Gender as a tool for diversification

Antonio Díaz[a], Ana Escribano[a], Rocío Hidalgo[a]

[a] *University of Castilla-La Mancha, Plaza de la Universidad, 1, Albacete, 02071, España*

Abstract

This study investigates the impact of managerial gender on portfolio risk, based on the assumption that women are more risk averse than their male counterparts. The research focuses on a key question: Does this risk aversion manifest itself in the stock market performance of firms that are majority-led by women? To answer this question, we constructed two distinct portfolios based on the gender of top managers: one composed of predominantly female-led companies and one composed of exclusively male-led companies. The selection of companies was based on MSCI's annual global gender diversity reports, and the analysis was conducted over a sample period from 2018 to 2022. Portfolio risk was assessed using the value-at-risk (VaR) metric, with dynamic optimisation procedures applied through an AR(1)-EGARCH(1,1) model to minimise variance. Our results reveal that portfolios composed of predominantly female-managed companies exhibit lower risk, as measured by VaR, compared to portfolios of male-only managed companies.

Keywords: Board Gender Diversity, Corporate Social Responsibility, Portfolio Risk Management, Backtesting, VaR

Email addresses: antonio.diaz@uclm.es (Antonio Díaz), ana.escribano@uclm.es (Ana Escribano), rociohidalgo98@gmail.com (Rocío Hidalgo)

1. Introduction

In recent years, corporations have witnessed a marked uptick in gender diversity within their boards of directors, attributable either to the imposition of regulatory mandates such as "female quotas," or to a prevailing empirical consensus substantiating that elevated gender diversity on boards correlates positively with enhanced organizational performance.

In the wake of this gender diversification, new scholarly inquiries have emerged within the broader scope of professional ethics and decision-making paradigms. Notably, Betz et al. (1989) elucidates that women in professional settings frequently adhere to more rigorous ethical guidelines and are less inclined to engage in ethically questionable activities for economic advantage. Complementary to this, Gul et al. (2011) posits that female professionals not only exhibit ethical comportment but also manifest heightened aversion to risk. Additional empirical studies, such as those by Byrnes et al. (1999), corroborate that women tend to adopt a more cautious and less aggressive stance in various decision-making contexts. Particularly salient is the work by Powell and Ansic (1997), which accentuates that such circumspection becomes notably pronounced in the realm of financial decision-making.

These observations set the stage for the primary research question addressed in this article: To what extent do observed risk-averse tendencies among women manifest in the stock market performance metrics of firms? To operationalize this inquiry, the present study employs the Value at Risk (VaR) analytical framework to assess two categorically distinct portfolios. The first portfolio comprises equities from corporations with a majority of female representation on their boards, while the second portfolio consists of equities from corporations with exclusively male boards of directors.

This study aims to extend the scope of extant research, as the existing literature has predominantly focused on scrutinizing the impact of board gender diversity from various disciplinary lenses. For instance, from an accounting perspective, Bhimani (2009) posits that boards function not merely as oversight mechanisms but also as arbiters of strategic direction, cost management, and risk mitigation. From the lens of organizational performance, Adams and Ferreira (2007) accentuates the advisory and supervisory roles of boards. Moreover, from a management theory standpoint, frameworks such as resource dependency theories and agency theory have been applied. Within these multiple frameworks, a substantial emphasis has been placed on corporate outcomes.

On the contrary, our study cuts across economic and psychological theories to try to give a more quantitative view to the conclusions proposed by the literature that women tend to show a lower propensity to take risks and to favour more conservative investment choices (Barber and Odean, 2001; Byrnes et al., 1999; Hinz et al., 1997; Chatjuthamard et al., 2021).

Thus, this paper hypothesizes that this risk-averse behaviour may translate into less risky stock market returns for companies with more women on the board of directors. This hypothesis has been empirically validated during the study period (from January 2017 to March 2024). Utilizing the Morgan Stanley Capital International annual reports as a foundational data source, we have constructed two distinct portfolios and implemented a monthly rebalancing procedure through the re-estimation of AR-EGARCH models. These portfolios are dynamically assembled at the end of each month, adopting two separate strategies: one that permits short-selling and another that restricts it. Through this rigorous active portfolio management process, we have unearthed empirical evidence supporting the proposition that portfolios comprised of companies with a preponderance of female leadership demonstrate a lower Value at Risk (VaR), thereby indicating a reduced propensity for risk assumption compared to firms with all-males on boards.

The structure of this study is delineated as follows. The next section includes an exhaustive literature review examining the manifold ways women influence various organizational facets, with a particular focus on risk propensity. In the third section the employed methodologies are elucidated. We present the sample dataset in the fourth section. The results and interpretation of empirical analyses are presented in the fifth section, and, finally, the last section concludes with insights.

2. Literature review

This section of the study is devoted to a comprehensive review of the existing academic literature on gender diversity on boards of directors. The aim is to elucidate the various perspectives that prevail in the literature regarding the implications of increasing female participation in corporate decision-making bodies, as well as to categorise the types of research conducted in this area. From this systematic review, it has been discerned that a significant segment of the literature converges on the idea that women tend to exhibit greater risk aversion compared to their male counterparts. This finding has led us to formulate the specific objective of our study: to investigate whether this propensity for risk aversion manifests itself in the stock market returns of firms that maintain a higher degree of gender diversity on their boards.

2.1. Board Gender Diversity

In contemporary discourse, the notion of Corporate Social Responsibility (CSR) has transcended its initial conceptual boundaries to assume a strategic position at the board level. This transition has catalysed elevated dialogues within corporate environments aimed at fulfilling social responsibilities, as highlighted in Mackey et al. (2007). The growing importance of CSR has led boards to pay increasing attention to gender diversity on boards, in particular the representation of women on boards, known as Board Gender Diversity (BGD).

Through a bibliometric analysis of CSR reports, Alhosani and Nobanee (2023) has shown that the BGD is the subject of much scholarly attention in terms of companies' stance on social, economic and environmental issues. The ascendancy of the BGD in the corporate sphere can be attributed in part to the under-representation of women on boards of directors, in contrast to their representation in the general population. However, mere numerical parity is not the only driver for diversifying board composition. Empirical research suggests that companies with a higher proportion of women on their boards show better CSR performance, prompting organisations to encourage female representation on boards as part of a broader strategy to legitimise CSR reporting. This is why countries such as Norway, Denmark, France, Germany, Belgium, Iceland, Italy, the Netherlands, Spain and Malaysia have instituted mandatory gender quotas on boards, ranging from 30-40%.

Other countries such as Israel, Finland, India and the United Arab Emirates require the inclusion of at least one woman on boards. China's efforts to harmonise its corporate governance laws with international standards have also been noted, although mandatory quotas for female board representation remain relatively small, as Shaheen et al. (2021) points out. However, as Fernández-Torres et al. (2021) argues, a minimal presence of women on boards is insufficient to substantially influence companies' CSR actions; a critical mass of at least three women is needed to make a tangible impact.

On the one hand, a subset of empirical research, including that of Alhosani and Nobanee (2023) and Herring (2009), questions the universally positive effects of gender diversity. These studies warn that diversity in top management could generate internal conflict and undermine group cohesion.

Furthermore, Earley and Mosakowski (2000) points out that homogeneous groups may show a higher frequency of communication, potentially due to shared perspectives among group members. On the other hand, Herring (2009) indicates that high gender diversity may be linked to higher rates of absenteeism and turnover, thus negatively affecting firm value. While it is imperative to recognise the contingency of these results across diverse institutional and cultural landscapes. Regulatory frameworks regarding gender representation on boards differ around the world, which influences the scope and scale of the impact of BGD on corporate performance.

On the other hand, Sartawi et al. (2014) posits that the inclusion of women on boards instigates a richer tapestry of social and ethical dialogues, thereby facilitating more nuanced and robust decision-making processes. These enriched dialogues enhance the adoption of sustainable and socially responsible business practices, culminating in the enhancement of overall business strategy. This position is also shared by García-Izquierdo et al. (2018), who comments in her study that improved business performance can be attributed to the diverse socio-economic backgrounds of female board members. These members, coming from non-traditional backgrounds, bring a multifaceted repertoire of expertise and show a propensity to serve on multiple boards. This diversity tends to orient corporate priorities towards the well-being of stakeholders in general rather than the interests of a particular group, as Wang and Coffey (1992) underlines. Bear et al. (2010) also corroborates that gender diversity on boards has favourable consequences for corporate reputation and institutional investment, which can strengthen corporate social responsibility (CSR) ratings, share prices and overall financial performance.

2.2. Impact of Board Gender Diversity on Corporate Dynamics

Academic research on the impact of gender diversity on corporate boards has been extensive, but geographically biased. Notable studies, such as those by Adams and Ferreira (2009) and Carter et al. (2003), focus on US companies, while Singh et al. (2001) and Brammer et al. (2009) focus on the UK. Similarly, the studies by Mateos de Cabo et al. (2012) and Rivas (2012) explore the European Union, while Lucas-Pérez et al. (2014), Ruigrok et al. (2007), Ahern and Dittmar (2012) and Torchia et al. (2011) focus on Spain, Switzerland and Norway, respectively. An outlier in this trend is Terjesen and Singh (2008), whose dataset spans the globe and incorporates Brazil, but omits other BRIC nations[1].

The methodological approaches employed in this field are varied, ranging from statistical modelling and experimental designs to bibliometric analysis and regression techniques. This multiplicity of methodologies parallels the complexity of the results, which go beyond mere representative metrics to encompass facets such as innovation, performance, risk appetite and CSR. The body of literature thus offers intricate insights into the interplay between gender diversity, corporate governance, performance and risk, presenting valuable considerations for policy makers, academics and industry leaders.

Our empirical investigation predominantly centers on three pivotal aspects: the impact of BGD on environmental performance, overall company performance, and risk management. We have directed heightened scrutiny towards risk management, given its centrality in our study's scope.

2.2.1. Environmental Performance

The empirical picture regarding the impact of gender diversity on boards of directors on environmental sustainability presents a multifaceted narrative. On the one hand, studies such as those by Naveed et al. (2022) and Nguyen et al. (2020) argue for the absence of a discernible correlation between these variables. Surprisingly, a minority stream of research, exemplified by Orazalin and Baydauletov (2020), even suggests a negative relationship between BGD and environmental performance. But another large body of literature, including work by Post and Byron (2015) and Orazalin and Mahmood (2021), identifies a favourable and statistically significant relationship between gender diversity on boards and various environmental sustainability indices.

Post et al. (2011) argues that women directors, characterised by their propensity for empathy and benevolence, increase the importance of environmental concerns on corporate boards. As a corollary, BGD is increasingly recognised as an integral component of Corporate Governance (CG), especially in the context of Green Innovation (GI) activities (Xu et al. (2020)). In addition, the participatory leadership style often exhibited by female board members fosters a more collaborative environment, characterised by increased information sharing during board deliberations (Adams and Fer-

[1]BRIC stands for Brazil, Russia, India, China; a term coined by Jim O'Neill to describe the major emerging economies. South Africa was later included, changing the acronym to BRICS.

reira (2009)). This enriched dialogue can potentially amplify the effectiveness of strategic changes aimed at eco-innovation. In a similar vein, Rehbein et al. (2013) posits that female executives demonstrate greater receptivity to community influencers - board members who possess a strong focus on ecological sustainability and community well-being - relative to their male counterparts.

2.2.2. Corporate Performance

Empirical evidence on the role of gender diversity on boards and its consequent impact on company performance also presents a convoluted picture. A number of studies (Larcker et al., 2007; Adams and Ferreira, 2009; Ahern and Dittmar, 2012; Gregory-Smith et al., 2014; Chapple and Humphrey, 2014) suggest that board composition has a negligible or even detrimental impact on firm performance. In particular, research by Lindstädt et al. (2011) and O'Reilly and Main (2012) found no statistically significant relationship between board gender diversity and corporate performance, attributing changes in board composition to regulatory pressures rather than profit-oriented objectives. A similar result is observed in Chapple and Humphrey (2014), who do not find strong evidence of a positive association between board gender diversity and financial performance.

The nuanced study by Adams and Ferreira (2009) offers a complex picture, arguing that while more gender diverse boards are more vigilant in oversight, this could make companies more susceptible to takeovers, which could be a negative outcome. However, for companies with weaker governance structures, this diversity can actually add value. On a related note, Shrader et al. (1997) examined the situation from an accounting perspective and observed a negative correlation between the presence of women on boards and accounting performance, measured through Return on Assets (ROA) and Return on Earnings (ROE).

The theoretical perspective offered by Demsetz and Lehn (1985) adds an additional layer of complexity, arguing that if female representation on boards actually added value, companies would naturally evolve to include more women without the need for mandatory quotas. The study warns that external interventions such as quotas could be counterproductive, particularly if the women appointed lack the experience or skills of their male counterparts. This leads to the *Golden Skirt* phenomenon, where a small number of highly qualified women serve on multiple boards due to gender quotas, calling into question the effectiveness of such policies in genuinely improving board diversity.

Other Danish-focused studies such as Smith et al. (2006) and Rose (2007) indicate that CEO gender does not materially affect firm profitability when gender balance elsewhere in the firm is taken into account. These findings neither refute nor confirm superior performance of female CEOs; however, they highlight the underlying benefits of diversified leadership, which tends to generate better average results.

On the affirmative side, research by Gul et al. (2011) suggests that boards with a higher proportion of female directors are associated with better stock price information due to improved public disclosure practices. Similarly, a study by Catalyst (2004), which examined 353 Fortune 500 companies, found that organisations with more women on their boards outperformed those with fewer women over the period 1996 to 2000.

In addition, research by Watson et al. (1993) and Gulamhussen and Santa (2015) highlights the positive influence of female board representation on a range of performance indicators, from accounting to market indicators. The Gulamhussen and Santa (2015) study emphasises that such diversity is linked to strong banking outcomes, such as improved loan quality and lower earnings volatility.

According to Post and Byron (2015), the role of gender diversity on corporate boards transcends the simplistic notion of a "numbers game". Research such as Adams and Funk (2012), Campbell and Minguez-Vera (2008), and Erhardt et al. (2003) corroborate the economic benefits that gender diversity can bring, beyond mere quota compliance. In the specific context of Erhardt et al. (2003), research on 112 US Fortune-listed companies showed a positive association between board diversity and both return on assets and return on investment.

To quantify corporate performance, many studies employ Tobin's Q as a key metric (Adams and Funk, 2012; Campbell and Minguez-Vera, 2008; Erhardt et al., 2003). Consistent with this, Carter et al. (2003) found that Fortune-listed companies with at least two female board members had higher Tobin's Q values, signifying a higher company valuation. Tobin's Q, a financial measure conceptualised by Nobel laureate James Tobin, is central to assessing the market value of a company's assets relative to their replacement cost, providing key insights into company valuation and investment strategies.

In the field of diversity metrics, some studies such as Ghafoor et al. (2022) use the Blau Index, a sociological tool designed to quantify the level of diversity in groups. Although comprehensive, the Blau Index does not consider intrinsic characteristics and possible interactions between different categories, which presents a limitation in its application to assess the true impact of diversity.

Finally, Sila et al. (2016) points out that much research on the relationship between gender and performance often relies on risk-neutral operational performance metrics such as ROA and ROE. This could obscure the full impact of gender diversity in companies, as firms with similar operational metrics may have different risk profiles. Consequently, gender diversity may exert its influence in a more subtle way, by changing the overall risk profile of an organisation rather than directly affecting operational performance.

2.2.3. Gender and Risk Management in Corporate Governance

Kahneman and Tversky (1979) stress that the gender of boards of directors not only affects the environmental and social sustainability of companies, and operational performance. It also has a significant impact on organisational decision-making, which in a business environment is inherently fraught with risk. However, they do not fully encompass the nuanced role of risk preferences, be they risk aversion or risk seeking.

According to the Prospect Theory, individuals generally adopt risk-averse positions in positive circumstances and are inclined towards risk-seeking behaviour in negative scenarios. When translated to a corporate environment, this implies that high performance conditions align with risk aversion, while low performance conditions encourage risk-seeking behaviour, a relationship known as Bowman's paradox (Bowman, 1980, 1982). Extending this theory, Kanter (1977) argues that during high uncertainty, group composition, specifically male dominance on boards, becomes increasingly salient. This assertion is supported by Adams and Ferreira (2009) and Mateos de Cabo et al. (2012), who found that firms or banks with more volatile returns are less likely to include women on their boards.

While several studies have explored the role of gender, particularly of CEOs and senior executives, in influencing risk dynamics (Berger et al., 2014; Faccio et al., 2016; Huang and Kisgen, 2013), the ramifications of gender diversity on boards as a modulating factor for organisational risk-taking are not yet definitively understood (Chatjuthamard et al., 2021).

Research findings vary significantly in different geographical and cultural contexts. For example, Campbell and Minguez-Vera (2008) observed positive market reactions to the appointment of female executives. In contrast, Adams and Ferreira (2007) linked reduced female board representation to increased stock market volatility. Such inconsistent results extend to the works of Berger et al. (2014) and Poletti-Hughes and Briano-Turrent (2019), who posit that female directorship might correlate with a higher propensity to take risks. In contrast, studies by Sila et al. (2016) and Bruna et al. (2019) found no discernible correlation, highlighting the complexity of this issue.

Betz et al. (1989) posits that women in professional roles are more likely to uphold strict ethical standards, thus reducing the likelihood of adopting unethical tactics for financial gain. In addition, women manifest greater risk aversion according to Gul et al. (2011), a characteristic corroborated by Byrnes et al. (1999) in various decision-making contexts. This risk-averse disposition is particularly pronounced in financial scenarios, as Powell and Ansic (1997) emphasises. But contrary to common perceptions, Sila et al. (2016) argues that companies with high female board representation do not necessarily compromise their competitive positioning through less risky strategies. Supporting this, Khan and Vieito (2013) found that reduced risk does not inherently lead to diminished returns, a point echoed in a study of US female fund managers (Atkinson et al., 2003).

In addition, Sila et al. (2016) further emphasises the critical importance of a balanced gender composition on boards for sound risk management. Chatjuthamard et al. (2021) similarly suggests that diversified boards can drive strategic risk mitigation, such as lower cash flow volatility or investment in assets for stable income streams, as part of a broader diversification strategy. From a macro perspective, gender diversity in leadership positions can influence organisations to make moderate gains while at the same time mitigating the potential for catastrophic losses, suggesting an avenue for sustained performance improvement.

The correlation between gender diversity and corporate risk-taking is not unequivocal. Anomalies exist, as demonstrated by Setiyono and Tarazi (2014), who found a negative correlation between board gender diversity and earnings volatility in the Indonesian context. In addition, Norwegian quota-induced studies on female board representation found little or no impact on firm leverage. In contrast, Berger et al. (2014) reported that an increase in female directorship within banks correlated with elevated portfolio risks. This finding is corroborated by Adams and Funk (2012) in the Swedish context, noting that female executives tend to be more risk tolerant than their male counterparts. Furthermore, Sapienza et al. (2009) found that women entering the financial sector show comparatively lower risk aversion than those joining other sectors.

This leads us to think that it is imperative to differentiate between sectors when analysing the influence of gender on risk aversion. Because on the other hand, also in the banking sector, we have the study by Wiersema and Bantel (1992) where the impact of gender diversity is particularly convincing. For Wiersema and Bantel (1992) suggests that female board members bring unique advantages, such as counteracting male biases in strategic and risk decisions, thus offering a nuanced perspective on risk management, crucial for strategic decision-making in financial institutions. This sector-specific trend underscores the need for further empirical studies to validate whether these observations extend beyond the financial domain.

On the other hand, it should not be forgotten that there is also a causal link between gender diversity and a firm's risk profile, largely because board compositions do not exist in a vacuum, but are shaped by a myriad of contextual variables (Adams and Ferreira, 2009; Coles et al., 2008; Harris and Raviv, 2008). That said, the literature recognises inherent gender-based differences in attitudes towards risk that translate into different corporate risk profiles. But as we have found, much of the literature argues that companies with high social responsibility, which are those with greater gender diversity, are better managed and therefore less risky for investors (McGuire et al., 1988), which tend to elicit more measured investor reactions during adverse market conditions (Godfrey, 2005).

Based on a critical review of existing literature, it is evident that the inclusion of women on corporate boards could significantly contribute to more cautious decision-making. Additionally, it may serve as a balancing mechanism against riskier tendencies, thereby mitigating overall organizational risk. This phenomenon is attributed, according to both financial and psychological sources, to women's greater propensity for risk aversion. In line with the findings presented by Farrell and Hersch (2005), corporations with higher female representation on their boards tend to display reduced volatility profiles as well as more robust performance metrics.

Within this theoretical framework, a quantitative inquiry has been undertaken using dynamic portfolio optimization analysis. The purpose is to verify whether the aforementioned propensity for risk aversion exhibited by female directors is effectively manifested in the stock returns of the companies that employ them.

3. Methodological Framework

This section elucidates the strategies employed for the periodic optimization of various active management portfolios, the approaches taken, and the metrics used to evaluate portfolio performance and associated risk.

3.1. Portfolio Strategies

The portfolio optimization in this study relies on two main approaches: passive management and active management. For the passive strategy, we employ equally-weighted (EW) portfolios as a benchmark. In the realm of active management, we examine the strategy of Minimum Variance (MV) portfolios. Equally-weighted portfolios allocate uniform weights to each asset, thus mitigating the risk of individual securities. These portfolios serve as our benchmark for passive management, given their static composition. Minimum Variance portfolios are grounded in the seminal framework introduced by Markowitz (1952). These portfolios are optimized taking into account volatility and covariance, thereby avoiding assets with high covariance within the entire portfolio. The efficient frontier, conceptualized by Markowitz, guides investors toward portfolios that maximize returns for a given level of risk under the assumption of market efficiency.

The optimization of these types of portfolios is conceptualized as a risk minimization problem, wherein assets with lower volatility and correlation or covariance with other assets are assigned greater weights. Mathematically, the optimization of a portfolio comprising N assets can be represented as follows:

$$\text{Minimize: } w_t' \Sigma_t w_t \tag{1}$$

$$\text{Subject to: } \sum_{i=1}^{N} w_{i,t} = 1 \tag{2}$$

Here, $w_{i,t}$ denotes the weight of the i^{th} asset at time t, and Σ_t is the variance-covariance matrix. The subscript t refers to the frequency of portfolio rebalancing, in our case will be monthly. For MV portfolios, both positive and negative weights are permissible, allowing for short positions and the use of leverage.

The variance-covariance matrix (Σ_t) can be formulated as:

$$\Sigma_t = \begin{bmatrix} \sigma_{1_t}^2 & \cdots & \sigma_{1n_t} \\ \vdots & \ddots & \vdots \\ \sigma_{n1_t} & \cdots & \sigma_{nt}^2 \end{bmatrix} \tag{3}$$

The estimation of Σ_t will be conducted using a univariate GARCH model. Specifically, a composite model is employed that incorporates an autoregressive model for the mean and an EGARCH (Exponential Generalized Autoregressive Conditional Heteroskedasticity) model for the volatility. To preserve the integrity of the time-series data, we estimate the conditional volatility (Σ_t) on a monthly basis, thus avoiding the influence of recency bias on older data points.

3.2. GARCH Model for Portfolio Optimization

The study employs a univariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model for portfolio optimization, more specifically the AR-EGARCH (Autoregressive-Exponential GARCH) model for the daily risk assessment of individual stock returns. This establishes a conditional volatility structure for each return series included in the portfolios under consideration.

The ARCH (Autoregressive Conditional Heteroskedasticity) model assists in estimating conditional variances based on past asset returns. The GARCH model serves as an extension of the ARCH framework, taking into account both historical volatilities and their influence on future volatility.

The first-order Autoregressive (AR) model can be mathematically formulated as:

$$r_{i,t} = \mu_i + \phi_i r_{i,t-1} + \varepsilon_{i,t} \tag{4}$$

$$\varepsilon_{i,t} = \sigma_{i,t} z_{i,t} \tag{5}$$

$$z_{i,t} \sim N(0,1) \tag{6}$$

The first-order Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model is expressed as:

$$\ln(\sigma_{i,t}^2) = \omega + \alpha \left(\frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} \right) + \beta \ln(\sigma_{i,t-1}^2) \tag{7}$$

When combining these models, the AR(1) - EGARCH(1,1) model is articulated as:

$$r_{i,t} = \mu_i + \phi_i r_{i,t-1} + \varepsilon_{i,t} \tag{8}$$

$$\ln(\sigma^2_{i,t}) = \omega + \alpha_i \left(\frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} \right) + \beta_i \ln(\sigma^2_{i,t-1}) \tag{9}$$

In these formulas, $r_{i,t}$ symbolizes the daily logarithmic returns for individual stocks. The parameter μ_i represents the unconditional mean, while ϕ_i quantifies the persistence of historical returns. The term $\varepsilon_{i,t}$ represents the residuals for the current period, which are influenced by the current volatility ($\sigma_{i,t}$) and standardized innovations ($z_{i,t}$), which are normally distributed. Additionally, for the EGARCH model, ω indicates the long-term variance; α_i is related to the ARCH component; and β_i reflects the impact of historical volatility.

The study adopts the Exponential GARCH (EGARCH) model to address the inherent limitations of traditional GARCH models. While GARCH models competently capture features like heavy tails and volatility clustering, they are symmetric and thus insensitive to the direction of past innovations. The EGARCH model, introduced by Nelson in 1991, accommodates leverage effects by allowing for asymmetries between positive and negative asset returns.

3.3. Portfolio Performance Through Risk-Adjusted Ratios

Subsequent to the portfolio construction, performance metrics will be evaluated to quantify risk-adjusted returns. The study proposes to utilize three principal ratios for this assessment: the Sharpe ratio, the Sortino ratio, and the Treynor ratio.

3.3.1. Sharpe Ratio

The Sharpe Ratio, introduced by William F. Sharpe in 1966 (Sharpe, 1966), serves as a measure to relate risk and reward by quantifying the excess return per unit of risk, as expressed through portfolio volatility. Mathematically, it is defined as:

$$R_{\text{Sharpe}} = \frac{\mu_p - r_f}{\sigma_p} \tag{10}$$

In this equation, μ_p signifies the portfolio's mean return, r_f represents the risk-free rate—which is assumed to be zero for the purposes of this study—and σ_p denotes the portfolio return's volatility. A higher Sharpe ratio suggests that the investment provides a more favorable risk-adjusted return relative to a risk-free asset.

3.3.2. Sortino and Price Ratio

The Sortino Ratio, developed by Frank A. Sortino and Robert van der Meer Price in 1994 (Sortino and Price, 1994), deviates from the Sharpe Ratio by emphasizing downside risk, or the risk of returns falling below a predetermined target level Θ. The formula for the Sortino Ratio is:

$$R_{\text{Sortino}} = \frac{\mu_p - \theta}{\sqrt{\frac{1}{T}\sum_{t=1}^{T} \min(r_{p,t} - \theta, 0)^2}} \tag{11}$$

Here, μ_p is the portfolio's average return, θ is the target return, and $\sqrt{\frac{1}{T}\sum_{t=1}^{T} \min(r_{p,t} - \theta, 0)^2}$ calculates the volatility of returns that are below this target level. A higher Sortino Ratio indicates that the investment offers a better risk-adjusted return concerning downside risk.

3.3.3. Treynor Ratio

The Treynor Ratio, introduced by Jack L. Treynor (Treynor, 1965; Treynor and Mazuy, 1966), measures the excess return per unit of systematic risk, encapsulated by the investment's beta (β_p). The Treynor Ratio is expressed as:

$$R_{\text{Treynor}} = \frac{\mu_p - r_f}{\beta_p} \tag{12}$$

In this equation, μ_p represents the mean return of the portfolio, r_f is the risk-free rate, and β_p is the portfolio's beta, representing its market sensitivity. A higher Treynor Ratio value implies that the investment efficiently compensates for the systematic risk it incurs.

3.4. Risk Metrics and Validation of Value at Risk via Backtesting Methods

Initiated in the latter part of the 20th century, Value at Risk (VaR) has emerged as an indispensable metric for the assessment of market risk, enjoying widespread applicability in both academic research and industrial applications (Díaz et al., 2017). VaR is conceptualized as a statistical measure, specifically denoted as the quantile of a financial distribution, encapsulating the maximum plausible losses over a predefined time horizon and a confidence interval $1 - \alpha$.

Among the various methodologies for calculating VaR, the historical simulation approach warrants special attention. This technique posits that future returns R_{t+1} can be adequately approximated by the empirical distribution of historical returns n, formally posed as R_{t+1} being a function of the empirical distribution $\{R_t\}_{t=1}^{n}$.

For a given confidence level $\alpha \in (0, 1)$, VaR can be mathematically expressed as:

$$
\begin{aligned}
VaR_\alpha(R_{t+1}) &= -q_\alpha(R_{t+1}) &\quad (13)\\
&= -\inf\left\{ r \;\middle|\; \frac{\#\{R_t \leq r\}}{n} \geq \alpha \right\} &\quad (14)
\end{aligned}
$$

In the present study, a daily parametric VaR has been employed for each portfolio, predicated on the assumption that the return series aligns with a normal distribution $X \sim N(\mu, \sigma)$. Given that the cumulative density function $\Phi_X(x) = P(X \leq x)$ is both invertible and continuous, it can be represented as:

$$
q_\alpha(\mu + \sigma\tilde{X}) = \mu + \sigma q_\alpha(\tilde{X}) \tag{15}
$$

This leads us to the VaR of X for $\alpha \in (0, 1)$ as:

$$
\begin{aligned}
VaR_\alpha(X) &= -\mu - \sigma q_\alpha(\tilde{X}) &\quad (16)\\
&= -\mu + \sigma VaR_\alpha(\tilde{X}) &\quad (17)\\
&= -\mu - \sigma\Phi^{-1}(\alpha) &\quad (18)
\end{aligned}
$$

For assessing the one-day VaR of a portfolio p at a significance level α, the following formula is applied:

$$
\text{VaR of portfolio}_{p,t}(\alpha) = -\mu_{p,t} + \sigma_{p,t} \cdot \chi(\alpha)^{-1} \tag{19}
$$

To ascertain the accuracy of VaR estimations, this study employs three distinct backtesting methodologies, as synthesized in the comprehensive review by Zhang and Nadarajah (2017), that is, Kupiec's Proportion of Failures Test (1995), Christoffersen's Conditional Coverage Test (1998), and the

Wald Test as articulated by Engle and Manganelli (2004). These tests are elaborated upon in subsequent sections.

3.4.1. Kupiec Test

The Kupiec test, initially introduced by Paul Kupiec in 1995 (Kupiec, 1995), serves as a seminal approach for the backtesting of VaR models. Specifically, the test aims to evaluate whether the observed frequency of VaR violations aligns with the model's predicted $100\alpha\%$ confidence level. The Probability of Failure (POF), employed as the test statistic, is mathematically articulated as follows:

$$POF = 2\ln\left[\left(\frac{1-\hat{\alpha}}{1-\alpha}\right)^{n-I(\alpha)}\left(\frac{\hat{\alpha}}{\alpha}\right)^{I(\alpha)}\right], \tag{20}$$

where

$$\hat{\alpha} = \frac{1}{n}I(\alpha),$$
$$I(\alpha) = \sum_{t=1}^{n} I_t(\alpha),$$

In this equation, n denotes the total number of observations. A POF value of zero implies that the observed and expected frequencies of VaR violations coincide, suggesting the absence of inadequacies in the VaR model. Conversely, a non-zero POF statistic indicates a potential misestimation of the portfolio's risk profile by the model.

One of the primary inherent strengths of the Kupiec test lies in its ease of implementation, providing a straightforward yet effective mechanism for model validation. However, it is crucial to consider that the test manifests statistical constraints when applied to datasets with a temporal dimension less than one year. Additionally, its focus is confined exclusively to the frequency of VaR violations, omitting the consideration of the temporal clustering of such risk events. In this regard, the Kupiec test may prove insufficient for the accurate identification of a model in which risk events are not uniformly distributed over time. For this reason, additional tests have been suggested to address these limitations.

3.4.2. Christoffersen Test

The Christoffersen test (Christoffersen, 1998), also known as the Markov Test or Independence Test, is an instrumental method aimed at examining the statistical independence of sequential VaR violations. The test is based on the analysis of whether the probability of a VaR breach on any given day is conditional upon the occurrence or non-occurrence of a violation on the preceding day. This test employs the principle of the likelihood ratio for its execution.

Drawing from the available portfolio performance data spanning n days, the indicator function I_t can be defined on each day as follows:

$$I_t = \begin{cases} 0, & \text{if VaR is not violated,} \\ 1, & \text{otherwise.} \end{cases} \tag{21}$$

The notation $N_{i,j}$ is introduced, where $i, j \in \{0, 1\}$, to denote the number of instances where the current day's state is j while the previous day's state was i. To elucidate, $N_{1,0}$ specifies the instances where $I_n = 0$ given that $I_{n-1} = 1$. These observed frequencies can be organized into a 2×2 contingency table as:

	$I_n = 0$	$I_n = 1$
$I_{n-1} = 0$	N_{00}	N_{01}
$I_{n-1} = 1$	N_{10}	N_{11}

(22)

Conditional probabilities π_0 and π_1 are defined as the likelihood of transitioning from states 0 to 1 and 1 to 1, respectively. Mathematically, $\pi_0 = \frac{N_{01}}{N_{00}+N_{01}}$ and $\pi_1 = \frac{N_{11}}{N_{10}+N_{11}}$.

The test statistic employed to assess the independence of VaR violations is articulated as:

$$LR = -2 \ln \left[(1-\pi)^{N_{00}+N_{01}} \pi^{N_{01}+N_{11}}\right] + 2 \ln \left[(1-\pi_0)^{N_{00}} \pi_0^{N_{01}} (1-\pi_1)^{N_{10}} \pi_1^{N_{11}}\right] \tag{23}$$

Under the null hypothesis, π_0 is assumed to be equal to π_1, indicating that the VaR violations are independent of their preceding states. A significant divergence between these probabilities would warrant the rejection of the null hypothesis, thereby calling the reliability of the extant VaR model into question. Notably, the asymptotic distribution of this test statistic adheres to a chi-square distribution with one degree of freedom.

3.4.3. Engle and Manganelli Test: Wald Statistic Approach

Lastly, Engle and Manganelli (Engle and Manganelli, 2004) introduced a sophisticated technique for VaR backtesting on their paper of 2004, employing a linear regression framework. They defined a variable denoted as $Hit_t(\alpha)$, mathematically articulated as:

$$Hit_t(\alpha) = I_t(\alpha) - \alpha = \begin{cases} 1-\alpha, & \text{if } r_t < VaR_t(\alpha), \\ -\alpha, & \text{otherwise.} \end{cases} \tag{24}$$

Upon establishing this variable, Engle and Manganelli proceeded to fit a linear regression model, incorporating historical data and the information set up to $t-1$:

$$Hit_t(\alpha) = \delta + \sum_{s=1}^{K} Hit_{t-s}(\alpha) + \sum_{s=1}^{K} \gamma_s g[Hit_{t-s}(\alpha), Hit_{t-s-1}(\alpha), \ldots, z_{t-s}, z_{t-s-1}, \ldots] + \eta_t, \tag{25}$$

Here, η_t refers to independently and identically distributed error terms. The function $g(\cdot)$ is dependent on previous violations and a set of variables z_{t-k} that belong to the available information at $t-1$. The terms δ_s and γ_s are coefficients in the model.

The null hypothesis postulates conditional efficiency, suggesting that δ and all coefficients are nullified:

$$H_0 : \delta = \beta_s = \gamma_s = 0, \tag{26}$$

for $s = 1, 2, \ldots, K$. According to this assumption, current VaR violations are statistically independent from previous violations. The concept of unconditional coverage efficiency is invoked when δ equals zero.

The likelihood ratio statistic is then delineated as:

$$LR = \frac{\hat{\varphi}^T Z^T Z \hat{\varphi}}{\alpha(1-\alpha)}, \tag{27}$$

where $\hat{\varphi}$ serves as an estimator for $\varphi = (\delta, \beta_1, \ldots, \beta_K, \gamma_1, \ldots, \gamma_K)^T$ and Z is a matrix of explanatory variables. The asymptotic distribution of this test statistic, as n approaches infinity, adheres to a chi-square distribution with $2K+1$ degrees of freedom.

It is pertinent to note that Engle and Manganelli, in subsequent works following their 2004 publication, explored methodological extensions to their initial model. Specifically, they employed binary models such as probit and logit with the aim of establishing a more precise relationship between current and past VaR violations. This methodological revision emerged in response to the limitations identified in their original linear regression model, which proved to be inefficient in adequately capturing the complexities associated with VaR violations.

3.5. Comparative Analysis Using Sample Tests

Beyond the specialized tests previously discussed for analyzing Value-at-Risk models, this section extends the inquiry to examine whether discrepancies between various portfolio measures hold statistical significance. The methodologies employed for this purpose encompass the t-test, the F-test, and the Wilcoxon test.

3.5.1. t-Test

The t-test stands as a robust statistical tool, predominantly used for comparing the arithmetic means between two different sets, with the aim of evaluating whether the observed differences reach statistical significance (Student, 1908). In the context of the present study, the intent is to contrast the means of investment portfolios predominantly comprised of assets managed by women, compared to the means of portfolios made up exclusively of assets managed by men. The mathematical formulation of the t-statistic is expressed as follows:

$$t = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}} \tag{28}$$

In this equation, $\bar{x}$ denotes the sample mean, which in the context of this research corresponds to the arithmetic mean of investment portfolios primarily comprised of assets managed by women. On the other hand, μ symbolizes the population mean of the second group in the comparison, which in this specific case is the mean of portfolios made up exclusively of assets managed by men. Additionally, s represents the standard deviation of the sample in question, while n refers to the sample size.

3.5.2. F-Test

The F-test is extensively used in the field of analysis of variance (ANOVA) for the purpose of comparing the between-group variance (Fisher, 1925). The F-statistic is mathematically formulated in the following manner:

$$F = \frac{\text{Variance between groups}}{\text{Variance within groups}} \quad (29)$$

3.5.3. Wilcoxon Test

As a non-parametric statistical method, the Wilcoxon test serves as a relevant methodological alternative to the t-test in situations where assumptions of normality are compromised (Wilcoxon, 1945). In the context of the present research, this test will be implemented with the aim of contrasting the sample medians.

4. Data Analysis

Over time, there has been an upward trend in female representation on boards of directors, although this increase has shown heterogeneous acceleration. Annual reports published by Morgan Stanley Capital International (MSCI) suggest that this may be due to the implementation of gender quotas in different jurisdictions.[2] They establish a resultant, albeit non-causal, correlation between gender diversity and improvement in financial metrics and environmental, social, and governance (ESG) performance indicators.

In this context, the main objective of the present research is to employ a quantitative methodological approach to evaluate whether the increase in the proportion of women occupying high-level management positions in companies, which is correlated with a lower propensity for corporate risk, leads to inherently less risky stock returns.

To achieve this objective, the study makes use of annual data series disclosed by MSCI. These data series focus on gender diversity in high-level corporate leadership roles. More specifically, data from corporations with more than 50% female representation on their boards are analyzed, as well as from those companies that have boards composed entirely of men.

MSCI has been methodically cataloging gender diversity statistics in corporate governance structures since 2009. The annual reports serve to monitor

[2]Morgan Stanley Capital International (MSCI) is a US-based firm that provides equity indices, fixed income benchmarks, tools for managing risk across various asset classes, and investment portfolio analysis.

the status of the 2,800 components of the MSCI ACWI index[3]. Given the lack of availability of prior data sets, this research relies on available reports spanning from 2017 to 2024. Within these documents, a selection of approximately ten corporations[4] was identified that exhibit the highest percentage of female board members (See Table A1 in the Annex), along with an equal number of all-male boards (See Table A2 in the Annex) (Ellis and Thwing Eastman, 2018; Emelianova and Milhomem, 2019; Milhomem, 2020, 2021; Matanda et al., 2022).

A notable observation when examining Table A2 is the geographic distribution of the companies, which corroborates earlier research Adams and Ferreira (2009) highlighting the scarcity of female representation on boards in Asia. Such under-representation is attributed to various sociocultural barriers, including family obligations, external professional commitments, and a largely gender-indifferent work ethic. Contradictory, our data set shows a divergence from the findings of Chin (2016); Chia (2017), who indicate the presence of a "glass ceiling" that prevents the upward mobility of women in U.S.-based companies. Evidently, U.S. companies appear in both gender-diverse and all-male categorizations in our sample, as illustrated in Tables A1 and A2.

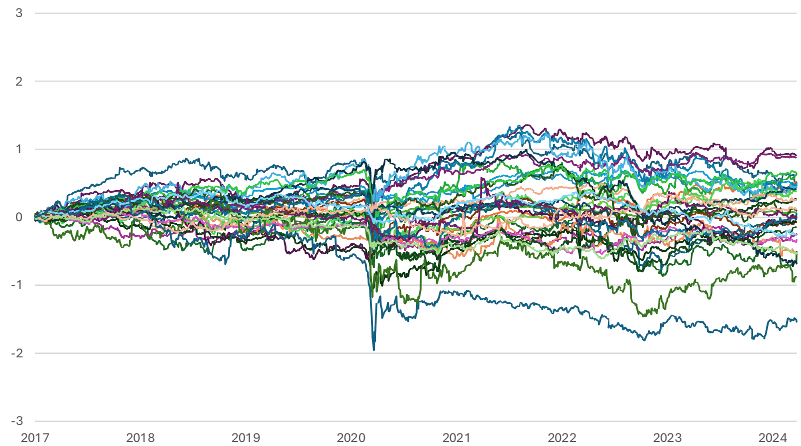
Using the previously described data sets, time-series price data were extracted corresponding to two subsets of companies. The first of these subsets comprises 34 corporations with female majority representation on their boards (50% or more), categorized as FM. The second encompasses 33 companies whose boards are exclusively all male, designated as AM. The collected data cover the time period from January 4, 2017 to March 27, 2024, over which we apply several filters. Given that the asset portfolio in question spans a variety of markets, a time alignment was carried out to ensure the matching of transaction dates across all considered assets. Likewise, a liquidity filter was implemented, excluding those companies that showed more than a 5% null returns during the study period. Additionally, to facilitate a homogeneous comparison between assets, all asset prices were normalized to the U.S. dollar (USD). After these adjustments, it results in a final set of

[3]ACWI stands for All Country World Index, which amalgamates the MSCI World and MSCI Emerging Markets indices, covering nearly 3,000 medium to large-cap corporations across 23 developed and 27 emerging countries.

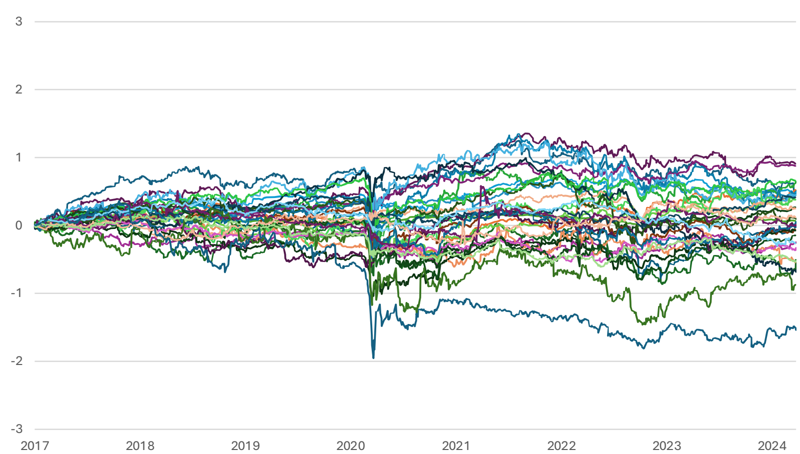
[4]This number is subject to annual fluctuations depending on asset liquidity and the availability of data for comprehensive analysis.

1,232 observations.

The aggregated data are illustrated in Figure 1, which shows the temporal evolution of cumulative returns for both categories of companies. The chart on the left breaks down the performance trends of FM companies, showing generally coherent performance patterns. In contrast, the chart positioned on the right, representing AM companies, indicates a significantly elevated volatility in returns. Nonetheless, both data sets exhibit inherent market trends. For example, a notable decline in returns for both categories is identified at the beginning of the year 2020, a phenomenon possibly attributable to the global repercussions stemming from the COVID-19 pandemic.



(a) Companies with female-majority boards



(b) Companies with all-male boards

Figure 1: Cumulative returns of companies in the MSCI ACWI with Female Majority and All-Males boards (2017-2024). The evolution of the cumulative returns in per cent for each company of the two types of companies (FM and AM) in the sample is shown. The period covered starts from January 2017 and ends in March 2024.

Table 1: Summary statistics for Companies with Majority Female Boards (2017-2024)

Code	Mean	Median	Min	Max	Sd. Dev.	Skewness	Kurtosis
A2	0.00043	0.00116	-0.13629	0.10589	0.02216	-0.44361	4.57394
A6	0.00042	-0.00016	-0.1328	0.13491	0.01927	0.02057	7.83403
A7	-0.00041	0.00065	-0.15294	0.16079	0.02598	0.18743	7.09408
A8	0.00041	0.00063	-0.11084	0.10888	0.01483	0.00567	10.05019
A9	-0.00020	0.00013	-0.10932	0.13753	0.01932	-0.07018	7.70545
A10	0.00006	0.00003	-0.02239	0.01863	0.00493	-0.10601	1.59727
B2	0.00023	0.00071	-0.17126	0.22412	0.02124	0.16668	19.24592
B5	0.00001	0.00083	-0.25241	0.17544	0.02137	-1.54235	31.58536
B6	0.00075	0.00125	-0.14432	0.11958	0.02162	-0.47323	5.71098
B7	0.00039	0.00087	-0.12218	0.15335	0.01613	0.12954	12.30166
B8	-0.00044	-0.00073	-0.14777	0.19261	0.02423	0.54200	8.24362
B9	0.00053	0.00074	-0.19023	0.18185	0.02644	-0.22477	7.44129
C2	0.00032	0.00089	-0.16997	0.16836	0.01825	-0.63271	18.68228
C4	0.00039	0.00107	-0.22900	0.17089	0.02630	-0.69325	9.40538
B14	0.00072	0.00078	-0.08036	0.08403	0.01563	0.24988	3.55317
B12	0.00037	0.00143	-0.18429	0.15053	0.02879	-0.53181	4.61491
C6	0.00020	0.00027	-0.09219	0.06429	0.01640	-0.41643	3.25250
D1	0.00031	0.00009	-0.10851	0.14494	0.02518	0.06467	2.62123
D2	-0.00005	0.00073	-0.14701	0.15102	0.01973	-0.47152	10.62651
D3	-0.00006	0.00058	-0.16757	0.12962	0.02151	-0.81104	9.99471
D4	-0.00002	0.00066	-0.17529	0.10567	0.02262	-0.63052	4.4881
D5	0.00008	0.00130	-0.1969	0.11251	0.02266	-1.21477	8.97969
E2	0.00055	0.00132	-0.15632	0.11250	0.02003	-1.29881	12.26534
E3	-0.00027	0.00013	-0.13846	0.0857	0.01590	-1.20431	11.70754
E4	0.00035	0.00085	-0.13109	0.09701	0.01583	-1.01829	9.68621
E6	-0.00012	0.00034	-0.15002	0.20209	0.02242	0.07479	11.00796
E7	0.00005	0.00027	-0.21442	0.13882	0.02321	-1.06988	14.58729
K1	0.00002	-0.00013	-0.17049	0.25604	0.02556	1.74183	20.45189
K2	-0.00070	0.00000	-0.25439	0.27747	0.03879	0.05098	8.74580
K3	0.00212	0.00026	-0.16158	0.1856	0.03466	0.57228	3.49822
K4	0.00011	0.00000	-0.18394	0.14549	0.01759	-0.12917	16.69535
K6	-0.00023	-0.00004	-0.06532	0.10806	0.01476	0.45688	5.57690
K7	-0.00043	0.00031	-0.14956	0.06577	0.01738	-1.43323	11.21587
K8	-0.00125	-0.00034	-0.28802	0.31702	0.03295	-0.15355	20.67572

Descriptive statistics of the daily returns of the 34 companies considered for the portfolio with majority women. The results correspond to the period between January 2017 to March 2024.

Table 2: Summary statistics for Companies with All-Male Boards (2017-2024)

Code	**Mean**	**Median**	**Min**	**Max**	**Sd. Dev.**	**Skewness**	**Kurtosis**
F1	-0.17079	0.00117	0.0005	0.12151	0.02235	-0.53734	5.39378
F2	-0.15152	0.00171	0.00136	0.16002	0.01845	-0.48074	14.45318
F3	-0.54155	0.00055	-0.00009	0.35519	0.04149	-1.67262	33.51235
F4	-0.24813	0.00113	0.00075	0.21836	0.02502	-0.63828	21.54431
F5	-0.26427	-0.00023	-0.00042	0.20535	0.03412	-0.26807	10.74205
F6	-0.17259	0.00000	0.00009	0.21050	0.03562	0.55888	3.98820
F7	-0.14611	0.00267	0.00158	0.13741	0.02398	-0.18713	5.17073
F8	-0.41577	-0.00051	-0.00096	0.31454	0.03359	-1.98488	38.06154
G1	-0.15349	0.00063	0.00113	0.12654	0.02177	-0.29133	3.81641
G2	-0.07598	-0.00023	-0.00046	0.07263	0.01717	-0.01031	1.96649
G6	-0.11308	0.00041	0.00047	0.10632	0.02628	-0.07284	1.62696
G8	-0.10231	-0.00107	-0.00045	0.10795	0.02109	0.22820	2.86035
G9	-0.29728	0.00000	0.00003	0.13922	0.03085	-1.58781	15.64963
H2	-0.12557	0.00108	0.00072	0.08906	0.01978	-0.13959	2.33919
H3	-0.11203	0.00052	0.00044	0.15082	0.02017	-0.06833	5.22472
H4	-0.13563	0.00107	0.00042	0.10071	0.01956	-0.29602	4.63237
H6	-0.08414	0.00000	0.00084	0.10031	0.02117	0.21999	1.68068
H7	-0.26814	-0.00045	-0.00015	0.33078	0.03224	0.49377	15.87473
I1	-0.11737	0.00000	0.00130	0.20256	0.03609	0.47159	2.86967
I2	-0.14090	0.00000	0.00035	0.10031	0.02283	-0.35335	3.71648
I3	-0.15611	0.00000	0.00098	0.17286	0.02661	0.11706	4.55583
I4	-0.15732	-0.00101	0.0007	0.11442	0.02859	-0.09778	2.81659
J1	-0.09418	-0.00114	-0.0001	0.10253	0.01828	0.45902	4.15301
J2	-0.15017	0.00028	-0.0002	0.08355	0.01645	-0.87642	10.41422
J3	-0.10164	0.00012	-0.00015	0.10676	0.02345	0.01022	3.15030
L1	-0.11248	0.00000	-0.00022	0.06871	0.01439	-0.96848	8.53679
L2	-0.13883	0.00001	0.00043	0.20459	0.02643	0.36126	5.72352
L3	-0.15899	0.00003	0.00085	0.0954	0.01665	-0.61268	10.18502
L4	-0.04578	-0.00004	-0.0001	0.03422	0.00661	-0.41987	6.22874
L5	-0.20139	0.00002	-0.00003	0.08180	0.01637	-1.35996	21.21515
L6	-0.42296	0.00107	-0.00029	0.17830	0.02972	-2.45351	36.5182
L7	-0.18711	0.00000	0.0006	0.11698	0.02892	-0.24888	3.61629
L8	-0.18369	0.00000	0.00049	0.12853	0.02933	-0.20651	3.40736

Descriptive statistics of the daily returns of the 33 companies considered for the all-male portfolio. The data correspond to the period between January 2017 to March 2024.

5. Empirical Analysis

In this section, the empirical results obtained from the implementation of the AR(1)-EGARCH(1,1) model are presented, as described in the Methodology section. Through this model, we have acquired the variance-covariance matrices at the end of each month (Σ_t), which facilitates a dynamic solution to the previously posed minimum variance optimization problem (see Equation 1).

It is pertinent to underline that the portfolio compositions are subject to annual reviews, aligned with MSCI's report publication schedule. As a result, a total of 65 variance-covariance matrices (Σ_t) have been generated for each portfolio cohort, starting from the initial portfolio formulation at the end of October 2018. This analytical framework will be applied to the minimum variance portfolios which will be compared to a static portfolio and two benchmark indices, the S&P 500 and the MSCI index.

The following empirical analysis will be structured around three fundamental components. The first of these components consists of a comparative evaluation of the performance of various investment portfolios, with a particular focus on both gross returns and risk-adjusted returns. The second component involves a scrutiny of the level of risk associated with each portfolio, using the Value at Risk (VaR) metric according to the methodology described in the corresponding section. The underlying purpose of this part of the study is to establish whether the risk-aversion tendency observed in women manifests in portfolios predominantly managed by female directors, in comparison to portfolios whose assets are managed exclusively by male directors. The third and final component of the analysis will implement backtesting techniques at different VaR levels with the aim of validating the robustness of the statistical model used.

5.1. Performance Metrics and Statistical Insights

Initially, a comparative analysis will be carried out to evaluate the performance-based results of the two types of portfolios considered. To this end, reference is made to Table 3, which provides key statistical indicators related to the returns of each portfolio, as well as the returns of the market indices. To determine the statistical significance of the observed differences, sample comparison statistical tests have been employed, the details of which are elaborated in the Methodology section (see Table 4). Subsequently, a risk-adjusted performance comparison will be carried out, using performance ratios as the evaluative metric. These ratios are also described in the Methodology section (see Table 5).

As for the specific returns of the portfolios, Table 3 indicates that portfolios composed of assets from companies with FM boards exhibit lower average returns, but they also demonstrate lower volatility compared to portfolios composed assets from companies with AM boards. These trends are consistent across both implemented strategies, dynamic and static. In juxtaposition with the benchmark results, it is discernible that portfolios formed with assets from companies largely managed by women produce average returns comparable to both indices, but exhibit reduced volatility, particularly when juxtaposed with the S&P 500. These findings suggest that investing in portfolios predominantly managed by women could yield returns comparable to those obtained from an S&P 500-based portfolio, albeit with reduced associated risk.

Table 3: Descriptive statistics of portfolio returns

		Mean	Median	Min	Max	Sd. Dev.	Skewness	Kurtosis
FM	MV	-0.00025	-0.00035	-0.10025	0.08633	0.01264	-0.43185	10.38268
	EW	-0.00011	0.00023	-0.10107	0.08790	0.01334	-0.42286	8.40242
AM	MV	0.00044	0.00030	-0.09229	0.07751	0.01555	-0.22791	2.90861
	EW	0.00019	0.00100	-0.09242	0.07817	0.01485	-0.59241	4.01805
Market SP500		0.00066	0.00117	-0.09997	0.08967	0.01443	-0.88559	8.30888
Market MSCI ACWI		0.00052	0.00103	-0.09985	0.08071	0.01237	-1.17865	11.45126

This table shows the main statistics of the portfolios returns. FM refers to portfolios of assets from companies managed mostly by women, and AM to portfolios of assets from companies managed only by men. The results are differentiated by strategy: Minimum Variance (MV) and Equally Weighted (EW). Also the benchmark portfolios results are shown. The data correspond to the sample period used to construct the portfolios, between October 2018 and March 2024.

To evaluate the statistical significance of variations between portfolio types and investment strategies, multiple tests have been employed, as can be seen in Table 4. Specifically, the T-Test is applied to assess the equality of means between the two sample groups, while the F-Test is used to compare the variances of the respective samples. Additionally, the Wilcoxon Test is used for comparing the medians of the samples under investigation. In all three cases, a low p-value would indicate a statistically significant difference between the samples.

Upon examining the results in Table 4, it is evident that the null hypotheses associated with both the T-Test and the Wilcoxon Test for the two strategies are not rejected, given that the obtained p-values are greater than 0.05. This suggests the absence of significant differences in both the means and medians of the portfolio returns. On the contrary, the F-Test yields a p-value close to zero for both strategies, i.e., dynamic and static, implying a statistically significant difference in variance between the two types of portfolios under these strategies.

Consequently, although the differences in average returns between portfolio types are statistically inconclusive, distinct differences in their volatilities are observed. These observations align with the hypothesis posited by Sila et al. (2016), suggesting that companies with a higher proportion of women on their boards tend to make less risky strategic decisions and investments.

Table 4: Sample Comparision Test for Portfolio Returns

	T-Test	F-Test	Wilcoxon Test
MV	-1.12013 (-0.26279)	0.66092 (0.00000)	572185.00000 (0.20375)
EW	-0.47957 (0.63158)	0.80702 (0.00042)	569857.00000 (0.15271)
Market	0.22936 (0.81861)	1.36125 (0.00000)	599427.00000 (0.55481)

The table shows the results of the various tests performed to see if the differences in the mean, median and variance of the portfolio returns are significant. The results are differentiated by strategy: Minimum Variance (MV) and Equally Weighted (EW). Also the benchmark portfolios results are shown. The data correspond to the sample period used to construct the portfolios, between October 2018 and March 2024.

With respect to risk-adjusted returns, various metrics are employed, as detailed in Table 5 and explained in the Methodology section. Specifically, the Sharpe Ratio evaluates the portfolio's risk-adjusted returns, while the Sortino Ratio modifies the Sharpe Ratio to distinguish downside volatility from total volatility. Lastly, the Treynor Ratio measures the returns earned in excess of a risk-free investment, for which the 1-month U.S. dollar LIBOR curve serves as a reference.

Table 5: Risk-adjusted return measures of portfolio returns

			R.Sharpe	R.Sortino	R.Treynor
FM	MV	SP500 MSCI	0.00504	0.06970	0.00012 0.00009
	EW	SP500 MSCI	0.01505	0.02082	0.00033 0.65247
AM	MV	SP500 MSCI	0.04788	0.06882	-0.12087 -0.06760
	EW	SP500 MSCI	0.03307	0.04508	0.00026 0.03940
Market SP500		SP500 MSCI	0.06676	0.09134	0.00096 0.00087
Market MSCI		SP500 MSCI	0.06721	0.09092	0.00102 0.00083

This table shows the results of the risk-adjusted return measures of portfolio returns. FM refers to portfolios of assets from companies managed mostly by women, and AM to portfolios of assets from companies managed only by men. The results are differentiated by strategy: Minimum Variance (MV) and Equally Weighted (EW). Also the benchmark portfolios results are shown. The data correspond to the sample period used to construct the portfolios, between October 2018 and March 2024.

Upon examining the data in Table 5, it is observed that portfolios of assets from companies primarily managed by women generally outperform their counterparts with assets exclusively managed by men under both strategies as evidenced by the Sharpe Ratio (0.00504 versus 0.04788, respectively, for the MV strategy; and 0.01505 versus 0.03307, respectively, for the EW strategy). However, the Sortino Ratio is higher in the case of portfolios of assets from companies majority lead by women than their all male counterparts under the MV strategy (0.06970 versus 0.06882, respectively). Finally, portfolios with assets exclusively managed by men exhibit a higher Sortino Ratio value (0.04508) compared to portfolios of assets from companies primarily managed by women (0.02082).

The differential performance in the Sortino Ratio between FM and AM portfolios in the MV strategy can be attributed to the diversification flexibility within the MV strategy respect to the EW strategy. The allowance for short-selling in the MV strategy enables a more diversified asset allocation, thereby mitigating the overall portfolio risk without proportional reductions in returns, which elevates the Sortino Ratio. Additionally, the ability to engage in short-selling provides improved control over market risk exposure, thus contributing to more efficient risk management and elevated risk-adjusted returns (Hull (2021); Fabozzi (2004)). Specifically, portfolios employing the MV strategy can more effectively manage downside risk, such as by shorting assets with heavier tail risks, thereby improving the Sortino Ratio.

5.2. Risk Analysis Results

In line with the objective of the present study, a comprehensive risk assessment has been carried out for various investment portfolios. This assessment has been conducted by calculating the VaR, in accordance with methods detailed in the study's corresponding Methodology section. Significance levels of 5% and 1% have been considered in the analysis. The choice of this metric is based on its summarized and easily interpretable nature, qualities that Pearson (2002) highlights as especially useful for comparing market risk across different portfolios. Furthermore, Pearson (2002) also mentions that VaR facilitates the comparison of risk within the same portfolio, effectively contributing to the communication of these risk assessments to company management.

The dataset encompasses 1,232 observations of daily returns for both actively and statically managed portfolios, as well as for the two market benchmark indices. VaR is calculated using a 250-day moving window, with daily re-estimation. This results in 982 VaR observations covering the period from late 2018 to March 2024.

To visually elucidate the evolution of VaR, Figures 2 and 3, are introduced. These figures represent the temporal progression of returns for both types of portfolios across the two investment strategies, MV and EW, and the corresponding VaR at the two selected significance levels (5% in red and 1% in green). Additionally, Figure 4 provides information on the evolution of returns and VaR levels for the benchmark indices at both significance levels.

Upon examining Figures 2 and 3, it becomes evident that portfolios categorized as type FM exhibit greater volatility compared to their type AM

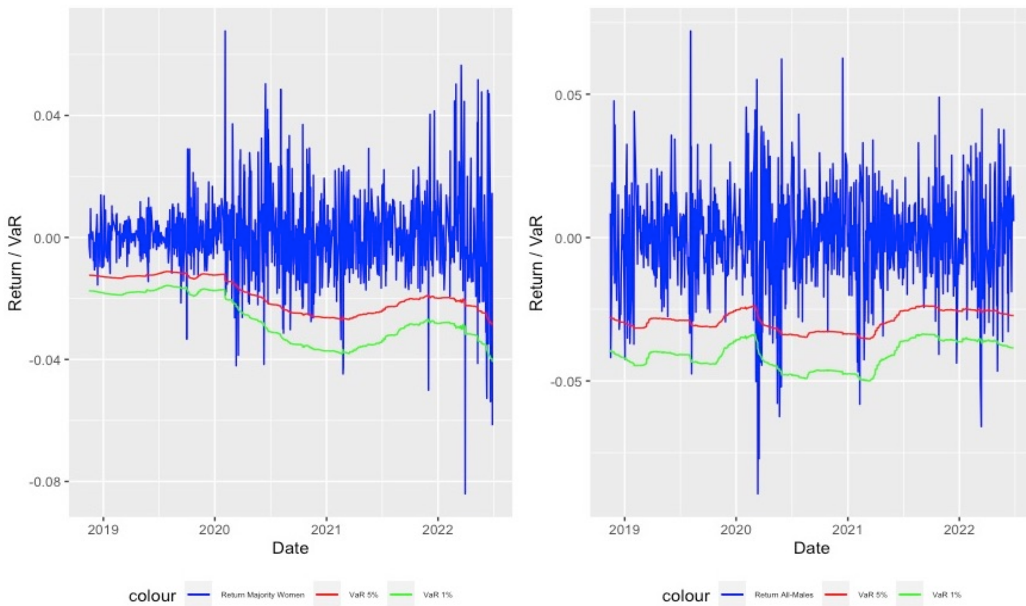


Figure 2: Returns and VaR Evolution for Minimum Variance Portfolios (2018-2024)

The performance evolution and the two VaR levels calculated for the two types of portfolios (FM on the left and AM on the right) are shown for the MV strategy for the entire available period (October 2018 to March 2024).

counterparts across all strategies. Generally, VaR levels are elevated in portfolios managed exclusively by men. When looking at the active management strategy, as demonstrated in Figure 2, the evolution of VaR at both significance levels presents a more pronounced difference for both types of portfolios. Contrary, the evolution of VaR for the EW strategy appears to be congruent, as shown in Figure 3.

Finally, compared to the benchmark indices (see Figure 4), the returns exhibit lower volatility compared to both type FM and type AM portfolios, resulting in lower VaR values.

To enrich the analytical quality of the present study, Table 6 has been prepared, consolidating a series of fundamental statistics related to VaR. This table reveals that under the paradigm of both strategies, MV and EW, and with both, 5% and 1% significance levels, FM portfolios exhibit lower average values of VaR than their counterparts. Particularly, FM (AM) portfolios under the MV and EM strategies presents an average VaR of 0.02132 (0.02649)

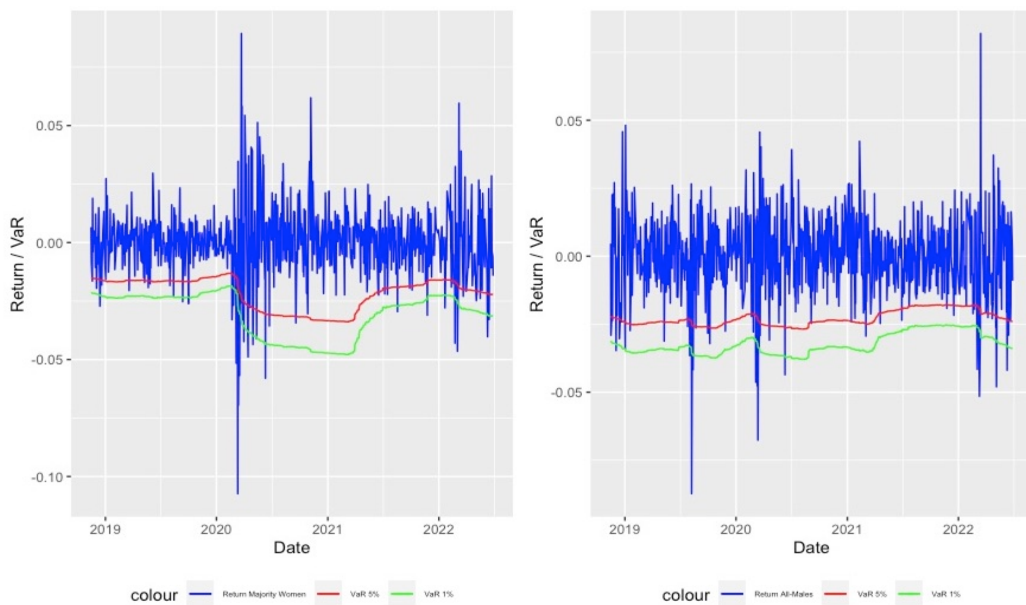


Figure 3: Returns and VaR Evolution for Equally-Weighted Portfolios (2018-2024)

The performance evolution and the two VaR levels calculated for the two samples portfolios (FM on the left and AM on the right) for the EQ strategy chosen for the entire available period (October 2018 to March 2024) are shown.

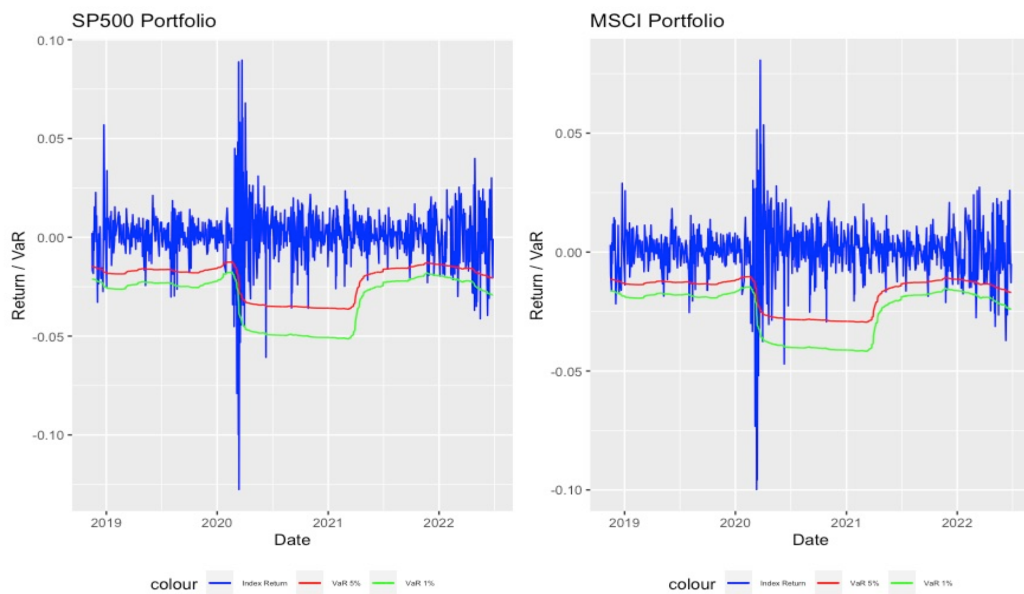


Figure 4: Returns and VaR Evolution for Market Indexes Portfolios (2018-2024)

The performance evolution and the two VaR levels calculated for the benchmark portfolios for the entire available period (October 2018 to March 2024) are shown. From left to right, the portfolio for the MSCI index and the portfolio for the SP500 index.

and 0.02303 (0.02533), respectively, for the 5% significance level, and an average VaR of 0.03015 (0.03747) and 0.03257 (0.03582), respectively, for the 1% significance level. Additionally, an interesting result is observed when comparing average VaR values of FM portfolios and Market portfolios since the FM portfolio under the MV strategy displays a lower average VaR than their market counterparts (for a 5% significance level, 0.02132 versus 0.02480 and 0.02134, for the SP500 and the MSCI, respectively; and for the 1% significance level, 0.03015 versus 0.03508 and 0.03018, for the SP500 and the MSCI, respectively). Besides, in a comparative assessment with benchmark portfolios, it is highlighted that AM portfolios have a higher average VaR compared to portfolios modeled based on the S&P 500 and MSCI indexes.

An additional important finding comes from the contrast between the VaRs calculated with confidence levels of 5% and 1%, as presented in Table 6. As could be expected, stepping up the confidence level from 5% to 1% leads to an amplification of VaR, indicating the inclusion of a wider range of 'tail risk.' Specifically, for MV portfolios, VaR values range from 0.02132 and 0.02649 at a 5% significance level to 0.03015 and 0.03747 at a 1% significance level for FM and AM portfolios, respectively. In this context, although the inherent risk level widens with a reduced significance level, the observation remains that portfolios with assets from companies primarily managed by women incur lower risk levels compared to portfolios with assets from companies exclusively managed by men.

Table 6: VaR principal statistics for portfolios based on gender and strategy

			Mean	Median	Min.	Max.
FM	MV	5%	0.02132	0.02330	0.00658	0.03182
		1%	0.03015	0.03296	0.0931	0.04500
	EW	5%	0.02303	0.02347	0.01361	0.03201
		1%	0.03257	0.03320	0.01925	0.04528
AM	MV	5%	0.02649	0.02646	0.02162	0.03140
		1%	0.03747	0.03743	0.03058	0.04441
	EW	5%	0.02533	0.02481	0.01895	0.03102
		1%	0.03582	0.03508	0.02681	0.04388
Market SP500		5%	0.02480	0.02425	0.01710	0.03390
		1%	0.03508	0.03430	0.02419	0.04795
Market MSCI		5%	0.02134	0.02114	0.01434	0.02921
		1%	0.03018	0.02989	0.02028	0.04131

VaR key statistics are shown at two confidence levels, for portfolios with assets managed mostly by women and for portfolios with assets managed only by men. The results are also differentiated by strategy type: Equally-Weighted, MV and MVS.

As in the section related to *Performance Results*, a set of statistical tests has been carried out, including the t-Test, F-Test, and Wilcoxon Test, to determine the statistical significance of the observed discrepancies in the mean, variance, and median. Table 7 describes the results of these statistical evaluations, carried out for the two investment strategies, MV and EW portfolios. Notably, both portfolios exhibit p-values close to zero in all tests. This empirical evidence strongly supports that there are statistically significant differences in the means, variances, and medians of VaR between portfolios of assets from companies primarily managed by women (FM) and those with assets exclusively managed by men (AM), regardless of the investment strategy employed.

In light of the statistical indicators of VaR and after statistical validation, it is possible to postulate that the empirical findings support the preliminary hypothesis established. Specifically, portfolios composed of assets from companies primarily managed by women show a lower average VaR compared to those comprised exclusively of assets from companies managed by men. This phenomenon corroborates the initial assumption that the lower risk propensity manifested by female managers translates into investment strategies and, consequently, into less volatile stock market returns.

Table 7: Sample Comparision Test for Portfolio's VaR

	T-Test	F-Test	Wilcoxon Test
MV	-18.04206 (0.00000)	8.38686 (0.00000)	204230.00000 (0.00000)
EW	-10.44995 (0.00000)	3.79325 (0.00000)	268337.00000 (0.00000)
Market	12.49367 (0.00000)	1,29203 (0.00022)	464739.00000 (0.00000)

The table shows the results of the various tests performed to see if the differences in the mean, median and variance of the portfolio VaR are significant.

5.3. Backtesting Results

After the completion of the risk assessment process for FM and AM portfolios, under two investment strategies, a backtesting analysis covering the time interval from the end of 2018 to March 2024 has been carried out. The results of this analysis are consolidated in Table 8. The first column of this table details the observed excesses from a set of 932 daily observations. Under the significance levels of 5% and 1%, the theoretically expected exceptions are approximately 52 and 11 days, respectively. To assess the efficacy of the implemented VaR model, various statistical tests have been applied: first, the Kupiec Unconditional Coverage Test; second, the Christoffersen Conditional Coverage Test; and finally, the Engle and Manganelli Test. These tests have been conducted for both investment strategies, Minimum Variance and Equally Weighted Portfolios, and portfolios based on the SP500 and MSCI Market Indices.

In the context of the Kupiec test, the fidelity of the VaR model is examined by comparing empirically observed exceptions to the theoretically expected frequency. For FM portfolios, the MV strategy registers 44 and 24 excesses at the significance levels of 5% and 1%, respectively. On the other hand, the EW strategy exhibits 41 and 22 excesses. Intriguingly, the p-values of the Kupiec test make the VaR estimates largely reliable for both types of portfolios, except for the significance level of 1% in the FM portfolios, where the p-value drops. In the case of AM portfolios, the EW strategy shows higher excesses, thereby having lower reliability, particularly at the 1% level, as demonstrated by a p-value of 0.00376. The Kupiec test, therefore, suggests that MV portfolios are relatively more skilled at reliably predicting VaR, albeit with room for improvement, especially at the 1% significance level.

Shifting the focus to Christoffersen's Conditional Coverage Test, this metric evaluates the efficiency of the VaR model in predicting exceptions based on prior market conditions. According to Table 8, all LR_{chris} values present p-values of 1, indicating that the model's performance is commendable across all investment strategies and demographic compositions, at least according to this specific measure.

Lastly, the Engle and Manganelli Test, symbolized as DQ, is employed to further evaluate the model's predictive acumen. The p-values equal to zero in all DQ measures denote a potential for improving the VaR model's ability to capture more intricate market dynamics more effectively.

Table 8: Results of the different backtesting tests for the portfolios differentiated by gender and strategy.

			Exceesses	LR_{kupiec}	LR_{chris}	DQ
FM	MV	5%	44	0.10908 (0.74119)	-7.25401 (1.00000)	126.67010 (0.00000)
		1%	24	19.56184 (0.00001)	-18.02660 (1.00000)	68.82477 (0.00000)
	EW	5%	41	0.02049 (0.88618)	-8.86619 (1.00000)	109.65020 (0.00000)
		1%	22	15.45340 (0.00008)	-5.61145 (1.00000)	71.45743 (0.00000)
AM	MV	5%	41	0.02049 (0.88618)	-0.00004 (1.00000)	80.91585 (0.00000)
		1%	15	4.27903 (0.03859)	-0.54748 (1.00000)	44.30231 (0.00000)
	EW	5%	45	0.23599 (0.62712)	-0.08576 (1.00000)	100.51370 (0.00000)
		1%	18	8.39484 (0.00376)	-0.79127 (1.00000)	47.38873 (0.00000)
Market	SP500	5%	42	0.00025 (0.98736)	-14.94066 (1.00000)	114.18440 (0.00000)
		1%	26	24.01383 (0.00000)	-7.27323 (1.00000)	91.37685 (0.00000)
	MSCI	5%	37	0.62687 (0.42850)	-8.01755 (1.00000)	119.43590 (0.00000)
		1%	26	24.01383 (0.00000)	-3.88802 (1.00000)	96.09321 (1.00000)

The table shows the backtesting results for two confidence levels of the VaR of portfolios with assets from companies managed mostly by women (FM) and the VaR of portfolios with assets from companies managed only by men (AM). The results are differentiated by strategy: Minimum Variance (MV) and Equally Weighted (EW). We present the number of excesses, the three contrast statistics and the p-value. LR_{kupiec} refers to Kupiec's unconditional hedging contrast statistic; LR_{chris} refers to Christoffersen's conditional hedging contrast statistic and DQ refers to Engle and Manganelli's contrast statistic.

6. Conclusions

The objective of this study is to empirically assess the influence of financial decisions made by women serving on boards, on the risk associated with stock market assets. Women in leadership roles often exhibit a more conservative approach, as highlighted by Gul et al. (2011) and Byrnes et al. (1999). The examination considers two different sets of portfolios: the first includes portfolios composed of shares from predominantly female-led companies, while the second set focuses on portfolios consisting solely of assets from male-led firms. Additionally, three investment strategies have been employed to discern any differential trends in risk metrics between active and passive portfolio management.

The data used come from MSCI's annual gender diversity reports, covering the period from 2018 to 2022. Portfolio construction and dynamic optimization were carried out using a minimum variance approach for actively managed portfolios, using an AR(1)-EGARCH(1,1) modeling framework. A multifaceted performance evaluation was subsequently conducted using various risk-adjusted performance metrics, including among others, the Sharpe and Sortino ratios.

Upon concluding the performance evaluation, the research proceeded to an in-depth risk analysis using Parametric Value at Risk (VaR) as an indicator. The empirical VaR data support our initial stance, confirming that portfolios mainly composed of female-led corporations incur lower risk exposure compared to their male-led counterparts. This aligns with existing literature suggesting that women's decision-making often leans towards a conservative stance, consequently attenuating the risk profile of the organizations they lead.

The results of this research confirm the initial hypothesis, evidencing that investment portfolios largely composed of assets managed by women exhibit lower volatility. This observation aligns with the conclusions delineated by Farrell and Hersch (2005). Such a result stands out as one of the most significant contributions of our study, suggesting that gender could be a relevant variable for risk mitigation in the context of active portfolio management.

However, it's crucial to highlight the inherent limitations of this study. In particular, the research is confined by its focus on a single risk metric. Additionally, deficiencies in the employed backtesting techniques, such as the Kupiec coverage tests and the *DQ* test by Engle and Manganelli, have been identified. These limitations point to the need for incorporating more sophisticated risk metrics in future research to affirm the robustness of the findings presented.

In this direction, we propose to continue with the research line focused on implementing advanced dynamic models for calculating the VaR of investment portfolios. Specifically, we recommend adopting the conditional copula-GARCH model, as outlined by Huang et al. (2009). The empirical results derived from this model demonstrate that, compared to more traditional methodological approaches, the conditional copula-GARCH captures VaR more accurately and effectively.

Appendix A. Appendix

Table A1: Companies with Majority Women on Boards (2018-2023)

	Code	Name of the company	Code	Currency	Country
2018	A2	Kering S.A	KER.PA	EUR	France
	A6	Thales S.A.	HO.PA	EUR	France
	A7	H & M	HM-B.ST	SEK	Sweden
	A8	Diageo plc	DEO	USD	UK
	A9	Omnicom Group Inc.	OMC	USD	USA
	A10	Icade S.A	ICAD.PA	EUR	France
2019	A2	Kering S.A.	KER.PA	EUR	France
	A7	H & M	HM-B.ST	SEK	Sweden
	B2	Sodexo S.A.	SW.PA	EUR	France
	B5	Etablissementen Franz Colruyt	COLR.BR	EUR	Belgium
	B6	Hexagon Aktiebolag	HEXA-B.ST	SEK	Sweden
	A6	Thales S.A.	HO.PA	EUR	France
	B7	American Water Works	AWK	USD	USA
	B8	Beijing Tongrentang Co.	600085.SS	CNY	China
	B9	General Motors Company	GM	USD	USA
	A9	Omnicom Group Inc.	OMC	USD	USA
2020	A9	Omnicom Group Inc.	OMC	USD	USA
	C2	AXA	CS.PA	EUR	France
	A2	Kering S.A	KER.PA	EUR	France
	A7	H & M	HM-B.ST	SEK	Sweden
	B2	Sodexo S.A.	SW.PA	EUR	France
	C4	Kinnevik	KINV-B.ST	SEK	Sweden
	B14	L' Oreal	OR.PA	EUR	France
	A6	Thales S.A.	HO.PA	EUR	France
	B12	Best Buy Co	BBY	USD	USA
	C6	Severn Trent	SVT.L	GBP	UK
2021	D1	The Bidvest Group	BVT.JO	Zac	South Africa
	A9	Omnicom Group Inc.	OMC	USD	USA
	A2	Kering S.A	KER.PA	EUR	France
	A8	Diageo plc	DEO	USD	UK
	C7	Cable One	CABO	USD	USA
	D2	Wendel	MF.PA	EUR	France
	D3	Publicis Groupe	PUB.PA	EUR	France
	B2	Sodexo	SW.PA	EUR	France
	D4	Tiger Brands	TBS.JO	Zac	South Africa
	D5	Fortum Oyj	FORTUM.HE	EUR	Finland
2022	D1	The Bidvest Group	BVT.JO	Zac	South Africa
	A8	Diageo plc	DEO	USD	UK
	E2	Macquarie Group	MQG.AX	AUD	Australia
	A9	Omnicom Group Inc.	OMC	USD	USA
	E3	Saputo Inc.	SAP.TO	CAD	Canada
	C4	Kinnevik	KINV-B.ST	SEK	Sweden
	E4	Intercontinental Exchange	ICE	USD	USA
	C7	Cable One	CABO	USD	USA
	E6	Accor	AC.PA	EUR	France
	E7	Citigroup	C	USD	USA
2023	K1	Seagen Inc.	BVT.JO	Zac	South Africa
	A8	Diageo plc	DEO	USD	UK
	E2	Macquarie Group	MQG.AX	AUD	Australia
	A9	Omnicom Group Inc.	OMC	USD	USA
	E3	Saputo Inc.	SAP.TO	CAD	Canada
	C4	Kinnevik	KINV-B.ST	SEK	Sweden
	E4	Intercontinental Exchange	ICE	USD	USA
	C7	Cable One	CABO	USD	USA
	E6	Accor	AC.PA	EUR	France
	E7	Citigroup	C	USD	USA

List of companies with majority of women on boards (more than 50 %) according to MSCI annually reports. This information correspond to the sample period of October 2018 to March 2024 (Ellis and Thwing Eastman, 2018; Emelianova and Milhomem, 2019; Milhomem, 2020, 2021; Matanda et al., 2022; Csonka and Milhomem, 2023).

Table A2: Companies with All-Males on Boards (2018-2023)

	Code	Name of the Company	Code	Currency	Country
2018	F1	Southern Copper Corporation	SCCO	USD	USA
	F2	Copart, Inc.	CPRT	USD	USA
	F3	Nektar Therapeutics	NKTR	USD	USA
	F4	Transdigm Group Incorporated	TDG	USD	USA
	F5	Tripadvisor, Inc.	TRIP	USD	USA
	F6	Nexteer Automotive Group Limited	1316.HK	HKD	USA
	F7	Veeva Systems Inc	VEEV	USD	USA
	F8	Plains GP Holdings, L.P	PAGP	USD	USA
2019	G1	Kweichow Mountai	600519.SS	CNY	China
	G2	China Mobile	CTM.F	EUR	China
	G6	Hangzhou Hikvision Digital Technology	002415.SZ	CNY	China
	G8	SAIC Motor Corporation Limited	600104.SS	CNY	China
	G9	Ecopetrol S.A.	EC	USD	Colombia
2020	G1	Kweichow Mountai	600519.SS	CNY	China
	G5	JD.Com	JD	USD	China
	G2	China Mobile	CTM.F	EUR	China
	H2	Keyence Corportation	KYCCF	USD	Japan
	H3	Fast Retailing Co.	FRCOY	USD	Japan
	H4	Shin-Etsu Chemical	SHECY	USD	Japan
	H6	China Shenhua Energy Company Limited	CSUAY	USD	China
	H7	Baidu, Inc.	BIDU	USD	China
	F1	Southern Copper Corporation	SCCO	USD	USA
2021	G1	Kweichow Mountai	600519.SS	CNY	China
	I1	Byd Company	BYDDY	USD	China
	H4	Shin-Etsu Chemical	SHECY	USD	Japan
	H3	Fast Retailing Co.	FRCOY	USD	Japan
	H7	Baidu, Inc.	BIDU	USD	China
	I2	China Shenhua Energy	CSUAY	USD	China
	I3	MediaTek Inc.	2454.TW	TWD	Taiwan
	F1	Southern Copper Corporation	SCCO	USD	USA
	I4	Jiangsu Yanghe Brewery Joint-Stock Co.	002304.SZ	CNY	China
2022	G1	Kweichow Mountai	600519.SS	CNY	China
	I1	Byd Company	BYDDY	USD	China
	H4	Shin-Etsu Chemical	SHECY	USD	Japan
	H7	Baidu, Inc.	BIDU	USD	China
	F1	Southern Copper Corporation	SCCO	USD	USA
	I4	Jiangsu Yanghe Brewery Joint-Stock Co.	002304.SZ	CNY	China
	J1	China State Construction Engineering Corporation Limited	601668.SS	CNY	China
	J2	Canon Inc.	CAJPY	USD	Japan
	J3	PT Telkom Indonesia	PTI.BE	EUR	Indonesia

List of companies with all-males on boards according to MSCI annually reports. This information correspond to the sample period of October 2018 to June 2024 (Ellis and Thwing Eastman, 2018; Emelianova and Milhomem, 2019; Milhomem, 2020, 2021; Matanda et al., 2022; Csonka and Milhomem, 2023).

References

Adams, R.B., Ferreira, D., 2007. A theory of friendly boards. The Journal of Finance 62, 217–250.

Adams, R.B., Ferreira, D., 2009. Women in the boardroom and their impact on governance and performance. Journal of Financial Economics 94, 291–309. https://doi.org/10.1016/j.jfineco.2008.10.007.

Adams, R.B., Funk, P., 2012. Beyond the glass ceiling: does gender matter? Managemet Science 58, 219–235.

Ahern, K.R., Dittmar, A., 2012. The changing of the boards: the impact on firm valuation of mandated female board representation. The Quarterly Journal of Economics 127, 137–197. https://doi.org/10.1093/qje/qjr049.

Alhosani, N.H.I., Nobanee, H., 2023. Board gender diversity and corporate social responsibility: A bibliometric analysis. Heliyon 9, e12734. https://doi.org/10.1016/j.heliyon.2022.e12734.

Atkinson, S.M., Baird, S.B., Frye, M.B., 2003. Do female mutual fund managers manage differently. Journal of Financial Research 26, 1–18.

Barber, B.M., Odean, T., 2001. Boys will be boys: Gender, overconfidence, and common stock investment. The Quarterly Journal of Economics 116, 261–292.

Bear, S., Rahman, N., Post, C., 2010. The impact of board diversity and gender composition on corporate social responsibility and firm reputation. Journal of Business Ethics 97, 207–221. https://doi.org/10.1007/s10551-010-0505-2.

Berger, A.N., Kick, T., Schaeck, K., 2014. Executive board composition and bank risk taking. Journal of Corporate Finance 28, 48–65.

Betz, M., O'Connell, L., Shepard, J.M., 1989. Gender differences in proclivity for unethical behavior. Journal of Business Ethics 8, 321–324.

Bhimani, A., 2009. Risk management, corporate governance and management accounting: Emerging interdependencies. Management Accounting Research 20, 2–5.

Bowman, E.H., 1980. A risk–return paradox for strategic management. Sloan Management Review 21, 17–31.

Bowman, E.H., 1982. Risk seeking by troubled firms. Sloan Management Review 23, 33–43.

Brammer, S., Millington, A., Pavelin, S., 2009. Corporate reputation and women on the board. British Journal of Management 20, 17–29.

Bruna, M.G., Dang, R., Scotto, M.J., Ammari, A., 2019. Does board gender diversity affect firm risk-taking? evidence from the french stock market. Journal of Management & Governance 23, 915–938.

Byrnes, J.P., Miller, D.C., Schafer, W.D., 1999. Gender differences in risk taking: A meta-analysis. Psychological Bulletin 125, 367–383.

Mateos de Cabo, M.R., Gimeno, R., Nieto, J.M., 2012. Gender diversity on european banks' boards of directors. Journal of Business Ethics 109, 145–162.

Campbell, K., Minguez-Vera, A., 2008. Gender diversity in the boardroom and firm financial performance. Journal of Business Ethics 83, 435–451. https://doi.org/10.1007/s10551-007-9630-y.

Carter, D.A., Simkins, B.J., Simpson, W.G., 2003. Corporate governance, board diversity, and firm value. Financial Review 38, 33–53. https://doi.org/10.1111/1540-6288.00034.

Catalyst, 2004. The bottom line: Connecting corporate performance and gender diversity. Technical Report. Catalyst. New York.

Chapple, L., Humphrey, J.E., 2014. Does board gender diversity have a financial impact? evidence using stock portfolio performance. Journal of Business Ethics 122, 709–723. https://doi.org/10.1007/s10551-013-1785-0.

Chatjuthamard, P., Jiraporn, P., Lee, S.M., 2021. Does board gender diversity weaken or strengthen executive risk-taking incentives? PloS one 16, e0258163. https://doi.org/10.1371/journal.pone.0258163.

Chia, K., 2017. Boys' clubs still dominate in company boardrooms across asia. URL: `https://www.bloomberg.com/news/articles/2017-06-12/asia-trailsrest-of-world-in-putting-women-on-company-boards`.

Chin, C., 2016. Women at the top. URL: https://www.pressreader.com/malaysia/the-starmalaysia/20161120/281732679076632.

Christoffersen, P.F., 1998. Evaluating interval forecasts. International Economic Review 39, 841–862.

Coles, J.L., Naveen, D., Naveen, L., 2008. Boards: does one size fit all? Journal of Financial Economics 87, 329–356.

Csonka, A., Milhomem, C., 2023. Women on boards and beyond: 2023 progress report. URL: https://www.msci.com/research-and-insights/women-on-boards-and-beyond-2023.

Demsetz, H., Lehn, K., 1985. The structure of corporate ownership: Causes and consequences. Journal of Political Economy 93, 1155–77.

Díaz, A., García-Donato, G., Mora-Valencia, A., 2017. Risk quantification in turmoil markets. Risk Management 19, 202–224. https://doi.org/10.1057/s41283-017-0018-8.

Earley, C.P., Mosakowski, E., 2000. Creating hybrid team cultures: an empirical test of transactional team. Academy of Management Journal 43, 26–49. https://doi.org/10.2307/1556384.

Ellis, M., Thwing Eastman, M., 2018. Women on boards progress report 2018. URL: https://www.msci.com/www/research-report/women-on-boards-progress-report/01210712745.

Emelianova, O., Milhomem, C., 2019. Women on boards: 2019 progress report. URL: https://www.msci.com/www/research-report/women-on-boards-2019-progress/01667826614.

Engle, R.F., Manganelli, S., 2004. Caviar: Conditional autoregressive value at risk by regression quantiles. Journal of Business & Economic Statistics 22, 367–381.

Erhardt, N.L., Werbel, J.D., Shrader, C.B., 2003. Board of director diversity and firm financial performance. Corporate Governance: An International Review 11, 102–11. https://doi.org/10.1111/1467-8683.00011.

Fabozzi, F.J., 2004. Short Selling: Strategies, Risks, and Rewards. Wiley.

Faccio, M., Marchica, M., Mura, R., 2016. Ceo gender, corporate risk-taking, and the efficiency of capital allocation. Journal of Corporate Finance 39, 193–209.

Farrell, K., Hersch, P., 2005. Additions to corporate boards: the effect of gender. Journal of Corporate Finance 11, 85–106.

Fernández-Torres, Y., Gutiérrez-Fernández, M., Gallego-Sosa, C., 2021. Environmental performance of the tourism sector from a gender diversity perspective. International Journal of Environmental Research and Public Health 18, 8834. https://doi.org/10.3390/ijerph18168834.

Fisher, R.A., 1925. Statistical Methods for Research Workers. Oliver and Boyd, Edinburgh.

García-Izquierdo, A.L., Fernández-Méndez, C., Arrondo-García, R., 2018. Gender diversity on boards of directors and remuneration committees: The influence on listed companies in spain. Frontiers in Psychology 9, 1351. https://doi.org/10.3389/fpsyg.2018.01351.

Ghafoor, S., Duffour, K.A., Khan, U.F., Khan, M.K., 2022. Social wellbeing, board-gender diversity, and financial performance: Evidence from chinese fintech companies. Frontiers in Psychology 13, 862897. https://doi.org/10.3389/fpsyg.2022.862897.

Godfrey, P.C., 2005. The relationship between corporate philanthropy and shareholder wealth: A risk management perspective. Academy of Management Review 30, 777–798.

Gregory-Smith, I., Main, B.G.M., O'Reilly, C.A., 2014. Appointments, pay and performance in uk boardrooms by gender. Economic Journal 124, F109–F128.

Gul, F.A., Srinidhi, B., Ng, A.C., 2011. Does board gender diversity improve the informativeness of stock prices. Journal of Accounting and Economics 51, 314–338.

Gulamhussen, M.A., Santa, S.F., 2015. Female directors in bank boardrooms and their influence on performance and risk-taking. Global Finance Journal 28, 10–23. https://doi.org/10.1016/j.gfj.2015.11.002.

Harris, M., Raviv, A., 2008. A theory of board control and size. Review of Financial Studies 21, 1797–1832.

Herring, C., 2009. Does diversity pay? race, gender, and the business case for diversity. American Sociological Review 74, 208–224. https://doi.org/10.1177/000312240907400203.

Hinz, R., McCarthy, D., Turner, J., 1997. Positioning pensions for the twenty-first century. University of Pennsylvania Press, Philadelphia, PA. chapter 6. pp. 91–103.

Huang, J., Kisgen, D.J., 2013. Gender and corporate finance: are male executives overconfident relative to female executives? Journal of Financial Economics 108, 822–839.

Huang, J., Lee, K., Liang, H., Lin, W., 2009. Estimating value at risk of portfolio by conditional copula-garch method. Insurance Mathematics & Economics 45, 315–324. https://doi.org/10.1016/j.insmatheco.2009.09.009.

Hull, J.C., 2021. Risk Management and Financial Institutions. 5th ed., Wiley.

Kahneman, D., Tversky, A., 1979. Prospect theory: An analysis of decision under risk. Econometrica 47, 263–291.

Kanter, R.M., 1977. Men and women of the corporation. Basic Books, New York.

Khan, W.A., Vieito, J.P., 2013. Ceo gender and firm performance. Journal of Economics and Business 67, 55–66.

Kupiec, P.H., 1995. Techniques for verifying the accuracy of risk measurement models. Technical Report 24. Division of Research and Statistics, Division of Monetary Affairs, Federal Reserve Board. Washington, DC.

Larcker, D.F., Richardson, S.A., Tuna, A.I., 2007. Corporate governance, accounting outcomes and organizational performance. The Accounting Review 82, 963–1008.

Lindstädt, H., Wolff, M., Fehre, K., 2011. Frauen in Führungspositionen: Auswirkungen auf den Unternehmenserfolg. Technical Report. Institut für Unternehmensführung, Karlsruher Institut für Technologie.

Lucas-Pérez, M.E., Mínguez-Vera, A., Baixauli-Soler, J.S., Martín-Ugedo, J.F., Sánchez-Martín, G., 2014. Women on the boards and manager's pay: evidence from spain. Journal of Business Ethics https://doi.org/10.1007/s10551-014-2148-1.

Mackey, A., Mackey, T.B., Barney, J.B., 2007. Corporate social responsibility and firm performance: investor preferences and corporate strategies. Academy of Management Review 32, 817–835. https://doi.org/10.5465/amr.2007.25275676.

Markowitz, H., 1952. Portfolio selection. Journal of Finance 7, 77–91.

Matanda, T., Wang, C., Emelianova, O., 2022. Women on boards progress report 2022. URL: https://www.msci.com/research-and-insights/women-on-boards-progress-report-2022.

McGuire, J., Sundgren, A., Schneeweis, T., 1988. Corporate social responsibility and firm financial performance. Academy Management Journal 31, 854–872.

Milhomem, C., 2020. Women on boards: 2020 progress report. URL: https://www.msci.com/www/women-on-boards-2020/women-on-boards-2020-progress/02212172407.

Milhomem, C., 2021. Women on boards: Progress report 2021. URL: https://www.msci.com/www/women-on-boards-2020/women-on-boards-progress-report/02968585480.

Naveed, K., Voinea, C.L., Roijakkers, N., 2022. Board gender diversity, corporate social responsibility disclosure, and firm's green innovation performance: Evidence from china. Frontiers in psychology 13, 892551. https://doi.org/10.3389/fpsyg.2022.892551.

Nguyen, T.H.H., Ntim, C.G., Malagila, J.K.M., 2020. Women on corporate boards and corporate financial and non-financial performance: a systematic literature review and future research agenda. International Review Financial Analisys 71, 101554. https://doi.org/10.1016/j.irfa.2020.101554.

Orazalin, N., Baydauletov, M., 2020. Corporate social responsibility strategy and corporate environmental and social performance: the moderating role of board gender diversity. Corporate Social Responsibility and Environmental Management 27, 1664–1676. https://doi.org/10.1002/csr.1915.

Orazalin, N., Mahmood, M., 2021. Toward sustainable development: board characteristics, country governance quality, and environmental performance. Business Strategy and the Environment 30, 3569–3588. https://doi.org/10.1002/bse.2820.

O'Reilly, C.A., Main, B.G.M., 2012. Women in the Boardroom: Symbols or Substance? Technical Report 2098. Stanford Graduate School of Business. Stanford, CA.

Pearson, N.D., 2002. Risk Budgeting: Portfolio Problem solving with Value-at-Risk. http://ci.nii.ac.jp/ncid/ba56109267.

Poletti-Hughes, J., Briano-Turrent, G., 2019. Gender diversity on the board of directors and corporate risk: A behavioural agency theory perspective. International Review of Financial Analysis 62, 80–90.

Post, C., Byron, K., 2015. Women on boards and firm financial performance: A meta-analysis. Academy of Management Journal 58, 1546–1571.

Post, C., Rahman, N., Rubow, E., 2011. Green governance: boards of directors' composition and environmental corporate social responsibility. Business & Society 50, 189–223. https://doi.org/10.1177/0007650310394642.

Powell, M., Ansic, D., 1997. Gender differences in risk behaviour in financial decision-making: An experimental analysis. Journal of Economic Psychology 18, 605–628.

Rehbein, K., Logsdon, J.M., Van Buren, H.J., 2013. Corporate responses to shareholder activists: considering the dialogue alternative. Journal of Business Ethics 112, 137–154. https://doi.org/10.1007/s10551-012-1237-2.

Rivas, J.L., 2012. Diversity and internationalization: the case of boards and tmt's. International Business Review 21, 1–12.

Rose, C., 2007. Does female board representation influence firm performance? the danish evidence. Corporate Governance: An International Review 15, 404–413.

Ruigrok, W., Peck, S., Tacheva, S., 2007. Nationality and gender diversity on swiss corporate boards. Corporate Governance: An International Review 15, 546–557.

Sapienza, P., Zingales, L., Maestripieri, D., 2009. Gender differences in financial risk aversion and career choices are affected by testosterone. Proceedings of the National Academy of Sciences 106, 15268–15273.

Sartawi, I.I.M., Hindawi, R.M., Bsoul, R., 2014. Board composition, firm characteristics, and voluntary disclosure: The case of jordanian firms listed on the amman stock exchange. International Business Research 7, 67. https://doi.org/10.5539/ibr.v7n6p67.

Setiyono, B., Tarazi, A., 2014. Does diversity of bank board members affect performance and risk? evidence from an emerging market. http://ssrn.com/abstract=2491145.

Shaheen, R., Yang, H., Bhutto, M.Y., Bala, H., Khan, F.N., 2021. Assessing the effect of board gender diversity on csr reporting through moderating role of political connections in chinese listed firms. Frontiers in psychology 12, 796470. https://doi.org/10.3389/fpsyg.2021.796470.

Sharpe, W.F., 1966. Mutual fund performance. Journal of Business 39, 119–138.

Shrader, C., Blackburn, V., Iles, P., 1997. Women in management and firm financial performance: An exploratory study. Journal of Managerial Issues 9, 355–372.

Sila, V., Gonzalez, A., Hagendorff, J., 2016. Women on board: Does boardroom gender diversity affect firm risk? Journal of Corporate Finance 36, 26–53. https://doi.org/10.1016/j.jcorpfin.2015.10.003.

Singh, V., Vinnicombe, S., Johnson, P., 2001. Women directors on top uk boards. Corporate Governance: An International Review 9, 206–216.

Smith, N., Smith, V., Verner, M., 2006. Do women in top management affect firm performance? a panel study of 2,500 danish firms. International Journal of Productivity and Performance Management 55, 569–593.

Sortino, F.A., Price, L.N., 1994. Performance measurement in a downside risk framework. The Journal of Investing 3, 59–64.

Student, 1908. The probable error of a mean. Biometrika 6, 1–25.

Terjesen, S., Singh, V., 2008. Female presence on corporate boards: a multi-country study of environmental context. Journal of Business Ethics 83, 55–63.

Torchia, M., Calabro, A., Huse, M., 2011. Women directors on corporate boards: from tokenism to critical mass. Journal of Business Ethics 102, 299–317.

Treynor, J.L., 1965. How to rate management of investment funds. Harvard Business Review January–February.

Treynor, J.L., Mazuy, K., 1966. Can mutual funds outguess the market? Harvard Business Review July.

Wang, J., Coffey, B.S., 1992. Board composition and corporate philanthropy. Journal of Business Ethics 11, 771–778. doi:10.1007/BF00872309.

Watson, W.E., Kumar, K., Michaelsen, L.K., 1993. Cultural diversity's impact on interaction process and performance: Comparing homogenous and diverse task groups. Academy of Management Journal 36, 590–602.

Wiersema, M.F., Bantel, K.A., 1992. Top management team demography and corporate strategic change. Academy of Management Journal 35, 91–191.

Wilcoxon, F., 1945. Individual comparisons by ranking methods. Biometrics Bulletin 1, 80–83.

Xu, S., Chen, X., Li, A., Xia, X., 2020. Disclosure for whom? government involvement, csr disclosure and firm value. Emerging Markets Review 44, 100717. https://doi.org/10.1016/j.ememar.2020.100717.

Zhang, Y., Nadarajah, S., 2017. A review of backtesting for value at risk. Communications in Statistics - Theory and Methods , 1–24https://doi.org/10.1080/03610926.2017.1361984.