REVISTA CONTABILIDADE, GESTÃO E GOVERNANÇA
E-ISSN 1984-3925 JOURNAL OF ACCOUNTING, MANAGEMENT AND GOVERNANCE

OPEN ACCESS

Editor Responsável: Jorge Katsumi Niyama
Jomar Miranda Rodrigues
Editor Associado: Jomar Miranda Rodrigues
Processo de Avaliação: Double Blind Review pelo SEER/OJS

Petrobras Corruption: Contagion Effect on Its Supply Chain

ABSTRACT

Objective: To analyze the contagion effect on the assets of Petrobras' supply chain firms following the corruption scandals uncovered by Operation Lava Jato.

Method: An event study was conducted using 60 assets from the S&P 500, with two key dates defined for analysis.

Originality/Relevance: The study provides evidence that the conduct of supply chain partners should be a key concern for managers and regulatory bodies. It also reinforces the premise that stock markets anticipate news and, at times, trigger abnormal movements, penalizing assets of organizations linked to firms allegedly involved in illicit practices.

Results: The identified returns were significantly negative and abnormal for the value chain.

Theoretical/Methodological Contributions: The findings demonstrate that corruption induces abnormal stock market fluctuations among suppliers of firms embroiled in corruption scandals.

Keywords: Corruption, Petrobras, Supply Chain, Abnormal Returns, Contagion Effect

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Received: November 25, 2023
Revised: March 12, 2025
Accepted: March 13, 2025
Published: March 31, 2025

How to Cite (APA)
Silva, R. C., Meurer, A. M., Barros, C. M. E. (2024). Petrobras Corruption: Contagion Effect on Its Supply Chain. *Revista Contabilidade, Gestão e Governança*, *27* (3), 342-376. http://dx.doi.org/10.51341/cgg.v27i3.3186

1 INTRODUCTION

Identifying and combating corruption schemes presents a challenge that extends beyond authorities, raising concerns among shareholders, regulatory framewords, customers, suppliers, and various social actors. This is because corruption can inflict both financial and reputational damage on organizations and nations, potentially affecting firms within the same sector or across different industries, as well as corporate supply chains (Shleifer & Vishny, 1993).

Bolgorian (2011), Lakshmi et al. (2021), and Mauro (1995) emphasize that economic growth in emerging markets such as Brazil tends to be more vulnerable to corruption due to political and economic fragility. Consequently, the number of companies engaged in corrupt practices involving supply chains in these markets has been increasing over the years (BSI, 2018; Wang et al., 2024).

The supply chain consists of a group of companies that perform integrated management to manufacture a final product or provide services. It comprises a focal firm, its customers, and its suppliers, and may extend this network to include customers' customers, suppliers' suppliers, and other enterprises that maintain any type of relationship with the focal firm (La Londe & Masters, 1994; Mentzer et al., 2001).

Several authors (Abe & Ye, 2013; Hendricks & Singhal, 2003, 2005; Papadakis, 2006) suggest that negative effects may arise for firms within a supply chain when capital markets identify operational failures in any network member. Nunes (2017) emphasizes that corporate social irresponsibility, fraud, and corruption can generate adverse effects across supply chains. Meanwhile, Jacobs and Singhal (2017) highlight reputational risks for companies participating in supply chains where members become involved in scandals.

In Brazil, Operation Lava Jato (Car Wash) stands as one of the largest anti-corruption and money laundering initiatives ever launched in the country. The operation began on March 17, 2014, with the objective of investigating a money laundering and foreign currency evasion scheme involving an estimated R$10 billion (USD 2.5 billion) in irregular transactions (Padula & Albuquerque, 2017; Federal Police [PF], 2014).

The allegations investigated involved irregularities in contracts with Petrobras' supply chain participants, including construction firms, goods and services suppliers, as well as political parties and affiliated figures. The scheme implicated 27 companies that, between 2004 and 2012, secured contracts with Petrobras and received improper payments from the corporation. Following the scandals uncovered by Operation Lava Jato in 2014, Petrobras reported a net loss of R$21.6 billion (approximately USD 6.9 billion at 2015 exchange rates; Petrobras SA Reference Form [FR Petrobrás SA], 2015)

The evidence presented by authorities revealed opaque decision-making regarding Petrobras' investment projects within its business segment. These projects violated the company's internal controls for service procurement, indicating conflicts of interest in commercial relationships (FR Petrobrás SA, 2016). This constituted an attempt at principal expropriation, leveraging the informational asymmetry between both parties in these transactions (Jensen & Meckling, 1976).

The information disclosed about Operation Lava Jato may have affected Petrobras' supply chain firms in various ways, given the operational complexity of the company's activities—including oil exploration, production, refining, and related operations (Vilela et al., 2018). This linkage occurs because such disclosures can influence investor decisions, as posited by the Efficient Market Hypothesis (EMH) in its semi-strong form (Fama, 1970).

Given its unprecedented scale, Operation Lava Jato may have triggered contagion effects in both domestic and international markets. Studies by Baig and Goldfajn (1999),

Bello et al. (2022), Calvo and Reinhart (1996), Ferreira and Mattos (2024), Frankel and Schmukler (1996), Ghorbel and Boujelbene (2013), Kang et al. (2023), Luchtenberg and Vu (2015), Mezghani and Boujelbène (2018), Peixe et al. (2023), Valdés (2000), and Wang et al. (2024) have empirically demonstrated financial contagion stemming from events affecting financial markets and their supply chains – even when originating in specific geographic region.

Therefore, this study examines contagion effects on the assets of Petrobras' supply chain firms following corruption scandals uncovered by Operation Lava Jato. The analysis first investigates Petrobras' asset behavior to establish how impacts on the focal firm propagated through its supply network. Results derive from two key events: (1) September 29, 2014, when money changer Alberto Youssef's plea bargain announcement became public; and (2) December 15, 2014, when new corruption charges emerged implicating additional defendants, including public personalities.

This study makes three key theoretical contributions: First, it addresses a gap in the literature concerning asset price behavior among supply chain participants during periods of corruption-driven market instability. Second, it extends financial contagion theory by empirically testing spillover mechanisms between focal firms and their supply networks. Third, it provides evidence of cross-firm transmission channels for corruption-related shocks, particularly examining how negative abnormal returns propagate through vertically linked enterprises.

By demonstrating contagion effects across Petrobras' supply chain assets, this study reveals a critical imperative for organizations: proactive monitoring of supply network participants is essential to avoid stock market penalties when deviant behavior is detected within the value chain.

2 CORRUPTION, SUPPLY CHAIN, AND CONTAGION EFFECT

According to Ahmed (2020), corruption encompasses a range of practices that extend beyond mere immorality. These include, but are not limited to, bribery, nepotism, lobbying, embezzlement, and other actions that deviate from socially accepted norms. When such practices become publicly known, they can escalate into scandals and reverberate across different social spheres (Bayley, 1966). On the other hand, some evidence suggests that corruption may yield benefits in terms of process optimization (Leff, 1964). Due to these contrasting perspectives, a substantial body of literature has documented studies examining corruption and its consequences.

Leff (1964) argued that corruption could potentially stimulate economic growth, as corrupt practices may circumvent bureaucratic inefficiencies, thereby accelerating decision-making processes. In contrast, Bayley (1966) examines the literature and highlights a higher prevalence of corruption among politicians and public officials in developing countries, emphasizing that corruption ultimately hinders both economic and social progress.

Shleifer and Vishny (1993) support Bayley's (1966) perspective and further argue that in emerging economies, weak governmental oversight of public agencies exacerbates corruption. Mauro (1995) conducted empirical research to identify the mechanisms through which corruption impedes economic growth, quantifying its detrimental effects. His findings revealed no evidence of a positive association between corruption and economic growth. Conversely, Bolgorian's (2011) cross-country study of 46 nations (2007–2009) demonstrated a statistically significant relationship between corruption and stock market development. Bolgorian (2011) emphasized that financial system improvements could mitigate corruption levels and, in turn, foster greater economic growth.

Lakshmi et al. (2021) examined the impact of corruption on stock returns in BRIC emerging economies (Brazil, Russia, India, and China) from 1994 to 2014. Their findings

indicate that corruption undermines both economic performance and consumer markets by increasing production costs. This effect subsequently diminishes corporate returns due to investor uncertainty regarding market conditions, consistent with the established relationship between economic growth and equity market performance.

Wang et al. (2024) investigated the spillover effects of corrupt practices on supply chains and broader industry performance. Their empirical findings revealed statistically significant negative impacts on the stock returns of both clients and suppliers within affected supply chains. Notably, the adverse effects were more pronounced for clients of firms engaged in corruption, while peer firms (non-directly linked industry counterparts) exhibited no measurable effects.

Notably, while corruption is not a phenomenon unique to the new millennium, technological advancements in communication have significantly increased the visibility of corruption scandals while simultaneously enabling more effective monitoring of illicit activities. More critically, the accelerated dissemination of information to financial markets creates immediate spillover effects with global reach, potentially triggering catastrophic financial and reputational consequences for both implicated firms and their extended supply networks (Abe & Ye, 2013; Hendricks & Singhal, 2003, 2005; Papadakis, 2006).

The supply chain was initially conceptualized by La Londe and Masters (1994) as an integrated network of firms collaboratively managing production processes to deliver end products to final consumers - essentially multiple entities coordinating with a focal company to manufacture finished goods. Building on La Londe and Masters' (1994) foundational work, Mentzer et al. (2001) established a three-tier taxonomy of supply chain complexity:

(i) Direct supply chain: The minimal configuration comprising only the focal firm, its immediate suppliers, and direct customers;

(ii) Extended supply chain: The direct network expanded to incorporate suppliers' suppliers and customers' customers;

(iii) Ultimate supply chain: The comprehensive ecosystem encompassing all organizations maintaining any form of commercial relationship with the focal enterprise.

Prior research has systematically examined the multifaceted impacts of disruptive events affecting supply chain participants. Seminal work by Hendricks and Singhal (2003, 2005) quantified supply chain vulnerability through operational disruptions, including production delays and shipping failures. Their analysis of over 500 publicly announced disruption events across both studies revealed statistically significant negative abnormal returns for affected firms within the supply network. Complementing these findings, Papadakis (2006) conducted an event study analysis of supply chain disruptions in the computer manufacturing sector following Taiwan's 1999 earthquake. The results demonstrated significant negative spillover effects on stock valuations throughout the technology sector, providing empirical evidence of cross-industry contagion.

Building on this research trajectory, Abe and Ye (2013) conducted a comprehensive assessment of global supply chain disruptions resulting from Japan's 2011 earthquake and Thailand's concurrent floods. Their analysis revealed substantial economic vulnerability in affected regions, with statistically significant negative impacts on both focal firms and their extended supply networks. Jacobs and Singhal's (2017) event study of the Bangladesh factory collapse yielded nuanced findings: while long-term financial market impacts were limited, the supply chain actors faced severe reputational damage due to perceived accountability for the disaster. Their research particularly highlighted systemic governance failures in supply chain oversight, including inadequate monitoring of working conditions by both upstream and downstream partners.

The empirical evidence demonstrating interconnections among supply chain firms suggests a plausible contagion effect on asset valuations when network participants become implicated in corruption scandals. We hypothesize that such events would generate negative abnormal returns across affected supply chain entities. La Londe and Masters' (1994) foundational work elucidates the significant investments firms make to establish high-trust commercial relationships. These relationships typically involve (i) Formal contractual agréments; (ii) Operational information sharing protocols; and (iii) Cost-reduction partnerships between focal firms and their network partners. However, the study also reveals the fragility of these arrangements - once trust is compromised, the resulting reputational damage can trigger a cascade effect throughout the entire supply network. This theoretical framework provides critical context for understanding how corruption-related shocks might propagate through interconnected business relationships.

This propagation of stock price impacts is formally termed *financial contagion*. Forbes and Rigobon (2001, 2002) establish that economic turbulence in one nation can transmit to others, demonstrating that contagion fundamentally arises from statistically significant cross-market correlations during crisis periods. Lee et al. (2007) provide a comprehensive typology of contagion effects, which may manifest as either: i) positive spillovers (beneficial transmission); or negative spillovers (adverse transmission). These effects originate either from: i) Common shocks affecting multiple markets simultaneously, or ii) Endogenous structural changes during periods of market volatility. Collins and Biekpe (2003) and Dornbusch et al. (2000) further identify investor behavior during crises as a critical contagion vector. Their research reveals that herding behavior amplifies cross-market transmission, market interconnectedness serves as the transmission channel localized shocks can generate disproportionate global impacts.

While Calvo and Reinhart (1996) demonstrated regional investor herding effects during the 1994 Mexican crisis - where market participants exhibited coordinated responses to shared economic shocks without global propagation - and while subsequent studies by Baig and Goldfajn (1999), Frankel and Schmukler (1996), and Valdés (2000) corroborated these findings through analysis of mutual fund flows, credit ratings, and volatility transmission in regional markets, contrasting evidence from Forbes and Rigobon (2002) established three notable exceptions where contagion effects were statistically insignificant: the 1987 U.S. market crash, the 1994 Mexican crisis itself, and the 1997 Asian financial crisis, with Lee et al. (2007) further qualifying these boundaries by showing that even geoeconomic shocks like the Southeast Asian tsunami generated only limited, sector-specific contagion (restricted to currency markets) rather than broader financial market transmission, suggesting that both the magnitude and channels of financial contagion are fundamentally contingent on the nature of the originating shock, the degree of regional financial integration, and the vulnerability of particular market segments to coordinated investor behavior.

The 2008 financial crisis triggered significant contagion effects across emerging markets, as Ghorbel and Boujelbene (2013), Luchtenberg and Vu (2015), and Mezghani and Boujelbène (2018) demonstrated through empirical evidence of spillovers in both Gulf Cooperation Council (GCC) markets and BRIC nations (Brazil, Russia, India, and China), while Bello et al.'s (2022) comprehensive analysis of multiple crises (2008 financial crisis, European debt crisis [EDC], Brexit, and COVID-19 pandemic) revealed distinct contagion patterns across individual African markets, with each crisis differentially affecting specific country groupings and thereby confirming the heterogeneous nature of financial contagion; similarly, Ferreira and Mattos (2024) identified clear financial contagion in Brazil's stock market specifically stemming from the 2008 crisis, whereas Kang et al. (2023) examined a different contagion vector by analyzing industry spillover effects from financial reporting

fraud and found that investor negative reactions were mitigated when competitor firms possessed specific competitive attributes, as market participants anticipated these firms would capitalize on emerging opportunities to strengthen their market position.

In the case of Petrobras, due to its influence on the national economy and its interaction with transnational companies, as well as the magnitude of the corruption scandal and the extensive media coverage it received, there is concern that these effects may have extended beyond the Brazilian economy.

Previous studies have examined Operation Car Wash in different contexts. Notably, Peixe et al. (2023) analyzed the impact of Operation Car Wash on the financial performance of publicly traded companies in Brazil through an event study covering the period from January 2014 to May 2017. Their findings showed that companies experienced negative effects on their returns, suggesting that the crisis triggered by the magnitude of the scandal may have contributed to these outcomes. This conjecture is grounded in Fama (1970), who proposed the Efficient Market Hypothesis (EMH), which asserts that market prices adjust as information is disclosed and outlines how investors react to unexpected events. Arguing that corruption can produce undesirable effects on a global economy, Operation Car Wash—given its scale—may have triggered a contagion effect across different markets, both domestic and international.

3 METHODS

This research adopts a quantitative approach, relying on numerical data and statistical methods. Furthermore, it is empirical in nature, as it is based on the analysis of real-world data such as stock prices extracted from the Refinitiv Eikon® database.

To achieve the research objective, an initial analysis of companies' cumulative returns was conducted using the sign test, followed by the application of event study methodology.

To assess asset behavior, significant returns of the sample firms were calculated and evaluated, and the Fama and French (1993) three-factor model was applied similarly employed by Demirer and Kutan (2010).

3.1 Event studies

The event study methodology is used to capture the effects of specific events on the stock returns of a company or group of companies (Boehmer et al., 1991). It was first employed in the 1930s and has been progressively refined over time (Campbell et al., 1997). To operationalize an event study, several steps are required, which Campbell et al. (1997) describe as: (i) event definition; (ii) sample selection criteria; (iii) evaluation of normal and abnormal returns; (iv) estimation; (v) testing to determine whether returns are abnormal; (vi) presentation of results; and (vii) interpretation and conclusion of findings.

Although the literature extensively examines results through event studies, some analytical limitations may arise, requiring additional analyses to address them. Peixe et al. (2023), while demonstrating negative results in their approach, conducted an event study covering the period of Operation Car Wash (Lava-Jato). However, extended time frames may distort findings, as multiple events with varying financial effects occurred throughout the period.

Kang et al. (2023) employed event study methodology to analyze industry contagion effects stemming from financial reporting fraud. Among the study's limitations, the authors noted their use of a short event window to avoid confounding events, consequently excluding long-term implications for competing firms. Furthermore, when conducting an event study, it is essential to control for external organizational factors that may be linked to economic conditions.

Despite the limitations imposed by the literature, the study of events allows for the immediate capture of investor behavior in the stock market, as information is disclosed or reported, and "has been a major focus of previous research because it provides a powerful setting for examining the informativeness of an event as assessed by market participants" (Konchitchki & O'Leary, p. 99, 2011).

3.1.1 Event definition and estimations

The study comprises the analysis of two events that form the estimation window, event window, and post-event window. The event window was set at 5 days before and 5 days after the event date [−5; 0; +5], totaling 11 days. The baseline date (day zero) for each event was defined as follows:

- First event: September 29, 2014 – News coverage of Alberto Youssef's full confession regarding the scheme and those involved.
- Second event: December 15, 2014 – Criminal charges filed against nine executives accused of participating in the corruption scheme.

The event selection criteria were based on each news item's media impact. The first event was chosen because it signaled potential revelations about new companies and politicians involved in the operation. The second event highlighted the scandal's scale by implicating nine executives - a development likely to concern investors, particularly risk-averse ones.

The estimation window, defined as the period of trading days preceding the event window, comprises 250 trading days prior to the event window. For both events, the starting date of the estimation window for calculating abnormal returns was set as September 16, 2013. Following Mackinlay's (1997) recommendation, a 15-day buffer period was maintained between the estimation window and event window to prevent parameter contamination in the

estimation of α and β. To examine the propagation of effects on company stocks, a 30-trading-day post-event window was established following day zero of the event window. This allowed analysis of whether the sample assets exhibited continued repercussions from the events.

According to Campbell et al. (1997), financial asset prices rapidly adjust to new information, enabling the measurement of such information's effects within a short timeframe. Operation Car Wash (Lava-Jato), by involving multiple significant events, triggered numerous market reactions. This research focuses on two specific events deemed to have the strongest impact on company returns. The selection of a 30-day window serves to: (1) capture the effects of the main events, while (2) minimizing interference from confounding events that could distort abnormal return analysis.

3.1.2 Sample

The sample consists of 60 assets comprising the S&P 500, including the most liquid Petrobras assets (the core company of the sample), all collected from the Refinitiv Eikon® database. The sample is divided into three research groups: (1) Petrobras assets traded in Brazil, the United States, the United Kingdom, and Germany; (2) assets of its direct customers (19 companies); and (3) assets of its direct suppliers (37 companies).

The sample of Petrobras' direct supply chain (customers and suppliers) consists of publicly listed companies classified as "public" in the Refinitiv Eikon® database, representing publicly traded firms listed on stock exchanges. Some companies were excluded from the sample due to unavailable trading data during the analysis period.

3.1.3 Accumulated returns

First, the calculation of abnormal returns (AR) was performed for each asset individually within the event window using Equation (1), where is the asset's daily return rate, α and β are estimated by running the market model regression over the estimation window, and is the market's daily return rate. The Fama and French (1993) model (Equation 2) was used, which proposes three factors: size (SMB); book-to-market ratio (HML); and the market portfolio risk premium (Mkt-RF) to measure normal performance and obtain a second estimate of abnormal returns (Demirer & Kutan, 2010; Fama & French, 1993).

$$AR_{it} = R_{it} - (\alpha_i + \beta_i R_{Mt}) \quad (1)$$

$$R_{ct} = b_{0c} + b_{1c}(R_{mt} - R_{ft}) + b_{2c}SMB_t + b_{3c}HML_t + e_{ct} \quad (2)$$

where ε represents the residual; α the regression intercept; β_1, β_2, and β_3 represent the factor regression coefficients; R_{it} the total return of a stock or portfolio i at time t; Rf_t the risk-free rate of return at time t; and R_{mt} the total return of the market portfolio at time t.

Next, the cumulative abnormal returns (CAR) were calculated using Equation (3). Then, in a third stage, the cumulative average abnormal returns (CAAR) were derived through Equation (4) for the specified period, using the mean CAR values from all companies comprising each study group.

$$CAR_{t1,t2} = \sum_{t=t1}^{t2} AR_i \quad (3)$$

$$CAAR_{t1,t2} = \frac{1}{n}\sum_{t=t1}^{t2} CAR_i \quad (4)$$

Thus, the results are obtained to analyze market movements and verify statistical significance at the 1%, 5%, and 10% levels, represented by ***, **, and *, respectively (Benninga & Czaczkes, 2014). The Boehmer, Musumeci, and Poulsen test with the Kolari and

Pynnonen adjustment was used for statistical significance. This procedure enhanced the robustness of the results, as it provides greater estimation accuracy when issues with random returns arise in the event window (Kolari & Pynnonen, 2011).

4 DATA ANALYSIS

The initial analysis of the event study addresses the CAR (Cumulative Abnormal Return) of the companies, divided into separate blocks for customers and suppliers, followed by descriptive analysis and sign tests of the sample. Subsequently, it delves deeper into the analysis of the CAAR (Cumulative Average Abnormal Return) for all firms in the customer and supplier groups across different event windows.

4.1 Event study

This section discusses the results generated by the abnormal return calculations. Initially, the AR (Abnormal Return) values were computed to measure normal and abnormal performance, followed by the calculation of CAR (Cumulative Abnormal Return) and CAAR (Cumulative Average Abnormal Return). Both metrics aim to produce results for analyzing market movements (Benninga & Czaczkes, 2014; Demirer & Kutan, 2010; Fama & French, 1993).

4.1.1 Cumulative abnormal returns

In the first event, the CAR (Cumulative Abnormal Return) was identified for Petrobras' most liquid assets, as described in Table 1.

Table 1

Evento 1: CAR Petrobrás

Securities	Event window					
	[-5,0]	**[-5,1]**	**[-5,2]**	**[-5,3]**	**[-5,4]**	**[-5,5]**
Petrobrás-Brasil	-10.53%*	-13.20%**	-18.35%**	-17.12%**	-11.68%	-1.22%
Petrobrás-EUA	-10.05%*	-13.33%**	-18.60%***	-17.66%**	-14.21%*	-2.01%
Petrobrás-Reino Unido	-10.05%*	-13.33%**	-18.60%***	-17.66%**	-14.21%*	-2.01%
Petrobrás-Alemanha	-10.34%	-13.06%*	-19.44%***	-20.76%***	-21.60%***	-2.27%

Notes. The one-tailed statistical significance is denoted by *** p-value < 0.01; ** p-value < 0.05; and * p-value < 0.10 for each individual firm. The event window corresponds to the period highlighted in each column, ranging from [-5,0] (representing 5 days before the event date up to day 0) to [-5,5] (5 days before up to 5 days after the event date).

Table 1 shows that Petrobras' assets experienced significant negative abnormal returns due to Event 1. Since the literature suggests an interrelationship with the supply chain, we examined whether this movement in Petrobras' assets affected its supply chain (Abe & Ye, 2013; Hendricks & Singhal, 2003, 2005; Nunes, 2017; Papadakis, 2006). Accordingly, Table 2 presents the CAR for customers, while Table 3 shows the CAR for suppliers, followed by the sign test.

Analysis of Table 2 reveals that some companies showed changes in their CAR results. Brookfield exhibited a significant negative trend at the 95% confidence level around the event period. However, no clear connection was established between this result and the analyzed event. The abnormal returns can instead be explained by the U.S. infrastructure crisis that led to bankruptcies among highway concession groups - in which Brookfield participated as an investor during the same period as the Lava-Jato scandal reports (Wright, 2014). Therefore, we cannot conclude that the company was affected by the Petrobras event.

Still considering Table 2, Teekay company shows strong positive results with 1% significance one day after the event. However, the available information does not demonstrate these results are related to the Petrobras event. The sign test reveals a prevailing negative trend, with negative returns representing 70% to 80% across all return windows, showing significance at both 1% and 5% levels.

Table 2

Event 1: CAR and signal test (clients)

Clients	Event window					
	[-5,0]	**[-5,1]**	**[-5,2]**	**[-5,3]**	**[-5,4]**	**[-5,5]**
Braskem	0,0253	0,0255	0,0507	0,0691	0,0607	0,0732
Ultrapetrol-Bahamas	0,0125	0,0269	0,0295	0,0459	0,0366	0,0507
Seadrill	-0,0418	-0,0479	-0,0504	-0,1013**	-0,1143**	-0,1030**
Centrais Elétricas Brasileiras	-0,0746	-0,084	-0,1109*	-0,1175*	-0,1160*	-0,0566
Brookfield Asset	-0,0387**	-0,0488**	-0,0455**	-0,0484**	-0,0514**	-0,0471*
BW Offshore	0,0702*	0,0919**	0,065	0,0258	0,043	0,0411
Helix Energy Solutions	-0,0425	-0,066*	-0,0694*	-0,0722*	-0,0855*	-0,0654
Ultrapar Participacoes	-0,0316	-0,0347	-0,0597*	-0,0675*	-0,0556	0,0004
Teekay	-0,0151	0,1189***	0,108***	0,1301***	0,1272***	0,1196***
China Petroleum	-0,0287	-0,0328	-0,0305	-0,0295	-0,0343	-0,0359
Repasl	-0,019	-0,0081	-0,0022	-0,0272	-0,0328	-0,0304
Bristow	-0,0176	-0,03	-0,0318	-0,0221	-0,015	-0,0032
HP	-0,0399	-0,0245	-0,0408	-0,0431	-0,0334	0,0123
Naturgy Energy	-0,0125	-0,0077	-0,0025	-0,0243	-0,0444	-0,0349
Reliance Industries	-0,0594*	-0,0406	-0,0598	-0,0657	-0,0637	-0,0606
Tetra Technologies	0,023	0,0061	-0,0009	-0,0225	-0,0392	-0,0345
Toyota Motor	-0,002	-0,0083	-0,0001	-0,0324	-0,0335	-0,0199
Tullow Oil	0,0012	-0,0151	-0,0265	-0,0577	-0,0794	-0,0646
Santos	-0,0489*	-0,0509*	-0,0526*	-0,0618*	-0,0615*	-0,0711*
Positive signs	5	5	4	4	4	6
Negativo signs	14	14	15	15	15	13
Mean	9,5000	9,5000	9,5000	9,5000	9,5000	9,5000
Standard deviation	2,1794	2,1794	2,1794	2,1794	2,1794	2,1794
Statistics (Z-Score)	-2,0647	-2,0647	-2,5236	-2,5236	-2,5236	-1,6059
p-value	0,0195	0,0195	0,0058	0,0058	0,0058	0,0541

Notes. One-tailed statistical significance is indicated by: *** p-value < 0.01; ** p-value < 0.05; and * p-value < 0.10 for each individual firm. The event window represents the period shown in each column, ranging from [-5,0] (five days before to the event date) to [-5,5] (five days before to five days after the event date).

Table 3 presents the CAR (Cumulative Abnormal Return) of Petrobras' supply chain suppliers.

Analysis of Table 3 reveals that suppliers showed greater variation in cumulative returns compared to Petrobras' supply chain customers. Several companies exhibited significant negative cumulative returns around the event period, particularly: Woodside, Comgas, Paragon Shipping, AP Moeller, Albemarle, BHP, and Daewoo Shipbuilding. Through the sign test, a strong tendency for negative returns among the sample companies is observed, with 95% confidence one day after the event and 99% confidence from two days after the event until the end of the event window.

Table 3

Event 1: CAR and signal test (Suppliers)

Suppliers	**Event window**					
	[-5,0]	**[-5,1]**	**[-5,2]**	**[-5,3]**	**[-5,4]**	**[-5,5]**
Dof	-0,0193	-0,044	-0,0318	-0,0631	-0,0442	-0,0694
SBM Offshore	0,0492	0,0569	0,0279	-0,004	0,0028	0,0238
Subsea 7	-0,0082	0,0217	-0,0195	-0,0321	-0,0463	-0,0546
Vallourec	-0,0132	-0,0005	-0,0175	-0,0421	-0,0418	-0,0478
Modec	0,0087	-0,0159	-0,0286	-0,0648	-0,0615	-0,037
Sapura Energy Bhd	-0,0117	-0,0213	-0,0149	-0,0409	-0,0334	-0,0356
Keppel Corporation	-0,0009	-0,0047	-0,0099	-0,0076	-0,0133	-0,0139
Vale	-0,0648	-0,0493	-0,0502	-0,0246	-0,0379	-0,0116
Chevron	-0,0167	-0,0279	-0,0301	-0,0301	-0,0357*	-0,034
BP PLC	-0,0323	-0,0389*	-0,0355	-0,063**	-0,057**	-0,0547*
Dril-Quip	0,043	0,0315	0,0146	0,0231	0,0168	0,0256
Equinor	-0,0391	-0,0378	-0,0414	-0,0682**	-0,0825**	-0,092***
Saipem	-0,0053	0,023	-0,011	-0,048	-0,0417	-0,0447
Prysmian	-0,0226	0,0021	-0,007	-0,0339	-0,0229	-0,033
Solstad Offshore	-0,0478	-0,0474	-0,0675*	-0,1194***	-0,1269***	-0,126***
Transocean	-0,0128	-0,0272	-0,0471	-0,0287	-0,0777*	-0,0502
Lupatech	-0,1078	-0,0353	-0,720***	-1,0601***	-0,8919***	-1,069***
Sembcorp Marine	0,0052	0,0007	-0,0115	-0,0366*	-0,0379	-0,038
Woodside Petroleum	-0,0377*	-0,0373*	-0,0346	-0,0426*	-0,0381	-0,0377
Cia de Gas de SP Comgas	-0,085***	-0,0573*	-0,0571*	-0,0398	-0,0339	-0,0275
Paragon Shipping	-0,1263*	-0,1466*	-0,2093**	-0,2597***	-0,318***	-0,354***
Conocophillips	-0,0144	-0,0302	-0,0381*	-0,0401*	-0,0488**	-0,0462*
General Electric	-0,0073	0,0025	-0,0016	-0,0002	0,0006	-0,0063
Halliburton	0,0177	0,0044	-0,0103	-0,0256	-0,0321	-0,0345
Fugro	-0,0086	0,0366	0,0095	-0,0439	-0,0249	-0,0126
Schlumberger	0,0257	0,012	-0,0032	-0,0117	-0,0206	-0,0144
Electromagnetic Geoservices	0,104*	0,077	0,0562	0,0491	-0,0087	-0,0225
AP Moeller	-0,075**	-0,084***	-0,083**	-0,1094***	-0,0972**	-0,1009**
Albemarle	-0,0500*	-0,0649**	-0,0724**	-0,0552*	-0,0617*	-0,0494
Exxon Mobil	-0,0104	-0,0149	-0,0151	-0,0066	-0,0113	-0,0059
YPF	0,0974	0,1162	0,0224	-0,0573	0,0141	-0,0436
BHP	-0,0583**	-0,0561**	-0,0517*	-0,0607*	-0,0698**	-0,093***
Nippon Yusen	-0,0375	-0,0419	-0,0468	-0,0666	-0,0725	-0,0661
Daewoo Shipbuilding	-0,1342**	-0,1165*	-0,1569**	-0,196***	-0,1999***	-0,1882**
Mitsubishi	0,0006	-0,0318	-0,0387	-0,0679*	-0,0684*	-0,068*
Enauta Participacoes	-0,0084	-0,0192	-0,0479	-0,0432	-0,021	0,0006
Oceaneering International	0,0439	0,0513*	0,055*	0,0457	0,0181	0,0249
Positive signs	10	13	6	3	5	4
Negative signs	27	24	31	34	32	33
Mean	18,5000	18,5000	18,5000	18,5000	18,5000	18,5000
Standard deviation	3,0414	3,0414	3,0414	3,0414	3,0414	3,0414
Statistics (Z-Score)	-2,7948	-1,8084	-4,1100	-5,0964	-4,4388	-4,7676
p-value	0,0026	0,0353	0,0000	0,0000	0,0000	0,0000

Notes. The one-tailed statistical significance is represented by *** p-value<0.01; ** p-value<0.05; and * p-value<0.10 individually by company. The event window represents the period highlighted in each column, ranging from the period [-5,0], which represents 5 days before up to day zero, to the period [-5,5], which represents 5 days before to 5 days after day zero.

Regarding the second event, Petrobrás' cumulative returns showed the results presented in Table 4.

Table 4

Event 2: CAR Petrobrás

Securities	Event Window					
	[-5,0]	**[-5,1]**	**[-5,2]**	**[-5,3]**	**[-5,4]**	**[-5,5]**
Petrobrás-Brasil	-24.86%***	-22.83%***	-21.10%**	-24.17%**	-20.67%**	-15.81%
Petrobrás-EUA	-27.84%***	-27.54%***	-23.01%**	-21.89%**	-19.48%*	-14.85%
Petrobrás-Reino Unido	-27.84%***	-27.54%***	-23.01%**	-21.89%**	-19.48%*	-14.85%
Petrobrás-Alemanha	-27.97%***	-29.38%***	-23.03%**	-22.66%**	-21.37%**	-19.59%*

Notes. One-tailed statistical significance is represented by *** p-value<0.01; ** p-value<0.05; and * p-value<0.10 individually by company. The event window refers to the period highlighted in each column, ranging from [-5,0], which represents 5 days before up to day zero, to [-5,5], which represents 5 days before to 5 days after day zero.

Second event related to Petrobrás (Table 4) presented significant and negative effect on its results, with 1% significance on the event day (day zero) and one day after the event. The cumulative return results for the company's supply chain, followed by the sign test, are presented in Table 5 for customers and Table 6 for suppliers.

The analysis of Table 5 begins with the company Braskem, which showed negative and statistically significant cumulative returns at a confidence level of up to 99% three days after Petrobrás' second event, when charges were filed against nine additional individuals involved in the scheme. Notably, the charges included Alcides Guilherme Barbassa (Chief Financial Officer and Investor Relations Officer) and José Alcides Santoro Martins (Director of Gas and Energy), both members of Braskem's Board of Directors at the time. This had an impact on the company's performance, resulting in negative cumulative returns (Valadares, 2014).

The companies Ultrapetrol-Bahamas, BW, Helix, Teekay, Naturgy, Tetra, Toyota, and Santos showed negative and significant cumulative returns without evidence of information related to random events. This result suggests that the customers involved in Petrobrás' supply chain experienced negative contagion caused by the company's second event.

Table 5

Event 2: CAR and sign test (Clients)

Clients	Event window					
	[-5,0]	**[-5,1]**	**[-5,2]**	**[-5,3]**	**[-5,4]**	**[-5,5]**
Braskem	-0,0988**	-0,0832*	-0,0965**	-0,1272***	-0,117**	-0,0968*
Ultrapetrol-Bahamas	-0,1608***	-0,1621***	-0,1615***	-0,0406	-0,0393	-0,0454
Seadrill	-0,0095	0,0335	0,0572	0,1347**	0,0704	0,0627
Centrais Elétricas Brasileiras	0,0053	-0,0359	0,0239	0,0202	0,0632	0,1141
Brookfield Asset	-0,0178	-0,013	-0,0145	-0,0124	-0,0178	-0,019
BW Offshore	-0,0895**	-0,0796*	-0,03	-0,0068	0,0072	-0,0069
Helix Energy Solutions	-0,0849**	-0,094**	-0,0984**	-0,1114***	-0,0736*	-0,1166**
Ultrapar Participacoes	-0,0122	-0,0129	0,0128	-0,0124	-0,0101	0,0129
Teekay	-0,0826**	-0,0781*	-0,0176	0,0007	0,0092	0,0141
China Petroleum	-0,1292***	-0,1019***	-0,0882**	-0,0979**	-0,0594	-0,0402
Repasl	-0,112***	-0,1045***	-0,1138***	-0,1133***	-0,1168***	-0,1179***
Bristow	-0,0074	-0,0156	-0,0047	-0,0118	0,0191	-0,0038
HP	-0,0081	-0,0099	0,0017	0,006	0,0019	-0,005
Naturgy Energy	-0,0952***	-0,0779***	-0,0743**	-0,0755**	-0,0755**	-0,0808**
Reliance Industries	-0,0832**	-0,1014***	-0,1031**	-0,0925**	-0,0702	-0,0673
Tetra Technologies	-0,0474	0,0323	0,1332***	0,112**	0,1993***	0,1521**
Toyota Motor	-0,0603*	-0,0726**	-0,0806**	-0,0665*	-0,0245	-0,028
Tullow Oil	-0,043	0,0287	0,0558	0,0422	0,1065*	0,0669
Santos	-0,1115***	-0,1344***	-0,0925***	-0,045	-0,0404	0,0222
Positive signs	1	3	6	6	8	7
Negative signs	18	16	13	13	11	12
Mean	9,5000	9,5000	9,5000	9,5000	9,5000	9,5000
Standard deviation	2,1794	2,1794	2,1794	2,1794	2,1794	2,1794
Statistics (Z-Score)	-3,9001	-2,9824	-1,6059	-1,6059	-0,6882	-1,1471
p-value	0,0000	0,0014	0,0541	0,0541	0,2456	0,1257

Notes. One-tailed statistical significance is represented by *** p-value<0.01; ** p-value<0.05; and * p-value<0.10 individually for each company. The event window refers to the period highlighted in each column, ranging from [-5,0], which represents 5 days before up to day zero, to [-5,5], which represents 5 days before to 5 days after day zero.

Repsol showed negative cumulative returns with 1% significance, a result stemming from financing for production expansion, which led to the acquisition of Talisman Energy after a period of contraction (Buck, 2014). Reliance Industries had negative and significant cumulative returns during the period; however, according to disclosed information, the company was facing transparency issues in its payments, suggesting that the effect may have been caused by this factor (Crabtree, 2014). The sign test indicated a stronger tendency toward negative returns, with 99% confidence, in the cumulative return on the event day (day zero) and one day after the event.

Table 6 presents the suppliers in Petrobrás' supply chain related to the second event.

Table 6

Event 2: CAR and sign tests (Suppliers)

Suppliers	**Event Window**					
	[-5,0]	**[-5,1]**	**[-5,2]**	**[-5,3]**	**[-5,4]**	**[-5,5]**
Dof	-0,2069***	-0,2319***	-0,1937***	-0,1418***	-0,1004**	-0,0747
SBM Offshore	-0,0942	-0,0558	-0,0579	-0,0252	-0,0295	-0,0405
Subsea 7	0,0108	0,0403	0,118**	0,1803***	0,1711***	0,158***
Vallourec	-0,1169***	-0,0899**	-0,091*	-0,0833	-0,1001*	-0,1025*
Modec	-0,1088**	-0,1511***	-0,1355**	-0,103*	-0,1085*	-0,074
Sapura Energy Bhd	-0,1402***	-0,1335***	-0,0764*	-0,0767*	-0,0771*	-0,0097
Keppel Corporation	-0,0173	-0,0141	0,0145	0,0341	0,0528**	0,0834***
Vale	-0,1502***	-0,1247**	-0,1088**	-0,0699	-0,0051	-0,0107
Chevron	-0,0449**	-0,0295	-0,005	-0,0001	0,0301	0,0204
BP PLC	-0,0973***	-0,0653**	-0,0394	-0,0397	-0,0169	-0,0157
Dril-Quip	-0,0359	-0,0264	-0,0084	-0,0186	0,0186	0,0017
Equinor	-0,0403	-0,0263	0,0065	0,0423	0,035	0,0435
Saipem	-0,0885*	-0,0323	-0,0357	-0,0593	-0,0167	-0,0305
Prysmian	-0,0114	0,0386	0,0082	0,0016	0,0009	0,025
Solstad Offshore	-0,0372	-0,0499	-0,0491	0,0218	0,034	0,0722
Transocean	-0,0792**	-0,0504	0,0079	-0,0003	0,0726	0,0537
Lupatech	-0,213	-0,0335	-0,0381	-0,0623	-0,0597	-0,2098
Sembcorp Marine	-0,0123	-0,0028	0,085***	0,0673***	0,089***	0,1301***
Woodside Petroleum	-0,0134	-0,0396*	-0,0084	0,0235	0,0557**	0,0801***
Cia de Gas de SP Comgas	-0,0058	-0,0088	-0,0233	-0,025	-0,0215	-0,0364
Paragon Shipping	-0,0639	-0,0655	-0,1043	-0,1076	0,0139	0,0158
Conocophillips	-0,0435**	-0,0108	0,0271	0,042*	0,0538**	0,0306
General Electric	-0,0076	-0,0029	-0,0149	-0,0199	-0,0056	-0,0044
Halliburton	0,0126	0,0322	0,0353	-0,0082	0,0157	-0,0085
Fugro	-0,0594	-0,0298	-0,0352	-0,032	-0,021	-0,0488
Schlumberger	-0,0315	-0,022	-0,0118	-0,0225	0,0092	-0,0026
Electromagnetic Geoservices	-0,0844	-0,0636	-0,0651	0,1237	0,0804	0,069
AP Moeller	-0,0325	-0,036	-0,014	0,0133	0,0161	0,0266
Albemarle	-0,0784***	-0,0643**	-0,0475*	-0,0462	-0,0531*	-0,0344
Exxon Mobil	-0,0293*	-0,0277	-0,0148	-0,0135	0,0087	0,0036
YPF	-0,2726***	-0,2162***	-0,1815**	-0,2483***	-0,2617***	-0,2293**
BHP	-0,0756***	-0,1066***	-0,0993***	-0,0775**	-0,0429	-0,0127
Nippon Yusen	-0,0395	-0,0589	-0,0537	-0,0288	-0,0019	0,0081
Daewoo Shipbuilding	0,0001	-0,0124	-0,0019	-0,0134	0,0132	0,0172
Mitsubishi	-0,0598*	-0,0909***	-0,096**	-0,0945**	-0,0488	-0,0332
Enauta Participacoes	-0,1585***	-0,1769***	-0,1478***	-0,1657***	-0,1643***	-0,1644***
Oceaneering International	-0,0811***	-0,065**	-0,0849**	-0,1027***	-0,1012***	-0,105***
Positive signs	3	3	8	10	18	17
Negative signs	34	34	29	27	19	20
Mean	18,5000	18,5000	18,5000	18,5000	18,5000	18,5000
Standard deviation	3,0414	3,0414	3,0414	3,0414	3,0414	3,0414
Statistics (Z-Score)	-5,0964	-5,0964	-3,4524	-2,7948	-0,1644	-0,4932
p-value	0,0000	0,0000	0,0003	0,0026	0,4347	0,3109

Notes. One-tailed statistical significance is represented by *** p-value<0.01; ** p-value<0.05; and * p-value<0.10 individually for each company. The event window corresponds to the period highlighted in each column, ranging from [-5,0], which represents 5 days before up to day zero, to [-5,5], which represents 5 days before to 5 days after day zero.

An analysis of Table 6 reveals large negative variations among the assets. In the search for information, with the exception of Subsea 7 — which underwent financial restructuring, justifying its negative and significant cumulative returns (Skarsaune, 2014) — no events were identified involving the other companies with negative returns. The sign test showed that the cumulative return up to three days after the event presented a large number of negative returns, with 1% significance.

4.1.2 Cummulated average abnormal return (CAAR)

The CAAR was calculated by averaging all the companies that make up each group in the sample, that is, Petrobrás' assets and those of the supply chain (customers and suppliers). The CAAR for Petrobrás' assets is presented in Table 7.

Table 7

CAAR Petrobrás

Panel A	**Event window**					
	CAAR [-5,0]	**CAAR [-5,1]**	**CAAR [-5,2]**	**CAAR [-5,3]**	**CAAR [-5,4]**	**CAAR [-5,5]**
Event 1	-10.10%***	-13.09%***	-18.60%***	-18.15%***	-15.25%**	-1.64%**
Event 2	-27.05%***	-26.74%***	-22.44%***	-22.54%***	-20.13%***	-16.15%***
Panel B	**Event window**					
	CAAR[-5,0]	**CAAR[-5,10]**	**CAAR[-5,15]**	**CAAR[-5,20]**	**CAAR[-5,25]**	**CAAR[-5,30]**
Event 1	-10.10%***	9.61%	-10.87%***	-36.52%***	-35.73%***	-43.65%***
Event 2	-27.05%***	-17.65%***	-30.84%***	-20.98%***	-12.99%	-8.42%

Notes. Statistical significance is represented by *** p-value<0.01; ** p-value<0.05; and * p-value<0.10 individually for each company. The Boehmer, Musumeci, and Poulsen test was used, with the Kolari and Pynnonen adjustment for statistical significance. The event window refers to the period highlighted in each column, ranging from [-5,0], which represents 5 days before up to day zero, to [-5,5], which represents 5 days before to 5 days after day zero in Panel A, and in Panel B, [-5,30], where the final period extends to 30 days.

Table 7 presents the CAAR results related to the two events for Petrobrás, estimating the event window in Panel A and including the post-event window in Panel B. The results in Panel A show that both events had an impact on the company's returns, generating negative and statistically significant abnormal returns at the 1% level throughout most of the event window. The analysis in Panel B shows that the effects of the events gradually dissipated over the post-event window. Twenty days after day zero, returns began to stabilize, resulting in a

progressive reduction in the difference between the percentages. In the case of Event 2, this dissipation led to a loss of statistical significance in returns after 25 days. However, for Event 1, despite the reduction in differences over time, returns remained statistically significant until the end of the analysis window. Table 8 presents the CAAR for the company's supply chain.

Table 8

CAAR Supply chain

Event 1						
Panel A	**Event window**					
	[-5,0]	**[-5,1]**	**[-5,2]**	**[-5,3]**	**[-5,4]**	**[-5,5]**
CAAR-Clients	-1,80%*	-1,17%	-1,70%	-2,70%**	-3,07%**	-1,68%
CAAR-Suppliers	-1,74%**	-1,11%	-1,63%	-2,62%	-2,98%	-1,58%
Panel B	**Event window**					
	[-5,0]	**[-5,10]**	**[-5,15]**	**[-5,20]**	**[-5,25]**	**[-5,30]**
CAAR-Clients	-1,74%**	-3,81%**	-4,10%**	-5,45%**	-3,71%	-4,43%
CAAR-Suppliers	-1,70%	-9,29%***	-10,44%***	-11,63%***	-12,54%***	-10,41%***
Event 2						
	Event window					
Panel A	**[-5,0]**	**[-5,1]**	**[-5,2]**	**[-5,3]**	**[-5,4]**	**[-5,5]**
CAAR-Clients	-6,36%***	-5,45%***	-3,34%*	-2,26%	-0,47%	-0,51%
CAAR-Suppliers	-6,82%***	-5,39%***	-3,83%*	-2,65%	-0,80%	-0,59%
	Event window					
Panel B	**[-5,0]**	**[-5,10]**	**[-5,15]**	**[-5,20]**	**[-5,25]**	**[-5,30]**
CAAR-Clients	-6,36%***	0,19%	-1,15%	-3,78%	-3,78%	-2,84%
CAAR-Suppliers	-6,82%***	0,79%	0,03%	-2,82%	-1,03%	0,54%

Notes. One-tailed statistical significance is represented by *** p-value<0.01; ** p-value<0.05; and * p-value<0.10 individually for each company. The event window refers to the period highlighted in each column, ranging from [-5,0], which represents 5 days before up to day zero, to [-5,5], which represents 5 days before to 5 days after day zero in Panel A, and in Panel B, [-5,30], where the final period extends to 30 days.

Analyzing the CAAR in Table 8, it is observed that in the first event, the effect on the assets did not show major variations during the event window. However, a negative average cumulative return with high significance occurred in the post-event period, with 99% confidence for suppliers and 95% confidence for customers. The results dissipated among customers, suggesting that suppliers absorbed market information more intensely, partially aligning with the findings of Nunes (2017).

Regarding the second event, similar effects are observed for both customers and suppliers during the event window, with 1% significance only up to one day after the event.

However, this result dissipated in the post-event period, showing cumulative returns without statistical significance.

5 DISCUSSIONS

The analysis revealed significant results regarding the impacts of Petrobras' corruption events on the supply chain. In the first event, a significant decline in the CAR (Cumulative Abnormal Returns) of Petrobras' assets was observed. When examining the supply chain clients in Table 2, it becomes apparent that several companies exhibited negative returns, suggesting possible financial contagion. However, the company Brookfield, despite its highly significant negative returns, showed no direct connection to the Petrobras scandal, given that it was part of a group of U.S. highway concessionaires undergoing financial crises at the time. Nevertheless, the need for more detailed analyses is emphasized.

The analysis of suppliers (Table 3) revealed greater variation in cumulative returns compared to clients. Some companies exhibited significant negative results, such as Woodside Petroleum and Comgas. These findings suggest the presence of financial contagion among suppliers.

The second event also resulted in significant declines in Petrobras' CAR, as evidenced in Table 4. The analysis of clients (Table 5) revealed that companies such as Braskem and Ultrapetrol-Bahamas also experienced negative returns, suggesting financial contagion stemming from the event. Negative signals predominated, indicating a trend of negative contagion among clients following the second event.

Regarding suppliers in this event, the results (Table 6)—such as those for Dof—suggest that these companies were strongly impacted, reinforcing the hypothesis of financial contagion within the supply chain. The analysis of the signals confirms the trend toward negative returns, highlighting the extent of the adverse effects on suppliers.

The results from CAAR (Table 7) corroborate the CAR results observed up to 5 days after the event in both cases. For Event 1, despite a reduction in the CAAR percentage gap 20 days post-event, substantial CAAR fluctuations persisted, maintaining *significant negative abnormal returns* throughout the entire analysis period. In contrast, Event 2 showed statistically significant effects until day 20, after which its significance dissipated.

Similarly, when analyzing the supply chain (Table 8) during Event 1's timeline, we observe significant negative CAAR variations exclusively among suppliers throughout the entire 30-day post-event period - a finding consistent with Nunes (2017). However, Event 2's results show an immediate dissipation of abnormal returns after the event, yielding statistically insignificant outcomes in the analysis.

Thus, corruption is presumed to drive severe consequences for the economy by undermining investor confidence, destabilizing financial markets, and impairing long-term economic growth. Furthermore, corruption scandals may increase asset volatility, raise firms' cost of capital, and damage the business environment, ultimately leading to adverse effects on resource allocation and market efficiency. In this context, this study aligns with prior research by Baig and Goldfajn (1999), Bello et al. (2022), Calvo and Reinhart (1996), Ferreira and Mattos (2024), Frankel and Schmukler (1996), Ghorbel and Boujelbene (2013), Kang et al. (2023), Luchtenberg and Vu (2015), Mezghani and Boujelbène (2018), Peixe et al. (2023), Valdés (2000), and Wang et al. (2024), which has demonstrated the presence of contagion effects in financial market-related events.

As argued in the literature (Bayley, 1966; Bolgorian, 2011; Lakshmi et al., 2021; Leff, 1964; Peixe et al., 2023; Shleifer & Vishny, 1993; Wang et al., 2024), society's understanding of corruption can trigger actions that challenge socially acceptable practices regarding this issue. This clarification could foster growth and development in emerging countries, while developed nations may experience lesser social effects, as the presence of regulatory agencies

can mitigate negative social impacts. Consequently, as new events become circumscribed, the stock market tends to absorb such information and adjust its resource allocation behavior more conservatively. This movement is explained by the Efficient Market Hypothesis (EMH) in its semi-strong form.

6 CONCLUDING REMARKS

The finding that supply chains can be affected by corruption involvement among their members is significant, as it reinforces the need for proper compliance structures and corporate governance to minimize misconduct risks. This is particularly crucial since both legal consequences and negative financial effects may result from corruption-aligned practices. From a managerial perspective, monitoring supply chain participants' conduct represents this study's key contribution to executives. Organizations may see their assets impacted by partners' external actions. Thus, supplier selection processes, client interactions, and reputational risk monitoring constitute essential elements for managerial consideration.

The study's limitations stem from the unavailability of financial data from privately-held companies in the supply chain, which were excluded from the sample. While this did not distort the research results, it reduced the sample size. Additionally, an event of the magnitude of Operation Car Wash (Lava-Jato) may contain confounding events and external factors related to either the economy or the supply chain – elements that could influence the results. Nevertheless, despite their scope, these factors were addressed during the results analysis.

This study examined the direct supply chain of Petrobras, as a future path suggests expansion of the sample from the direct to the extended supply chain, including customers of customers and suppliers of suppliers. It is also suggested that an analysis be carried out by countries, allowing the visualization of a possible contagion effect according to economic

capacity and assessing whether companies from emerging countries are more vulnerable to financial contagion.

The identification of contagion effects with a negative trend among assets comprising Petrobras' direct supply chain—including both clients and suppliers—highlights the need to scrutinize actions and organizational structures within the company's network of relationships. This study's findings, which analyzed data from a government-influenced multinational corporation in an emerging market, provide compelling evidence of corruption's adverse effects. By temporally mapping stock market reactions to specific events, the research contributes to the literature on financial contagion.

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Corrupção Petrobrás: Efeito Contágio sobre sua Cadeia de Suprimentos

RESUMO

Objetivo*: analisar o efeito contágio nos ativos das empresas da cadeia de suprimentos da Petrobras diante dos escândalos de corrupção abrangidos pela Operação Lava-Jato.*

Método: *foi realizado estudo de eventos com 60 ativos que compõem o S&P500 sendo definidas duas datas para a análise.*

Originalidade/Relevância: *o estudo fornece evidências de que as condutas dos diferentes parceiros da cadeia de suprimentos devem figurar como uma preocupação dos gestores e dos órgãos reguladores, bem como reforça a prerrogativa de que o mercado acionário busca antecipar notícias e, por vezes, realizar movimentos anormais punindo ativos de organizações que se relacionam com empresas supostamente vinculadas a condutas ilícitas.*

Resultados: *os retornos identificados foram anormais negativos e significantes para a cadeia de valor.*

Contribuições Teóricas/Metodológicas*: os efeitos identificados apontam que a corrupção causa oscilações anormais no mercado de ações para aqueles que fornecem suprimentos para empresas envolvidas em escândalos de corrupção.*

Palavras-chave*: Corrupção, Petrobrás, Cadeia de Suprimentos, Retornos Anormais, Efeito Contágio*

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Recebido: Novembro 25, 2023
Revisado: Março 12, 2025
Aceito: Março 13, 2025
Publicado: Março 31, 2025


REVISTA CONTABILIDADE, GESTÃO E GOVERNANÇA
JOURNAL OF ACCOUNTING, MANAGEMENT AND GOVERNANCE