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CEO gender, corporate risk-taking, and the efficiency of capital allocation

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ABSTRACT

We extend the literature on how managerial traits relate to corporate choices by documenting that firms run by female CEOs have lower leverage, less volatile earnings, and a higher chance of survival than otherwise similar firms run by male CEOs. Additionally, transitions from male to female CEOs (or vice versa) are associated with economically and statistically significant reductions (increases) in corporate risk-taking. The results are robust to controlling for the endogenous matching between firms and CEOs using a variety of econometric techniques. We further document that this risk-avoidance behavior appears to lead to distortions in the capital allocation process. These results potentially have important macroeconomic implications for long-term economic growth.

1. Introduction

Among the *Fortune 500* companies, the number of female CEOs reached its historic high in mid-2014.[4] Despite that, with a headcount of only 24 (or 4.8% of the Fortune 500 firms), female CEOs remain an exception rather than a rule in corporate America. This "gender gap" in corporate leadership is not specific to large U.S. firms. In fact, according to a recent *Wall Street Journal* article, only 3% of the largest 145 Scandinavian companies have a female CEO.[5] Are the women who climb to the top of the corporate ladder close substitutes for male executives? Furthermore, are there differences in the decisions that female CEOs make after taking the corporate reins? And, are there implications for the efficiency of the capital allocation process?

In this paper, we investigate the relation between CEO gender, corporate risk-taking choices, and the efficiency of capital allocation. Using a large sample of privately held and publicly traded European companies from the *Amadeus Top 250,000* database, 9.4% of which are run by female CEOs, we first document that female CEOs tend to associate with less risky firms. In the cross-section, firms run by female CEOs are less leveraged, have less volatile earnings, and are more likely to remain in operation than firms run by male CEOs. Additionally, in the time-series, transitions from male to female CEOs (or vice versa) are associated with an economically and statistically significant decline (increase) in corporate risk-taking.

These findings are based on evidence from four different samples that are specifically selected to *mitigate* different endogeneity concerns. First, we compare firms run by female CEOs to a (propensity score) matched sample of peers run by male CEOs that are

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[4] http://fortune.com/2014/06/03/number-of-fortune-500-women-ceos-reaches-historic-high/
[5] *Wall Street Journal*, May 21, 2014, "Even Scandinavia Has a CEO Gender Gap."

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virtually indistinguishable in terms of observable characteristics. More specifically, peers are selected from the same country, industry, year, and public/private status, and then matched on a number of firm- and CEO-level characteristics. The basic propensity score results show that firms run by female CEOs take significantly less risk than otherwise similar firms run by male CEOs. Second, we employ a sample of firms experiencing a transition from male to female CEOs or vice versa (henceforth referred to as "transition firms"). Focusing on transition firms allows us to compare the risk-taking of the same firms, as run by CEOs of different genders. Those tests indicate that CEO transitions are associated with changes in corporate risk-taking. In particular, transitions from male to female CEOs are associated with a reduction in corporate risk-taking. As the timing of CEO transitions is unlikely to be random, we supplement our analyses with a third sample. This consists of a propensity score matched sample of transition firms. In this analysis, we compare the change in risk-taking observed around transitions from male to female CEOs with the change in risk-taking of otherwise similar firms that are run by male CEOs during the entire sample period. The propensity score matching analysis of transition firms confirms a significant change in corporate risk-taking around CEO transitions, over and beyond what is observed (during the same period) among otherwise identical peers.

To investigate whether CEO gender still plays a role in financial and investment policies after explicitly accounting for self-selection due to unobservables, we employ a variation of the Heckman two-step approach: the treatment effects model. Our choice of an exogenous determinant of the propensity to select a female CEO is based on the *familiarity* of a firm's male directors with female CEOs. More specifically, our first-stage instrumental variable is the fraction of firms with a female CEO and above-average risk-taking among *all other firms* in which the firm's male directors also serve as directors. We argue that it is unlikely that this familiarity, combined with *above-average* risk-taking (in other firms), will be correlated with outcomes (in particular, risk-avoidance) *except* through its effect on CEO gender. The results of the treatment effects model provide little support for the notion that the differences in corporate risk-taking observed between firms run by female and male CEOs are due to self-selection. Thus, the results appear to be consistent with CEO gender influencing corporate risk-taking.

To the extent that the documented differences in corporate risk-taking are driven by female CEOs imposing their preferences on corporate choices, the efficiency of the capital allocation process could be undermined. This would occur if female CEOs choose to forgo positive net present value investment opportunities. For example, female CEOs of high growth opportunity firms may be too risk averse and fail to increase investment to fully capitalize on these opportunities. The second source of inefficiency is over-investment. For example, for firms with poor investment opportunities, female CEOs may be reluctant to make divestitures and thus overinvest.[6] To assess the efficiency of capital allocation, we borrow the basic idea from Wurgler (2000) and estimate the sensitivity of corporate investment to value-added growth. We document that male CEOs invest more in industries that have better investment opportunities (as proxied by higher value-added growth). However, investments of firms run by female CEOs are less sensitive to the quality of investment opportunities. Thus, female CEOs do not appear to allocate capital *as efficiently* as male CEOs. Similar conclusions are reached when we use marginal Q as the proxy for the quality of investment opportunities, as in Durnev et al. (2004).

Why does CEO gender help explain corporate risk-taking? Under perfect capital markets, managers should choose investments so as to maximize the market value of the firm. In this framework, neither the preferences or characteristics of managers nor those of the firm's owners play any role in the investment selection choice. Traditional finance theories propose agency and asymmetric information as ways in which a decision maker's preferences and characteristics may play a role in a firm's investment selection choice. Additional explanations include differences in risk aversion between genders (Bertrand, 2011; Croson and Gneezy, 2009), overconfidence (Malmendier and Tate, 2005, 2008; Malmendier et al., 2011), differences in incentives structures, differences in unemployment risk, as well as social norms related to the role of women in a given society (Akerlof and Kranton, 2000; Altonji and Blank, 1999; Booth and Nolen, 2012; Guiso et al., 2008). We discuss these mechanisms in Section 5.

This paper contributes to the literature investigating managerial traits and experiences that influence corporate decision making. Those studies include Bertrand and Schoar (2003), Malmendier and Tate (2005, 2008), Malmendier et al. (2011), Benmelech and Frydman (2015), Cronqvist et al. (2012), and Cain and McKeon (2016). We add to this literature by showing that CEO gender is also an important trait associated with differences in corporate choices.

Our paper also relates to earlier studies investigating how gender diversity correlates with differences in corporate decisions or outcomes. For example, Weber and Zulehner (2010) document that start-ups with female first hires display a higher likelihood of survival. Adams and Ferreira (2009) provide evidence that CEO turnover correlates more strongly with poor performance when the *board of directors* is more gender-diverse. Ahern and Dittmar (2012) document that the introduction of mandatory board member gender quotas led to an increase in acquisitions and performance deterioration in Norwegian publicly traded firms.[7] However, more recent studies by Adams and Ragunathan (2013) and Berger et al. (2014) document that banks with more women on their boards appear to take *more* risk (or at least *not less* risk) than banks with fewer female board members. In a recent study that employs a large sample of U.S. firms, Sila et al. (2016) document that the cross-sectional correlation between gender diversity and equity risk disappears once they account for the endogeneity of the gender selection choice.

However, there is little evidence investigating the relation between the gender of *top* corporate *insiders* and corporate choices. One exception is Huang and Kisgen (2013), who document that the propensity to make acquisitions is lower in companies with female CFOs. Their sample includes 19 female CEOs and 97 female CFOs. A second exception is a study of privately owned (U.S.) firms by Cole (2013), who reports cross-sectional evidence that female-owned firms have lower leverage than

[6] We thank the Referee for highlighting these channels.
[7] Other works focusing on gender diversity in corporate boards include Matsa and Miller (2013) and Levi et al. (2010, 2014).

male-owned firms. We add to this literature by documenting significant differences in the risk-taking profile of firms run by male and female CEOs.

The paper also contributes to the literature on the efficiency of capital allocation (Durnev et al., 2004; McLean et al., 2012; Morck et al., 2011; Wurgler, 2000). Our paper is the first to provide evidence that differences in managerial traits, in particular gender, appear to have implications for the quality of the capital allocation process—a fundamental underpinning of economic growth (Bagehot, 1873; Beck et al., 2000; Greenwood and Jovanovic, 1990; John et al., 2008).

The rest of the paper is organized as follows. Section 2 describes the data. Section 3 investigates the relation between CEO gender and corporate risk-taking. Section 4 investigates the implications for the quality of the capital allocation process. Section 5 discusses the economic reasons why CEO gender could impact risk-taking (including differences in risk aversion) and Section 6 concludes.

2. Data

Most of the data used in the paper are taken from *Amadeus Top 250,000* and *Worldscop*e Amadeus is maintained by Bureau Van Dijk. From this database, we gather information on the name of the CEO, ownership data, and accounting data for every European privately held and publicly traded company that satisfies a minimum size threshold.[8] Disclosure requirements in Europe require private companies to publish annual information. Consequently, we are able to gather accounting, ownership, and gender information for a very large set of firms. The quality of data in *Amadeus Top 250,000* is discussed in detail in Faccio et al. (2011). We gather the data from the annual *Amadeus Top 250,000* DVDs.[9] Our sample period starts in 1999 (the first year for which we can gather ownership data from the DVDs) and ends in 2009 (the most recent year for which accounting and ownership data are available).

Later in the paper, we use *Worldscope* to gather stock price data and additional accounting data for publicly traded firms. Those data are employed to estimate the marginal Q of each 3-digit SIC industry in each country, as described in detail in Appendix A.

To select our sample, we start with the 41 countries covered in *Amadeus*. From these, we exclude countries that are not covered in *Worldscope* in the earlier years. Those are primarily Eastern European countries and smaller countries such as Liechtenstein and Monaco. This leaves us with a sample of 21 countries. Finally, we exclude the Czech Republic, Poland, and the Russian Federation as, for these countries, the *World Bank* provides GDP deflators only starting in 1990.[10] After these exclusions, the final sample used throughout the paper consists of the following 18 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

2.1. CEO gender

We identify the gender of a CEO primarily based on his/her first name, as reported in "*Amadeus Top 250,000*." Since 2007, DVDs indicate the gender of the CEO. As a starting point, we use this information to classify CEOs from 2007 forward. We also use this information to classify those same individuals in the prior years. Prior to 2007, *Amadeus* does not indicate the gender of the CEO. However, at least in some instances, *Amadeus* reports a salutation. We use the salutation when it indisputably allows identifying the gender of the CEO.[11] If these methods do not conclusively identify the CEO's gender, we employ country-specific Internet-based sources to classify gender based on each individual's first name.[12] Using country-specific sources is important to avoid misclassification. For example, Simone is used for women in France but for men in Italy. Finally, when we could not identify the gender from the names lists found on the web, we used *OneSource*, *LinkedIn*, *Google*, and *Facebook* to further research the CEO and assess whether a specific name is a male or female name.

When we are unable to classify the gender of an individual, we drop the observation. Across all countries and all years, this procedure allows us to identify the gender of the CEO in 338,397 firm-year observations. As shown in Table 1, 9.4% of the CEOs in the sample are women. By contrast, Huang and Kisgen (2013) document that only 2% of the CEOs of large publicly traded U.S. companies are women. The higher number (as well as percentage) of female executives in our sample is, at least in part, due to the inclusion of a large number of private firms in our sample. Consistent with this, our data show that the percentage of female CEOs is higher among privately held firms (10.2%) than among publicly traded firms (7.2%).

[8] For France, Germany, Italy, Spain, and the United Kingdom, the database includes all companies that meet at least one of the following criteria: (1) revenues of at least €15 m, (2) total assets of at least €30 m, (3) at least 200 employees. For the other countries, the database includes all companies that meet at least one of the following criteria: (1) revenues of at least €10 m, (2) total assets of at least €20 m, (3) at least 150 employees.

[9] *Amadeus* removes firms from the database 5 years after they stop reporting financial data. These drawbacks are also discussed in Klapper et al. (2006) and Popov and Roosenboom (2009). In order to avoid potential survivorship bias, we collect data starting with the 2011 DVD and progressively move backward in time. By doing so, no firms are dropped from the sample.

[10] The procedure employed to construct marginal Qs requires data starting from 1983 (see Appendix A).

[11] For instance, "Mr" versus "Ms/Mrs./Miss" or "Dr." versus "Dr.ª" (more commonly used in Portugal).

[12] For instance, www.babynology.com, www.nordicnames.de, babynamesworld.parentsconnect.com, www.namepedia.org/en/firstname.

Table 1
Univariate statistics.
Leverage is defined as the ratio of financial debt divided by the sum of financial debt plus equity. Financial debt is the sum of long-term debt (excluding "other non-current liabilities") plus short-term loans. $\sigma(ROA)$ is the volatility of the firm's operating return on assets (ROA), defined as the ratio of earnings before interests and taxes to total assets. *Likelihood of survival* is an indicator variable that takes the value of 1 if the firm survives at least 5 years, and 0 otherwise. *Female CEO* is an indicator variable that takes the value of 1 if the CEO is a woman, and 0 otherwise. *CEO ownership* is the cash flow rights of the CEO on the firm's earnings. *Ln* (*CEO wealth*) is the natural logarithm of the CEO's equity wealth. To determine equity wealth for each CEO, we approximate the dollar value of the investment in each firm in which he/she appears as a shareholder by multiplying the individual's ownership in the firm by the firm's book value of equity. We then sum the value of all equity investments across firms to obtain the CEO's total equity wealth. *Ln* (*CEO age*) is the natural logarithm of the CEO's age. *Cash flow rights* is the ownership rights of the largest ultimate shareholder. *Sales growth* is calculated as the annual rate of growth of sales. *Ln* (*Size*) is the natural log of total assets (in thousands US$), expressed in 2000 prices. Total assets is the sum of total fixed assets (tangible and intangible fixed assets and other fixed assets) and current assets (inventory, receivables, and other current assets). *Ln* (1 + *Age*) is the natural logarithm of (1 + the number of years since incorporation). *Tangibility* is calculated as the ratio of fixed to total assets. *Private firm* is an indicator denoting firms that are not publicly traded. Δ *gross PPE/Total fixed assets* is the ratio of capital expenditure relative to the capital stock. Capital expenditures are computed as the annual change in (net) total fixed assets plus depreciation. *Value-added growth* is computed as the difference between the natural log of value added in year t and the natural log of value added in year t-1. Value added, in constant US dollars (year 2000 prices), is defined as earnings before interest and taxes plus cost of employees. *Marginal Q* measures the change in the market value of firm associated with an (unexpected) change in capital investment. It is estimated by industry, country, and year. *Cash flow/Total fixed assets* is net income plus depreciation, divided by total fixed assets. With the exception of *Likelihood of survival*, all statistics are computed for the panel of observations. *Likelihood of survival* can only be computed cross-sectionally.

Full sample	Full sample			Female CEOs	Male CEOs	p-value of diff.
	Mean	Median	Stnd. dev.			
Leverage	0.374	0.329	0.326	0.324	0.379	0.000
σ(ROA)	0.048	0.030	0.057	0.027	0.050	0.000
Likelihood of survival	0.517	1	0.500	0.614	0.505	0.000
Female CEO	0.094	0	0.292			
CEO ownership	0.044	0	0.167	0.060	0.043	0.000
Ln(CEO wealth)	7.525	7.583	1.922	7.486	7.529	0.079
Ln(CEO age)	3.919	3.932	0.190	3.902	3.921	0.000
Cash flow rights	0.638	0.680	0.358	0.576	0.644	0.000
ROA	0.059	0.049	0.108	0.065	0.058	0.000
Sales growth	0.217	0.050	0.834	0.184	0.221	0.000
Ln (Size)	10.313	10.132	1.400	10.127	10.332	0.000
Ln (1 + Age)	2.906	2.944	0.809	2.929	2.904	0.000
Tangibility	0.212	0.129	0.233	0.209	0.213	0.063
Private firm	0.954	1	0.210	0.969	0.952	0.000
Δgross PPE/Total fixed assets	0.353	0.167	0.864	0.370	0.351	0.029
Value-added growth	0.088	0.055	0.396	0.089	0.088	0.204
Marginal Q	1.123	0.948	1.152	0.862	1.149	0.000
Cash flow/Total fixed assets	1.129	0.273	4.012	1.113	1.131	0.135

2.2. Risk-taking

We consider three measures of risk-taking. The first measure, *Leverage*, is a measure of the riskiness of corporate financing choices. The intuition is simple: given a (negative) shock to a firm's underlying business conditions, the higher the leverage, the greater the (negative) impact of the shock on the firm's net profitability (including a higher probability of default). *Leverage* is defined as the ratio of financial debt divided by the sum of financial debt plus equity. Financial debt is the sum of long-term debt (excluding "other non-current liabilities") and short-term loans. Across the firms in our sample, the average *Leverage* ratio is 37.4%. This ratio is 32.4% for firms with a female CEO and 37.9% for firms with a male CEO (the p-value of the difference between the two is less than 0.001).

The other two risk-taking variables are measures of the riskiness of outcomes. $\sigma(ROA)$ is the volatility of the firm's operating return on assets, defined as the ratio of earnings before interest and taxes to total assets. Volatility of returns is a standard proxy for risk in the financial economics literature. This variable captures the riskiness of investment decisions. Further, earlier work by John et al. (2008) establishes that the volatility of firm-level operating profits has a positive impact on long-term economic growth. We focus on the volatility of accounting returns (as opposed to stock market returns) as the vast majority of firms in our sample are privately held. We calculate the standard deviation of the returns over 5-year overlapping windows (1999–2003, 2000–2004, 2001–2005, 2002–2006, 2003–2007, 2004–2008, and 2005–2009). Across all firms in the sample, the average volatility of ROA is 4.8%. As with *Leverage*, there is a significant difference in this variable (p-value <0.001) between firms run by female CEOs (2.7%) and firms run by male CEOs (5.0%).

Third, we exploit the notion that riskier firms are less likely to survive, and focus on the likelihood of surviving over a 5-year period. For a firm to enter this analysis, we only require that CEO gender, ownership, and accounting data be available for at least 1 year during 1999–2005. Since firms that enter our sample in 2005 or earlier could have up to 5 years or more of data, we focus on these observations to assess the likelihood of survival. This specification has two main advantages. First, there is no survivorship bias, as both surviving and non-surviving companies are included in the analysis. Second, this measure of risk-taking is unaffected by accounting manipulation. We find that 51.7% of the firms in the sample survive at least 5 years. The likelihood of survival is 61.4% for firms with a female CEO and 50.5% for firms with a male CEO. The difference between female and male CEOs is statistically significant with a p-value of less than 0.001.

2.3. Control variables

The models employed in our analyses include a number of firm-level control variables. *ROA* is defined as the ratio of earnings before interest and taxes to total assets. We include firm profitability to control for differences in management quality. *Sales Growth* is calculated as the annual rate of growth of sales. Since most of the firms in the sample are private, we use sales growth (rather than the market-to-book ratio) as a control variable. *Ln* (*Size*) is the natural log of total assets (in thousands US$), expressed in 2000 prices. ("Total assets" is the sum of fixed assets (tangible and intangible fixed assets and other fixed assets) and current assets (inventory, receivables, and other current assets).) *Ln* (*1* + *Age*) is the natural logarithm of (1 + the number of years since incorporation). This variable controls for differences in the life cycle/stage of a firm. *Tangibility* is calculated as the ratio of fixed to total assets. *Private firm* is an indicator denoting firms that are not publicly traded. We use this variable as a proxy for capital constraints. *Cash flow rights* is the ownership rights of the largest ultimate shareholder.[13] The higher the ownership of a large shareholder, the greater the incentive to monitor the CEO. This would in turn mitigate agency conflicts. *CEO Ownership* is calculated as the cash flow rights of the CEO on the firm's earnings. Since a high level of ownership aligns the CEO's incentives with those of minority shareholders, we use CEO ownership to control for agency conflicts.

In some of the models we also control for CEO age and CEO wealth. However, the availability of data on these additional CEO characteristics is limited. Adding these controls thus considerably reduces the sample size. For this reason, these controls are not included in all the tests. The inclusion of these controls is motivated by earlier evidence suggesting that younger CEOs (Forbes, 2005; Kovalchik et al., 2005; Taylor, 1975) and wealthier CEOs (Arrow, 1984; Calvet and Sodini, 2014; Paravisini et al., forthcoming) are more prone to take risks. Data in *Amadeus* allow us to construct a proxy for the equity wealth for a subsample of CEOs. To determine the equity wealth for each CEO, we first calculate the dollar value of the investment in each firm in which he/she appears as a shareholder. This is computed by multiplying the individual's ownership in the firm by the firm's book value of equity. (We use book values because most of the firms in the sample are privately held). Next, we sum the value of all equity investments to obtain each CEO's total equity wealth.

To reduce the impact of outliers, we winsorize the accounting variables (other than sales growth, $\sigma(ROA)$, and leverage) at the top and bottom 1% of the distribution. Since sales growth, $\sigma(ROA)$, and leverage exhibit large positive skewness, these three variables are winsorized at the bottom 1% and at the top 5% of the distribution.

Summary information for all the variables is reported in Table 1. The sample includes 132,590 firms and 338,397 firm-year observations. A comparison of the sample means for firms run by female and male CEOs reveals important differences in the characteristics of both firms and CEOs. Firms run by female CEOs tend to be older and more profitable. In contrast, firms run by male CEOs tend to be larger and grow at faster rates. The fraction of private firms is higher among those run by a female CEO. With respect to CEO characteristics, we notice that female CEOs tend to own a larger share of the equity of the firms that they run. At the same time, these firms have a more dispersed ownership structure. Male CEOs tend to be, on average, marginally wealthier and older than female CEOs.

3. CEO gender and corporate risk-taking

To investigate the relation between CEO gender and corporate risk-taking, we start by regressing our measures of risk-taking on CEO gender and other determinants of risk-taking that, if excluded, could induce spurious correlations. The results are reported in Table 2. *Leverage* is the dependent variable in Regression (1). Regression (1) is a panel ordinary least squares (OLS) regression with standard errors clustered at the firm level. The results of Regression (1) indicate that firms run by female CEOs use significantly less leverage and therefore take less financial risk than firms run by male CEOs. The coefficient of *Female CEO* indicates that after controlling for several other determinants of capital structure choices, the leverage of firms run by female CEOs is 0.034 lower on average than the leverage of firms run by male CEOs. This appears to be a sizeable difference, given an average value of *Leverage* of 0.374 for the entire sample. The coefficient on the gender variable has a p-value of less than 0.001.

The volatility of firm-level profitability ($\sigma(ROA)$) is the dependent variable in Regression (2). We again employ a panel OLS specification with standard errors clustered at the firm level. In this Model (as well as in Regression (3)), all independent variables are measured at the first year-end of the 5-year sample period over which the volatility of earnings (or the likelihood of survival) is measured. The results show that the volatility of a firm's ROA is significantly lower when the firm is run by a female CEO (p-values ≤ 0.001). As with *Leverage*, the difference in the volatility of firm-level profitability between firms run by female and male CEOs is sizeable (1.998/100 = 0.020) relative to the sample mean (0.048).

Regression (3) is a cross-sectional probit regression of the *Likelihood of survival*, in which the outcome is 1 if a company survives for at least 5 years and 0 otherwise. The results in Table 2 indicate significantly higher survival rates for companies run by female CEOs. To the extent that firms that take more risk are less likely to survive through time, this result is consistent with the notion that companies managed by women tend to engage in less risky projects.

Thus, in the cross-section, both corporate choices (such as leverage) and corporate outcomes (volatility of profitability and the likelihood of survival) vary significantly depending on the gender of the CEO.

[13] To identify the largest ultimate shareholder, for each company that has available ownership data in *Amadeus*, we identify its owners, the owners of its owners, and so on.

Table 2
Female CEOs and corporate risk-taking.
In Regression (1), the dependent variable is *Leverage*, defined as the ratio of financial debt divided by the sum of financial debt plus equity; in Regression (2), the dependent variable is the volatility of the firm's operating return on assets $\sigma(ROA) \times 100$, where ROA is defined as the ratio of earnings before interest and taxes to total assets; in Regression (3), the dependent variable is an indicator denoting whether the firm survived over a 5-year period. Regressions (1) and (2) are run for the panel of observations. Regression (3) can only be run cross-sectionally. *Female CEO* is an indicator variable that takes the value of 1 if the CEO is a woman, and 0 otherwise. Control variables are defined in Table 1. P-values, adjusted for heteroskedasticity and clustering at the firm level (in the panel regressions), are reported in brackets below the coefficients. *, ** and *** indicate statistical significance levels of 10%, 5% and 1%, respectively.

	(1)	(2)	(3)
	Leverage	σ(ROA) × 100	Likelihood of survival
Female CEO	−0.034***	−1.998***	0.253***
	[0.000]	[0.000]	[0.000]
CEO ownership	0.095***	−0.910***	−0.212***
	[0.000]	[0.000]	[0.000]
Cash flow rights	−0.001	0.654***	0.051***
	[0.714]	[0.000]	[0.005]
Leverage		−0.447***	−0.057***
		[0.000]	[0.001]
ROA	−0.626***	−3.525***	0.891***
	[0.000]	[0.000]	[0.000]
Sales growth	0.009***	−0.045**	−0.021***
	[0.000]	[0.029]	[0.000]
Ln (Size)	0.013***	−0.144***	0.166***
	[0.000]	[0.000]	[0.000]
Ln (1 + Age)	−0.042***	−0.423***	0.102***
	[0.000]	[0.000]	[0.000]
Tangibility	0.174***	−1.116***	0.163***
	[0.000]	[0.000]	[0.000]
Private firm	0.095***	−0.858***	−0.365***
	[0.000]	[0.000]	[0.000]
Country fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
R-squared	0.184	0.101	0.132
No. of observations	338,397	113,614	67,089
No. of firms	132,590	47,208	

However, the comparison of the firm and CEO characteristics tabulated in Table 1 makes the issue of non-random selection immediately apparent. To mitigate sample selection concerns in the comparison of firms run by female and male CEOs, in the remainder of this section, we analyze four different samples: (1) a propensity score matched sample; (2) a sample of firms experiencing a transition from male to female CEOs or vice versa; (3) a propensity score matched sample of firms undergoing a CEO transition; and (4) a treatment effects model.

3.1. Propensity score matched samples

We begin our analysis of the differences in corporate risk-taking between female and male CEOs by employing a propensity score matching procedure (Rosenbaum and Rubin, 1983). This methodology allows us to identify a control sample of firms that are run by male CEOs and that exhibit no *observable* differences in characteristics relative to the firms run by female CEOs. Thus, each pair of matched firms is virtually indistinguishable from one another except for one key characteristic: the gender of the CEO. Matching on observable firm and CEO characteristics mitigates (but does not eliminate) concerns related to non-random selection.

To implement this methodology, we first calculate the probability (i.e., the propensity score) that a firm with given characteristics is run by a female CEO. We start by calculating this probability as a function of firm-level characteristics. More specifically, in Panel A of Table 3, the propensity score is estimated within a country–industry–year–public/private status category, as a function of ROA, sales growth, the natural log of total assets, the natural log of firm age, asset tangibility, the ownership of the CEO, and the ownership of the largest ultimate shareholder. To ensure that the firms in the control sample are sufficiently similar to the firms run by a female CEO, we require that the maximum difference between the propensity score of the firm run by a female CEO and that of its matching (male CEO run) peer does not exceed 0.1% in absolute value.

A comparison of *Leverage*, $\sigma(ROA)$, and *Likelihood of survival* between the matched samples reveals that firms with female CEOs tend to take less risk than firms with male CEOs even when several other observable characteristics between the firm pairs are virtually identical. As the results in Panel A of Table 3 show, the average leverage of firms run by female CEOs is 33.1%, compared with 36.2% for otherwise similar firms run by male CEOs. The average volatility of ROA is 2.6% for firms run by female CEOs and 4.1% for firms run by male CEOs. The likelihood of survival over a 5-year period is 66.2% for firms run by female CEOs and 56.3% for firms run by male CEOs. All differences in risk-taking between the two groups are statistically significant with p-values of less

Table 3
Propensity score matching estimators
In this table, we identify a control sample of firms that are run by male CEOs by employing a propensity score matching procedure. The propensity score is estimated within a country–industry–year–public/private status category, using all firm characteristics included in our regression analyses. We require that the difference between the propensity score of the firm run by a Female CEO and its matching peer does not exceed 0.1% in absolute value. We then compare the levels of *Leverage*, $\sigma(ROA) \times 100$ and the likelihood of survival between the two groups. *Leverage* is defined as the ratio of financial debt divided by the sum of financial debt plus equity. Financial debt is the sum of long-term debt (excluding "other non-current liabilities") plus short-term loans; the volatility of the firm's operating return on assets is $\sigma(ROA) \times 100$, where ROA is defined as the ratio of earnings before interest and taxes to total assets; the *Likelihood of survival* is an indicator denoting whether the firm survived over a 5-year period. *, ** and *** indicate statistical significance levels of 10%, 5% and 1%, respectively.

Panel A: The propensity score is estimated within a country-industry-year-public/private status category using available firm-level observables.

	No. of observations	Mean	Difference (Female CEOs − Male CEOs)	P-value of diff.
Leverage (female CEOs)	21,848	0.331	−0.031***	0.000
Leverage (male CEOs)		0.362		
σ(ROA) × 100 (female CEOs)	6566	2.580	−1.503***	0.000
σ(ROA) × 100 (male CEOs)		4.083		
Likelihood of survival (female CEOs)	3617	0.662	0.099***	0.000
Likelihood of survival (male CEOs)		0.563		

Panel B: The propensity score is estimated within a country–industry–year–public/private status category using available firm-level observables as well as CEO wealth and CEO age.

	No. of observations	Mean	Difference (Female CEOs − Male CEOs)	P-value of diff.
Leverage (female CEOs)	1129	0.467	−0.022*	0.074
Leverage (male CEOs)		0.489		
σ(ROA) × 100 (female CEOs)	220	2.074	−0.594***	0.002
σ(ROA) × 100 (male CEOs)		2.668		
Likelihood of survival (female CEOs)	43	0.790	0.16	0.228
Likelihood of survival (male CEOs)		0.674		

than 0.001. Importantly, these results suggest that the gender-related differences in risk-taking observed in the univariate analysis are not due to *observable* differences in firm characteristics.

In Panel B of Table 3, we match firms within a country–industry–year–public/private status category, as a function of firm-level *and* CEO-level characteristics (namely, CEO wealth and CEO age) that are available on a more limited basis. Even with this very restrictive matching, our conclusions remain unchanged.

3.2. Regression analysis of transition firms

A limitation of the propensity score matching results is that the documented correlation between CEO gender and corporate risk-taking may simply reflect *unobservable* characteristics that influence both CEO gender choice and corporate risk-taking choices. The omission of these controls might lead us to incorrectly attribute the differences in risk-taking to differences in CEO gender.

In this section, we exploit the panel dimension of our dataset to control for *time-invariant* firm-specific characteristics that may be correlated with omitted explanatory variables. For this purpose, we run (panel) regressions with firm fixed effects. The inclusion of firm fixed effects in the regression models removes any purely cross-sectional correlation between gender and risk-taking, reducing the risk of spurious correlation. In particular, in firm fixed effects regressions, we compare CEOs of different genders operating the same firm.

In this analysis, we include only firms that experience a change from a male CEO to a female CEO or vice versa, as only those firms contribute to the identification. *Leverage* is the dependent variable in Regression (1) of Table 4. Regression (1) is a panel regression with firm fixed effects and standard errors clustered at the firm level. The results indicate that firms run by female CEOs use significantly less leverage and therefore take less financial risk than firms run by male CEOs. The coefficient of *Female CEO* indicates that after controlling for several other determinants of capital structure choices, a firm's leverage is 0.028 lower, on average, when the firm is run by a female CEO vs. when the same firm is run by a male CEO. This appears to be a sizeable difference, given an average value of *Leverage* of 0.374 for the full sample. The coefficient on the gender variable has a p-value of less than 0.001.

The volatility of firm-level profitability ($\sigma(ROA)$) is the dependent variable in Regression (2). We again employ a panel specification with firm fixed effects and standard errors clustered at the firm level. In this Model (as well as in Regression (4)), all independent variables are measured at the first year-end of the 5-year sample period over which the volatility of earnings is measured. The results show that the volatility of a firm's ROA is significantly lower when the firm is run by a female CEO (p-values ≤ 0.001). As with *Leverage*, the difference in the volatility of firm-level profitability between firms run by female and male CEOs is sizeable ($1.584/100 = 0.016$) relative to the sample mean (0.048).

A possible concern with the analysis of CEO transitions is that they are likely to be accompanied by changes in CEO characteristics other than gender. To the extent that these characteristics affect risk-taking and have been omitted from the previous analyses, we could have incorrectly attributed the change in risk-taking observed at the time of a transition to gender. We note that for non-gender-related CEO (or any) characteristics to explain the gender results, changes in these characteristics must (1) occur

Table 4
Female CEOs and corporate risk-taking.
This table reports panel regression results with firm fixed effects. In Regressions (1) and (3), the dependent variable is *Leverage*, defined as the ratio of financial debt divided by the sum of financial debt plus equity. In Regressions (2) and (4), the dependent variable is the volatility of the firm's operating return on assets $\sigma(ROA) \times 100$, where ROA is defined as the ratio of earnings before interest and taxes to total assets. *Female CEO* is an indicator variable that takes the value of 1 if the CEO is a woman and 0 otherwise. Control variables are defined in Table 1. P-values, adjusted for heteroskedasticity and clustering at the firm level, are reported in brackets below the coefficients. In this analysis, we include only firms that experience a change from a male CEO to a female CEO or vice versa, as only those firms contribute to the identification.*, ** and *** indicate statistical significance levels of 10%, 5% and 1%, respectively.

	(1)	(2)	(3)	(4)
	Leverage	σ(ROA) × 100	Leverage	σ(ROA) × 100
Female CEO	−0.028***	−1.584***	−0.020*	−0.876***
	[0.000]	[0.000]	[0.096]	[0.007]
CEO ownership	−0.013	0.271	0.057*	−0.842
	[0.200]	[0.586]	[0.094]	[0.509]
Cash flow rights	0.01	−0.189	0.052	0.528
	[0.132]	[0.642]	[0.379]	[0.696]
Leverage		0.603		1.287
		[0.103]		[0.264]
ROA	−0.376***	−3.640**	−0.527***	−5.127
	[0.000]	[0.017]	[0.000]	[0.323]
Sales growth	0.006***	0.059	0.011*	−0.178
	[0.000]	[0.309]	[0.059]	[0.611]
Ln (Size)	0.040***	−0.329	0.127***	−1.1
	[0.000]	[0.210]	[0.000]	[0.484]
Ln (1 + Age)	−0.046***	1.501*	0.076	3.557
	[0.004]	[0.089]	[0.261]	[0.401]
Tangibility	0.111***	−2.735**	0.142**	−1.822
	[0.000]	[0.015]	[0.036]	[0.407]
Private firm	0.013	0.602	0.061	3.803
	[0.303]	[0.586]	[0.390]	[0.353]
Ln (CEO wealth)			−0.045***	−0.008
			[0.000]	[0.968]
Ln (CEO age)			0.093**	−0.24
			[0.047]	[0.864]
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
R-squared	0.724	0.421	0.83	0.553
No. of observations	46,513	22,879	2926	1473
No. of firms	11,150	8213	1124	623

around the time of the transition (as in the firm fixed-effects specifications identification comes from time series changes), (2) be different for the subsample of firms (initially) run by male CEOs and female CEOs, and (3) credibly affect risk-taking choices.

To address this concern, we add controls for two CEO-level characteristics (CEO age and CEO wealth) that we are able to observe at least for some of the firms in our sample. Importantly, the regression results in the last two columns of Table 4 continue to show differences in risk-taking across genders after controlling for these additional CEO characteristics. This mitigates the possibility that our results might be due to time-varying, CEO-specific omitted variables. Admittedly, we recognize that we cannot control for other potentially relevant CEO characteristics that might change around the time of transitions. Therefore, with this test we cannot rule out the omitted variable issue completely.

3.3. Propensity score matching analysis of transition firms

One specific concern with the transition sample is that transitions occur at "special" times. The inclusion of firm fixed effects in the regression models is not sufficient to address this selection concern. To better address this concern, in Table 5 we present a propensity score analysis of the firms experiencing a transition from male to female CEOs.[14] To minimize the possible impact of confounding events, those firms are matched with a control group of firms that are run by male CEOs during the entire sample period. In this analysis, we match firms within a country–industry–year–public/private status category as a function of firm-level characteristics.

We find that transition firms on average experience a reduction in *Leverage* from an average of 0.400 (under a male CEO) to an average of 0.374 (under a female CEO). This change is statistically significant with a p-value of less than 0.001. By contrast, the leverage of otherwise similar firms that were always run by a male CEO does not change significantly during the same time periods. The difference between the change in leverage of the transition firms and that of the control group is statistically significant with a p-value of less than 0.001. Similar conclusions obtain when we look at the change in the volatility of firm

[14] For the subset of firms experiencing a transition from *female* to *male* CEOs, we find a significant *increase* in risk-taking after the transition. However, we do not have enough control firms (i.e., firms always run by female CEOs) from the same country–industry–year and public/private status category to undertake a propensity score analysis using the matching algorithm described above.

Table 5
Propensity score matching estimators for transition firms.
In this table, we identify control samples of firms that are always run by male CEOs by employing a propensity score matching procedure. The propensity score is estimated within a country–industry–year–public/private status category, as a function of ROA, sales growth, the natural log of total assets, the natural log of firm age, asset tangibility, the ownership of the largest ultimate shareholder, and the ownership of the CEO. The treatment group in this Table includes firms experiencing a transition from male to female CEOs. We require that the difference between the propensity score of the firm run by a female CEO and its matching peer does not exceed 0.1% in absolute value. *Leverage* is defined as the ratio of financial debt divided by the sum of financial debt plus equity. Financial debt is the sum of long-term debt (excluding "other non-current liabilities") plus short-term loans; the volatility of the firm's operating return on assets is $\sigma(ROA) \times 100$, where ROA is defined as the ratio of earnings before interest and taxes to total assets.*, ** and *** indicate statistical significance levels of 10%, 5% and 1%, respectively.

	No. of observations	Mean	Difference (Post- – Pre-transition)	P-value of diff.
Treatment group				
Pre-transition leverage (male CEOs)	4101	0.400	−0.026***	0.000
Post-transition leverage (female CEOs)		0.374		
Control group				
Pre-transition leverage (male CEOs)	4101	0.398	−0.009	0.175
Post-transition leverage (male CEOs)		0.389		
		Diff.-in-Diff.	−0.017***	0.000
Treatment group				
Pre-transition σ(ROA) × 100 (male CEOs)	891	3.639	−1.144***	0.000
Post-transition σ(ROA) × 100 (female CEOs)		2.495		
Control Group				
Pre-transition σ(ROA) × 100 (male CEOs)	891	3.676	−0.172	0.218
Post-transition σ(ROA) × 100 (male CEOs)		3.504		
		Diff.-in-Diff.	−0.972***	0.000

level profitability, $\sigma(ROA)$. While we again acknowledge that CEO gender might not be randomly assigned, this result provides additional evidence of changes in corporate risk-taking around CEO transitions.

3.4. Endogenous matching between firms and CEOs

Our results thus far document an economically and statistically significant association between CEO gender and corporate risk-taking. The propensity score approach and the analysis of CEO transitions help mitigate omitted variables concerns. However, as we have discussed, those methodologies are not free of possible limitations. Importantly, the differences in risk-taking observed between firms run by male and female CEOs are not purely cross-sectional, as our time-series analysis of CEO transitions shows that transitions are associated with *changes* in corporate risk-taking. Therefore, any proposed mechanism behind the observed association between CEO gender and corporate risk-taking needs to be able to explain why risk-taking changes around CEO transitions.

To investigate the extent to which self-selection might explain our results, we employ a variation of the Heckman (1979) two-step approach: the treatment effects model. The first stage of this model is a binary outcome equation (specifically, a probit equation) which models the choice of hiring a male or female CEO. In the second step, we include the inverse Mills ratio (derived from the first stage) alongside an indicator variable characterizing CEO gender and our prior controls.

To facilitate identification, in the first stage, we use an exogenous determinant of the likelihood that the board might appoint a female CEO. In prior work, Grinblatt and Keloharju (2001), Huberman (2001), and Seasholes and Zhu (2010), among others, document that *familiarity* appears to be important to investors in an investment setting.[15] We borrow from these studies and build on the notion of familiarity to develop an instrument.

To proxy for familiarity, we suggest that male board members who serve on other boards with female CEOs are more familiar with working with women in executive roles. To the extent that their participation in these boards reflects an appreciation and familiarity with female executives, they might be more inclined to propose a woman for the position of CEO. With this in mind, we focus on the fraction of firms with a female CEO among all other firms in which the firm's male directors also serve as directors. More specifically, among all other firms in which the firm's male directors also serve as directors, we compute the fraction of firms with (1) a female CEO, (2) above-average leverage, (3) above-average volatility of ROA in the subsequent 5 years, and (4) lack of survival during the following 5 years. A benefit of using this fractional measure is that it does not vary based on the *number* of boards on which a director sits. This mitigates any concern that the variable might correlate with connections through networks, which would likely not satisfy the exclusion restriction.

We recognize that this strategy is not without caveats. However, for an omitted variable to explain our results, this variable would need to explain (1) CEO gender selection, (2) board selection, (3) *below*-average risk-taking for the firm in question and (curiously), at the same time, (4) *above*-average risk-taking among the other firms in which the firm's male directors serve

[15] Somewhat consistent with this idea, Farrell and Hersch (2005) document that the probability that a woman is added to the board significantly increases following the departure of a female director.

Table 6
Treatment effects
In the *second-stage regressions*, in Regression (1), the dependent variable is *Leverage*, defined as the ratio of financial debt divided by the sum of financial debt plus equity; in Regression (2), the dependent variable is the volatility of the firm's operating return on assets $\sigma(ROA) \times 100$, where ROA is defined as the ratio of earnings before interests and taxes to total assets; in Regression (3), the dependent variable is an indicator denoting whether the firm survived over a 5-year period. In the first-stage regressions, we use the fraction, among all other firms in which the firm's male directors also serve as directors, of firms with (1) a female CEO, (2) above-average leverage, (3) above-average volatility of ROA in the subsequent 5 years, and (4) lack of survival during the following 5 years as an exogenous determinant of the CEO gender selection choice. Control variables are defined in Table 1. The *Inverse Mills ratio* is calculated from the predicted values of the first stage probit regressions. P-values, adjusted for heteroskedasticity and clustering at the firm level are reported in brackets below the coefficients.*, ** and *** indicate statistical significance levels of 10%, 5% and 1%, respectively.

Panel A: Second-stage regressions

Dependent variable	(1)	(2)	(3)
	Leverage	σ(ROA) × 100	Likelihood of survival
Female CEO	−0.070***	−2.746***	0.268**
	[0.000]	[0.000]	[0.015]
CEO ownership	−0.014**	0.006	−0.169***
	[0.015]	[0.984]	[0.000]
Cash flow rights	0.014***	−0.198	0.061***
	[0.000]	[0.295]	[0.008]
Leverage		−0.054	0.041
		[0.773]	[0.128]
ROA	−0.419***	−4.149***	0.835***
	[0.000]	[0.000]	[0.000]
Sales growth	0.006***	0.03	−0.012**
	[0.000]	[0.256]	[0.014]
Ln (Size)	0.041***	−0.262**	0.143***
	[0.000]	[0.039]	[0.000]
Ln (1 + Age)	−0.045***	1.223***	0.123***
	[0.000]	[0.003]	[0.000]
Tangibility	0.133***	−1.816***	0.154***
	[0.000]	[0.000]	[0.000]
Private firm	0.006	1.562***	−0.428***
	[0.185]	[0.001]	[0.000]
Inverse mills ratio	0.018**	0.430*	0.063
	[0.014]	[0.096]	[0.289]
Country fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
No. of observations	223,710	79,809	43,805
No. of firms	96,020	36,111	43,805

Panel B: First stage probit model

Dependent variable	(1)	(2)	(3)
	Female CEO		
Fraction of firms with a female CEO and high risk-taking among other firms in which male directors serve	1.509***	1.551***	1.724***
	[0.000]	[0.000]	[0.000]
Control variables	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
No. of observations	223,710	79,809	43,805
No. of firms	96,020	36,111	43,805

(we focus on this scenario, by choice, in the construction of our instrument). Any omitted variable responsible for our main results would need to explain all of these (often opposing) outcomes, which certainly stands in contrast to a basic "law of simplicity."

Another potential concern is that the sample of firms in which the firm's male directors also serve as directors which have (1) a female CEO and (2) above-average risk-taking is relatively small—3674 observations in Regression (1) of Table 6. We leave it to the readers to decide whether such a sample is too small to draw any inferences. At minimum, however, we notice that the different methodologies employed so far to address causality appear to provide consistent evidence.

In line with our prediction, we find that our proxy for familiarity is correlated with CEO gender (see Panel A of Table 6). Further, the inverse Mills ratio is marginally significant in two out of three regressions in Panel B of Table 6. Importantly, in each and every second stage model, CEO gender remains statistically significant after controlling for self-selection due to unobserved firm or CEO characteristics; if anything, the magnitude of the CEO gender coefficient estimates becomes greater after controlling for self-selection.[16]

[16] We also employed a second variation of the Heckman's (1979) two-step procedure: a switching regression analysis with endogenous switching. Untabulated results show that for firms run by female CEOs, risk-taking choices (leverage) and outcome (volatility of ROA and survival) would have been higher had the firms been run by a male CEO. Results are available upon request.

Despite all the tests employed to address the issue of endogeneity (firm fixed effects, CEO transitions, propensity score matching, and treatment effects models), we find little evidence that the endogenous matching between firms and CEOs explains the documented association between CEO gender and corporate risk-taking. While causality represents a possible explanation for the changes in risk-taking observed *following* CEO transitions, explicitly testing for causality remains a challenge (given the impossibility of randomly assigning CEOs to firms). With these caveats in mind, however, these tests confirm the previous evidence and suggest that, even after controlling for self-selection, women CEOs tend to take on less risk compared to their male counterparts.

4. CEO gender and the efficiency of capital allocation

So far we have documented that female CEOs make less risky corporate choices than male CEOs. To the extent that this outcome is driven by female CEOs imposing their preferences on corporate choices, the efficiency of the capital allocation process may be undermined. In this section, we investigate whether this appears to be the case. We employ two approaches to measure the efficiency of capital allocation. First, we use the approach proposed by Wurgler (2000) - - and use value-added growth to proxy for the quality of investment opportunities. Second, we look at the degree to which investment is related to the marginal (Tobin's) Q, as advocated by theory. The Wurgler approach is discussed in Section 4.1. The marginal Tobin's Q approach is discussed in Section 4.2. In Section 4.3., we discuss the possible explanations for the lesser degree of efficiency of capital allocation observed among female CEOs.

4.1. Value-added growth

In order to achieve an efficient allocation, capital should be invested in sectors with good investment opportunities and be withdrawn from those sectors that have poor investment opportunities. Wurgler (2000) proposes that optimal investment implies investing more in growing industries and decreasing investment in declining industries. He points out that, since gross domestic product (GDP) is the sum of the value added across all the firms in the economy, and given that economic growth is often measured as growth in GDP, looking at growth in value added is a natural way to measure growth. Accordingly, value-added growth is used as a proxy for the quality of investment opportunities.

In this section, we follow this insight and estimate the sensitivity of investment to the growth in value added. Value-added growth is computed as the difference between the natural log of value added in year t and the natural log of value added in year $t-1$. Value added, in constant US dollars (year 2000 prices), is defined as earnings before interest and taxes plus the cost of employees. The richness of our data allows us to measure value-added growth at the firm level.

To assess the efficiency of capital allocation, for all companies in *Amadeus*, we estimate a simple version of the Fazzari et al. (1988) model of investment, augmented by an indicator denoting a female CEO and the interaction of this indicator with each firm's growth in value added[17]:

$$\begin{aligned}\frac{\Delta\,\text{Gross PPE}_{j,t}}{\text{Total Fixed Assets}_{j,t-1}} &= \alpha+\beta\cdot\ \ln\frac{\text{Value Added}_{j,t}}{\text{Value Added}_{j,t-1}}+\\ &+\gamma\cdot\frac{\text{Cash Flow}_{j,t}}{\text{Total Fixed Assets}_{j,t-1}}+\delta\cdot Ln\,(1+Age)_{j,t}+\zeta\cdot Female\ CEO_{j,t}+\\ &+\theta\cdot\ \ln\frac{\text{Value Added}_{j,t}}{\text{Value Added}_{j,t-1}}\cdot Female\ CEO_{j,t}+\mathrm{u}^{\mathrm{i}}_{\mathrm{j,t}}\end{aligned} \tag{1}$$

where $\frac{\Delta\ \text{Gross PPE}_{j,t}}{\text{Total Fixed Assets}_{j,t-1}}$ represents the capital expenditures of firm j at time t, relative to the capital stock; $\Delta\ Gross\ PPE_{j,t}$ is the annual change in net *Total Fixed Assets*, with depreciation added back; *Total Fixed Assets* is the sum of tangible fixed assets, intangible fixed assets, and other fixed assets (all net of accumulated depreciation); $\ln\frac{\text{Value Added}_{j,t}}{\text{Value Added}_{j,t-1}}$ is the growth in value added and it reflects the quality of the firm's investment opportunities; $Cash\ Flow_{j,t}$ is net income plus depreciation. $Ln\ (1+Age)_{j,t}$ is the natural logarithm of (1 + the number of years since incorporation). We control for firm age to capture the possibility that risk-taking may be dependent on the stage of the firm. β represents the sensitivity of investments to growth opportunities. *Ceteris paribus*, the better (worse) the growth opportunities, the more a value maximizing-value manager should invest (divest). θ is our coefficient of interest which measures the difference in the investment sensitivity to growth opportunities between firms run by female and male CEOs. If CEO gender is "irrelevant" for investment efficiency, then $\theta = 0$.

Table 7, Panel A, presents regressions of firm investment on value-added growth, CEO gender, the interaction between these two variables, and other controls. In the estimation, we add firm and year fixed effects to mitigate endogeneity concerns from omitted variables. Consistent with optimal capital budgeting, the results in Table 7 show that there is a positive and significant association between investments and value-added growth for firms run by male CEOs. For example, Regression (1) shows that, for male CEOs, the coefficient of the sensitivity of investment to growth opportunities is 0.154, with a p-value of less than

[17] See Hubbard (1998) and Bond and van Reenen (2007) for extensive surveys on alternative models on investment. As in Wurgler (2000), we rely on a relatively simple regression specification as more elaborate specifications give similar results.

Table 7
Female CEOs and the efficiency of capital allocation.
This table reports OLS regression results. In both panels, the dependent variable is the ratio of capital expenditure relative to the capital stock. Capital expenditures are computed as the annual change in (net) total fixed assets plus depreciation. The capital stock is defined as the sum of tangible fixed assets plus intangible fixed assets plus other fixed assets. *Value-added growth* is computed as the difference between the natural log of value added in year t and the natural log of value added in year $t-1$. Value added, in constant US dollars (year 2000 prices), is defined as earnings before interest and taxes plus cost of employees. *Marginal Q* measures the change in the market value of a firm associated with an (unexpected) change in capital investment. It is estimated by industry, country, and year. *Cash flow/Total fixed assets* is net income plus depreciation, divided by total fixed assets. *Ln* (1 + *Age*) is the natural logarithm of (1 + the number of years since incorporation). *Female CEO* is an indicator variable that takes the value of 1 if the CEO is a woman, and 0 otherwise. The *Inverse Mills ratio* is calculated from the predicted values of the first stage probit regressions. *Risk-avoidance* is an index constructed by adding 1 when (1) a firm's leverage is in the bottom 20% of the distribution; (2) the volatility of firm-level profitability is in the bottom 20% of the distribution; and (3) if the firm survives at least 5 years. The index ranges from 0 to 3, with higher scores denoting greater risk-avoidance. In Panel A, p-values are adjusted for heteroskedasticity and clustering at the firm level. In Panel B, bootstrapped p-values are reported in brackets below the coefficients (except for model 2).*, ** and *** indicate statistical significance levels of 10%, 5% and 1%, respectively.

Panel A: Growth-model of investment

	(1)	(2)	(3)
Value-added growth	0.154***	0.176***	0.150***
	[0.000]	[0.000]	[0.000]
Cash flow/Total fixed assets	0.085***	0.083***	0.103***
	[0.000]	[0.000]	[0.000]
Ln (1 + Age)	−0.190***	−0.193***	−0.287***
	[0.000]	[0.000]	[0.000]
Female CEO	0.011	−0.096	−0.025
	[0.298]	[0.363]	[0.212]
Female CEO * Value-added growth	−0.073***	−0.092**	−0.073
	[0.009]	[0.020]	[0.227]
Inverse Mills ratio		0.048	
		[0.352]	
Risk-avoidance			−0.023*
			[0.050]
Risk-avoidance * Value-added growth			−0.001
			[0.362]
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
R-squared	0.097	0.098	0.099
No. of observations	173,111	118,135	49,645
No. of firms	75,876	55,330	22,776

Panel B: *Q*-model of investment

	(1)	(2)	(3)
Marginal Q	0.013***	0.013***	0.008**
	[0.000]	[0.000]	[0.031]
Cash flow/Total fixed assets	0.053***	0.052***	0.061***
	[0.000]	[0.000]	[0.000]
Ln (1 + Age)	−0.042***	−0.037***	−0.040***
	[0.000]	[0.000]	[0.000]
Female CEO	0.015*	−0.229***	0.006
	[0.073]	[0.007]	[0.815]
Female CEO * Marginal Q	−0.020***	−0.040***	−0.007
	[0.000]	[0.000]	[0.464]
Inverse Mills ratio		0.124***	
		[0.004]	
Risk-avoidance			−0.013**
			[0.048]
Risk-avoidance * Marginal Q			−0.030*
			[0.067]
Country fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
R-squared	0.081	0.075	0.089
No. of observations	174,111	120,571	47,376
No. of firms	77,785	57,076	22,427

0.001. In other words, these results are consistent with male CEOs investing more when their firm is operating in an industry with good prospects, and divesting capital (or invest less) when the prospects of their firm are poor.

By contrast, the coefficient on the interaction between CEO gender and value-added growth is negative and significant (coeff. = −0.073, p-value < 0.001), implying that corporate investments are less responsive to value-added growth in firms run by female CEOs. This result suggests that women do not appear to allocate capital as efficiently as male CEOs. In unreported tests, we find that the results are robust to including other controls such as ownership concentration, profitability, sales growth, firm size, asset tangibility, and a private firm indicator. Regression (2) indicates the results are also robust to using a treatment effects specification which partially controls for the endogeneity of the CEO selection choice.

To assess the extent to which risk-avoidance is associated with less efficient capital allocation in firms run by female CEOs, in Regression (3), we augment our specification with both an index that measures the degree of risk-avoidance and the interaction of this index with value-added growth. We construct an index based on the three variables used to measure the degree of risk-avoidance. In particular, the index is constructed by adding 1 when (1) a firm's leverage is in the bottom 20% of the distribution; (2) the volatility of firm-level profitability is in the bottom 20% of the distribution; and (3) if the firm survives at least 5 years. The index ranges from 0 to 3, with higher scores denoting greater risk-avoidance. As shown in Regression (3), the risk-avoidance index is negatively correlated with the level of investment, indicating that more risk-averse CEOs invest less.

4.2. Marginal Q

To assess the efficiency of capital allocation, we also evaluate the extent to which investment is related to the marginal Q, as advocated by theory. While marginal Q is a theoretically grounded measure of the quality of investment opportunities, using Q becomes problematic if firm valuation is contaminated by investor sentiment or if there is mispricing of any kind. Additionally, marginal Q can only be computed for publicly traded firms. The extent to which it can be used to proxy for the quality of investment opportunities faced by (predominantly) private firms is, of course, subject to debate. With those caveats in mind, we note that optimal decision making in perfect capital markets requires that managers undertake *all* projects with positive expected net present value, and reject *all* projects with negative expected net present value. If projects were to be ranked based on their expected net present value per dollar of capital invested, managers should invest up to the point where, for the next project in line, the net present value is zero. By doing so, managers would maximize firm value. Equivalently, managers should invest up to the point where the firm's marginal Q is 1. A firm's marginal Q ($\dot{q}$) measures the change in the market value of firm, ΔV, associated with an (unexpected) change in capital investment, ΔI. In other words,

$$\dot{q} = \frac{\Delta V}{\Delta I} = \frac{1}{C}\{E[NPV] + C\} \tag{2}$$

where C represents the set-up cost for the capital investment, and E[NPV] is its expected net present value or, equivalently, the present value of all incremental cash flows yielded by the project in the future (net of its set-up cost). For any given $C > 0$, $E[NPV] > 0$ implies a $\dot{q} > 1$. Conversely, $E[NPV] < 0$ implies a $\dot{q} < 1$. Stated differently, value maximization implies $\dot{q} = 1$. A $\dot{q} > 1$ implies underinvestment, while a $\dot{q} < 1$ implies overinvestment.

To estimate $\dot{q}$, we largely follow Durnev et al. (2004). A few changes to their methodology are necessary because of differences in corporate disclosure in Europe. For clarity, in Appendix A, we describe each step employed in the estimation procedure, largely borrowing from Durnev et al. (2004) paper. As shown earlier in Table 1, the average marginal Q is 1.123, and the median is 0.948. We find a great deal of variation in the estimates of the marginal Q across industries. Interestingly, the marginal Q does not cluster around 1, as we would expect if, across all industries, firms were investing up to the "optimal point." Rather, there is evidence of both underinvestment and overinvestment in different industries.

As with value-added growth, to assess the efficiency of capital allocation, we estimate a simple version of the Fazzari et al. (1988) *q*-model of investment, as in Eq. (1). In the new model, we replace firm-level value-added growth with marginal Q. Table 7, Panel B, presents regressions of firm investment on marginal Q, CEO gender, the interaction between these two variables, and other controls. (In this Panel, we use bootstrapped standard errors as marginal Qs are estimatEd.) We include country, industry, and year fixed effects to mitigate measurement error problems in the estimation of marginal Q. As we pointed out above, under perfect capital markets, optimal capital budgeting requires that managers undertake all (and only) positive expected net present value projects. Equivalently, managers should undertake all investments with $\dot{q} > 1$, and avoid (or divest) those with $\dot{q} < 1$. As a consequence, given the presence of differences in the quality of investment opportunities across industries, optimal capital budgeting implies a positive relation between investments and each industry's marginal Q, $\hat{\dot{q}}_t^{i,c}$.

Consistent with optimal capital budgeting, and in line with the results in Panel A of Table 7, the results in Panel B show that there is a positive and significant association between investments and Tobin's Q for firms run by male CEOs. For example, Regression (1) shows that, for male CEOs, the coefficient of the sensitivity of investment to marginal Q is 0.013, with a p-value of less than 0.001. By contrast, the coefficient on the interaction between CEO gender and marginal Q is negative and significant (coeff. = −0.020, p-value < 0.001), once again implying that corporate investments are less responsive to marginal Q in firms run by female CEOs. This result, again, suggests that women do not appear to allocate capital as efficiently as male CEOs. As with Panel A, Regression (2) indicates that the results are robust to using a treatment effects specification to control for the endogeneity of the CEO selection choice.

In Regression (3), we augment our specification with the index that measures the degree of risk-avoidance and the interaction of this index with marginal Q. As the Table shows, the risk-avoidance index is negatively correlated with the level of investment, corroborating the earlier results that more risk-averse CEOs invest less. In addition, the index's interaction with marginal Q indicates that investment is less sensitive to marginal Q when risk-avoidance is high.

4.3. Interpretation of the evidence

There are two possible (non-mutually exclusive) explanations for the less efficient capital allocation observed among female CEOs. The first is underinvestment. This would occur if female CEOs do not undertake some of the projects with positive net present value (NPV). Underinvestment implies that women "leave money on the table" by not undertaking all available positive NPV investment opportunities. For example, to the extent that the impact of gender or risk-taking depends on the stage of the firm, for firms with high growth opportunities, female CEOs may be too risk averse to increase investment. The second source of inefficiency is overinvestment. This occurs if women do not avoid (and/or do not divest) projects with negative NPV. For example, for firms with poor investment opportunities, female CEOs may be reluctant to make divestitures and thus overinvest. Unfortunately, due to data limitations, the precise channel behind our results is difficult to identify empirically. More specifically, *Amadeus Top 250,000* does not report gross investment and divestitures separately. Instead, we are only able to observe net investments.

5. Discussion

Besides traditional explanations such as agency and informational asymmetries, possible economic reasons for why CEO gender could "influence" risk-taking include (but are not limited to) more pronounced risk aversion in female CEOs (compared to male peers), less overconfidence, differences in incentives structures, differences in unemployment risk, and social norms. In this section, we discuss alternatives to these traditional explanations.

To the extent that female executives tend to be more risk averse on average than their male peers, women might choose to reduce corporate risk-taking to a level that fits their preferences once they have become CEOs. Indeed, the experimental economics and psychology literature have documented gender-related differences in preferences and risk tolerance (see Croson and Gneezy (2009), and Bertrand (2011) for surveys).[18] However, we recognize that while it is well documented women are less risk tolerant than men *in general* (Bernasek and Shwiff, 2001; Bruce and Johnson, 1994; Hudgens and Fatkin, 1985; Johnson and Powell, 1994; Sundén and Surette, 1998), there may not necessarily be a difference between males and females among *top executives*, given the specific and rare combination of skills needed to ascend to a high management position (Adams and Funk, 2012; Adams and Ragunathan, 2013).[19]

The results are also consistent with the possibility that less overconfident agents *reduce* risk after they become CEOs. In the behavioral literature, women are typically found to be less overconfident than men, at least (on average) in the population (e.g., Barber and Odean, 2001; Lundeberg et al., 1994). Huang and Kisgen (2013) conclude that male executives appear to be more overconfident than female executives documenting that female executives are less likely to engage in acquisitions and less likely to issue debt than male executives.

Differences in the structure of compensation and incentives may also explain the documented association between gender and risk-taking. In particular, low-risk firms may be more likely to offer fixed pay contracts and may be more likely to attract female executives. Consistent with this type of matching, in Bandiera et al.'s (2015) model, more risk-averse and less talented managers match with firms offering low-powered incentives—a prediction that they confirm empirically using survey data on Italian managers combined with longitudinal data from administrative records. Using survey data from the *British Workplace Employees Relations Survey*, Manning and Saidi (2010) report fewer women in establishments that use variable (as opposed to fixed) pay.[20]

Additionally, unemployment risk differences faced by different sets of agents may also influence their matching choice or help explaining any causal impact of gender on corporate choices. More specifically, if corporate risk-taking is positively correlated with the likelihood that a CEO loses his/her job, and if finding a new job is more difficult for women than men, women might choose to self-select into low risk firms or to reduce firm risk once they have become a CEO. Indeed, across the countries and over the time period included in our study, the average unemployment rate among women who previously held a managerial position is 3.9%. By comparison, this rate is 2.7% for men.[21] Earlier studies further document that women tend to remain unemployed for longer periods than men after losing a managerial job (Phelps and Mason, 1991).

Finally, expectations by society about what is appropriate for women to do (see, for example, Altonji and Blank (1999), Akerlof and Kranton (2000), and Guiso et al. (2008)) may affect not only a woman's decision to work, but also the sorting of men and women across occupations, industries, and firms. These societal expectations might also affect the choices that women make in specific occupations (such as CEO). In a seminal study by Akerlof and Kranton (2000), deviating from the behavior that is expected by society decreases the agent's utility. To the extent that a society expects women to stay at home, the model predicts a lower participation of women to the workforce. Their model also explains occupational segregation by gender, which is further validated by Goldin (1990), Altonji and Blank (1999), and Bertrand et al. (2010). To the extent that managing high-risk firms involves longer working hours and less flexible schedules, women might disproportionately self-select into low-risk firms to be better

[18] These differences could have biological roots (e.g., Bröder and Hohmann, 2003; Maestripieri et al., 2009) could be the outcome of environmental influences (e.g., Booth and Nolen, 2012), or both (e.g., Edwards and O'Neal, 2009).

[19] The empirical evidence on this point is mixed. While Bandiera et al. (2015) provide survey-based evidence that Italian female managers are on average less risk tolerant than their male peers, Adams and Funk (2012) find Swedish female directors to be on average less risk-averse than male directors.

[20] It is, however, unclear whether there is any systematic gender pay gap at the CEO level. For example, using recent U.S. data on CEO pay, Bugeja et al. (2012) find no evidence of a gender pay gap at the CEO level. Geiler and Renneboog (2015) reach a similar conclusion using a U.K. sample—although these authors document gender pay gaps for lower ranked executives.

[21] These statistics are computed using data from the *European Labor Force Survey*.

able to accommodate the child rearing and household tasks that they often disproportionately carry (Goldin and Katz, 2010). Women might also reduce corporate risk-taking to a level that is compatible with their personal constraints after they become CEOs.

Of course, the documented association between CEO gender and corporate risk-taking could be the outcome of endogenous matching between firms and CEOs. While in our analyses, we attempted to mitigate this possibility, we recognize that non-random matching cannot be ruled out.

6. Conclusions

We investigate how CEO gender relates to corporate risk-taking choices. We document that firms run by female CEOs tend to make financing and investment choices that are less risky than those of otherwise similar firms run by male CEOs. Further, an analysis of changes in risk-taking around CEO transitions indicates that the risk-taking of a given firm tends to decrease (increase) around the transition from a male to a female CEO (or vice versa). The documented change in risk-taking around CEO transitions is over and beyond what is observed around a matched sample of peers that are always run by male CEOs.

Overall, at least in our sample, it appears that women who climbed the corporate ladder are different from their male peers. The results do not appear to be driven by unobserved CEO or firm traits that could give rise to non-random self-selection. Specifically, a multitude of tests indicate that, even after controlling for self-selection, women CEOs tend to take on less risk compared to their male counterparts. Importantly, in our large sample of female CEOs, we document that gender-related differences in risk-taking documented in experimental economics and psychology studies extend to top corporate executives.

We further show that the risk-avoidance of female CEOs appears to have implications for the efficiency of the capital allocation process. We observe a positive association between the quality of investment opportunities and the level of investments for firms run by male CEOs, while this association is significantly weaker among firms run by female CEOs. Thus, female CEOs do not appear to allocate capital as efficiently as male CEOs.

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Appendix A. Estimation of a firm's marginal Q ($\dot{q}$)

To estimate $\dot{q}$, we rewrite (2) as

$$\dot{q}_{j,t} = \frac{V_{j,t} - V_{j,t-1}\left(1 + \hat{r}_{j,t} - \hat{d}_{j,t}\right)}{A_{j,t} - A_{j,t-1}\left(1 + \hat{g}_{j,t} - \hat{\delta}_{j,t}\right)} \tag{3}$$

where $\dot{q}_{j,t}$ is the marginal Q of firm j at time t. $V_{j,t}$ is the market value of firm j at time t, and $A_{j,t}$ is the stock of capital of firm j at time t. $\hat{r}_{j,t}$ is the expected return from owning j; $\hat{d}_{j,t}$ is the expected disbursement rate to providers of capital; $\hat{g}_{j,t}$ is the expected rate of growth of the stock of capital; and $\hat{\delta}_{j,t}$ is its expected rate of depreciation. Thus, $V_{j,t} - V_{j,t-1}(1 + \hat{r}_{j,t} - \hat{d}_{j,t})$ is the change in the market value of firm and $A_{j,t} - A_{j,t-1}(1 + \hat{g}_{j,t} - \hat{\delta}_{j,t})$ is the unexpected change in the stock of capital.

Eq. (3) can be rewritten as

$$\frac{V_{j,t} - V_{j,t-1}}{A_{j,t-1}} = -\dot{q}_{j,t}\left(\hat{g}_{j,t} - \hat{\delta}_{j,t}\right) + \dot{q}_{j,t}\frac{A_{j,t} - A_{j,t-1}}{A_{j,t-1}} + \hat{r}_{j,t}\frac{V_{j,t-1}}{A_{j,t-1}} - \hat{d}_{j,t}\frac{V_{j,t-1}}{A_{j,t-1}} \tag{4}$$

which we estimate separately for each 3-digit SIC i industry in each country c, using all firms with available accounting and market data in any given year, as follows:

$$\frac{\Delta V^{i,c}_{j,t}}{A^{i,c}_{j,t-1}} = \beta^{i,c}_0 + \beta^{i,c}_1\frac{\Delta A^{i,c}_{j,t}}{A^{i,c}_{j,t-1}} + \beta^{i,c}_2\frac{V^{i,c}_{j,t-1}}{A^{i,c}_{j,t-1}} + \beta^{i,c}_3\frac{\hat{d}^{i}_{j,t}V^{i,c}_{j,t-1}}{A^{i,c}_{j,t-1}} + u^{i,c}_{j,t} \tag{5}$$

The coefficient $\beta_1^{i,c}$, estimated across all publicly traded firms in a given industry *i* and country *c*, represents the marginal Q for that industry in that country. We estimate the regression using ordinary least squares with rolling panels of 5 years to obtain yearly estimates of marginal Q ($\hat{q}_t^{i,c}$).

Estimates of $\hat{q}_t^{i,c}$ are determined at the industry level, rather than firm level, for three main reasons. First, estimation at the firm-level would require many years of data and could therefore suffer from severe survivorship bias. Second, as the production technology employed may change through time, estimates based on long-term event windows could be unreliable. Third, measuring across firms should reduce the impact of noise on our estimation.[22] Mitigating noise is important as we use marginal Q estimated across publicly traded firms to proxy for the investment opportunities faced by (mostly) private firms.

We define $V_{j,t}$ as $(CS_{j,t}+PS_{j,t}+LTD_{j,t}+STD_{j,t})/GDP\ deflator_t$. $CS_{j,t}$ is the market value of outstanding common shares of firm *j* at the end of year *t* (*Worldscope* item WC08001). $PS_{j,t}$is the value of preferred shares of firm *j* at the end of year *t* (*Worldscope* item WC03451). $LTD_{j,t}$ and $STD_{j,t}$ are the book values of firm *j*'s long-term and short-term debt, respectively (*Worldscope* items WC03251 and WC03051). GDP deflators are taken from the World Bank, World Development Indicators and from EconStats.[23] We use them to convert values into 2000 prices.

We define $A_{j,t}$ as $(K_{j,t}+STA_{j,t})$. $K_{j,t}$ is the estimated market value of firm *j*'s property, plant and equipment (PPE). We use a perpetual inventory formula to estimate the market value of PPE, using data for the previous 10 years.[24] In particular, the estimated market value of PPE at the end of year *t* is computed as

$$K_{j,t} = (1-\delta)K_{j,t-1} + \frac{\Delta\ \text{Gross PPE}_{j,t}}{GDP\ deflator} \tag{6}$$

We set $K_{j,t-10} = \frac{\text{Net PPE}_{j,t-10}}{GDP\ deflator}$. Net PPE is gross property, plant and equipment, less accumulated reserves for depreciation, depletion, and amortization (*Worldscope* item WC02501). We assume a constant annual depreciation rate, δ , of 10%. The change in gross PPE (*Worldscope* item WC02301) measures the annual spending in PPE. Therefore, the estimated market value of PPE at the end of year *t* is equal to the estimated market value of PPE at the end of year $t-1$ minus 10% depreciation plus (deflated) capital spending during year *t*.

$STA_{j,t}$ is the book value of firm *j*'s short-term assets (*Worldscope* item WC02201), expressed in 2000 prices. We do not attempt to estimate the market value of short-term assets, as *Worldscope* does not provide information on the method used to evaluate inventories (e.g., LIFO vs. FIFO). Finally, we define $\hat{d}_{j,t}^{1}V_{j,t-1}$ as dividends plus interest expense (*Worldscope* items WC04551 and WC01251).

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[23] http://www.econstats.com/wdi/wdiv_758.htm.
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