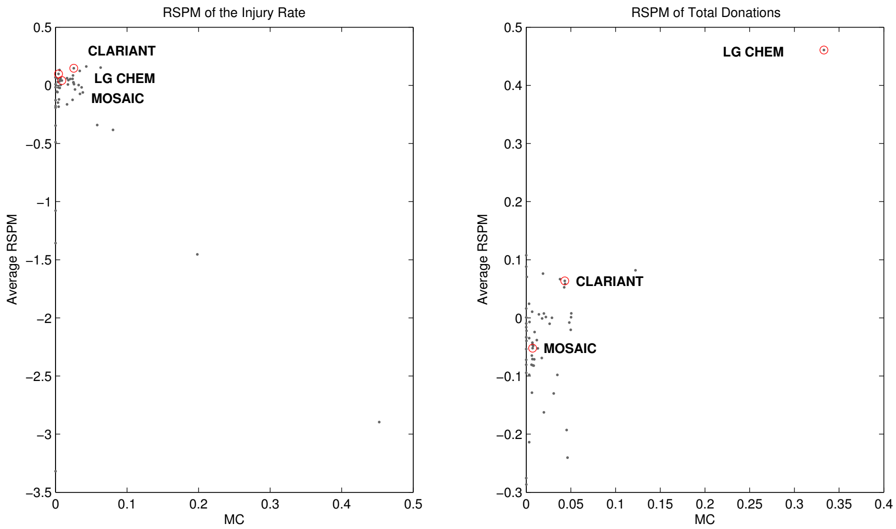

Figure 5: 2D analysis for individual social resources

This figure shows the 2D analysis for social resources individually. Each point corresponds to a company.

each individual resource or combination of them, we believe that this 2D graphical sustainability analysis can be a useful tool in investment decision making.

6 Conclusions

In this paper we present two measures that enable sustainable investment decisions to be made, following the TBL approach: the $RSPM$, which shows how well a company performs in environmental and social matters; and the MC, which detects which companies have decreased their interest in those matters. Both measures are very flexible and thus really useful because they can be calculated for different resources and resource combinations (in which the resources can be weighted as desired in line with the investor's preferences) and for different time frames.

This is a contribution to the sustainable investment literature, because to the

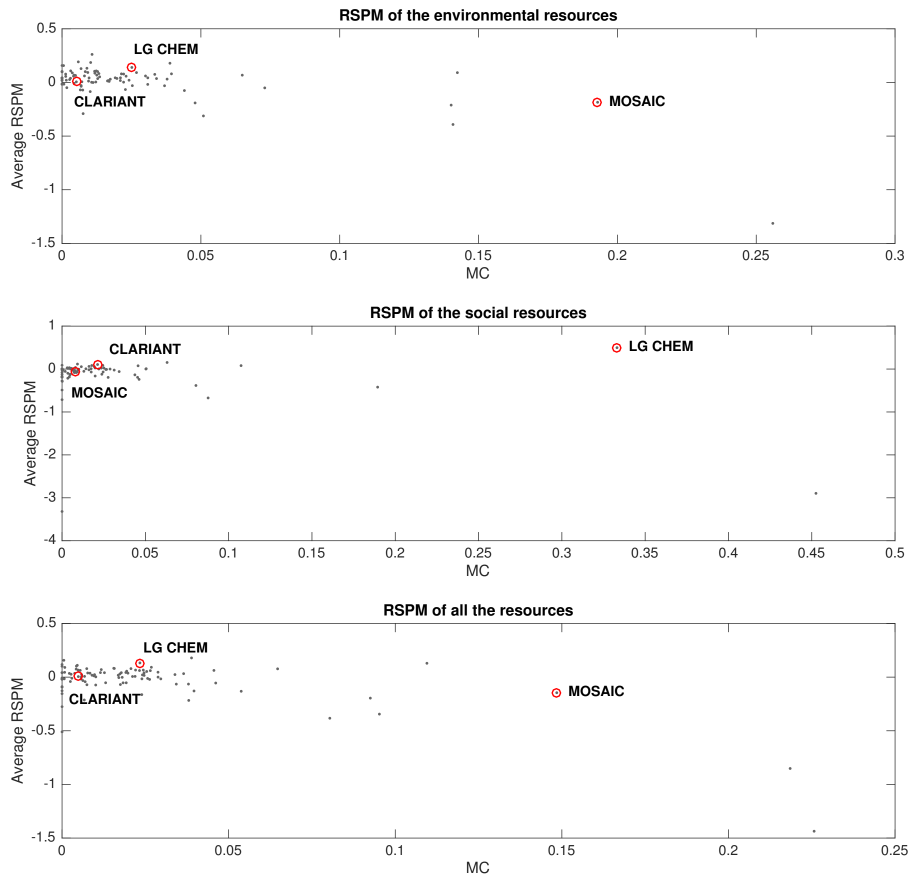

Figure 6: 2D analysis for grouped resources

This figure shows the 2D analysis for the grouped resources: environmental, social and total. Each point corresponds to a company.

best of our knowledge no-one has presented measures with calculation formulas, and to date there have been no dynamic measures such as the MC.

We also apply these measures to real public data on companies in the chemical sector and validate them. Particularly, we show that the $RSPM$ is different from the $ROTA$ and that the MC is different from the standard deviation of the $RSPM$. It is noteworthy that both the measures proposed are applicable to any industrial sector and that the relevant/selected resources may be different in each one.

Moreover, we propose an intuitive 2D graphical analysis based on the two measures proposed. This is a useful tool that can help investors make investment decisions. It is useful both to investors seeking to maximise profits and to those more concerned about non-economic issues, since it can be supplemented by well known economic and financial measures.

In our opinion it would be very useful for the databases that investors use in their analysis of companies (Datastream and Bloomberg, for instance) to include our analysis, so that investors can also easily take into account the non-financial performance of companies.

In addition, the measures and the 2D graphical sustainability analysis that we propose could also be useful for policy-makers during the regulation making process, helping to define limits in the use of some resources, or even levying different taxes on companies depending, for example, on whether and with what frequency they report, or on their $RSPM$ and MC directly.

Finally, companies could also benefit from our measures, since they can be seen as a tool for assessing their sustainability performance. Thus, companies can use the information that they offer to manage and improve their efficiency in the use of a resource in their production process, possibly selecting another similar company as a benchmark.

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