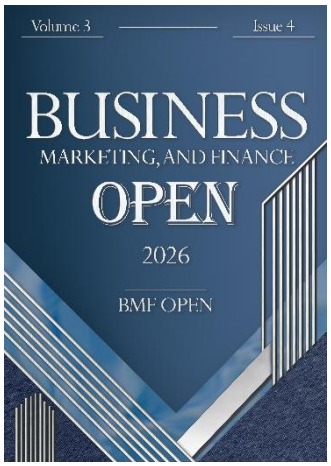
The Effect of Environmental Information Disclosure on Cash Flow Volatility with the Moderating Role of Firm Size and Ownership Structure



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Abstract: The continuation of economic sanctions and persistent financial difficulties for firms in recent years has highlighted the importance of managing cash flow volatility. In this context, based on stakeholder theory and legitimacy theory, the present study examines the effect of environmental information disclosure on cash flow volatility in order to better understand the determinants of reducing such volatility. Furthermore, to investigate heterogeneous effects arising from differences in firm characteristics, the moderating roles of firm size and ownership structure are also emphasized in this study. This research is a descriptive–correlational study conducted using a multivariate regression analysis approach. The screened statistical population consists of 153 companies listed on the Tehran Stock Exchange during the period from 2013 to 2022, yielding a total of 1,530 firm-year observations. The required data were collected from online information sources, including audited financial statements and annual performance reports available on the Codal system. Data analysis and hypothesis testing were performed using econometric techniques and EViews software. The findings indicate that environmental information disclosure leads to a reduction in cash flow volatility; however, this effect does not differ significantly between large and small firms, implying that firm size does not have a significant moderating effect on the relationship between environmental information disclosure and cash flow volatility. Nevertheless, the results reveal that the negative effect of environmental information disclosure on cash flow volatility is weakened in firms with government ownership structures.

Keywords: Environmental Information Disclosure, Cash Flow Volatility, Firm Size, Ownership Structure

1. Introduction

The increasing complexity of business environments in recent decades, coupled with intensified economic uncertainties, has elevated the importance of corporate risk management and financial stability, particularly in relation to cash flow volatility as a critical determinant of firm sustainability and performance. Cash flow volatility reflects the extent of fluctuations in firms' operational cash inflows and outflows and serves as a key indicator of financial resilience, liquidity management, and risk exposure. In emerging and developing markets, where firms often face structural constraints, regulatory uncertainties, and external shocks such as economic sanctions or market instability, managing cash flow volatility becomes even more crucial. Prior

studies have demonstrated that high levels of cash flow volatility can exacerbate financial constraints, reduce investment capacity, and increase the cost of capital, ultimately undermining long-term firm value [1]. Consequently, identifying mechanisms that can mitigate such volatility has become a central concern in accounting, finance, and management research.

In this context, the growing emphasis on environmental, social, and governance (ESG) practices, particularly environmental information disclosure, has attracted considerable scholarly attention as a potential tool for enhancing corporate transparency, reducing information asymmetry, and improving stakeholder trust. Environmental information disclosure refers to the extent to which firms voluntarily or mandatorily report their environmental performance, policies, and impacts. Theoretical frameworks such as stakeholder theory and legitimacy theory suggest that firms engage in environmental disclosure to align with societal expectations, strengthen stakeholder relationships, and maintain organizational legitimacy in the eyes of investors, regulators, and the public. Empirical evidence indicates that firms with higher levels of environmental disclosure are more likely to gain investor confidence, improve access to financial resources, and reduce perceived risk [2, 3]. Furthermore, environmental disclosure has been associated with enhanced corporate reputation and reduced negative customer perceptions, particularly in situations involving adverse events, thereby contributing to organizational resilience [4].

Recent empirical studies have increasingly examined the financial implications of environmental disclosure, particularly its impact on risk-related outcomes. For instance, evidence suggests that environmental information disclosure can mitigate corporate risk by reducing uncertainty, improving transparency, and facilitating more informed decision-making by stakeholders [5]. Similarly, environmental, social, and governance performance has been shown to influence firms' cost of equity capital, indicating that investors reward transparent and responsible firms with lower required returns [6]. Other studies have highlighted the role of ESG disclosure in enhancing financial performance and firm value, particularly when supported by strong investor engagement and institutional frameworks [7, 8]. In addition, environmental disclosure has been linked to increased access to financial facilities and improved financing conditions, suggesting that transparency in environmental practices can reduce credit risk and enhance financial flexibility [9].

Beyond its direct financial implications, environmental disclosure also interacts with broader organizational and institutional factors that shape its effectiveness. For example, the presence of sustainability committees and governance mechanisms has been shown to strengthen environmental disclosure practices and enhance their credibility in global markets [10]. Similarly, institutional investors and international frameworks such as responsible investment principles play a significant role in promoting high-quality environmental disclosure and increasing its salience in capital markets [11]. Cultural and institutional contexts also influence disclosure behavior, as firms operating in different environments may face varying pressures and incentives to disclose environmental information [12]. Moreover, advancements in digital technologies and social media have transformed the landscape of corporate disclosure, enabling greater interaction between firms and stakeholders and improving the quality and accessibility of sustainability-related information [13].

Despite the growing body of literature on environmental disclosure, its relationship with cash flow volatility remains relatively underexplored, particularly in emerging markets. While some studies have suggested that environmental disclosure can stabilize cash flows by reducing uncertainty and enhancing stakeholder confidence, others have highlighted the complexity of this relationship, which may be influenced by firm-specific characteristics and external conditions [2]. For instance, environmental disclosure may facilitate green innovation, improve

operational efficiency, and enhance long-term financial performance, thereby contributing to more stable cash flows [14]. At the same time, increased disclosure may impose additional costs and resource requirements, which could offset its potential benefits in certain contexts. Therefore, a nuanced understanding of the determinants and consequences of environmental disclosure is necessary to fully capture its impact on financial stability.

One important factor that may influence the relationship between environmental disclosure and cash flow volatility is firm size. Larger firms typically have greater resources, more diversified operations, and stronger governance structures, which may enable them to implement more comprehensive environmental practices and disclosures. At the same time, larger firms are subject to greater scrutiny from regulators, investors, and the public, increasing their incentives to engage in transparent reporting. Empirical studies have shown that firm size plays a significant role in shaping corporate behavior, including disclosure practices, risk management, and financial performance [15, 16]. However, the extent to which firm size moderates the relationship between environmental disclosure and cash flow volatility remains an open question, with mixed evidence in the literature. While some studies suggest that larger firms benefit more from disclosure due to economies of scale and enhanced credibility, others argue that the marginal impact of disclosure may be similar across firms of different sizes.

Another critical factor is ownership structure, particularly the presence of government ownership. Firms with significant government ownership may face unique challenges and opportunities that influence their financial performance and disclosure practices. On the one hand, government ownership may provide access to financial resources, reduce bankruptcy risk, and enhance stability. On the other hand, it may introduce inefficiencies, bureaucratic constraints, and reduced managerial autonomy, which can affect operational performance and risk management. Prior research has shown that ownership structure plays a crucial role in shaping corporate governance, disclosure behavior, and financial outcomes [17, 18]. In addition, government policies and environmental regulations can directly impact firms' environmental practices and disclosure incentives, further complicating the relationship between environmental disclosure and financial outcomes [19, 20].

The broader literature on corporate social responsibility and sustainability also provides valuable insights into the mechanisms through which environmental disclosure may influence financial stability. CSR activities have been shown to reduce corporate risk, enhance reputation, and improve stakeholder relationships, all of which can contribute to more stable financial performance [21, 22]. Moreover, CSR initiatives can foster organizational commitment, improve employee performance, and strengthen alignment between organizational values and stakeholder expectations, thereby enhancing overall firm resilience [23, 24]. Environmental awareness and sustainability initiatives have also been linked to market development and innovation, further highlighting their strategic importance in modern business environments [25, 26].

Recent advancements in sustainability research have also emphasized the dynamic and forward-looking nature of environmental disclosure, particularly in the context of climate change, green finance, and corporate resilience. Firms that actively engage in environmental disclosure are better positioned to manage transition risks, adapt to regulatory changes, and capitalize on emerging opportunities in sustainable markets [27]. Furthermore, the integration of environmental considerations into corporate strategy has been associated with enhanced innovation, improved resource efficiency, and long-term value creation [14]. These developments underscore the importance of examining environmental disclosure not only as a reporting mechanism but also as a strategic tool for managing risk and enhancing financial stability.

Given the theoretical and empirical significance of environmental disclosure, as well as the potential moderating roles of firm size and ownership structure, there is a clear need for comprehensive empirical investigations that

integrate these dimensions within a unified framework. While prior studies have explored various aspects of ESG disclosure and financial performance, limited attention has been paid to the interplay between environmental disclosure, cash flow volatility, and firm-specific characteristics, particularly in the context of emerging markets such as Iran. This gap in the literature highlights the importance of conducting empirical research that examines these relationships using robust econometric methods and comprehensive datasets.

Therefore, the aim of this study is to examine the effect of environmental information disclosure on cash flow volatility, with the moderating roles of firm size and ownership structure, in companies listed on the Tehran Stock Exchange.

2. Methodology

This study is considered an applied research, and in terms of its implementation, it falls within the category of descriptive–correlational studies. In this study, a regression analysis approach was employed to test the hypotheses. Accordingly, multivariate regression models were specified, and after applying econometric techniques, data analysis, relationship examination, and hypothesis testing were conducted. In this regard, data from 153 companies listed on the Tehran Stock Exchange during the period from 2013 to 2022 were collected as the screened statistical population from financial statements and annual reports available on the Codal system and the Tehran Stock Exchange archives, and these data were used to analyze the relationships.

To test the hypotheses, multivariate regression models were utilized. Thus, regression model (1) was employed to test the first hypothesis, adapted from the study by Cheng and Fang (2023).

$$CFV_{it} = \beta_0 + \beta_1 EID_{it} + \beta_2 AGE_{it} + \beta_3 LEV_{it} + \beta_4 LIQ_{it} + \beta_5 TAN_{it} + \beta_6 INV_{it} + \beta_7 DIV_{it} + \beta_8 SALE_{it} + \varepsilon_{it}$$

Furthermore, the regression model used to test the second hypothesis is presented as model (2), which is also derived from Cheng and Fang (2023).

$$CFV_{it} = \beta_0 + \beta_1 EID_{it} + \beta_2 SIZE_{it} + \beta_3 EID_{it} \times SIZE_{it} + \beta_4 AGE_{it} + \beta_5 LEV_{it} + \beta_6 LIQ_{it} + \beta_7 TAN_{it} + \beta_8 INV_{it} + \beta_9 DIV_{it} + \beta_{10} SALE_{it} + \varepsilon_{it}$$

Finally, the regression model used to test the third hypothesis is presented as model (3), which is also derived from Cheng and Fang (2023).

$$CFV_{it} = \beta_0 + \beta_1 EID_{it} + \beta_2 OWNS_{it} + \beta_3 EID_{it} \times OWNS_{it} + \beta_4 AGE_{it} + \beta_5 LEV_{it} + \beta_6 LIQ_{it} + \beta_7 TAN_{it} + \beta_8 INV_{it} + \beta_9 DIV_{it} + \beta_{10} SALE + \varepsilon_{it}$$

In these models, CFV is the dependent variable representing cash flow volatility; EID is the independent variable representing environmental information disclosure; SIZE is the moderating variable representing firm size; OWNS is the moderating variable representing ownership structure; AGE is the control variable representing firm age; LEV is the control variable representing financial leverage; LIQ is the control variable representing current liquidity; TAN is the control variable representing fixed assets; INV is the control variable representing inventory; DIV is the control variable representing dividends; SALE is the control variable representing the sales ratio; i denotes firms; t denotes the time period; β represents coefficients; and ε represents the model residuals.

This study considers a set of control variables that may increase or decrease cash flow volatility. Firm age is controlled because firms can accumulate relevant knowledge over time to mitigate cash flow volatility. Since debt and liquidity significantly affect cash flow (Aivazian et al., 2005; DeAngelo et al., 2002), these factors are controlled by including financial leverage and the current liquidity ratio in the model. In addition, fixed assets are controlled because they influence the cash flow–investment relationship and, consequently, cash flow volatility (Moshirian et al., 2017). Inventory is also included in the model because it reflects the firm's ability to allocate resources efficiently. Finally, dividends and the sales ratio are also controlled.

Dependent Variable: Cash Flow Volatility

There is no consensus regarding the measurement of cash flow volatility. Some studies directly use the standard deviation or variance of cash flow over a period (Bates et al., 2009; Harris & Roark, 2019). Others standardize the variance by scaling it with total assets to reduce size effects (Jayaraman, 2008). However, these measures eliminate nonlinear industry effects that cannot be captured by dummy variables. Several studies have also used the coefficient of variation scaled by asset growth as a measure of cash flow volatility (Sun & Ding, 2020). Nevertheless, the range of cash flows may undermine the validity of the coefficient of variation, as positive and negative cash flows across different periods may offset each other. Ultimately, similar to Zhao and Singh (2016) and Baldi et al. (2021), this study measures relative cash flow volatility. Specifically, net cash flow from operating activities is first extracted, and the rate of cash flow (ROC), defined as operating cash flow divided by total assets, is calculated. Then, cash flow volatility is estimated as the deviation of ROC from the industry mean ROC over a given period. Subsequently, cash flow volatility is computed as the standard deviation of the difference between the firm-level cash flow ratio and the industry-level average cash flow ratio over a three-year period from year t to t–2. This method not only accounts for asset size but also incorporates nonlinear industry effects on cash flow volatility that are not captured by other methods. In other words, industry-adjusted cash flow volatility is calculated in this manner (Cheng & Fang, 2023).

Independent Variable: Environmental Information Disclosure

Measuring environmental information disclosure has been challenging due to the lack of a consensus measurement tool. Therefore, previous studies have employed various subjective indices and measures to capture this variable. Among different approaches, the unweighted index approach has been used due to its application in multiple studies to measure the breadth of environmental performance. In this study, the checklist developed by Rafiei Shahraki and Ghasemi (2019) is used to measure environmental performance, which has been adapted to the disclosure context in Iran. The scoring procedure is such that the items disclosed in the board of directors' reports are counted, and the total score obtained is divided by the total number of items that could potentially be implemented and disclosed as part of the firm's environmental performance strategy.

Level of Environmental Responsibility Disclosure = Number of Disclosed Items / Total Disclosable Items

Moderating Variables

Firm Size: First, the natural logarithm of total assets for each firm-year is calculated, and then the average natural logarithm of total assets for firms within each industry-year is computed. Next, the firm's asset logarithm for each year is subtracted from the corresponding industry average. If the resulting value is positive, it indicates that the firm is larger than the industry average and is assigned a value of 1 (large firm); if negative, it indicates that the firm is smaller than the industry average and is assigned a value of 0 (small firm).

Ownership Structure: Ownership structure in this study refers to the extent of government ownership, measured as the percentage of shares held by government entities.

Control Variables

Firm Age: The natural logarithm of the number of years since the firm's establishment; Financial Leverage: The ratio of total debt to total assets; Current Liquidity: The ratio of current assets to current liabilities; Fixed Assets: The ratio of fixed assets to total assets; Inventory: The ratio of inventory to total assets; Dividends: The ratio of dividends paid to total assets; Firm Sales: The ratio of total sales to total assets.

3. Findings and Results

Non-stationarity of variables may lead to spurious regression and distort the interpretation of results; therefore, it is necessary that all variables used in regression models are stationary at the same level. To examine this assumption, the Levin, Lin, and Chu (LLC) unit root test was employed.

Table 1. Unit Root Test at Level Form of Variables

Variable Name	Variable Symbol	Test Statistic	Significance Level	Test Result
Cash Flow Volatility	CFV	-26.322	0.000	Stationary
Environmental Information Disclosure	EID	-33.828	0.000	Stationary
Firm Size	SIZE	-4.087	0.000	Stationary
Ownership Structure	OWNS	-31.608	0.000	Stationary
Firm Age	AGE	-64.686	0.000	Stationary
Financial Leverage	LEV	-26.091	0.000	Stationary
Current Liquidity	LIQ	-8.937	0.000	Stationary
Fixed Assets	TAN	-17.305	0.000	Stationary
Inventory	INV	-21.346	0.000	Stationary
Dividends	DIV	-175.211	0.000	Stationary
Firm Sales	SALE	-20.993	0.000	Stationary

The results of the stationarity test indicate that all variables are stationary at the level form, as the significance level of each variable's test statistic is less than 0.05. Therefore, the presence of spurious regression can be ruled out, and there is no need to perform cointegration testing.

Table 2. Correlation Test

Variable	CFV	EID	SIZE	OWNS	AGE	LEV	LIQ	TAN	INV	DIV	SALE
CFV	1	-0.123 (0.000)	0.006 (0.794)	0.141 (0.000)	-0.018 (0.459)	0.051 (0.044)	-0.085 (0.000)	-0.114 (0.000)	0.047 (0.060)	0.051 (0.044)	-0.078 (0.002)
EID		1	0.110 (0.000)	0.018 (0.465)	0.027 (0.285)	0.038 (0.135)	-0.028 (0.264)	-0.010 (0.687)	0.001 (0.884)	-0.043 (0.092)	-0.021 (0.405)
SIZE			1	0.044 (0.085)	0.122 (0.000)	-0.109 (0.000)	0.043 (0.086)	-0.042 (0.093)	-0.195 (0.000)	0.222 (0.000)	0.014 (0.561)
OWNS				1	0.062 (0.013)	0.025 (0.309)	-0.035 (0.163)	-0.018 (0.459)	-0.104 (0.000)	-0.009 (0.709)	-0.040 (0.111)
AGE					1	0.073 (0.004)	-0.056 (0.028)	-0.030 (0.239)	-0.084 (0.001)	-0.143 (0.000)	-0.061 (0.016)
LEV						1	-0.731 (0.000)	-0.138 (0.000)	0.098 (0.000)	-0.407 (0.000)	0.111 (0.000)
LIQ							1	-0.321 (0.000)	0.131 (0.000)	0.377 (0.000)	0.025 (0.321)
TAN								1	-0.288 (0.000)	-0.117 (0.000)	-0.134 (0.000)
INV									1	0.082 (0.001)	0.337 (0.000)
DIV										1	0.106 (0.000)
SALE											1

Cash flow volatility and environmental information disclosure exhibit a negative and significant correlation, indicating that firms with higher levels of environmental information disclosure experience lower cash flow volatility. This result provides preliminary support for the first research hypothesis and suggests that increased environmental disclosure is significantly associated with reduced cash flow volatility. Cash flow volatility does not have a significant correlation with firm size, but it has a positive and significant correlation with government ownership, indicating that firms with higher levels of government ownership tend to exhibit greater cash flow volatility. Among the control variables, cash flow volatility has a positive and significant correlation with financial leverage and dividends, while it has a negative and significant correlation with current liquidity, fixed assets, and firm sales, and no significant correlation with firm age and inventory. These findings suggest that firms with higher borrowing levels and financial leverage, or those distributing higher dividends, tend to experience greater cash flow volatility, whereas firms with higher liquidity, greater fixed assets, or higher annual sales exhibit lower cash flow volatility. Furthermore, the correlation test indicates that there is no severe multicollinearity among the explanatory variables in the regression models. The highest significant correlation is observed between financial leverage and current liquidity at -0.731, which does not exceed the conventional threshold, indicating an acceptable level of collinearity. Therefore, there is no concern regarding spurious regression, and the estimated regression results can be interpreted with confidence.

Table 3. Results of Regression Assumptions Testing for Model (1)

Test Type	Test Statistic	Significance Level
Jarque–Bera test for normality of residuals	46.123	0.000
Durbin–Watson test for absence of serial autocorrelation	1.831	---
Breusch–Pagan–Godfrey test for heteroskedasticity	3.053	0.000

Generalized Least Squares (GLS) estimation was employed to address violations of classical assumptions.

To examine the assumption of no serial autocorrelation among residuals, the Durbin–Watson statistic is used. If the value of the Durbin–Watson statistic lies within the range of 1.5 to 2.5, this assumption is satisfied. The observed value falls within the acceptable range; therefore, this classical assumption holds. Regarding the other assumptions, if the significance level of the test exceeds 0.05, the null hypothesis is accepted; otherwise, it is rejected. The results show that the significance level of the heteroskedasticity test is less than 0.05, indicating the presence of heteroskedasticity in the residuals; therefore, this classical assumption is violated. Consequently, the Estimated Generalized Least Squares (EGLS) technique was employed to correct for heteroskedasticity.

Table 4. Diagnostic Tests for Model (1)

Test Type	Test Statistic	Significance Level	Test Result
Chow test	3.695	0.000	The effects-based method (panel data) is appropriate.
Hausman test	19.620	0.011	The fixed-effects model is appropriate.

Based on the results of the diagnostic tests, it was determined that the best estimation method for Model (1) is fixed-effects regression; therefore, this model was estimated using the fixed-effects approach.

Table 5. Estimation of Model (1) Using the Fixed-Effects Method

Variable Name	Coefficient	Standard Error	t-Statistic	Significance Level
Constant	0.004	0.003	1.168	0.272
Environmental information disclosure	-0.211	0.041	-5.145	0.000
Firm age	-0.0009	0.002	-0.328	0.750
Financial leverage	0.016	0.007	2.323	0.045
Current liquidity	-0.047	0.007	-6.050	0.000

Fixed assets	-0.018	0.007	-2.510	0.033
Inventory	0.032	0.018	1.799	0.105
Dividends	0.060	0.008	7.565	0.000
Firm sales	-0.038	0.011	-3.285	0.009
F-statistic	7.447	Significance level of F-statistic	0.000	
R-squared	0.665	Adjusted R-squared	0.602	

After estimating each regression model, it is necessary to assess its goodness of fit. This is important in order to interpret the research findings with confidence. The goodness of fit of each regression model is evaluated using the F-statistic and its significance level, the coefficient of determination, and the adjusted coefficient of determination. The significance level of the F-statistic, which is smaller than 0.05, indicates that the overall estimated model is significant. The coefficient of determination is equal to 0.665, showing that the explanatory power of the model is satisfactory and that 66.5% of the changes in the dependent variable are explained by the independent variables. On the other hand, since the adjusted coefficient of determination is close to the value of the coefficient of determination, it may be concluded that appropriate variables have been included in the model. Therefore, the model has a good fit and its results are valid; accordingly, the obtained findings and coefficients can now be interpreted with confidence.

Since the significance level of the t-statistic for the environmental information disclosure variable is 0.000 and smaller than 0.01, it can be concluded that the effect of environmental information disclosure on cash flow volatility is significant at the 1% error level; therefore, the first hypothesis is confirmed with 99% confidence. The coefficient of environmental information disclosure is also equal to -0.211, and given its negative sign, it can be concluded that the effect of environmental information disclosure on cash flow volatility is negative. In other words, a one-unit increase in environmental information disclosure leads to a 0.211-unit decrease in cash flow volatility.

Table 6. Results of Regression Assumptions Testing for Model (2)

Test Type	Test Statistic	Significance Level
Jarque–Bera test for examining the normal distribution of residuals	45.325	0.000
Durbin–Watson test for examining the absence of serial autocorrelation among residuals	1.828	---
Breusch–Pagan–Godfrey test for heteroskedasticity	3.763	0.000

The Estimated Generalized Least Squares (EGLS) method was used to address violations of the classical assumptions.

The results of testing the classical assumptions indicate that the residuals are not normally distributed; however, given the nature of the data, the estimators remain efficient and possess minimum variance. The Durbin–Watson statistic falls within the conventional range of 1.5 to 2.5, and the problem of heteroskedasticity in the residuals is corrected using the Estimated Generalized Least Squares (EGLS) method.

Table 7. Diagnostic Tests for Model (2)

Test Type	Test Statistic	Significance Level	Test Result
Chow test	3.679	0.000	The effects-based method (panel data) is appropriate.
Hausman test	21.728	0.016	The fixed-effects model is appropriate.

Table 8. Estimation of Model (2) Using the Fixed-Effects Method

Variable Name	Coefficient	Standard Error	t-Statistic	Significance Level
Constant	0.0009	0.005	0.179	0.861
Environmental information disclosure	-0.248	0.048	-5.115	0.000
Firm size	0.002	0.002	1.070	0.312
Interactive effect of firm size and environmental information disclosure	0.006	0.005	1.157	0.277
Firm age	-0.002	0.003	-0.737	0.479
Financial leverage	0.058	0.007	7.356	0.000
Current liquidity	-0.003	0.001	-2.012	0.048
Fixed assets	-0.019	0.007	-2.739	0.022
Inventory	0.013	0.006	1.948	0.083
Dividends	0.070	0.022	3.198	0.010
Firm sales	-0.061	0.022	-2.741	0.022
F-statistic	7.379	Significance level of F-statistic	0.000	
R-squared	0.666	Adjusted R-squared	0.603	

The significance level of the F-statistic, which is smaller than 0.05, indicates that the overall estimated model is significant. The coefficient of determination is equal to 0.666, showing that the explanatory power of the model is satisfactory and that 66.6% of the changes in the dependent variable are explained by the independent variables. On the other hand, since the adjusted coefficient of determination is close to the coefficient of determination, it can be concluded that appropriate variables have been used in the model. Therefore, the model has a good fit and its results are valid; accordingly, the obtained findings and coefficients can now be interpreted with confidence.

Table 9. Results of Regression Assumptions Testing for Model (3)

Test Type	Test Statistic	Significance Level
Jarque–Bera test for examining the normal distribution of residuals	45.782	0.000
Durbin–Watson test for examining the absence of serial autocorrelation among residuals	1.829	---
Breusch–Pagan–Godfrey test for heteroskedasticity	3.124	0.000

The Estimated Generalized Least Squares (EGLS) method was used to address violations of the classical assumptions.

The results of testing the classical assumptions indicate that the residuals are not normally distributed; however, given the nature of the data, the estimators are efficient and possess minimum variance. The Durbin–Watson statistic falls within the conventional range of 1.5 to 2.5, and the problem of heteroskedasticity in the residuals is resolved using the Estimated Generalized Least Squares (EGLS) method.

Table 10. Diagnostic Tests for Model (3)

Test Type	Test Statistic	Significance Level	Test Result
Chow test	6.087	0.000	The effects-based method (panel data) is appropriate.
Hausman test	22.568	0.012	The fixed-effects model is appropriate.

Based on the results of the diagnostic tests, it was determined that the most appropriate estimation method for Model (3) is fixed-effects regression; therefore, this model was estimated using the fixed-effects approach.

Table 11. Estimation of Model (3) Using the Fixed-Effects Method

Variable Name	Coefficient	Standard Error	t-Statistic	Significance Level
Constant	0.003	0.004	0.787	0.451
Environmental information disclosure	-0.215	0.040	-5.275	0.000
Ownership structure (government ownership)	0.035	0.013	2.675	0.025
Interaction effect of government ownership and environmental information disclosure	0.012	0.005	2.271	0.049
Firm age	0.0006	0.002	0.221	0.829
Financial leverage	0.016	0.007	2.293	0.047
Current liquidity	-0.060	0.008	-7.566	0.000
Fixed assets	-0.018	0.007	-2.438	0.037
Inventory	0.002	0.001	1.876	0.093
Dividends	0.076	0.024	3.092	0.012
Firm sales	-0.039	0.011	-3.393	0.008
F-statistic	7.329	Significance level of F-statistic	0.000	
R-squared	0.664	Adjusted R-squared	0.601	

The significance level of the F-statistic, which is less than 0.05, indicates that the overall estimated model is statistically significant. The coefficient of determination is equal to 0.664, suggesting that the model has good explanatory power and that 66.4% of the variation in the dependent variable is explained by the independent variables. Moreover, since the adjusted coefficient of determination is close to the coefficient of determination, it can be concluded that appropriate variables have been included in the model. Therefore, the model exhibits a good fit and its results are reliable; consequently, the estimated coefficients can be interpreted with confidence.

The significance level of the t-statistic for the environmental information disclosure variable is less than 0.01 and its coefficient is negative; therefore, the negative and significant effect of environmental information disclosure on cash flow volatility is confirmed once again, indicating the robustness of the results. The significance level of the t-statistic for the government ownership variable, as one of the explanatory variables representing ownership structure, is equal to 0.025 and less than 0.05; thus, this variable has a statistically significant effect on cash flow volatility at the 5% error level. Its coefficient is equal to 0.035, indicating that the effect of government ownership on cash flow volatility is positive, meaning that firms with a higher proportion of shares held by government institutions tend to experience greater cash flow volatility. It appears that firms with government ownership structures may experience higher volatility due to regulatory constraints and oversight issues. These constraints may include dependence on government decisions, governmental control over operational and managerial activities, and limited financial and fiscal flexibility, all of which can contribute to increased cash flow volatility. Additionally, continued government financing and reliance on public financial resources may intensify cash flow volatility in government-owned firms, as changes in government fiscal policies can significantly affect firms' cash flows.

The significance level of the t-statistic for the interaction variable between government ownership and environmental information disclosure is equal to 0.049 and less than 0.05, indicating that this interaction variable has a statistically significant effect on cash flow volatility at the 5% error level; therefore, the third hypothesis is confirmed with 95% confidence. Its coefficient is equal to 0.012, indicating that in firms with higher government ownership, the negative effect of environmental information disclosure on cash flow volatility is weakened and reduced by 0.012 units. In other words, the negative effect of environmental information disclosure on cash flow

volatility is conditional on ownership structure, and government ownership attenuates this negative effect. Therefore, the impact of environmental information disclosure on cash flow volatility is heterogeneous across firms with different ownership structures, and in firms with higher levels of government ownership, this effect is partially reversed. The effects of control variables on cash flow volatility in this model are consistent with previous findings, indicating the robustness of the results.

Table 12. Summary of Hypothesis Testing Results

Hypothesis Path	Independent Variable	Moderating Variable	Dependent Variable	Coefficient	t-Statistic	Significance Level	Result
1	Environmental information disclosure	—	Cash flow volatility	-0.211	-5.145	0.000	Confirmed
2	Environmental information disclosure	Firm size	Cash flow volatility	0.006	1.157	0.277	Rejected
3	Environmental information disclosure	Ownership structure (government ownership)	Cash flow volatility	0.012	2.271	0.049	Confirmed

Based on the results of hypothesis testing, it was determined that out of the three proposed hypotheses, two were confirmed and one was rejected. Overall, the evidence obtained from estimating the three regression models indicates that environmental information disclosure plays a significant role in reducing firms' cash flow volatility, and firms can use environmental disclosure as an effective tool to stabilize their cash flows. Furthermore, the results show that this effect does not depend on firm size, and firm size cannot explain the heterogeneity in the relationship between environmental information disclosure and cash flow volatility. In other words, regardless of firm size, environmental information disclosure is expected to reduce cash flow volatility; however, the impact of environmental information disclosure on cash flow volatility is heterogeneous across firms depending on their ownership structure, and in firms with predominantly government ownership, this effect is attenuated and partially reversed.

4. Discussion and Conclusion

The findings of this study provide robust empirical evidence regarding the relationship between environmental information disclosure and cash flow volatility, as well as the moderating roles of firm size and ownership structure. The results indicate that environmental information disclosure has a negative and statistically significant effect on cash flow volatility, suggesting that firms with higher levels of environmental disclosure experience more stable cash flows. This finding is consistent across multiple model specifications, reinforcing the robustness of the relationship and supporting the theoretical expectations derived from stakeholder theory and legitimacy theory. From an empirical standpoint, this result aligns with prior studies that emphasize the role of environmental disclosure in reducing corporate risk and uncertainty by enhancing transparency and improving the quality of information available to stakeholders [2, 5]. By reducing information asymmetry and increasing investor confidence, environmental disclosure enables firms to access financial resources under more favorable conditions, which ultimately contributes to the stabilization of cash flows.

The observed negative relationship between environmental disclosure and cash flow volatility can be further interpreted through the lens of financial market behavior and corporate governance mechanisms. Firms that engage in extensive environmental disclosure are likely to signal higher levels of accountability and commitment to

sustainable practices, which enhances their credibility in capital markets. This credibility reduces perceived risk among investors and creditors, leading to lower financing costs and improved liquidity conditions. Such outcomes are consistent with evidence suggesting that ESG performance and disclosure are associated with reduced cost of capital and improved financial performance [6, 7]. Moreover, environmental disclosure can strengthen stakeholder relationships, including those with customers, regulators, and employees, thereby contributing to more predictable operational outcomes and reduced volatility in cash flows. For instance, CSR-related activities have been shown to mitigate negative customer experiences and enhance firm resilience in adverse conditions [4].

Another important dimension of the findings relates to the role of environmental disclosure in enhancing corporate resilience and long-term sustainability. By integrating environmental considerations into their strategic decision-making processes, firms can improve operational efficiency, foster innovation, and reduce exposure to environmental risks. These benefits are particularly relevant in the context of increasing regulatory pressures and growing stakeholder expectations regarding sustainability. Empirical evidence supports the notion that environmental disclosure is positively associated with green innovation and improved resource allocation, which can contribute to more stable financial performance over time [14]. Additionally, firms that actively engage in sustainability reporting are better positioned to adapt to changing environmental regulations and market conditions, thereby reducing the likelihood of unexpected financial shocks.

In contrast to the significant effect of environmental disclosure, the results indicate that firm size does not have a significant moderating effect on the relationship between environmental disclosure and cash flow volatility. This finding suggests that the stabilizing impact of environmental disclosure is relatively uniform across firms of different sizes, and that both large and small firms can benefit from increased transparency in environmental reporting. While prior research has highlighted the importance of firm size in shaping corporate behavior and disclosure practices [15, 16], the present findings imply that the effectiveness of environmental disclosure in reducing cash flow volatility is not contingent upon firm size. This may be explained by the fact that the informational benefits of disclosure, such as reduced information asymmetry and enhanced stakeholder trust, are relevant to firms regardless of their size. Furthermore, advances in digital communication and reporting technologies have reduced the costs associated with disclosure, enabling smaller firms to adopt similar practices as larger firms.

The absence of a significant moderating effect of firm size also suggests that the relationship between environmental disclosure and financial stability is driven primarily by qualitative factors, such as the credibility and relevance of disclosed information, rather than quantitative factors such as firm scale. This interpretation is supported by studies emphasizing the importance of disclosure quality and stakeholder engagement in determining the effectiveness of sustainability reporting [13, 28]. In this context, firms that provide high-quality, transparent, and consistent environmental information are more likely to achieve reductions in cash flow volatility, irrespective of their size.

In contrast, the results reveal that ownership structure, specifically government ownership, plays a significant moderating role in the relationship between environmental disclosure and cash flow volatility. The findings indicate that while environmental disclosure generally reduces cash flow volatility, this effect is weakened in firms with higher levels of government ownership. This suggests that the benefits of environmental disclosure are not uniformly distributed across firms and may be influenced by institutional and governance factors. One possible explanation for this finding is that government-owned firms may face unique constraints and incentives that affect their financial performance and disclosure practices. For example, such firms may be subject to political pressures,

regulatory constraints, and bureaucratic inefficiencies, which can limit their ability to fully realize the benefits of environmental disclosure.

This interpretation is consistent with prior research highlighting the complex role of ownership structure in shaping corporate behavior and financial outcomes [17, 18]. Government ownership may provide access to financial resources and reduce bankruptcy risk, but it may also reduce managerial incentives and operational efficiency, leading to higher volatility in financial performance. Additionally, government-owned firms may rely more heavily on public funding and may be less sensitive to market-based signals, such as those conveyed through environmental disclosure. As a result, the impact of disclosure on reducing uncertainty and improving financial stability may be attenuated in such firms.

Furthermore, the moderating effect of government ownership can be understood in the context of institutional environments and regulatory frameworks. Government policies and environmental regulations can significantly influence firms' disclosure practices and financial outcomes [19, 20]. In some cases, government-owned firms may be required to disclose environmental information as part of regulatory compliance, rather than as a strategic choice aimed at enhancing transparency and stakeholder engagement. This distinction may reduce the signaling value of disclosure and limit its effectiveness in reducing cash flow volatility. Additionally, the dependence of government-owned firms on public funding may expose them to fluctuations in government budgets and policy changes, further contributing to financial instability.

The findings also highlight the importance of considering contextual factors in analyzing the relationship between environmental disclosure and financial performance. Cultural, institutional, and market-specific factors can influence the incentives and constraints faced by firms, thereby shaping the effectiveness of disclosure practices. For instance, variations in investor awareness, regulatory enforcement, and market development can affect the extent to which environmental disclosure translates into tangible financial benefits [3, 12]. Similarly, the role of institutional investors and sustainability-oriented governance mechanisms can enhance the credibility and impact of disclosure, leading to improved financial outcomes [10, 11].

In addition to the main variables of interest, the results related to control variables provide further insights into the determinants of cash flow volatility. The positive relationship between financial leverage and cash flow volatility suggests that firms with higher levels of debt are more exposed to financial risk and uncertainty, consistent with prior findings on the relationship between financial constraints and investment behavior [1]. Similarly, the positive effect of dividend payments on cash flow volatility may reflect the financial pressures associated with maintaining dividend policies, particularly in the presence of fluctuating earnings. On the other hand, the negative relationship between liquidity, fixed assets, and sales with cash flow volatility indicates that firms with stronger operational performance and financial flexibility are better able to manage cash flow fluctuations. These findings are consistent with the broader literature on corporate risk management and financial stability [21, 22].

Overall, the results of this study contribute to the growing body of literature on environmental disclosure and financial performance by providing empirical evidence on the role of environmental information disclosure in reducing cash flow volatility and highlighting the moderating effects of ownership structure. The findings underscore the importance of transparency and sustainability practices in enhancing corporate resilience and financial stability, particularly in emerging markets. Moreover, the results emphasize the need for policymakers and practitioners to consider firm-specific and institutional factors when designing and implementing disclosure policies.

The present study is subject to several limitations that should be considered when interpreting the findings. First, the study focuses on firms listed on the Tehran Stock Exchange, which may limit the generalizability of the results to other contexts with different institutional and regulatory environments. Second, the measurement of environmental information disclosure is based on a checklist approach, which may not fully capture the qualitative aspects of disclosure quality and credibility. Third, the study relies on secondary data from financial statements and annual reports, which may be subject to reporting biases and limitations in data availability.

Future research can extend the findings of this study by exploring the relationship between environmental disclosure and cash flow volatility in different institutional contexts and across various industries. Researchers may also consider incorporating alternative measures of disclosure quality, such as textual analysis or machine learning approaches, to capture more nuanced aspects of sustainability reporting. Additionally, future studies can examine the role of other moderating variables, such as corporate governance mechanisms, board characteristics, and investor composition, in shaping the relationship between environmental disclosure and financial stability.

From a practical perspective, the findings of this study suggest that firms should prioritize environmental information disclosure as a strategic tool for enhancing financial stability and reducing cash flow volatility. Managers are encouraged to adopt comprehensive and transparent reporting practices that provide stakeholders with reliable and relevant information about environmental performance. Policymakers can also play a crucial role by establishing clear guidelines and standards for environmental disclosure, thereby promoting consistency and comparability across firms. Furthermore, investors and other stakeholders should consider environmental disclosure as an important factor in evaluating firm performance and risk, as it provides valuable insights into firms' sustainability practices and long-term prospects.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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