

# An Analysis of Scenarios and Sensitivity Following Environmental Damage: the Vale Do Rio Doce and Petrobrás Case

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Received 14 March 2022

Accepted 3 June 2022

## ABSTRACT

The human activity that generates profits also brings impacts, whose losses can trigger several other problems. Upon considering the last ecological disasters that took place in Brazil, this study aims at identifying the understanding of what happens with the profit of companies that disclose events that involve environmental damages by using the Petróleo Brasileiro Petrobrás S.A. and Vale S. A. share prices as a study compared with Ibovespa, the Brazilian stock index. The research is classified as a quantitative, descriptive approach carried out through a Survey. Data collection was performed via stock opening and closing prices, maximum and minimum quotes, and the number of days until the stocks regained their value, which happened immediately before disclosure. The results showed investors, managers, and researchers that stock profit averages from companies that disclose their environmental damages have no meaningful differences concerning the non-diversified, systemic Ibovespa index, but recovering such profits takes longer.

**Keywords:** *Sensitivity and Scenario Analysis, Asset Pricing, Environmental Damage, Competitive Intelligence*

## Introduction

Social responsibility is every corporation's duty, and, according to Anholon et al. (2016), there are several definitions for the Corporative Social Responsibility expression, which can be seen as

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<https://doi.org/10.32038/mbrq.2022.21.03>



the commitment a company must have to the whole society and is demonstrated through actions and attitudes that positively impact the organisation itself. In this new, more competitive, thorough, and demanding scenario, the companies face a heavy demand of requirements. Hadani et al. (2019) show that organisations come across more and more people searching for social improvements, social corporative policies, and practices regarding various issues concerning social responsibility.

In the state of Minas Gerais, Brazil, more precisely in the sub-district of Bento Rodrigues, Nov 5<sup>th</sup>, 2015, witnessed the worst environmental tragedy ever reported in the country until then, when approximately 34 million cubic metres of mining waste were dumped into the Doce River, adding up to other 16 million cubic metres until the load reached the Atlantic Ocean (JÚNIOR; COUTINHO; JÚNIOR; TEODORO; LIMA; SHAKIR; GOIS; JOHANN, 2018), which shows that the Brazilian nation has advanced very little when it comes to social responsibility in the organisations. Anholon et al. (2016) observe that this topic is still immature concerning the reality in Latin America, even though few companies develop and include Corporate Social Responsibility practices in their operation.

Within this context, highlighting the most adverse uncertainties in the organisations, and facing a world with rapid transformations, there is the need to anticipate the possible scenarios and establish actions that aim to smooth and even seize the changes by using the competitive intelligence as a practical way of thinking and acting. Wright et al. (2019) state that, upon building up a scenario, the results achieved can generate growth due to the context itself. This procedure might occur inappropriately due to the possibility of a single scenario becoming a reality. However, several situations can provide plausible chains of coincidences, even if they are different.

Competitive intelligence is a tool that captures and organises the useful information available from the market in an anticipating way, aiming to strengthen the company in the short- and long-term strategical decision-making processes. Opait et al. (2016) state that some organisations can project entrepreneurial intelligence infrastructure based on their capability to predict changes and understand risks, which can allow a better competitive position based on previous information and knowledge of the environment where they operate, for, if the information is not considered as a value, the companies' survival might be at risk.

According to Holm et al. (2018), accurate information interpretation that explains the results through simple mechanism analysis leads to a change in the casualty variable. Therefore, it is necessary to check which simple mechanisms are involved. This is why this topic is relevant and necessary in investigating natural and artificial phenomena, intending to evaluate how the assets can be analysed after disclosures from events involving environmental damages.

Some organizations take more risks than others in their activities; the Petrobrás and Vale companies, for instance, had their images and assets worn out in several episodes in the history of this country. Recently, there was the rupture of one of the dams of the Brazilian multinational mining company, Vale, in January 2019, in Brumadinho, State of Minas Gerais, whose story brought much commotion and was reported worldwide. Upon evaluating the damages, there were

even wastes connected to affections which influenced the assets pricing, enabling this pricing model to successfully capture the impacts of such anomalies (Bathia & Bredin, 2018).

Therefore, the objective of this work is to investigate the share profit behaviour of companies such as Petrobrás S. A. and Vale S. A., compared to the Ibovespa (Ibov) non-diversified, systemic index to detect how profit variations behave in their assets after environmental damage.

### Theoretical framework

This section presents the concepts of social responsibility related to environmental damages according to recent publications on the theme. As Neves Almeida et al. (2017) stated, specialised literature has widely discussed the relationship that contrasts the ecosystems' economic growth and social responsibility. However, the results still show several contradictions. This way, recent research in the area is catalogued below to emphasise these topics: a) Social responses to volcanic eruptions: a review of key concepts, by Torrence (2019); b) the appearance of social cohesion after a disaster (regarding two places affected by flooding in the District of Colombo, Sri Lanka), by Samarakoon and Abeykoon (2018); c) Social responsibility of major infrastructure projects in China, by Zeng et al. (2015); and d) Social determining bonds to corporate social responsibility: existing criteria for the mining sector, by Dimmler (2017).

Torrence (2019) states that using a gross temporal scale in most research and monitoring recovery patterns after a disaster enables a more realistic look than using social responses only. Concerning monitoring the relationships of scientific articles revised by peers and based on patterns to delimit the borders of this knowledge, here is the following table:

**Table 1.**  
Monitoring articles and international social recoveries

Author	Summary
(Zeng et al., 2015)	Aims at knowing the social responsibility of major infrastructure projects (MIP-SR) since MIP-SR offers basic public services for the production and social-economic development, which impacts people's lives. The study shows that MIP-SR has been determining support for China's national economy and social progress.
(Dimmler, 2017)	The mining industry must progressively adapt the social responsibility practices to improve occupational, environmental, and public health requirements in communities where they operate. The study reassesses the relationship between social responsibility and its impact on life expectancy and improved policies connected to human rights.
(Samarakoon & Abeykoon, 2018)	It aims at showing that the non-victims of disasters tend to see stressful situations as "our" problem instead of "your" problem. This collective, shared feeling creates social cohesion in catastrophic situations. The study results showed that social media are a source of information and an agent that promotes social integration.
(Torrence, 2019)	From a more realistic perspective, it suggests observing how the populations deal with and explore environmental changes, following up on resilience and innovation along with generations. The environmental record, which monitors the ecosystem's recovery concerning the acquisition of food supplies, may favour the subsistence strategies.

Source: Elaborated by the authors.

In these articles, the objectives emphasise the social response, the collective feeling that brings social cohesion, the social responsibility of major infrastructure projects before social responsibility, and the corporate social responsibility review in the relationship with life expectancy, respectively. Dimmler (2017) states that the meaning of business responsibility is to follow each meaningful task according to its operations' size and nature. In order to achieve this task, the organisations usually adopt the models of Corporate Social Responsibility.

Zeng et al. (2015) imply that the organisational and environmental agents reflect on the sustainability management need and urgency in major infrastructures, linked to the complex dimensions connected to social responsibility within the administrations. Among the findings are the discussions that try to structure the social responses to environmental disasters. Social media bring social integration, public events are created due to the lack of social responsibility, and the government must supervise the mining and oil industry responsibility to guarantee the safety of workers, society, and the environment.

Zeng et al. (2015), Dimmler (2017), Samarakoon and Abeykoon (2018), Torrence (2019) are concerned about demonstrating, in their works, the need social responsibility has to be present in various topics and the direct relationship with the role and duty of public organs, private organisations, and natural persons involved.

Concerning studies with Brazilian samples, the topics addressed also show their tendency toward social responsibility and lead to the same directions observed in foreign studies. Garcia and Fonseca (2018) mention that several countries, including Brazil, adopt different sanction combinations, both in the civic and criminal spheres. There are major debates about the pros and cons of each type of sanction established.

Thus, here are some of the most recent national researches on social responsibility, as shown in Table II: a) Fatigue and workability in Brazilian textile companies in the different corporate social responsibility of score groups, by Metzner and Fischer (2010); b) Assessing corporate social responsibility concepts used by a Brazilian manufacturer of airplanes: a case study at Embraer, by Anholon et al. (2016); c) the Brazilian program of social fuel seals: few strikes, several engraving mistakes, and stumbles, by Oliveira et al. (2019); and Corporate Social Responsibility in Brazil according to SA 800: case studies and the correlation with the supply chain, by Andrade and Bizzo (2019).

**Table 2.**

Monitoring articles and national social recovery

Author	Summary
(Metzner & Fischer, 2010)	It noted that the corporate social responsibility levels could change the results related to work and fatigue from the perspective of the executives and workers in a certain company.
(Anholon et al., 2016)	It checks whether Embraer, the largest Brazilian manufacturer of airplanes, developed well-structured projects on Education based on corporate social responsibility, impacting six main areas of operation.
(Oliveira et al., 2019)	It notes whether the high dominance of soy in the formulation of raw materials used in biodiesel production in Brazil follows the government's objectives, which represents a regional disadvantage.

Author	Summary
(Andrade & Bizzo, 2019)	<p data-bbox="415 247 1419 344">It examines the main results of the Social Fuel seal and suggests improvements for the realignment between the Brazilian programs and the policies that are similar to those applied in other developing countries.</p> <p data-bbox="415 352 1419 449">It points out that, despite the location, the sector, and the several activities, the Brazilian organisations have implementation and management problems concerning the requirements established by the SA 8000 norm.</p>

Source: Elaborated by the authors.

The results found in the articles show that the Brazilian reality is not very different from that of the rest of the world. There is the need to include workers in the implementation projects of social responsibility; there are companies with a good evaluation concerning social responsibility; there are organisations with references to the Brazilian government's disagreement concerning its policies; there are issues related to the management within the organisations. The contribution of these works serves as a parameter for new evaluations. Moreover, there is the interest from the authors, shown in Table II, to show the need for social responsibility and the search for solutions for this topic in the most varied scenarios.

In this context, the lack of social responsibility and the non-follow-up on regulations can generate environmental damages that may affect the financial relationships, such as the Petrobrás S. A. and Vale S. A. companies.

### *Scenarios analysis*

Batrouni et al. (2018) show that the study is similar to the set of methodologies and techniques that aim to bring about an insight that covers the strategy for political decisions and decision-makers. The past decades have seen a constant trend with a great meaning: a growth in material and immaterial losses as a result of disasters caused by human intervention or omission. Kul'ba et al. (2016) report that one of the main driving forces of this situation is the lack of resourcefulness in the prevention systems and emergencies that should occur fast and assuredly during the event.

To the authors, planning and prevention control of natural and artificial emergency types are strictly connected to the advanced analyses of scenarios to guarantee the generation of the prediction of its development before the event. In essence, the analysis of scenarios operates to prevent situations that could jeopardise the companies, and in the preparation of alternatives in case it is necessary to adopt an emergency measure. Wright et al., (2019) observe that the eventual uncertainty lies in the same environment where the probabilities are associated with possible results and is based on reasoning or the frequency of specific results in similar events.

In 2008 the financial crisis set off, which triggered an enormous recession. This was a clear example that the financial markets are environments with many variations (Owadally et al., 2019). In this context, it is possible to see that the lack of monitoring of possible scenarios may result in several unexpected adverse situations for the companies and all the agents involved, both in external and internal scenarios, which can determine the organization's future.

Research by Balachandran and Williams (2018) reports on how important it is for the agents to monitor the events and have skills and tools to detect relevant information that meets the demand

perspectives. Research by Balachandran and Williams (2018) addresses how important it is for the agents to monitor events, have skills and tools to highlight relevant information, and promptly meet existing demands. It is also important that they know how to differentiate the results, which entail efforts connected to strategic management, the results connected to mistakes or hypotheses. This research points out that the strategies used in the financial scenario scope are managed through tools that can distinguish and block irrelevant information by improving analyses and results.

To analyse financial scenarios, the participation of all the agents involved in the acquisition of variables comes as a suggestion. Oh and Kim (2007) mention that the daily variations of opinions issued by specialists in these scenarios are very useful with all the economic environments' transformations. Wachtmeister et al. (2018, p. 138) mention that: "Scenarios and estimates are important for decisions and policy formulation. The accuracy of previous estimates can be useful both for the scenery users and for the designers to get the sensation about the current estimate's uncertainty and lead improvement efforts".

### *Sensitivity analysis*

According to Félix et al. (2019, p. 836), "The sensitivity analysis is an important tool commonly used to confirm the acquisition of the ideal set of parameter values obtained through regression analysis". Thus, it can be stated that sensitivity analysis is a method of great importance in the financial area to establish a feasibility level of a given intention.

One of the advantages of using sensitivity analysis is that it allows the manager to outline scenarios to adjust the available project budget to future possibilities and complications. Lucay et al. (2019) state that it is necessary to identify the uncertainties' collaboration comprised by the input variables over the output variables. In a mathematical model, sensitivity can be analysed through a local or global model. However, there can be some disadvantages depending on choosing the local model, which may influence the results.

To Bouazizi et al. (2018, p. 65), "The sensitivity analysis supplies each model with an index called 'sensitivity index'. There are several techniques to determine these indexes. These indexes can be calculated if the model is analytically known and simple. However, in most cases, the model is more complicated". The sensitivity analysis is a very useful tool to either confirm or not some set of values, thus avoiding evaluation mistakes.

In turn, Savall et al. (2019) mention that the sensitivity analyses effectively establish the spatial and temporal resolution, and which ones will be more appropriate for the models and for the minimisation of the factors to be measured or estimated, with a higher level of accuracy.

Evaluating the impact of some percentage variations of a variable of the project's performance indexes does not reflect the incidence probability of this variation. The financial and economic performance indexes' probability distributions can be estimated by attributing adequate probability distributions to the critical variables. Duprez et al. (2019) state that the sampling process of sensitivity analysis can generate some input elements, called "project alternatives", which aim to evaluate each alternative directly related to its possible performance.

The sensitivity evaluation is done through possible simulations for the different project variables representing a high uncertainty level in the future. There is a variation in price and sales volume, some costs, exchange rates, and the project's financing conditions. In this sense, Bouazizi et al. (2018) stated that, practically speaking, system functioning mistakes can be avoided before they happen from a choice based on the project's initial parameters.

## Method

This is quantitative and descriptive research carried out through a Survey. It aims at analysing the relationship between disclosures and variations in share prices of companies listed in stock markets, operated via the registration of every daily share quotation of the Bovespa index, from the Petrobrás S. A. and Vale S. A. companies for almost 12 years, that is, from Feb 26<sup>th</sup>, 2007 to Jan 28<sup>th</sup>, 2019. All these quotations were listed in Brazilian stock markets as several variables were collected, such as opening and closing prices, day's high and low quotations, return – the mean between the opening and the closing prices – and the number of days up until the recovery of the share price loss due to the event involving environmental damage.

In order to operationalise the investigation, events that occurred during the time mentioned above were identified. They brought about expressive drops in the companies' share prices mentioned above. There were 23 events involving Ibovespa (Ibov), 19 events involving Petrobrás, and 15 events involving Vale.

**Table 3.**

Adverse events' history involving Petrobrás, Vale, and Ibovespa

Date	Company	Description	Event
Jul 24 <sup>th</sup> , 2007	IBOV	USA subprime crisis begins	I1
Jan 11 <sup>th</sup> , 2008	IBOV	Recession in the USA	I2
May 29 <sup>th</sup> , 2008	IBOV	FED statement indicating an increase in interest rates and a consequent Dollar valorisation, causing a vending pressure	I3
Sep 29 <sup>th</sup> , 2008	IBOV	Crisis in the USA	I4
Oct 6 <sup>th</sup> , 2008	IBOV	Crisis in the USA	I5
Oct 10 <sup>th</sup> , 2008	IBOV	Crisis in the USA	I6
Oct 15 <sup>th</sup> , 2008	IBOV	Crisis in the USA	I7
Oct 22 <sup>nd</sup> , 2008	IBOV	Crisis in the USA	I8
Oct 20 <sup>th</sup> , 2009	IBOV	Tax on Financial Transactions (IOF) for foreign investors begins	I9
Apr 26 <sup>th</sup> , 2010	IBOV	Crisis in Greece	I10
Aug 8 <sup>th</sup> , 2011	IBOV	Risk agencies lower USA credit memo	I11

Date	Company	Description	Event
May 14 <sup>th</sup> , 2012	IBOV	Risk aversion in the international market	I12
Sep 29 <sup>th</sup> , 2014	IBOV	The electoral pool shows Dilma Rousseff ranking first	I13
Oct 27 <sup>th</sup> , 2014	IBOV	Dilma Rousseff is re-elected in Brazil	I14
May 13 <sup>th</sup> , 2016	IBOV	Operation Car Wash, political crisis	I15
Sep 9 <sup>th</sup> , 2016	IBOV	Federal banks concerned about the global economy	I16
Nov 1 <sup>st</sup> , 2016	IBOV	The electoral pool shows Donald Trump as favourite	I17
Nov 9 <sup>th</sup> , 2016	IBOV	Donald Trump is elected in the USA	I18
Feb 23 <sup>rd</sup> , 2017	IBOV	Implementation of profits and political scenery	I19
May 18 <sup>th</sup> , 2017	IBOV	JBS company casts blame upon Michel Temer	I20
Aug 29 <sup>th</sup> , 2017	IBOV	Market awaits the government's fiscal goals, Long-Term Rate (LTR) voting, North Korea launches a missile over Japan	I21
Jun 7 <sup>th</sup> , 2018	IBOV	Ibovespa rate decreases due to uncertainty in political scenery, truck drivers go on strike, ore prices decrease	I22
Sep 3 <sup>rd</sup> , 2018	IBOV	The downfall of emerging markets and political scenery	I23
Jul 24 <sup>th</sup> , 2007	PETROBRÁS	Recession in the USA, a decrease in oil price, and the Chinese economic slowdown	P1
Nov 9 <sup>th</sup> , 2011	PETROBRÁS	Campos Basin oil spill – CHEVRON held accountable	P2
Jan 26 <sup>th</sup> , 2012	PETROBRÁS	Oil spill on a beach in Tramandaí, state of Rio Grande do Sul/RS	P3
Feb 9 <sup>th</sup> , 2012	PETROBRÁS	Graça Foster is appointed president of Petrobrás	P4
Feb 10 <sup>th</sup> , 2012	PETROBRÁS	Disclosure of the 4Q2011 results with a 52% net profit lower than the one in the same time in the previous year	P5
May 4 <sup>th</sup> , 2012	PETROBRÁS	Oil production decreases in March, and oil price decreases in the international scenery	P6
Jan 28 <sup>th</sup> , 2013	PETROBRÁS	Petrobrás no longer holds the position as the largest Latin American company	P7
Jul 4 <sup>th</sup> , 2014	PETROBRÁS	Oil spill on a beach in Tramandaí, state of Rio Grande do Sul/RS	P8
Dec 15 <sup>th</sup> , 2014	PETROBRÁS	Operation Car Wash finds issues, corruption, property loss, and drawback connected to Petrobrás	P9
Feb 11 <sup>th</sup> , 2015	PETROBRÁS	FPSO ship platform, operated by Norwegian BW Offshore, explodes. Nine are killed	P10
Jun 29 <sup>th</sup> , 2015	PETROBRÁS	2015-2019 investment plan is 37% less than expected; crisis in Greece	P11



Date	Company	Description	Event
Jan 8th, 2016	PETROBRÁS	Reduction in the 2015-2019 investment plan, reduction in the production plan, oil price decreases in the international scenery, Operation Car Wash	P12
Jan 22nd, 2016	PETROBRÁS	P-31 oil rig disruption	P13
Apr 7th, 2016	PETROBRÁS	Oil spill on a beach in Tramandaí, state of Rio Grande do Sul/RS	P14
May 17th, 2018	PETROBRÁS	JBS company casts blame upon Michel Temer; dollar rates increase, oil price decreases in the international scenery	P15
Jun 1st, 2018	PETROBRÁS	Petrobrás president, Pedro Parente, leaves the company	P16
Nov 7th, 2018	PETROBRÁS	Disclosure of the 3Q2018 results below the expected, tensions with USA parliamentary election	P17
Jan 3rd, 2019	PETROBRÁS	Campos Basin rig in the state of Rio de Janeiro spills 1,400 oil barrels	P18
Feb 22nd, 2019	PETROBRÁS	Onerous transfer contract review	P19
Feb 26th, 2007	VALE	Debt due to purchasing an Australian mining company	V1
Aug 14th, 2007	VALE	Building occupation in order to claim for re-nationalisation, USA subprime crisis	V2
Oct 3rd, 2007	VALE	Vale company terminates the North-South railway sub-concession	V3
Oct 19th, 2007	VALE	The Vale do Rio Doce company pays shareholders of 2007, Federal Supreme Court (STF) closes a Vale appeal against the Administrative Council for Economic Defense (CADE), which forced Vale to either sell the FERTECO mining company or give up the purchase preference of the ore produced in the Casa de Pedra mine	V4
Sep 19th, 2012	VALE	Despite the global optimism of the Japanese government, VALE plans to inject US\$ 172 billion into the country's economy	V5
Jan 14th, 2015	VALE	Ore price in China decreases	V6
Aug 3rd, 2015	VALE	Ore price increases, but there are signs of a slowdown in the Chinese economy	V7
Oct 13th, 2015	VALE	Highest downfall in 7 years due to ore price decrease in China	V8
Nov 6th, 2015	VALE	The Mariana Dam ruptures and releases 43.7 million cubic meters of waste, killing 19 people. The largest environmental disaster in the Brazilian history	V9
Jan 22nd, 2016	VALE	Exportation at the Tubarão port in the state of Santa Catarina, Brazil, is interrupted	V10
Nov 18th, 2016	VALE	The Public Prosecutor's Office (MPF) denounces 22 people and the Samarco, Vale, BHP Billiton, and VogBR companies due to the Mariana dam rupture	V11
Nov 29th, 2016	VALE	Ore price decreases	V12
Mar 21st, 2017	VALE	Ore price decreases	V13

Date	Company	Description	Event
Feb 27th, 2018	VALE	Disclosure of the 4Q2017 net profit, 64% lower than the 3Q2017	V14
Jan 28th, 2019	VALE	The Brumadinho dam ruptures. 203 people were killed, and 105 went missing (as of Mar 14 <sup>th</sup> , 2019) after 40 million cubic meters of a waste leak	V15

Source: Elaborated by the authors.

Since this is quantitative research, a descriptive analysis was performed through an Exploratory Factor Analysis (EFA), making it possible to check each variable. Before EFA, Cronbach's Alpha, KMO, Community, and Factor Load were identified. Subsequently, the variance analysis (ANOVA) detected the mean and the standard deviation. Through ANOVA, it was possible to see the existence of differences between variables such as "profit" and "the number of days up until the environmental damage's recovery" (Guimarães et al., 2016). Later on, the variables were analysed in Post Hoc tests after their differences were established, the companies were investigated, and the Ibovespa index was disclosed. For the tests, spreadsheets from Microsoft Excel and IBM's SPSS software, version 20, were used.

**Table 4.**

Factor load of the observable variables and the Varimax Rotation

Observable Variables	Factor Load	Community
Opening price	.996	.993
Closing price	.996	.993
Day's high	.996	.993
Day's low	.996	.993
Profit	.993	.987
Number of days to a positive return		.135

Mean: 0.0005; Standard Deviation 0.0253; Cronbach's Alpha 0.937; KMO 0.691

Source: Research Data.

### Results' analysis and discussion

This research was carried out with three groups, between indexes and shares. They include 2,908 daily quotations from the Bovespa index, 3,045 daily quotations from the Petróleo Brasileiro S. A. (ticker PETR3), and 2,845 daily quotations from Vale S. A. (ticker VALE3). The shares were collected according to the opening and closing quotation values, day's high and low quote, profit – the mean between the closing and the opening prices – and the number of days up until the profit was positive due to the event. Since the group sample size is unequal, the harmonic mean of 2,930 quotations was applied to each group.

For research validation, the SPSS 20.0 software was applied. Then, the following precepts were observed: i) 6 variables (Table 5) and the descriptive statistics; ii) extraction through the Main Component Analysis, based on Exploratory Factor Analysis self-values; iii) ANOVA variance analysis, and iv) Post Hoc Analysis.

**Table 5.**

Variables' mean and standard deviation

Event	Mean	N	St. deviation	Event	Mean	N	St. deviation
I1	.00099	114	.019989	P6	-.00010	357	.025325
I2	.00176	92	.021343	P7	-.00370	113	.039978
I3	-.00391	86	.025513	P8	-.00038	38	.054326
I4	-.02415	5	.067695	P9	.00606	92	.033061
I5	-.04465	4	.007386	P10	-.00405	130	.039415
I6	.04168	3	.095330	P11	-.02055	10	.049629
I7	-.01045	5	.070063	P12	.01020	50	.054898
I8	.00257	245	.027106	P13	.00257	522	.025684
I9	.00038	125	.014357	P14	-.03217	10	.075824
I10	-.00073	335	.012273	P15	.00312	109	.029212
I11	.00071	200	.016204	P16	-.00281	35	.024117
I12	.00004	603	.013089	P17	.00473	35	.015605
I13	-.00445	20	.027958	P18	.00344	42	.022890
I14	.00022	379	.017157	P19	.00140	117	.021383
I15	.00156	83	.012383	V1	.01165	35	.028965
I16	.00216	36	.012474	V2	-.00144	11	.033299
I17	-.00210	5	.026450	V3	.00078	1046	.024727
I18	.00102	73	.014284	V4	-.00054	581	.019552
I19	-.00021	55	.012114	V5	-.00083	136	.036583
I20	.00079	72	.013635	V6	.00385	49	.039486
I21	.00044	188	.012100	V7	-.01005	17	.038370
I22	.00021	61	.013568	V8	-.01168	50	.034753
I23	.00173	258	.015715	V9	.00579	205	.042929
P1	.00018	1081	.027756	V10	.03340	7	.038131
P2	.00279	56	.019806	V11	.00095	75	.033879
P3	-.00043	10	.012905	V12	.00214	230	.020873
P4	-.00217	1		V13	.00113	225	.020790
P5	-.00318	60	.020452	V14	-.00540	24	.058974
P6	-.00029	192	.021160	V15	-.00010	357	.025325
Total	M=.00059	N=8798				St.d=.025015	

Source: Research data.

The mean tests placed the profits for each event, and the standard deviation test measures the response dispersion around the average.

Upon performing the Exploratory Factor Analysis, the process and the behaviour of the observable variables, the Cronbach's Alpha test scales, the Kaiser-Meyer-Olkin (KMO) test for sampling adequacy, the Bartlett's Sphericity Test, the commonality analysis, and the factor load with VARIMAX rotation were examined.

Through EFA, the analysis of the observable variables grouped up the variables and their three groups: i) Ibovespa index; ii) Petrobrás share prices; and iii) Vale share prices. Table 5 shows the Principal Component Analysis results and presents the variables and their means, standard deviation, and respective factor loads. Thus, considering these three groups, two variables explain 84.92% of data variation.

The Cronbach's Alpha test measures the simple reliability of the data sample. In order to be meaningful, the result needs to be higher than 0.70 (Lee & Hooley, 2005; Hair et al., 2009). The test result was higher than 0.7 (Table IV) for the dataset, and the result of 0.937 shows that the data sample is reliable.

Then, the Kaiser-Meyer-Olkin (KMO) test was performed. This test measures the sampling adequacy dimension. Bartlett's Sphericity test investigates the hypothesis that the correlation matrix is an identity matrix by demonstrating the correlation between the variables. In order to be meaningful, the results must be higher than 0.5 and lower than 0.05, respectively (Pestana & Gageiro, 2014). The KMO test was higher than 0.5 (Table 4) for the dataset (0.691). The Bartlett's Sphericity Test checks the H0 null hypothesis, and the correlation matrix is an identity matrix; that is, the variables are not correlated in the population. In order to refute H0, the test needs to have a significance of  $p < 0.01$ , and, for the dataset, the result was 0.000.

The research observed the variance of each original variable: the communality. In order to be meaningful in the Commonality Analysis, the result must be higher than 0.5 (Lee & Hooley, 2005). All the variables presented a communality higher than 0.5. Concerning the factor analysis with VARIMAX rotation, it aims at studying and determining the influence of the independent variables (the cause) over the dependent variable (the effect) by validating the position of the variables in the components that grouped them up. In order to be significant, the factor load needs to reach higher than 0.4 (Hair et al., 2009). According to Table 4, the variables have a factor load above 0.4, except the variable "Number of days to positive return". As this is an important variable for the study, it was kept. This way, there was no need to discard any of the variables. As for the research instrument grouping and its variables, it is possible to notice they belong to their groups.

In order to view the factors' variance from most means versus the lowest means of the independent variables, it is necessary to explain the dependent variables. The ANOVA Variance Analysis was used to investigate the variables' variance and their significance, checking whether there is a meaningful difference in the mean. In order for the result to be meaningful in the null hypothesis, it needs to present  $p > 0.05$  (Hair et al., 2009) and show that the variables' data are not different from the groups' means; the independent variables' data do not have any significance for the dependent variables. In the alternate hypothesis,  $p < 0.05$  shows that its results are different from the means among the groups, which means that the independent variables' data show the significance of the dependent variable among the groups.

The Ibov index is non-diversifiable; it is systemic, and the Petrobrás and Vale share prices are diversified assets with diversified and individualised quotations.

According to Table VI below, the Return variable was higher than 0.05, which shows its mean results are not different from the profit means in the Ibov, Petrobrás, and Vale groups. This means that the return data from the Bovespa index and the Petrobrás and Vale shares do not have any significance for the behaviour of the Return variable among the groups. Concerning the variable Number of days until the return was positive, the result was lower than 0.05, which shows the results are different from the means and that the quotation data from the Bovespa index and the Petrobrás and Vale shares present a significance for the number of days until a positive return

among the variables, even between different groups, since each one has a recovery behaviour for a different reason.

**Table 6.**  
Factors' Anova

		Sum of squares	df	Mean Square	F	Sig.
Return	Among the groups	.001	2	.000	.457	.633
	In the groups	5.504	8795	.001		
	Total	5.505	8797			
Number of days to a positive return	Among the groups	37972397.960	2	18986198.980	313.124	.000
	In the groups	533282793.400	8795	60634.769		
	Total	571255191.361	8797			

Source: Research data.

Upon analysing the return means among the groups, it is possible to see that the return means for the share prices from the Petrobrás and Vale companies are higher than the Ibovespa index, that is, 0.00051 (or 0.051% for PETR3), 0.00094 (or 0.094% for VALE3) and 0.00033 (or 0.033% for IBOV) (Table VII). Note that the result contests the understanding that, due to being systemic and non-diversifiable, the index has a lower return because the diversifiable systemic risk is lower.

**Table 7.**  
Descriptive statistics of the Return's independent variable among the groups

Return	N	Mean	Standard Deviation	Standard Model	Mean reliability interval of 95%		Low	High
					Low limit	High limit		
					Ibov	2908		
Petrobrás	3045	.00051	.028887	.000523	-.00051	.00154	-.149	.161
Vale	2845	.00094	.027094	.000508	-.00005	.00194	-.245	.148
Total	8798	.00059	.025015	.000267	.00007	.00111	-.245	.161

Source: Research data.

However, the average days to positive return is quite low for the Ibov index: 143.8 days for the companies, with Petrobrás at 282.1 days and Vale at 284.9 days (Table VIII). Likewise, the number of days concerning the Ibov index is lower. Since it is systemic and non-diversifiable, it seizes a wide mean of several other assets which are not necessarily impacted by the diversified, individual assets' events and, therefore, recovers more quickly.

**Table 8.**

Descriptive statistics of the independent variable Number of days to positive return among the groups

	Number of days to a positive return							
	N	Mean	Standard deviation	Standard model	Mean reliability interval of 95%		Low	High
					Low limit	High limit		
Ibov	2908	143.83	138.474	2.568	138.80	148.87	0	602
Petrobrás	3045	282.13	286.615	5.194	271.95	292.32	0	1080
Vale	2845	284.90	282.819	5.302	274.51	295.30	0	1045
Total	8798	237.32	254.828	2.717	231.99	242.64	0	1080

Source: Research data.

As these means are different, it is necessary to investigate the reason in Post Hoc tests, which will show the differences between the groups' means. The ANOVA variance analysis identified that the variable Return did not present any meaningful difference in medium returns among the groups, with  $p > 0.05$ . In the Post Hoc test and the multiple comparisons among the groups, both for the LSD and Bonferroni tests, the hypothesis was confirmed with  $p > 0.05$  in every comparison. In the Dunnett's test, which compares the groups with a control group, a reference group, the result also showed to be significant with  $p > 0.05$ , showing that the return means of the shares of the diversified asset from Petrobrás and Vale against the Ibov index are not different (Table IX).

**Table 9.**

Post Hoc test with multiple comparisons among groups for the Return variable

Dependent variable			Mean difference (I-J)	Standard model	Sig.	Liability interval of 95%		
						Low limit	High limit	
Return	LSD	Ibov	Petrobrás	-.000187	.000649	.773	-.00146	.00108
			Vale	-.000615	.000660	.351	-.00191	.00068
		Petrobrás	Ibov	.000187	.000649	.773	-.00108	.00146
			Vale	-.000429	.000652	.511	-.00171	.00085
		Vale	Ibov	.000615	.000660	.351	-.00068	.00191
			Petrobrás	.000429	.000652	.511	-.00085	.00171
	Bonferroni	Ibov	Petrobrás	-.000187	.000649	1.000	-.00174	.00137
			Vale	-.000615	.000660	1.000	-.00219	.00096
		Petrobrás	Ibov	.000187	.000649	1.000	-.00137	.00174
			Vale	-.000429	.000652	1.000	-.00199	.00113
		Vale	Ibov	.000615	.000660	1.000	-.00096	.00219
			Petrobrás	.000429	.000652	1.000	-.00113	.00199
Dunnett's test (2 sided) <sup>a</sup>	Petrobrás	Ibov	.000187	.000649	.941	-.00125	.00162	
	Vale	Ibov	.000615	.000660	.546	-.00084	.00207	

Source: Research data.

Note: <sup>a</sup>The Dunnett's test handles a group as a control and compares it with all the other groups.

However, the ANOVA test showed that the mean number of days to positive return among the groups behaved differently, with  $p < 0.01$ . To identify which group has a mean that is different from the other groups' mean and if there is any group with a mean that behaves likewise, the Post Hoc test was performed for the multiple comparisons for the variable "number of days to positive return", which identified  $p > 0.05$  for the means when comparing Petrobrás to Vale, and also when comparing Vale to Petrobrás, both for the LSD test and for the Bonferroni test. Dunnett's test still shows that the means of the number of days to positive return among the Petrobrás and Vale groups with the Ibov control group are not significant, with  $p < 0.05$ , and are different from each other (Table X).

**Table 10.**  
Post Hoc test

Dependent variable			Mean difference (I-J)	Standard model	Sig.	Liability interval of 95%		
						Low limit	High limit	
Number of days to positive return	LSD	Ibov	Petrobrás	-138,301*	6,385	.000	-150.82	-125.79
			Vale	-141,071*	6,493	.000	-153.80	-128.34
		Petrobrás	Ibov	138,301*	6,385	.000	125.79	150.82
			Vale	-2,770	6,421	.666	-15.36	9.82
		Vale	Ibov	141,071*	6,493	.000	128.34	153.80
			Petrobrás	2,770	6,421	.666	-9.82	15.36
	Bonferroni	Ibov	Petrobrás	-138,301*	6,385	.000	-153.59	-123.01
			Vale	-141,071*	6,493	.000	-156.62	-125.52
		Petrobrás	Ibov	138,301*	6,385	.000	123.01	153.59
			Vale	-2,770	6,421	1,000	-18.14	12.60
		Vale	Ibov	141,071*	6,493	.000	125.52	156.62
			Petrobrás	2,770	6,421	1,000	-12.60	18.14
Dunnett's test (2 sided) <sup>a</sup>	Petrobrás	Ibov	138,301*	6,385	.000	124.18	152.43	
	Vale	Ibov	141,071*	6,493	.000	126.71	155.44	

Source: Research data.

Note: <sup>a</sup>The Dunnett's test handles a group as a control and compares it with all the other groups.

### Final remarks

The research demonstrated that the return means of companies that disclose information on events with environmental damages follow the return means from the Ibovespa systemic index but quickly recover after such index. Thus, it was possible to confirm the hypotheses studied and highlight the importance of understanding the assets' sensitivity after catastrophic events and its time to reset the negative effects over its return.

Furthermore, it was possible to see that, even though the mean return between the Petrobrás and Vale company shares are compatible with the Ibovespa index, the time it takes to reset the negative effects over the companies' share return is higher than the Ibovespa index. As it is non-diversified and systemic, the other assets that compose it are not necessarily involved with the disclosure event, and it recovers its return more quickly. However, the return percentage total is

expressed less significantly since it is about an index that reflects the quotation means from several companies.

Concerning the objective suggested, the study brought in some contributions by pointing out to investors and researchers the results that show the expected return and the time it takes for the Petróleo Brasileiro Petrobrás S. A. and Vale S. A. companies to recover after they disclose information on events involving environmental damages.

The study faces some limitations concerning statement generalisation, since it deals with a Survey and the environment studied, for it represents only two companies in two activity sectors. After accomplishing the statistical analyses, the study validated the confirmed theoretical assumptions as an academic contribution. The results showed investors, managers, and researchers that stock profit averages from companies that disclose their environmental damages have no meaningful differences concerning the non-diversified, systemic Ibovespa index, but recovering such profits takes longer.

As a suggestion for future research, there should be an action in other economic areas and a higher number of companies equally quoted in the Brazilian Stock Market.

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### **Acknowledgments**

Not applicable.

### **Funding**

Not applicable.

### **Conflict of Interests**

No, there are no conflicting interests.

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