Finance, Markets and Valuation Vol. 7, Num. 2 (July-December 2021), 139–154

Finance, Markets and Valuation

Multi-objective selection of portfolios using ESG controversies

Selección multi-objetivo de carteras incluyendo como criterio las controversias ESG

Javier Oliver [1]

[1]Departamento Economía y Ciencias Sociales, Universitat Politècnica de València, Valencia, Spain. jaolmun@ade.upv.es

JEL: C61, G11, M14

Abstract

It is increasingly common for investors to demand a certain degree of compliance and commitment to environmental, social and governance (ESG) variables in their investments, without renouncing to maximising returns with the minimum possible risk. In this paper, a multi-objective optimisation model applied to Dow Jones stocks is used to analyse the construction of portfolios taking into account the level of controversies of each asset in the portfolio. Controversies are associated with non-compliance by companies in ESG areas, either due to a lack of dedication of resources or a lack of control. The *a priori* expected positive relationship between higher profitability and low number of controversies is not confirmed. This means that those companies with the highest returns are not necessarily those with the less controversies and *vice versa*. This finding contradicts the results obtained by some previous studies and underline the importance of applying multi-objective models to properly account for investors' preferences, including ESG compliance.

Keywords: Multi-objective portfolio selection; Controversies score; Sustainable investments.

Resumen

Cada vez es más frecuente que los inversores exijan a sus inversiones cierto grado de cumplimiento y compromiso con los valores propios de la responsabilidad social corporativa, sin renunciar a maximizar la rentabilidad con el mínimo riesgo posible. En este trabajo, se analiza mediante un modelo de optimización multi-objetivo aplicado a las acciones del Dow Jones, la construcción de carteras teniendo en cuenta el nivel de controversias de cada activo que las componen. Las controversias se asocian con incumplimientos, por parte de las empresas, sobre las áreas de ESG, bien por falta de dedicación de recursos o por falta de control. Los resultados esperados a priori no se confirman, en el sentido de que no existe una relación significativa entre rentabilidad y comportamiento socialmente responsable. Este hecho implica que las empresas que aportan más rentabilidad a la cartera de inversión no son necesariamente las que se ven involucradas en menos controversias, y viceversa. Este resultado contradice las conclusiones obtenidas en otros estudios previos y subrayan la

DOI: 10.46503/EAXN2149

Corresponding author
Javier Oliver

Received: 17 Nov 2021
Revised: 06 Dec 2021
Accepted: 10 Dec 2021

Finance, Markets and Valuation
ISSN 2530-3163.

How to cite: Oliver, Javier. (2021) Multi-objective selection of portfolios using ESG controversies. Finance, Markets and Valuation, 7(2), 139–154. DOI: https:\\doi.org\10.46503/EAXN2149

importancia de contar con modelos multi-objetivo que incluyan las controversias como función objetivo adicional a minimizar.

Palabras clave: Selección multi-objetivo portfolio; Controversias; Inversiones sostenibles.

1. Introduction

For any investor in the stock markets, it is necessary to create a portfolio with the fundamental objective of risk control. Based on Markowitz's (1952) selection of portfolios, it is clear that the creation of a portfolio manages to reduce the overall risk of the investment. These portfolios have been configured on the basis of the risk-return trade-off. Increasingly, however, there is a demand for portfolios to be constructed with additional objectives in mind. Aoui *et al*. (2018) analyze the existing criticisms of the Markowitz model. Among them, they point out that the Markowitz model does not provide for the possibility of adding other criteria in addition to return and risk. As investment decisions are becoming increasingly complex, there is a need for portfolio selection optimization models that can incorporate new and potentially important additional objectives for the investor. One such additional objective that is frequently incorporated is portfolio liquidity (Mansour *et al*., 2019). This can be of interest, for example, when one wishes to construct a portfolio with stocks from an emerging market, where there are liquidity problems in the assets. In García *et al*. (2019), they use the price earnings ratio (PER) as the third objective to minimize in portfolio construction. Given that it is understood that an asset with a low P/E in the market is likely to increase its return in the future, by incorporating this objective in the construction of a portfolio, the possibility of obtaining an additional return is being incorporated given that the assets that make up the portfolio are trading at a lower price than they should be. This study concludes that portfolios with a moderate-low P/E obtain higher returns. On the other hand, Gupta *et al*. (2013) propose three objective functions. One of them is the liquidity of the portfolio. The other two objective functions maximize the long-term return and short term return, from a credibilistic point of view, i.e. using fuzzy numbers.

Investors are increasingly considering not only risk-return but also socially responsible criteria such as environmental, social and governance (ESG) in their decision making. There are many studies that analyze the relationship between ESG criteria and corporate financial performance (Fernando García, González-Bueno, Guijarro, & Oliver, 2020). Orlitzky *et al*. (2003) analyzed 52 studies to date and concluded that there is a positive relationship between the two. Lu *et al*. (2014) also conducted an analysis of 84 studies between 2002-2011 on the debate on the nexus between ESG and corporate financial performance. One of the main conclusions is that this relationship is not static and varies over time. Corporate social responsibility cannot be explained without application of stakeholder theory (Roberts, 1992). According to this author, the empirical results support stakeholder theory and confirm the work developed by Ullmann (1985). Thus, the different actions and decisions in corporate social responsibility are determined by social, political and economic external pressures. Each type of stakeholder has different influences at different levels on the social body. Benyaminova *et al*. (2018) analyze the drivers affecting CSR decisions in the Russian energy sector. They conclude that organizations are exposed to a variety of forces, both endogenous and exogenous. In some cases, these are convergent with some CSR areas and in others they are not.

Other studies analyze the effect on socially responsible investing on portfolio performance (Kempf *et al*., 2007). Building a portfolio by taking long positions in stocks with high ESG rating and taking short positions in stocks with low socially responsible ratings tends to lead to higher portfolio returns. Jain et al. (2019) analyze the use of sustainability indices as a measure of performance. They further conclude the existence of a bi-directional volatility relationship between the sustainable indices and the conventional indices. They indicate that portfolios should take into account both types of indices for risk diversification. However, it is also true that in many cases, there is no significant difference between the two groups of companies listed in the sustainability index and the others (Charlo *et al*., 2017). However, Bramer *et al*. (2006) analyze the relationship between corporate social performance and stock returns for UK stocks. They conclude that stocks with higher social performance scores have lower returns than those with very low ESG scores, which even outperform the market or stock index.

Some studies relate company size to the level of ESG (Drempetic *et al*., 2017). In other words, there is a significant correlation between company size (in this case measured by the number of employees) and ESG score. Other studies reach the same conclusion (Gavana *et al*., 2017). On a disaggregated basis, it is observed that there is a positive persistence between the environmental score of the last three years and financial performance. This effect is more pronounced for larger firms (Tebini *et al*., 2016). An asymmetry in the financial impact of negative versus positive environmental actions is also detected. While the environmental concerns are negative and persistent over the time, the positive actions and the strong environmental impact have a scope of only one year. This asymmetry means that companies need to be proactive in their environmental strategies, since, if environmental concerns arise, they will have a very significant and long-lasting cost over time.

Sanches *et al*. (2016) indicate that only one of the ESG performance, environmental performance, can have benefits on company returns. On the other hand, companies with a high overall ESG level tend to have lower profitability. Moreover, in emerging markets these results are even more accentuated. Hull *et al*. (2008) conclude that if companies combine innovation and strategic ESG actions they can be important tools for differentiation from their competitors.

The aim of this paper is to analyze whether it is possible to create investment portfolios which maximize return and minimize risk while investing in socially responsible companies. Previous studies have concluded that giving priority to companies' behavior may lead to portfolios which are not properly diversified (I. Arribas, Espinós-Vañó, García, & Morales-Bañuelos, 2019; Iván Arribas, Espinós-Vañó, García, & Tamosiuniene, 2019; Espinós-Vañó, García, & Oliver, 2018). Another important issue is how irresponsible behavior is defined (I. Arribas, Espinós-Vañó, García, & Oliver, 2019). In this research we will use the concept of controversy, following previous studies (Iván Arribas, Espinós-Vañó, García, & Riley, 2021).

The remainder of the paper is structured as follows. Section 2 presents the multi-objective model with the three objective functions for the constitution of the portfolios (profitability, risk and controversies). The model is used to obtain the portfolios that form the Pareto frontier by simultaneously taking into account the three criteria. Section 3 presents the main results of the application of the model to stocks belonging to the Dow Jones index. In addition, the relationship between profitability and controversies is analyzed. Subsequently, section 4 summarizes the main conclusions of the paper, ending with the references and bibliography section.

2. Methodology

Multi-objective models are used in several areas such as problem solving in management (Caramia *et al*., 2020) and finance (F García, Guijarro, & Moya, 2011, 2013, Doumpos *et al*., 2020). The well-known problem of portfolio selection is one of the main uses of this type of models (Garcia, González-Bueno, Guijarro, Oliver, & Tamošiūnienė, 2020).

The resolution of multi-objective models involves obtaining the Pareto optimal frontier. The evolutionary algorithms are efficient for the construction of this frontier (Castillo *et al*., 2007). In this paper we propose a model with three objective functions for the construction of optimal portfolios with the Dow Jones index stocks. The first objective function seeks to maximize the return of the portfolio (1).

$$f(1) = \sum_{i=1}^{n} X_i * R_i \quad (1)$$

Where X_i represents the weighting of the stocks in the portfolio and R_i the average return on assets. This return has been calculated using the continuous return $LN(\frac{P_t}{P_{t-1}})$.

The second function attempts to minimize portfolio risk (2) measured in its classical form as the variance of the portfolio.

$$f(2) = \sum_{i=1}^{n} \sum_{j=1}^{n} X_i * \sigma_{ij} * X_i \quad (2)$$

Where σ_{ij} is the variance-covariance matrix of the portfolio's stock returns. Lastly, the third objective function seeks to minimize the portfolio disputes associated with the assets that make up the portfolio (3). To calculate the portfolio's controversies, we have chosen to weight the average number of controversies of each security according to its weight in the portfolio. However, this objective function could also be included as the sum of the average number of disputes of the securities that make up the portfolio.

$$f(3) = \sum_{i=1}^{n} X_i * Controversies_i \quad (3)$$

The model constraints are as follow:

- Capital budget constraint on the assets is expressed as

$$\sum_{i=1}^{n} X_i = 1, \quad i = 1,2,\dots,n \quad (4)$$

- No short selling of assets is expressed as

$$X_i \geq 0, \quad i = 1,2,\dots,n \quad (5)$$

The multiobjective mean-variance-controversial portfolio selection model is formulated as:

$$Max\ f_1(X_i) \tag{6}$$

$$Min\ f_2(X_i) \tag{7}$$

$$Min\ f_3(X_i) \tag{8}$$

$$s.t.\begin{cases}\sum_{i=1}^{n} X_i = 1, & i = 1,2,\dots,n\\ X_i \geq 0, & i = 1,2,\dots,n\end{cases} \tag{9}$$

The restrictions here are, on the one hand, that the weights can only take positive values. In other words, short positions are not allowed in the portfolio. In addition, another model similar to the previous one has been estimated, in which the orientation of the objective function 3 has been modified. In this case, the objective is to maximize controversies (12).

$$Max\ f_1(X_i) \tag{10}$$

$$Min\ f_2(X_i) \tag{11}$$

$$Max\ f_3(X_i) \tag{12}$$

$$s.t.\begin{cases}\sum_{i=1}^{n} X_i = 1, & i = 1,2,\dots,n\\ X_i \geq 0, & i = 1,2,\dots,n\end{cases} \tag{13}$$

Multi-objective optimization becomes an NP-hard problem. To solve it, one of the most widely used multi-objective evolutionary algorithms has been used. The NSGA-II (Non-dominate Sorting Genetic Algorithm II) algorithm proposed by Dev (2001), Dev *et al*. (2002), involves obtaining the Pareto frontier. Evolutionary algorithms present the best and efficient techniques in generating the Pareto frontier for multi-objective problem solving (Ngatchou *et al*., 2005). This algorithm is an evolution of its predecessor proposed by Srinivas *et al*., 1994. They highlight three advantages of NSGA-II over its predecessor. Firstly, the search process for non-dominated elements is more efficient, which reduces computational complexity. Secondly, uses an elitist selection method for obtaining the Pareto frontier. Finally, uses an operator to maintain distance and avoid crowding to maintain the diversity of the population.

The process of the NSGA-II algorithm is described as follows (Dev *et al.* 2002; Palanikumar *et al.* 2009):

Step 0: Initially, a random parent population of P_t is generated. This population is sorted based on non-domination level. A fitness level has been assigned to each solution, the best level being 1. The algorithm minimizes the fitness function. Selection and mutation are used to create descendants of the population Q_t (Figure XXX).

Step 1: First, a combined population (parent and offspring) $R_t=P_t \cup Q_t$ of size 2N is formed, which is sorted according to a fast non-domination procedure. This results in different non-dominated fronts F_1, F_2, etc;

Step 2: The new parent population P_{t+1} is formed by adding solutions from the first front F_1 and continuing until the size exceeds N;

Step 3: The solutions of the last accepted front are sorted according to a crowded-comparison criterion ($\prec$n) and the first N points are picked;

Step 4: The population P_{t+1} of size N is constructed using the above method in which selection, crossover and mutation are used to create the new population $Q_{t+1}$of size N.

It is important to mention here that the non-dominated sorting in step 1 and the filling up of population P_{t+1} can be performed together. Each time a non-dominated front is found, its size can be checked to see whether it can be included in the new population. If not, then no more sorting is needed. This will reduce the run time of the algorithm.

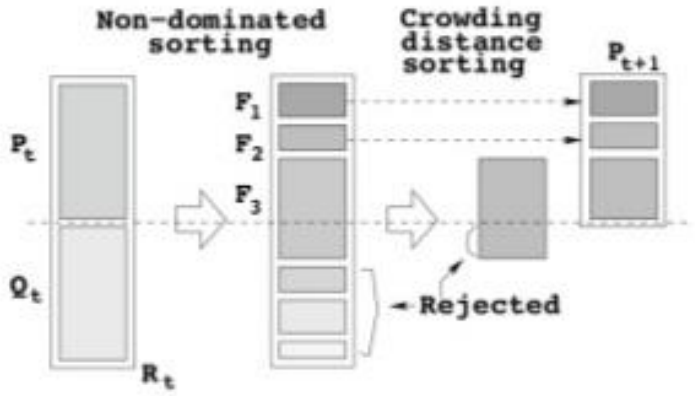

Figura 1. Non-dominated selection
Source: Deb *et al.* 2002

The experimental parameter configuration used for testing the NSGA-II algorithm, for solving the multi-objective problem in this work, are presented in table 1:

Table 1. Descriptive analysis of the variables

Parameters	Value
Population Size	400
Maximum Number of Generations	2000
Probability of Mutation	0.01
Probability of Crossover	0.9
Distribution Index for Mutation	50
Distribution Index for Crossover	10

3. Data and Results

3.1. Data

The model described above has been applied to construct the different portfolios taking into account controversies as an objective function, along with return and risk. The database contains the ESG score on controversies for each Dow Jones stock from 2003 to 2019 for 27 of the 30 stocks that make up the Dow Jones. Daily closing prices for this period are also available. First, the controversies variable has been transformed using the inverse of the value. In this way, a high value of this variable implies a low degree of sustainability, as the company is involved in many controversies annually. On the other hand, a low value implies that the company has a high degree of sustainability because it has a low number of incidents during the year. Table 2 shows, for each security and for the entire period analyzed, the descriptive statistics of the disputes, as well as the average profitability and risk: 40.74% (11/27) have obtained in some of the years a low level of disputes (min value equal to 0), such as MMM or APPL.

Table 2. Descriptive analysis of the variables

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	Return	Risk
MMM	0,00	0,00	33,33	35,72	60,71	79,17	0,0003	0,0141
AXP	6,19	13,01	19,01	35,94	71,74	81,88	0,0004	0,0227
AAPL	0,00	91,18	96,15	87,54	96,67	97,22	0,0009	0,0189
T	83,33	93,55	94,05	93,16	96,88	98,86	0,0000	0,0135
BA	13,33	62,50	72,22	73,49	96,15	97,06	0,0005	0,0183
CAT	0,00	0,00	18,75	28,77	37,88	93,75	0,0002	0,0205
CVX	32,69	60,78	89,42	81,36	96,67	98,75	0,0001	0,0165
CSCO	0,00	25,00	42,86	50,81	78,57	94,44	0,0002	0,0181
KO	16,67	71,43	93,75	80,20	95,45	95,83	0,0002	0,0112
XOM	73,33	76,92	91,03	85,83	93,94	97,92	-0,0001	0,0148
GS	65,63	75,00	91,67	87,54	97,22	98,21	0,0001	0,0230
HD	0,00	0,00	57,69	50,27	86,00	93,48	0,0007	0,0159
IBM	0,00	17,07	34,78	43,84	70,00	90,38	0,0000	0,0140
INTC	4,55	21,43	61,76	56,86	80,77	93,33	0,0004	0,0180
JNJ	30,56	86,36	94,44	85,51	98,44	99,07	0,0003	0,0107
JPM	92,05	93,66	96,03	96,08	98,91	99,33	0,0004	0,0249
MCD	12,00	84,78	94,44	86,32	97,62	98,00	0,0004	0,0114
MRK	0,00	50,00	58,33	61,61	79,73	89,06	0,0003	0,0156
MSFT	13,04	79,31	90,00	80,16	93,90	95,45	0,0006	0,0171
PFE	69,44	74,32	82,14	85,47	95,83	98,15	0,0002	0,0139
PG	0,00	12,50	63,89	53,15	79,17	96,88	0,0002	0,0111
UNH	0,00	0,00	25,00	32,79	55,00	67,86	0,0007	0,0194
VZ	47,62	60,26	89,77	81,21	94,79	95,71	0,0002	0,0132
V	0,00	18,52	39,02	40,29	63,24	88,55	0,0009	0,0184
WBA	0,00	28,57	65,79	52,95	84,78	86,11	0,0002	0,0173
WMT	15,00	92,11	97,22	89,06	97,37	98,44	0,0003	0,0123
DIS	5,17	71,74	84,38	78,63	97,50	98,48	0,0005	0,0167

Table 3 shows, for all the companies and the period analysed, the correlation between the different quartiles of controversies, as well as return and risk. It can be seen that the relationship between the level of controversies and the return-risk of the assets does not seem to be significant. This could indicate that the incorporation of controversies as an additional objective function in the portfolio construction model would not provide better solutions in terms of risk-return.

Table 3. Descriptive analysis of the variables

		correlation	p-value
Min.	**1st Qu.**	0,716625	2,61E-05
Min.	**Median**	0,662219	0,000168
1st Qu.	**Median**	0,931051	1,91E-12
Min.	**Mean**	0,766097	3,19E-06
1st Qu.	**Mean**	0,944361	1,41E-13
Median	**Mean**	0,954358	1,24E-14
Min.	**3rd Qu.**	0,707105	3,73E-05
1st Qu.	**3rd Qu.**	0,874485	2,49E-09
Median	**3rd Qu.**	0,899237	1,84E-10
Mean	**3rd Qu.**	0,898183	2,08E-10
Min.	**Max.**	0,74587	7,98E-06
1st Qu.	**Max.**	0,811374	2,83E-07
Median	**Max.**	0,808732	3,31E-07
Mean	**Max.**	0,857753	1,08E-08
3rd Qu.	**Max.**	0,892383	4,03E-10
Min.	**Return**	-0,34892	0,074461
1st Qu.	**Return**	-0,05289	0,793322
Median	**Return**	-0,06381	0,751862
Mean	**Return**	-0,17827	0,373668
3rd Qu.	**Return**	-0,00611	0,975887
Max.	**Return**	-0,19597	0,327258
Min.	**Risk**	-0,17319	0,387636
1st Qu.	**Risk**	-0,1816	0,36466
Median	**Risk**	-0,32392	0,099295
Mean	**Risk**	-0,25031	0,207943
3rd Qu.	**Risk**	-0,23569	0,236615
Max.	**Risk**	-0,2558	0,197804
Return	**Risk**	0,360195	0,064955

3.2. Results

This section presents the main results of the multi-objective model proposed in section 2 applied to Dow Jones stocks. The controversies of each of the stocks comprising the index have been obtained from the Thomson Reuters database between 2008 and 2019. As indicated above, portfolios have been constructed to

maximise return, minimise risk and have a low level of controversy. This is intended to allow investors to channel their investments into companies with lower controversy with the lowest possible risk and without giving up some return. In addition, portfolios have been constructed in which the objective function of the controversies has been maximized in order to compare the two models. A low level of controversy is indirectly associated with companies that do things right at all levels including ESG areas (Aouadi *et al*., 2018). Given that high levels of ESG controversies have a high impact on US and European stock returns, it is necessary to construct portfolios that can manage the level of controversies (de Franco, 2020).

Figure 2 shows the efficient frontier with the Pareto solutions obtained as a solution to the multi-objective model using the NSGA-II algorithm. For this purpose, 400 portfolios have been obtained that comply with the optimisation of the three functions proposed simultaneously. In this case, the objective function on controversies has been minimized. In these portfolios, no short positions have been allowed and the percentage of investment in each security, as well as the number of securities in the portfolio, have not been restricted.

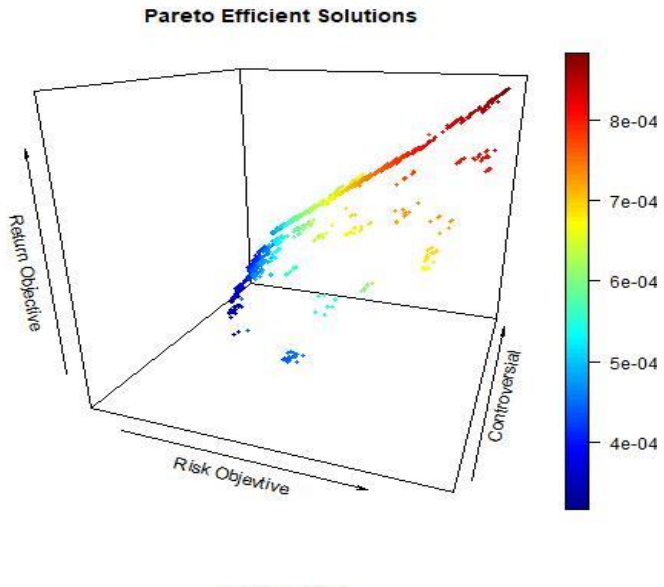

Figure 2. Pareto efficient solutions. Min f(3)
Source: Author elaboration

In figure 3, the Pareto efficient frontier is presented, but maximizing the controversy objective function.

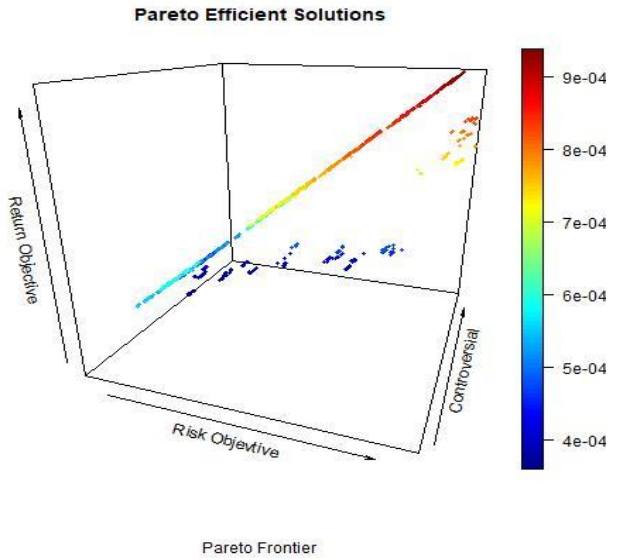

Figure 3. Pareto efficient solutions. Max f(3)
Source: Author elaboration

Figure 4 analyses in a two-dimensional graph thre return and risk portfolios, together with the controversies for the case of minimization of the objective function of the controversies. In this case, it`s observed that those portfolios with lower risk-resturn are those with high number of controversies. In addition, it's possible to achieve higher return portfolios with more moderate levels of controversies.

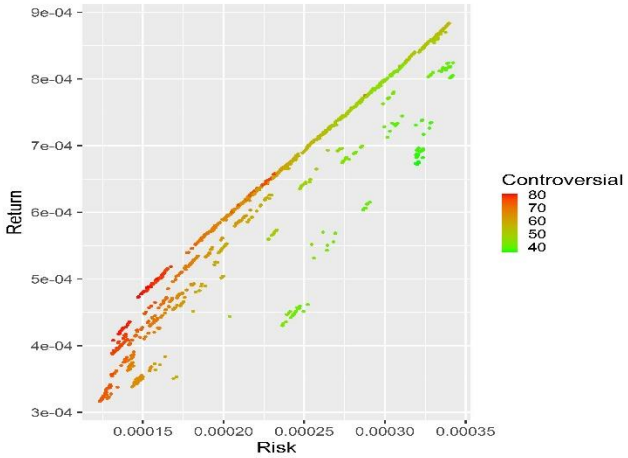

Figure 4. Return-risk. Min f(3)
Source: Author elaboration

However, when the objective function on the controversial variable is maximized (figure 5), this relationship is no longer so evident

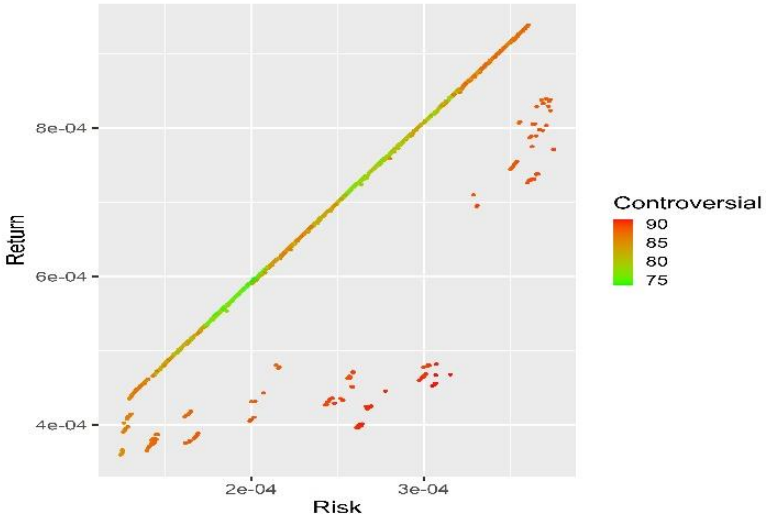

Figure 5. Return-risk. Max f(3)
Source: Author elaboration

However, a comparison of figures 4 and 5 show that by minimizing the controversial variable, it`s possible to obtain more sustainable portfolios for the same level risk-return than in case of maximization. The market does not seem to be assessing in any way whether stocks have a higher or lower level of controversy. This result would agree with some studies such as Dorfleitner et al. (2020). These portfolios have been constructed with all stocks in the sample. Next, we have analysed portfolios contrained to 5 stocks. Firstly, the five titles with the lowest average number of disputes for the period analysed were selected. The titles selected were CAT, UNH, MMM, PG, HD.

Figure 6 shows how, despite constructing portfolios with low level of controversies, it's no necessary to increase the weigthing in those stocks with a higher number of controversies in order to obtain portfolios with higher returns.

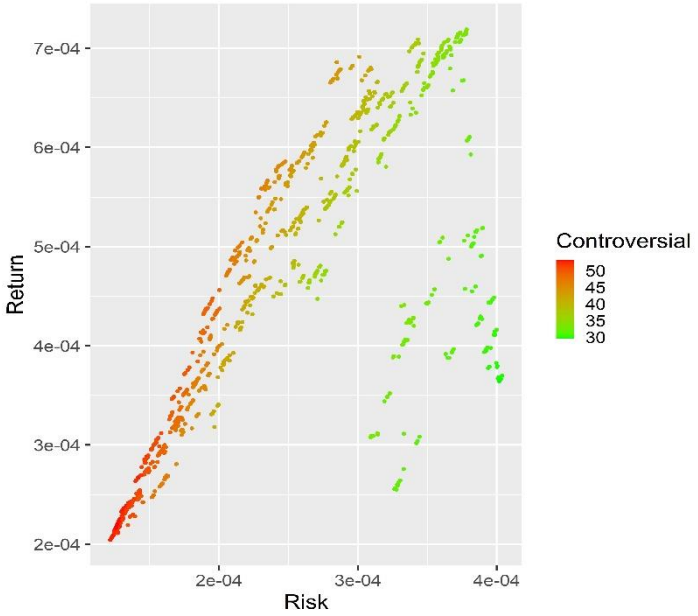

Figure 6. Return-risk. 5 stocks with low controversies
Source: Author elaboration

In contrast, figure 7 show the portfolios obtained with the five stocks with highest number of controversies. In this case, these portfolios are constructed of the followins stocks JPM, JNJ, MCD, DIS, WMT. On the one hand, it is possible to obtain efficient portfolios with stocks with weights such that the level of controversy is lower, within the high levels of their components.

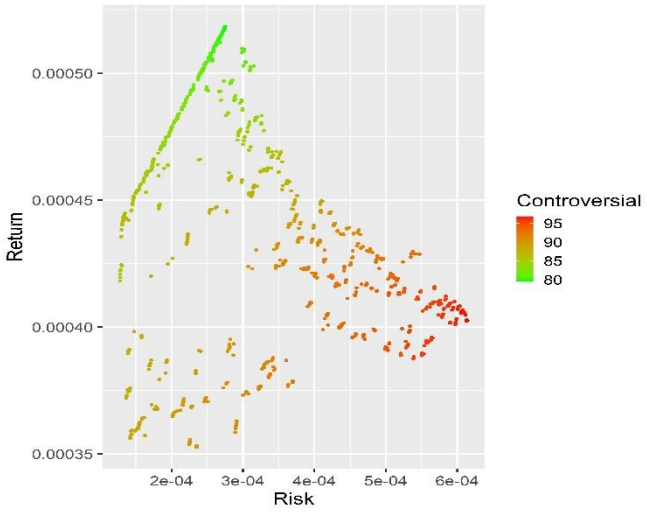

Figure 7. Return-risk. 5 stocks with high controversies
Source: Author elaboration

On the other hand, if we compare figures 5 and 6, we can see that if we select the 5 stocks with highest level of controversy, it is possible to obtain higher returns for the same level of risk than if we select the 5 stocks with lowest level of controversy.

According to Dorfleitner et al. (2020), low or zero levels of disputes have a higher profitability potential. However, this is true for small companies. Since this study has analysed assets belonging to the Dow Jones index, it is understood that these are large companies and therefore there would be no conflict with the results of these studies.

4. Conclusions

In this paper, a multi-objective model for the construction of portfolios has been proposed. The aim is to determine whether it is possible to obtain portfolios whose stocks present a reduced number of controversies, e.g., irresponsible activities, without forgetting the maximisation of profitability with controlled risk. The incorporation of controversies as an objective function to be minimised in the model implies the search for companies that are concerned, to a certain extent, with the three ESG dimensions. In this research, the model has been applied to the Dow Jones index stocks.

By analysing the different optimal portfolios obtained, some interesting conclusions can be drawn about the relationship between the variables profitability, risk and number of controversies (as a proxy for irresponsible behaviour of companies).

First, the classic positive relationship between return and risk is confirmed. In order to obtain portfolios with higher returns, investors must assume greater risk.

Second, when creating a portfolio which can invest in all the stocks included in the Dow Jones index, no clear relationship between the return-risk performance of the portfolio and the number of controversies in which the selected companies have been involved. In other words, the market does not reward companies with reduced numbers of controversies over less responsible companies. This has been confirmed by Spearman's correlation between return-risk and controversies which has been found to be non-significant. Using information from a sample of 27 companies of the Dow Jones index during the period from 2003 to 2019, no significant correlation is found neither between ESG behaviour and return nor between ESG behaviour and risk.

As a result, it is possible to obtain different portfolios which have a similar return-risk performance but quite different ESG performance in terms of controversies. This is an interesting result, as it may be possible to create efficient portfolios in the return-risk plane while considering the social responsibility of the selected companies.

It is important to mention that all these outcomes may change if the analysis is performed on other samples and the potential investment universe is changed. There are studies, already mentioned above, which conclude that smaller companies that devote resources to ESG decision-making improve their returns without significantly increasing their risk. In future work, other objective functions such as the different dimensions of ESG can be considered and other proxies for ESG behaviour may be used.

References

Aouadi, A. & Marsat, S. (2018). Do ESG Controversies Matter for Firm Value? Evidence from International Data. *Journal of Business Ethics*, 151, 1027-1047. https://doi.org/10.1007/s10551-016-3213-8.

Aouni, B., Doumpos, M., Pérez-Gladish, B. & Steuer, R.E. (2018). On the increasing importance of multiple criteria decisión aid methods for portfolio selection. *Journal of the Operation Research Society*, 69(10), 1525-1542. https://doi.org/10.1080/01605682.2018.1475118.

Arribas, I., Espinós-Vañó, M. D., García, F., & Morales-Bañuelos, P. B. (2019). The inclusion of socially irresponsible companies in sustainable stock indices. *Sustainability (Switzerland)*, *11*(7). https://doi.org/10.3390/su11072047

Arribas, I., Espinós-Vañó, M. D., García, F., & Oliver, J. (2019). Defining socially responsible companies according to retail investors' preferences. *Entrepreneurship and Sustainability Issues*, *7*(2). https://doi.org/10.9770/jesi.2019.7.2(59)

Arribas, I., Espinós-Vañó, M. D., García, F., & Riley, N. (2021). Do irresponsible corporate activities prevent membership in sustainable stock indices? The case of the Dow Jones Sustainability Index world. *Journal of Cleaner Production*, *298*, 126711. https://doi.org/10.1016/j.jclepro.2021.126711

Arribas, I., Espinós-Vañó, M. D., García, F., & Tamosiuniene, R. (2019). Negative screening and sustainable portfolio diversification. *Entrepreneurship and Sustainability Issues*, *6*(4). https://doi.org/10.9770/jesi.2019.6.4(2)

Benyaminova, A., Mathews, M., Langley, P. & Rieple, A. (2018). The impact of changes in stakeholder salience on corporate social responsability activities in

Russian energy firms: A contribution to the divergence/convergence debate. *Corporate Social Responsability and Enviomental Management*, 1-13. https://doi.org/10.1002/csr.1743.

Bramer, S., Brooks, C. & Pavelin, S. (2006). Corporate Social Performance and Stock Returns: UK Evidence from Disaggregate Measures. *Financial Management*, 97-116.

Caramia, M. & Dell'Olmo, Palo. (2020). Multi-objective Optimization. *Multi-objective Management in Freight Logistics*. https://doi.org/10.1007/978-3-030-50812-8_2.

Castillo, M.G. & Coello, C.A. (2007). Appications o multi-objective evolutionary algorithms in economics and finance: A survey. *IEEE Congress on Evolutionary Computation*. https://doi.org/10.1109/CEC.2007.4424516.

Charlo, M.J., Moya, I. & Muñoz, A.M. (2017). Sustainable Development in Spanish Listed Companies: A Strategic Approach. *Corporate Social Responsibility and Environmental Management*, 24, 222-234. https://doi.org/10.1002/csr.1403

De Franco, C. (2020). ESG Controversies and Their Impact on Performance. *The Journal of Investing ESG*. 29(2), 33-45. https://doi.org//10.3905/joi.2019.1.106.

Deb, K. (2001). Multi-Objective Optimization Using Eolutionary Algorithms. *John Wiley & Sons, USA.* ISBN 047187339X.

Deb, K., Agawal, K., Pratap, A. & Meyarivan, T. (2002). A Fast Elitist Non-dominated Sorting Genetic Algorithm for Multi-objective Optimiation: NSGA-II. *IEEE Trans. Evol.Compt.*, 6, 182-187. https://doi.org/10.1109/4235.996017

Dorfleitner, G., Kreuzer, C. & Sparrer, C. (2020). ESG controversies and controversial ESG: about silent saints and small sinners. *Journal of Asset Managment*, 21, 393-412. https://doi.org/10.1057/s41260-020-00178-x

Doumpos, M. & Zopounidis, C. (2020). Multi-objective optimization models in finance and investments. *Jouna of Global Optimization*, 76, 243-244. https://doi.org/10.1007/s10898-019-00873-z.

Drempetic, S., Klein, C. & Zwergel, B. (2017). The influence of Firm Size on the ESG Score: Corporate Sustainability Ratings Under Review. *Journal of Business Ethics*. https://doi.org/10.1007/s10551-019-04164-1.

Espinós-Vañó, M. D., García, F., & Oliver, J. (2018). The ethical index FTSE4Good Ibex as an alternative for passive portfolio strategies in Spain. *Finance, Markets and Valuation*, *4*(1), 117–129. https://doi.org/10.46503/MUKB2397

Garcia, F., González-Bueno, J., Guijarro, F., Oliver, J., & Tamošiūnienė, R. (2020). Multiobjective approach to portfolio optimization in the light of the credibility theory. *Technological and Economic Development of Economy*, *26*(6), 1165–1186. https://doi.org/10.3846/tede.2020.13189

García, F, Guijarro, F., & Moya, I. (2011). The curvature of the tracking frontier: A new criterion for the partial index tracking problem. *Mathematical and Computer Modelling*.https:/doi.org/10.1016/j.mcm.2011.02.015

García, F, Guijarro, F., & Moya, I. (2013). A multiobjective model for passive portfolio management: An application on the S&P 100 index. *Journal of Business Economics and Management*. https://doi.org/10.3846/16111699.2012.668859

García, F., González-Bueno, J., Guijarro, F., & Oliver, J. (2020). Forecasting the environmental, social, and governance rating of firms by using corporate financial performance variables: A rough set approach. *Sustainability (Switzerland)*, *12*(8). https://doi.org/10.3390/SU12083324

García, F., González-Bueno, J., Oliver, J. & Tamosiuniene, R. (2019). A credibilistic mean-semivariance-per portfolio selection model for Latin America. *Journal of Business Economics and Management*, 20(2), 225-243. https://doi.org/10.3846/jbem.2019.8317

Gavana, G., Gottardo, P. & Moisello, A.M. (2017). The effect of equity and bond issues on sustainability disclosure. Family vs non-family Italian firms. *Social Responsibility Journal*, 13(1), 126-142. https://doi.org/10.1108/SRJ-05-2016-0066.

Gupta, P., Inuiguchi, M., Kumar, M. & Mittal, G. (2013). Multiobjective credibilistic portfolio selection model with fuzzy chance-constraints. *Information Sciencies*, 229, 1-17. https://doi.org/10.1016/j.ins.2012.12.011.

Hull, C. E. & Rothenberg, S. (2008). Firm performance: The interactions of corporate social performance with innovation and industry differentiation. *Strategic Management Journal*, 29, 781-789. https://doi.org/10.1002/smj.675

Jain, M., Sharma, G. D. & Srivastava, M. (2019). Can Sustainable Investment Yield better Financial Returns: A Comparative Study of ESG Indices and MSCI Indices. *Risks*, 7(15), 1-18. https://doi.org/10.3390/risks7010015.

Kempf, A. & Osthoff, P. (2007). The effect of socially responsible investing on portfolio performance. *European Financial Management*, 13(5), 908-922. https://doi.org/10.1111/j.1468-036X.2007.00402.x.

Lu, W., Chau, K.W., Wang, H. & Pan, W. (2014). A decade's debate on the nexus between corporate social and corporate financial performance: a critical review of empirical studies 2002-2011. *Journal of Cleaner Production*, 79, 195-206. https://doi.org/10.1016/j.jclepro.2014.04.072

Mansour, N., Sadok, M. & Abdelfattah, W. (2019). Multi-objective imprecise programming for financial portfolio selection with fuzzy returns. *Expert Systems with Applications*, 138. https://doi.org/10.1016/j.eswa.2019.07.027.

Markowitz, H. (1952). Portfolio Selection. *Journal of Finance*, 7, 77-91.

Ngatchou, P., Zarei, A. & El-Sharkawi, A. (2005). Pareto Multi Objective Optimization. *Proceedings of the 13th International Conference on Intelligent Systems Application to Power Systems*. https://doi.org/10.1109/ISAP.2005.1599245.

Orlitzky, M., Schmidt, F. & Rynes, S. (2003). Corporate Social and Financial Performance: A Meta-analysis. *Organization Studies*, 24(3), 403-411.

Palanikumar, K., Latha, B., Senthilkumar, V.S. & Karthikeyan, R. (2009). Multiple performance optimization in machining of GFRP composites by PCD tool using non-dominated sorting genetic algorithm (NSGA-II). *Met Mater Int. The Korean Institute of Metals and Materials,* 2009(15), 249-258. https://doi.org/10.1007/s12540-009-0249-7

Roberts, R. (1992). Determinants of corporate social responsibility disclosure: An application of stakeholder theory. *Accounting Organizations an Society*, 17(6), 595-612.

Sanches García, A., Mendes-Da-Silva, W. & Orsato, R. J. (2017). Sensitive industries produce better ESG performance: Evidence from emerging markets. *Journal of Cleaner Production*, 150, 135-147. https://doi.org/10.1016/j.clepro.2017.02.180.

Sortino, F.A. (1994). Performance Measurement in a Downside Risk Framework. *The Journal of Investing*, 3, 59-64. https://doi.org/10.3905/joi.3.3.59.

Srinivas, N., & Dev, K. (1994). Multiobjective Optimization Using Nondominated Sorting in Genetic Algorithms. *Evolutionary Computing, MIT Press,* 1994:2, 221-248. https://doi.org/10.1162/evco.1994.2.3.221

Tebini, H., M´Zali, B., Lang, P. & Perez-Gladish, B. (2016). The Economic Impact of Enviromentally Responsible Practices. *Corporate Social Responsibility and Environmental Management*, 23, 333-344. https://doir.org/10.1002/csr.1383.

Ullmann, A. (1985). Data in Search of a Theory a Critical Examination of the Relationship Among Social Performance, Social Disclosure, and Economic Performance. *Academy of Management Review*, 540-577.