Data Science

Capstone Report - Fall 2022

Gender Differences in Executives' Corporate Decision Making in the Covid-19 Pandemic

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Abstract

In this study, we examine gender differences in executives' corporate decision-making during the Covid-19 pandemic. According to previous research, women generally take fewer risks when making financial decisions, but they also tend to be more resilient to stress than men. The recent Covid-19 global pandemic adversely affects many industries, which provides us with the opportunity to investigate gender differences in corporate decision-making under risky, uncertain, and stressful conditions. We gathered corporate and executive data of U.S. publicly listed companies between 2016 and 2021 and applied the panel data analysis method to explore gender differences in corporate decision-making during the pandemic. The results indicate that, surprisingly, companies with more female executives tend to make more risky corporate decisions and are less affected by Covid-19. We further discuss the policy, management, and social implications of our research, as well as limitations and future directions.

Contents

1 Introduction

A considerable amount of literature has investigated gender differences in decision-making under risk and uncertainty. Experimental studies consistently show that males tend to invest more than females and are more financially risk-taking [1, 2, 3, 4]. This behavior pattern has also been validated by survey data. For example, the 1989 Survey of Consumer Finances revealed that 57 percent of females reported that they were unwilling to take financial risks, compared to 41 percent of males [5]. These repeatedly observed gender differences in risk-taking were found to be associated with differences in biological traits and cultural norms [6, 7].

Although females are found to be more risk-averse than males, there is also evidence suggesting that females are more resilient to pressure than males [8, 9, 10]. However, a major limitation of studies of this type is that they are typically conducted in laboratories where physiological reactions and choices are measured in response to stimuli and hypothetical questions, and it is unclear whether the experimental results are reliable since compensations are usually small and may not motivate participants enough to elicit meaningful responses. Thus, the question remains as to how gender differences in decision-making play out in real-world situations involving stress and risk, especially in corporate settings where executives are responsible for the majority of decisions.

This study thus aims to address the above issues and explore gender differences in decision-making in real-world settings. The breakout of the Covid-19 pandemic starting in 2019 provides an exogenous shock that enables us to analyze gender differences in executives' reactions to the pressure and risks it brought about when making corporate decisions. Therefore, the goal of this project is to determine how the impact of Covid-19 on corporate decisions varies by the gender of the executives. Are these gender differences further exaggerated or diminished due to Covid-19? What will be their potential impact on future corporate performance? We are particularly interested in three major aspects of corporate decision-making, including risk-taking, cash-holding decisions, and innovation.

In order to answer the above research questions, we gathered data containing corporate activities and executive characteristics of U.S. publicly listed companies between 2016 and 2021. We also obtained the financial accounting data from Compustat, a market and corporate finance database on global companies worldwide. Data related to executives such as compensation, working experience, and demographic information were collected from ExecuComp. Stock market data

including the return, price, and volatility will be gathered from CRSP. We merge these data and construct an archived panel data set that contains pre-Covid and post-Covid data for our main statistical analysis.

The results of our study indicate that companies with more female executives on their boards increased their leverage more, experienced a lower increase in stock market volatility, reduced cash holdings more, and reduced Research and Development (R&D) spending more than companies with fewer female executives on their boards. These patterns indicate that companies with more female executives generally took more risks and were less affected by the pandemic when making corporate decisions.

2 Related Work

This section will look into previous works and provide relevant information regarding the following three aspects: first of all, we will go through some studies that summarize how the Covid-19 pandemic influences corporate performance to better explain our intuition on the formulation of research questions for this project. Next, we will introduce some recent research works related to corporate decisions in order to present a general overview of some common methodologies up to date. Furthermore, since gender difference is the primary focus of this project, we will compare and review some related research works on female and/or male executives in the last section.

2.1 Covid-19 Pandemic Influences

The outbreak of the novel Coronavirus (Covid-19) has rapidly spread throughout the globe starting from 2020. Multiple countries and regions have implemented quarantine measures due to the high infectiousness of this health emergency [11]. These measures have effectively restricted population mobility and infection rates, but have also significantly affected people's lives and production activities around the world. The global economy has been suffering from a severe decline, which can be seen in different sectors such as the labor market and the stock market, according to previous studies [12, 13].

Using empirical data from China, researchers found that after the outbreak of the pandemic, China's first-quarter GDP declined by 6.8% compared to the same period in 2019, and further analysis confirm the severe negative impact of the pandemic on firms' performance in China, suggesting that Chinese firms' investment scales and total revenue have been significantly decreased

and ultimately resulted in a negative return rate in most cases [14]. Similarly, there is also evidence from Malaysia that Covid-19 has negatively impacted the governance structure, dividend, liquidity, leverage, and many other corporate characteristics [15].

As corporate fundamentally consists of the national and worldwide economies, how corporations respond to the negative impact under such a major public health emergency, especially in the context of the United States, which lacks in-depth research and evidence, therefore becomes our main area of interest in this research.

2.2 Corporate Decisions

Decisions made by corporations can encompass a wide range of aspects, including hiring decisions, financial decisions, business structure decisions, etc. Despite the fact that Covid-19 may impact almost every aspect of corporate decision-making, this project specifically examines the effects of Covid-19 on risk-taking, cash holdings, and innovation. These three domains in corporate decision-making are among the most relevant aspects impacted by Covid-19, as the outbreak of the pandemic exposed firms to a systematically higher level of risk in the market, forcing them to make decisions under risk, how much cash to hold instead of property and bonds, and whether to invest in innovation for long-term growth or to focus on ensuring short-term stability during the pandemic.

2.2.1 Corporate Risk-taking

Risky decisions made by firms play a significant role in their performance and survival, especially during volatile economic times [16]. Numerous studies have explored different factors influencing corporate risk-taking. For example, the composition of shareholders is found to be a significant factor in corporate risk-taking; firms with more heterogeneous large shareholders tend to take more risks when investing [17]. Corporate risk-taking can be also affected by shareholders' identity and it has been found that there is a negative association between state ownership and risk-taking [18]. Besides, external and social factors like cultures can also influence corporate risk-taking, and corporate risk-taking is found to be positively associated with individualism [17].

Three main approaches have been applied to measure corporate risk-taking in the existing literature. The first measure is leverage, which is calculated by dividing financial debt by financial debt plus equity [19]. The term financial debt refers more specifically to the sum of long-term and short-term loans. Leverage can be used to measure corporate risk-taking because when a

company's underlying business conditions encounter a negative shock, the higher the leverage is, the more negatively its profitability is affected by the shock. Other studies have also confirmed that finance firms engage in excessive risk-taking primarily through the use of leverage [20], confirming the validity of this approach.

The second risk-taking variable is σ(ROA), which measures the riskiness of outcomes of corporate decisions. σ(ROA) captures the volatility of the firm's operating returns on assets (ROA), calculated as earnings before interest and taxes divided by total assets. σ(ROA) is one of the most common proxy to measure risk and has been widely used in financial economics literature [16, 21, 22]. This measure, however, has several disadvantages. Previous literature often calculates σ(ROA) by taking the variance of twelve monthly ROAs to represent a company's risk-taking level in a given year. Using such a measurement with low frequency can fail to capture a company's risk-taking tendency accurately. Therefore, in this study, we measure risk-taking based on the volatility of daily stock prices in a given year, which is a more frequent and precise measurement of corporate risk-taking.

The third variable to measure corporate risk-taking is the likelihood of surviving over a 5-year period [19]. The intuition is that riskier firms are less likely to survive, thus the higher the likelihood of survival, the less risk-taking the firm. However, this method of measuring risk-taking might be contaminated by survival bias, so it requires more careful analysis and specification of the data before being applied.

2.2.2 Cash Holdings

Recently, corporate cash holdings have been receiving increasing attention in the finance literature, and studies have examined the effect of economic downturns on corporate cash holdings, finding that the propensity of firms to save cash out of their cash flow is positively associated with international diversification during downturns [23]. Cash holdings is obtained by calculating the ratio of cash and marketable securities to year-end book value minus cash and marketable securities [24].

2.2.3 Corporate Innovation

A substantial amount of literature found that innovation plays a key role in the growth of firms and the overall economy [25, 26]. A variety of methods have been used in financial economics literature to measure innovation, but they mainly focus on three main aspects: innovation input,

innovation output, and innovation quality.

Innovation input is often captured by expenditures on research and development (R&D) scaled by book assets [27, 28, 29]. The use of R&D expenditures and inputs alone as a measure of innovation, however, has several limitations. First, scholars argued that R&D expenditures only reflect one specific input that can be observed and quantified [30], and they can be affected by different accounting norms [31]. Moreover, measurement errors can lead to inaccurate information on R&D expenditures in online databases [28].

As another measure of innovation, innovation output encompasses the effective use of all innovation inputs, no matter observable or not. Innovation output is often measured by the number of patents applied for in a given year that are eventually granted [29]. However, this measure of innovation is also limited as it only considers the quantity of patents but does not account for the quality.

Therefore, innovation quality is necessary to be considered as well when measuring corporate innovation, which is usually measured using the number of patent citations [32, 29]. Corporate innovation can be evaluated more comprehensively if innovation input, innovation output, and innovation quality are all considered.

2.3 Gender Differences in Executives

Gender differences have long been one of the main areas of interest in decision-making in various disciplines. In the psychological context, previous studies consistently provide evidence that females demonstrate higher levels of resilience in the face of stress compared to males [8, 10]. However, others also suggest that in more specific scenarios such as financial decision-making, males seem to be much more willing to take financial risks than females [1, 2]. Researchers come up with the above conclusions mostly through lab or field experiments conducted with subjects, while real-world evidence requires further research.

Gender has also been extensively examined in the corporate context, where executives like CEOs and CFOs are in charge of making financial decisions. Male and female executives have been found to behave differently in different domains and corporate contexts. Regarding risk-taking, it is found that female executives generally tend to prefer less risky decisions compared to male counterparts [33], leading to distorted capital allocation due to the tendency to avoid risks [19]. It might then appear that female executives might lead to the lower overall performance of the firms, however, male executives are also found to show relative overconfidence when making

significant corporate decisions compared to female executives [34], and corporate boards tend to benefit from the unique skills of women executives [35]. Regarding innovation, gender-diverse boards that include female executives are associated with more patents, novel patents, as well as a high level of innovation [36].

3 Data

3.1 Executive characteristics

We obtained most of the executive data from Execucomp, a database including information about public companies' executives in the United States. Since the companies reporting their annual information of on-board executives to this database take up over 80 percent of the total market capitalization of all US public firms, we were able to gather detailed information on top executives' first and last names, ages, gender and total compensation of each corporation [37]. The data we collected are from 2186 corporations in total starting in 2016 and ending in 2021, as we intended to maintain a five-year fiscal period including the most up-to-date year (2021) with complete data available in Execucomp and other databases we used. For each corporation, Execucomp includes all top executives, with an average number of five. Because our research concentrates on gender as the key factor influencing executives' corporate decisions, we took in all listed executives for each corporation, computed age, total compensation by average and gender by percentage (i.e., the percentage of females in all executives on board per corporation), regardless of the number of different corporations. We further generated a new variable, $female\_dom$, indicating whether the corporation has more female executives than males.

3.2 Corporate data

In terms of corporations' financial data, we referred to Compustat, a market and corporate finance database on global companies. After a careful round of literature review, we determined both measures of corporate decisions and control variables of companies' financial characteristics. We therefore collected 24 variables needed for calculation according to the formulas widely used in previous studies. By filtering currency as USD only (as we focus on U.S companies), we obtained data of altogether 7878 corporations from Compustat ranging from 2014 to 2021, one year more than the executive data, because some variables require to be lagged for one year when being calculated. We then dropped the observations with key information missing for the following

calculations.

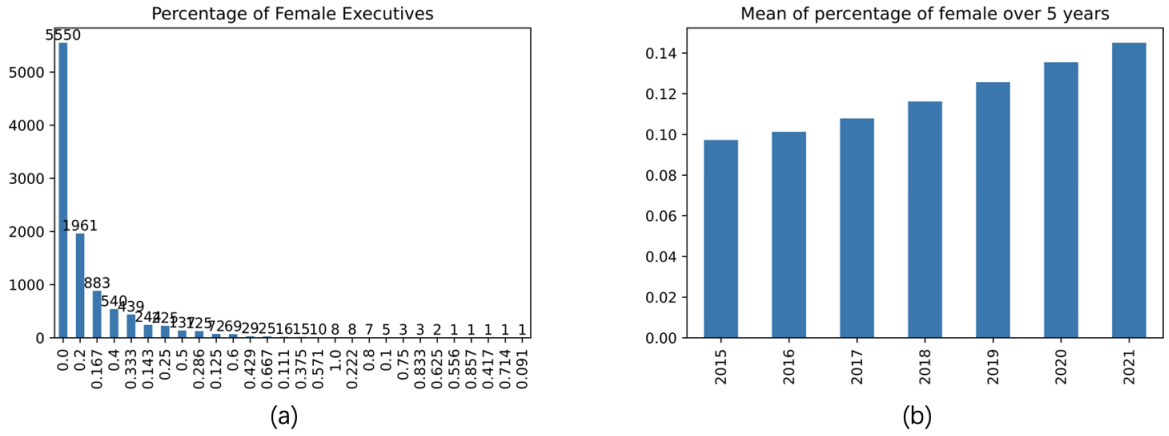
3.2.1 Corporate Decision-Making

As we already discussed in Section 2, our research specifically focused on risk-taking, cash holdings, and innovation as three main aspects of corporate decisions. We consider *Leverage* and $Volatility$ as the two measures of risk-taking. *Leverage* is computed as the ratio of the sum of Long-Term Debt Due in One Year ($DD1$) and Total Long-Term Debt ($DDLT$) to Total Asset (AT) multiplied by 100. In terms of $Volatility$, we referred to Annual Price Close ($PRCC\_F$) at first, which was obtained from Compustat as monthly reported data. However, since there are also variations in daily closing prices within a month, and the monthly reported ($PRCC\_F$) is not able to capture the volatility within a month, we then decided to manually calculate the variance on a daily rather than monthly basis. We thus utilized CRSP US Stock Database, a comprehensive database containing market and corporate action data for over 32,000 securities. We were, therefore, able to merge the datasets from CRSP and from Compustat through $GVKEY$, and then calculate the variance of Annual Price Close ($PRCC\_F$) from everyday data and generate the variable ($PRCCD\_VAR$). Cash holding is measured by the ratio of Cash and Short-Term Investment (CHE) to Total Asset (AT). $R\&D$, the innovation variable is calculated by the ratio of Research and Development Expense (XRD) to Total Asset (AT). Therefore, we collected all variables required for the above calculations from databases accordingly.

3.2.2 Control variables

Apart from dependent variables, the regression models we utilized include a variety of corporate-level control variables as follows: $Log(at)$, $Log(sale)$, Market-to-Book Ratio ($M\&B$), Total Property, Plant and Equipment ($Ppent$), Liquidity ($Liquidity\_lagged$) and Returns on Assets (ROE). Total Property, Plant and Equipment ($Ppent$) is directly acquired from Compustat. $Log(at)$ is calculated as the natural log of total assets. Similarly, $Log(sale)$ is the natural log of sales. The Market-to-Book Ratio is defined as the ratio of a company's market value, calculated as the sum of Common Shares Outstanding ($CSHO$) and Annual Price Close ($PRCC\_F$) minus Total Equity (CEQ) minus Deferred Taxes Balance ($TXDB$), to total asset (AT), and then minus one. To obtain Liquidity, we calculated the ratio of the cash balance, i.e., the ratio of Depreciation and Amortization (DP) and Income before Extraordinary Items (IB) to Total Property, Plant and Equipment ($Ppent$) lagged by one year. Lastly, ROE is defined as Net Income (NI) divided

Figure 1:



by Total Equity (CEQ). We further collected industrial information according to the Fama & French 12 industries classification, geographical information about the state that corporations belong to, and according to political attitudes of whether Democratic and Republican for future analysis.

All continuous variables were winsorized at the top and bottom 1% of the distribution to reduce the negative influence of outliers. Detailed summary statistics for all independent, dependent, and control variables are reported in Table 1.

Table 1: Summary Statistics after Winsorizing

Statistic	N	Mean	St. Dev.	Min	Max
at	10,381	14,066.830	33,459.050	65.422	237,532.600
sale	10,381	8,046.880	24,592.940	0.000	556,933.000
M&B	10,381	2.135	1.616	0.658	9.982
ppent	10,381	3.209	8.224	0.0004	53.918
avg_TDC1	10,381	3.423	2.910	0.305	16.687
liquidity	10,315	4.490	239.198	−465.200	22,155.250
avg_age	10,381	54.435	3.983	44	65
ROE	10,381	0.076	0.615	−3.331	3.121
xrd	10,381	382.434	1,227.858	0.000	31,562.000
CashHolding	10,381	0.140	0.155	0.001	0.729
Leverage	10,381	28.160	21.642	0	101
prccd_var	10,380	145.453	520.497	0.147	4,250.613
R&D	10,381	0.047	0.046	0.000	0.291
politics	10,381	0.816	0.687	0	2
have_fem	10,381	0.465	0.499	0	1
pct_female	10,381	0.117	0.148	0	1

4 Methodology and Results

In order to investigate how Covid-19 affects companies with different gender compositions on boards differently, we separately regress our measures of risk-taking, cash holdings, and innovation (dependent variables) on the interaction term between measures of gender compositions and a dummy variable $post\_covid$, which equals 1 if the year is post-covid, along with other control variables.

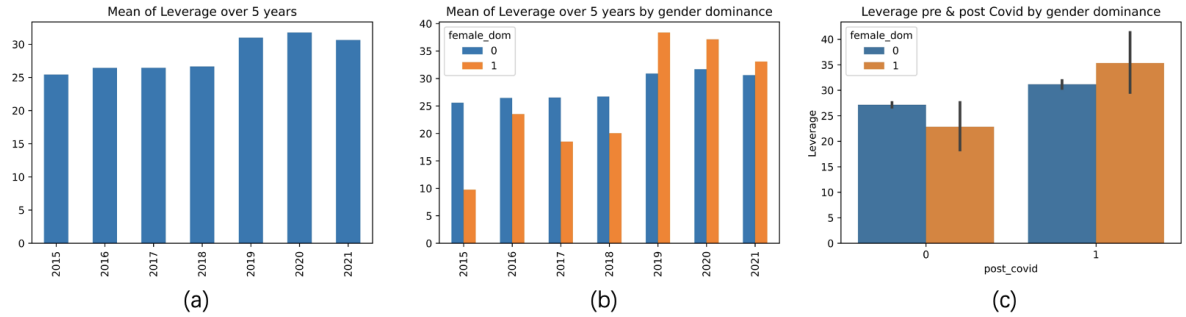
We use two measures of board gender composition to check the robustness of our results. The first is $have\_female$, which equals 1 if at least one female executive is among the top 5 executives with the highest compensation. The other measure is pct_female, which is calculated as the proportion of female executives among the top five highest-paid executives in a company. Using panel ordinary least squares (OLS) regression, we regress each of the four dimensions (leverage, stock market price volatility, cash holdings, expenditures of Research and Development) of corporate decision-making on $have\_female$ and on pct_female, with standard errors clustered at either firm+year level or industry+year level. Hence, we report four regression models for each dimension and discuss the results.

4.1 Risk-taking

4.1.1 Leverage

We obtain two measures for corporate risk-taking, including leverage and stock market price volatility, which are both commonly used in the existing literature. We will first focus on leverage and begin by visualizing data patterns of how Covid-19 affects the use of leverage using figures. According to (a) in Figure 2, companies generally increase the use of leverage after the breakout of Covid-19. Furthermore, (b) in Figure 2 illustrates that companies with female-dominated board compositions used less leverage before Covid-19, but their leverage significantly increased and even exceeded that of companies with male-dominated board compositions after 2019. Lastly, we use bar plots to show how the use of leverage differs across companies with male-dominated and female-dominated boards in response to Covid-19. As shown in (c) in Figure 2, companies with female-dominated board compositions tended to use less leverage before Covid-19, and they increased the use of leverage after Covid-19 and even exceeded companies with male-dominated board compositions, patterns that are consistent with the previous figure. However, it remains unknown whether the observed patterns are significant, given the relatively large confidence

Figure 2: Data Visualization of Leverage



intervals in the bar plots.

Therefore, we turn to regressions to test the significance of our observed data patterns. We regress leverage on gender composition measures. The results are reported in Table 2. There is broad consistency among these four regressions, indicating that all companies significantly increased their use of leverage after Covid-19, controlling for the company and executive characteristics. Furthermore, the coefficient of the term $post\_covid * have\_female$ indicates that after Covid-19, for companies that have at least one female executive on their board, the increase in leverage is 3.457 higher than that of companies without female executives, after controlling for corporate and executive characteristics. In addition, the coefficient of the term $post\_covid * pct\_female$ indicates that an increase of 1 percent in female representation on the board is associated with 0.1354 more increase in leverage post-Covid, controlling for corporate and executive characteristics. These patterns are consistent with the figures we presented, suggesting that companies with more female executives on the board generally show a greater propensity to take financial risks when making corporate decisions after Covid-19, in contrast to previous studies showing that females tend to take fewer risks than males.

4.1.2 Stock price volatility

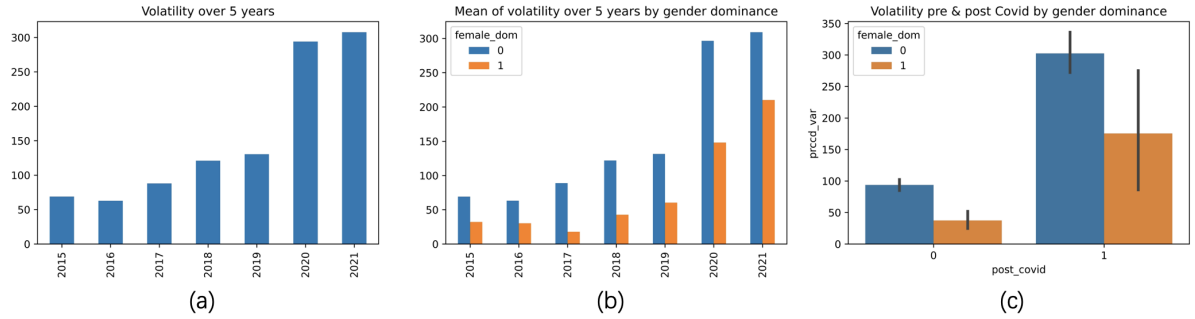
Next, we turn to stock market price volatility as the other proxy for corporate risk-taking. In the same way, we first look at the summary figures to take in the data patterns. We can observe from (a) in Figure 3 that the volatility of stock market prices increased dramatically after Covid-19. Furthermore, (b) in Figure 3 suggests that the volatility of the stock market price of companies with female-dominated board composition increased more than those with male-dominated board composition, which is consistent with the patterns shown in (c) in Figure 3.

Table 2: Leverage

	Dependent variable:			
	Leverage			
	(1)	(2)	(3)	(4)
post_covid	2.947***	2.947**	3.034***	3.034**
	(0.283)	(1.082)	(0.370)	(1.115)
have_female	−2.644***	−2.644***		
	(0.738)	(0.609)		
pct_female			−10.980***	−10.980***
			(3.126)	(2.670)
log(at)	2.326**	2.326	2.278**	2.278
	(0.971)	(3.980)	(0.964)	(3.948)
log(sale)	1.096	1.096	1.108	1.108
	(0.749)	(3.149)	(0.746)	(3.125)
M&B	0.073	0.073	0.080	0.080
	(0.370)	(0.863)	(0.371)	(0.878)
ppent	−0.225***	−0.225	−0.223***	−0.223
	(0.069)	(0.169)	(0.068)	(0.173)
avg_TDC1	−0.087	−0.087	−0.079	−0.079
	(0.229)	(0.366)	(0.226)	(0.368)
Liquidity_lagged	−0.605***	−0.605***	−0.617***	−0.617**
	(0.213)	(0.124)	(0.211)	(0.178)
avg_age	−0.537***	−0.537***	−0.544***	−0.544***
	(0.099)	(0.136)	(0.099)	(0.142)
ROE	−1.891***	−1.891**	−1.897***	−1.897**
	(0.660)	(0.765)	(0.653)	(0.763)
post_covid * have_female	3.457***	3.457***		
	(0.449)	(0.863)		
post_covid * pct_female			13.540***	13.540***
			(2.396)	(2.900)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Politics Fixed Effects	Yes	Yes	Yes	Yes
Clustered Standard Errors	Company + Year	Industry + Year	Company + Year	Industry + Year
Observations	10,356	10,356	10,356	10,356
R^2	0.153	0.153	0.154	0.154
Adjusted R^2	0.151	0.151	0.152	0.152
Residual Std. Error (df = 10326)	19.927	19.927	19.913	19.913

Note: *p<0.1; **p<0.05; ***p<0.01

Figure 3: Data Visualization of Stock Market Price Volatility



We then run panel ordinary least squares (OLS) regressions again to test the effect. Our regression results suggest that the volatility of stock market prices increased for all companies after Covid-19. According to column (1) and column (2) in Table 3, the interaction term between *post_covid* and *have_female* is not significant in our model specification. Therefore, there is no evidence that the impact of Covid-19 on stock market volatility varies systematically between companies with and without female executives. However, the interaction term between *post_covid* and *pct_female* turns out to be significantly negative when standard errors are clustered at the industry and year level, as reported in column (4). The coefficient of *post_covid * pct_female* indicates that an increase of 1 percent in female representation on the board is associated with 0.32919 less increase in volatility of stock market price post-Covid, controlling for corporate and executive characteristics.

4.2 Cash Holdings

In this section, we will examine how Covid-19 impacts cash-holding decisions and how it is affected by board gender compositions. (a) in Figure 4 reveals that companies on average tended to increase their cash holdings after the breakout of Covid-19. However, a closer examination of (b) and (c) in Figure 4 reveals that these increases are primarily caused by companies with male-dominated boards, and in contrast, companies with female-dominated boards tend to exhibit a decrease in cash holdings after Covid-19.

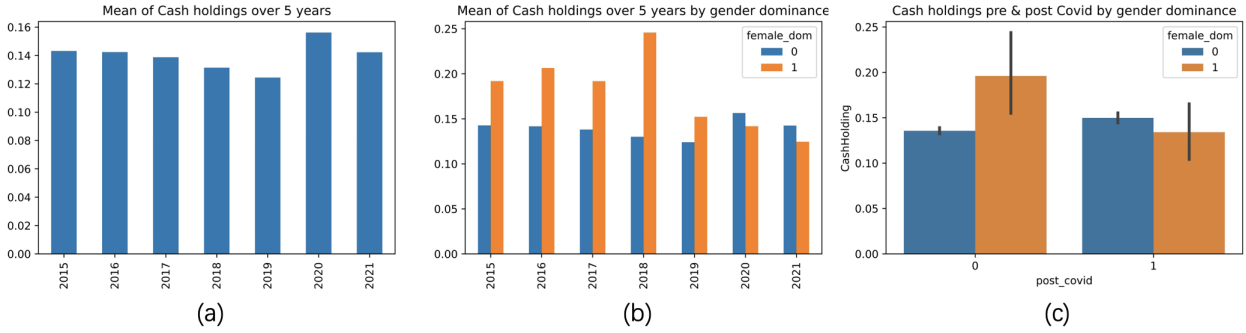
We then turn to verify our observations through panel OLS regressions. As reported in Table 4, the regression results are consistent with the patterns in the figures. The negative coefficients of *post_covid* and *post_covid * have_female* indicate that companies generally decrease their cash holdings after Covid-19. Moreover, the negative coefficients of *post_covid * have_female* suggest that companies that have at least one female executive on the board decrease cash-holdings 0.008

Table 3: Stock price volatility

	Dependent variable:			
	prccd_var			
	(1)	(2)	(3)	(4)
post_covid	151.079***	151.079***	160.495***	160.495***
	(26.281)	(29.198)	(23.135)	(27.979)
have_female	−10.979	−10.979		
	(14.002)	(21.315)		
pct_female			−50.682	−50.682
			(40.554)	(55.593)
log(at)	53.026***	53.026**	52.841***	52.841**
	(17.258)	(18.021)	(17.277)	(18.069)
log(sale)	−6.714	−6.714	−6.490	−6.490
	(11.183)	(13.832)	(11.014)	(13.948)
M&B	114.256***	114.256***	114.371***	114.371***
	(30.908)	(27.549)	(30.995)	(27.617)
ppent	0.628	0.628	0.621	0.621
	(2.508)	(2.851)	(2.513)	(2.618)
avg_TDC1	6.965	6.965	6.962	6.962
	(7.326)	(6.358)	(7.345)	(6.392)
Liquidity_lagged	6.147	6.147	6.053	6.053
	(5.597)	(3.710)	(5.566)	(3.257)
avg_age	−4.357**	−4.357*	−4.483**	−4.483**
	(1.859)	(1.813)	(1.843)	(1.755)
ROE	−2.923	−2.923	−2.878	−2.878
	(14.371)	(12.967)	(14.245)	(13.306)
post_covid * have_female	6.845	6.845		
	(24.134)	(10.251)		
post_covid * pct_female			−32.919	−32.919*
			(33.179)	(14.859)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Politics Fixed Effects	Yes	Yes	Yes	Yes
Clustered Standard Errors	Company + Year	Industry + Year	Company + Year	Industry + Year
Observations	10,355	10,355	10,355	10,355
R^2	0.175	0.175	0.175	0.175
Adjusted R^2	0.173	0.173	0.173	0.173
Residual Std. Error (df = 10325)	473.928	473.928	473.868	473.868

Note: *p<0.1; **p<0.05; ***p<0.01

Figure 4: Data Visualization of Cash Holdings



more than those with no female executives on the board on average after Covid-19, ceteris paribus. Consistently, the coefficient of *post_ covid * pct_ female* is negative as well, indicating that having one percent more female executives on the board is associated with 0.00029 more decreases in cash-holdings in response to the Covid-19.

4.3 Innovation

Our final focus will be on corporate innovation. Due to the limited data access, we use research input as the only proxy for innovation, as measured by expenditures on R&D. We first generate figures to get a basic sense of the data patterns. According to (a) in Figure 5, there are slight decreases in expenditures on R&D after Covid-19. Furthermore, (b) and (c) in Figure 5 indicate that companies with female-dominated boards decrease more in R&D expenditures but it remains uncertain whether this effect is significant, given the large confidence intervals.

Then, we run panel OLS regressions again to analyze the effect of Covid-19 on innovation and its relationship to company board gender compositions. Results are reported in Table 5. The positive coefficients of *post_ covid * have_ female* suggest that companies that have at least one female executive on the board decrease R&D expenditures 0.004 less than those with no female executives on the board on average after Covid-19, ceteris paribus. Similarly, the positive coefficients of *post_ covid * pct_ female* indicate that having one percent more female executives on the board is associated with 0.012 fewer decreases in expenditures on R&D in response to Covid-19. These results show that companies with more female executives tend to decrease less on R&D expenditures after Covid-19.

Table 4: Cash Holdings

	Dependent variable:			
	CashHolding			
	(1)	(2)	(3)	(4)
post_covid	-0.005^{**}	-0.005	-0.006^{***}	-0.006
	(0.002)	(0.010)	(0.002)	(0.011)
have_female	0.009^{**}	0.009^{*}		
	(0.004)	(0.004)		
pct_female			0.037^{**}	0.037^{*}
			(0.016)	(0.019)
log(at)	-0.030^{***}	-0.030^{**}	-0.030^{***}	-0.030^{**}
	(0.004)	(0.012)	(0.004)	(0.012)
log(sale)	-0.011^{**}	-0.011	-0.012^{**}	-0.012
	(0.005)	(0.018)	(0.005)	(0.018)
M&B	0.023^{***}	0.023^{***}	0.023^{***}	0.023^{***}
	(0.003)	(0.004)	(0.003)	(0.004)
ppent	0.002^{***}	0.002^{**}	0.002^{***}	0.002^{**}
	(0.0003)	(0.001)	(0.0003)	(0.001)
avg_TDC1	0.010^{***}	0.010^{***}	0.010^{***}	0.010^{***}
	(0.001)	(0.002)	(0.001)	(0.002)
Liquidity_lagged	-0.004^{**}	-0.004	-0.004^{**}	-0.004
	(0.002)	(0.003)	(0.002)	(0.003)
avg_age	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
ROE	-0.001	-0.001	-0.001	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)
post_covid * have_female	-0.008^{***}	-0.008^{*}		
	(0.003)	(0.003)		
post_covid * pct_female			-0.029^{***}	-0.029^{**}
			(0.009)	(0.012)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Politics Fixed Effects	Yes	Yes	Yes	Yes
Clustered Standard Errors	Company + Year	Industry + Year	Company + Year	Industry + Year
Observations	10,356	10,356	10,356	10,356
R^2	0.377	0.377	0.377	0.377
Adjusted R^2	0.375	0.375	0.376	0.376
Residual Std. Error (df = 10326)	0.121	0.121	0.121	0.121

Note: *p<0.1; **p<0.05; ***p<0.01

Figure 5: Data Visualization of Stock Market Price Volatility

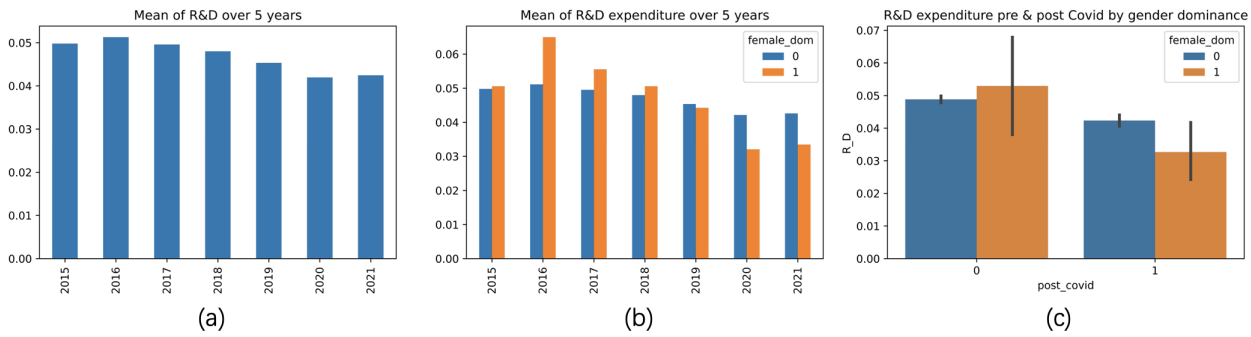


Table 5: R&D Expenditure

	Dependent variable:			
	R_D			
	(1)	(2)	(3)	(4)
post_covid	-0.011^{***}	-0.011^{***}	-0.011^{***}	-0.011^{***}
	(0.001)	(0.003)	(0.0004)	(0.002)
have_female	-0.003	-0.003		
	(0.002)	(0.002)		
pct_female			-0.012^{**}	-0.012
			(0.006)	(0.008)
log(at)	-0.00000	-0.00000	-0.0001	-0.0001
	(0.001)	(0.003)	(0.001)	(0.003)
log(sale)	-0.009^{***}	-0.009^{*}	-0.009^{***}	-0.009^{*}
	(0.001)	(0.004)	(0.001)	(0.004)
M&B	0.005^{***}	0.005^{**}	0.005^{***}	0.005^{**}
	(0.001)	(0.002)	(0.001)	(0.002)
ppent	0.0004^{***}	0.0004^{**}	0.0004^{***}	0.0004^{**}
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
avg_TDC1	0.002^{***}	0.002	0.002^{***}	0.002
	(0.0004)	(0.001)	(0.0004)	(0.001)
Liquidity_lagged	-0.004^{***}	-0.004^{*}	-0.004^{***}	-0.004^{*}
	(0.001)	(0.002)	(0.001)	(0.002)
avg_age	0.0003	0.0003	0.0002	0.0002
	(0.0002)	(0.0004)	(0.0002)	(0.0004)
ROE	-0.003^{**}	-0.003	-0.003^{**}	-0.003
	(0.001)	(0.002)	(0.001)	(0.002)
post_covid * have_female	0.004^{***}	0.004^{***}		
	(0.001)	(0.001)		
post_covid * pct_female			0.012^{***}	0.012^{***}
			(0.003)	(0.002)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Politics Fixed Effects	Yes	Yes	Yes	Yes
Clustered Standard Errors	Company + Year	Industry + Year	Company + Year	Industry + Year
Observations	10,356	10,356	10,356	10,356
R^2	0.317	0.317	0.318	0.318
Adjusted R^2	0.315	0.315	0.316	0.316
Residual Std. Error (df = 10326)	0.038	0.038	0.038	0.038

Note: *p<0.1; **p<0.05; ***p<0.01

5 Discussion

The results of our study generally indicate that female executives took more risks when making corporate decisions after Covid-19 and were less impacted by the pandemic than their male counterparts. These patterns are contradictory to most existing research that females are generally more risk-averse when it comes to financial risk. However, since we are using Panel Ordinary Least Squares as the primary method of analysis, we cannot infer causality from the regression results. If we can get more specific data on when Covid-19 started affecting different companies, which is difficult to obtain in reality, advanced econometric methods, such as Difference in Difference and Regression Discontinuity, could be applied to address this issue. This will be our primary next step in extending this project.

There are also some other important limitations of our research that need to be considered. First, other corporate-level factors, such as incentive structures, the real power held by executives, and decision-making processes within companies may differ, so our results would be more accurate and reliable if we are able to include these aspects in our regressions and analysis. It is difficult, however, to derive well-rounded and consistent measures of these aspects to capture the difference between companies, since they cannot be easily quantified.

Moreover, our regression results generally suggest that female executives are more likely to take risks and less affected by Covid-19 when making corporate decisions, but we remain uncertain about the mechanism and the underlying reasons for these behavioral patterns. This pattern might be driven, for example, by companies with more female executives performing better during the pandemic and thus being less affected by Covid-19. It might also be the case that companies that promote more females may have corporate cultures that are more open to risk and uncertainty brought about by shocks. However, we must conduct additional hypothesis testing and analysis to validate these conjectures before drawing conclusions about the underlying mechanisms.

6 Personal Contributions

Tian Jin conducted literature review, collected and processed data, assisted with data analysis and interpretation, and drafted the paper.

7 Conclusion

In this paper, we examine how Covid-19 affects corporate decision-making and how those effects vary between companies with different gender compositions on boards. Overall, compared to companies with fewer female executives on boards, those with more female executives tended to increase their leverage more, experience less increase in stock market volatility, decrease cash holdings more, and reduce R&D spending less after the Covid-19 breakout. The results of our study suggest that companies with more female executives generally took more risks and were less affected by the Covid-19 pandemic when making corporate decisions.

In spite of the lack of a clearer picture of the underlying mechanism of these observed patterns, our findings still have several profound policy, management, and social implications. Firstly, the most significant aspect of our findings is that the pandemic has a disproportionate effect on companies with different compositions of gender on their boards. In light of this, when developing policies aimed at companies or other units made up of different types of agents, policymakers should take into account the characteristics of the compositions of the targeted units, as they can be adversely affected by shocks or respond to policies in asymmetric ways. Therefore, a tailored policy based on the characteristics of the target units may be more effective if policymakers hold some expectations about how different units would respond to different policies.

Second, our findings also have important implications for corporate and organizational management regarding gender diversity and promotion strategy. When deciding who to promote, managers and leaders should take into account the potential differences between members of different social groups, ethnicity, gender, etc, and how these differences can have significant consequences for the organization when the promoted people hold power. Nevertheless, this is not suggesting that leaders should discriminate against any particular group; instead, they should weigh the advantages and disadvantages of promoting someone and choose the most qualified candidate. Managers and leaders are also encouraged to apply probation periods to test how candidates respond to emergencies and whether their behavior meets organizational expectations, before making promotion decisions, which will also help eliminate potential biases that they hold towards a certain group.

The results of our study also point to some significant social implications. As opposed to previous research findings and common sense, we found that females are not always more risk-averse than males. Therefore, we should realize that we may hold biased perceptions toward

certain social groups and that these biased perceptions can lead to a wide range of social issues, such as inequality and discrimination. In order to better overcome these biases, it is important that we avoid making assumptions about people based on their appearance, status, etc.

Despite broadly consistent and significant results across different model specifications, future work may also test the robustness of our results using different measures of corporate risk-taking and innovation. Moreover, future research could also test the internal validity of our results by adding more control variables, such as executive education, gender, and marital status, to isolate the effects of other variables. In addition, future research should examine whether these patterns also apply to other countries or other crisis situations, such as the financial crisis or other natural disasters that might affect corporate revenue and performance as well, which could test the external validity of our research findings.

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