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Effects of board gender diversity on firm investment and performance: Empirical evidence from Japan

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ABSTRACT

This paper examines the effects of female directors on firm investment behaviour and performance. Using panel data of more than 3,000 listed firms in Japan from 2009 to 2015, I find that only 10% of some 23,000 firm-year observations have female directors on the board. The results show that the presence of female directors is not associated with risk-averse behaviours. The firms without female directors achieve better CARs from M&A announcements compared with those of the firms with female directors. I find no significant impacts of female directors on ROA and Tobin's Q after having addressed several potential endogeneities. However, when I separate female directors into outside and inside female directors, I find variations in the investment behaviour between the different types of female directors and the performance of firms with outside female directors is negatively related to ROA and Tobin's Q in several analyses.

JEL classification: L25; G32; G34; G38

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1. Introduction

Boards are ultimately responsible for ensuring the firms they serve create value for their stakeholders (Adams, 2017). The important role of boards makes them a fascinating research topic and has attracted attention from academia for many years(1). Business leaders and policy makers worldwide have referred to research about the effects of gender quotas and more independent and diverse boards. However, because of board complexities, data limitations and limitations in the methods to deal with board-related endogeneities (Adams, 2017), results from a specific country may not be applicable to other countries. Therefore, it is important to conduct empirical studies about boards for different countries with different corporate governances to understand board dynamics and determine what makes a board effective in a specific country or corporate governance setting.

Worldwide, the effectiveness of corporate boards is a fascinating, impactful and fertile research topic, but surprisingly there are few studies using Japanese firm data. The most common problem for researchers is data limitations on boards of directors (Adams, 2017). The lack of public information about individual directors makes board diversity in Japan a poorly understood issue.

Research into board diversity in Japan has also been restricted by the slow changes in firms' corporate culture and corporate governance practices. Previous studies have described the unique patterns of Japanese corporate governance as having bank-based, relationship-oriented, network-based, insider-dominated, stakeholder-focused and highly co-ordinated characteristics

(1) Adams (2017) identified 569 papers on boards that were published in finance and other journals between 1990 and 2014. Kirsch (2018) reviewed research about the gender composition of corporate boards only and identified 310 papers published in 135 journals from 1981 to 2016.

(Aoki et al., 2007; Hirota, 2015) and boards of directors are often boys' clubs and composed primarily of inside directors (Saito, 2011). These conventional findings held true until the banking crisis occurred in the 1990s.

Following the collapse of the bubble economy, and faced with a long-term economic slump, Japanese firms were required to adapt to new patterns of corporate governance under the upsurge of governance reforms over and over. Miyajima and Saito (2021) documented that there have been a series of reform measures implemented over the last 20 years. The first group of reforms following the banking crisis in 1997 introduced the hybrid(2) board structure, while corporate governance reforms under "Abenomics"(3) led to a further transition of the corporate governance system towards a hybrid structure with subsequent refinement of this structure. The reforms required firms to enhance board advising and monitoring roles by diversifying board composition with more outside directors and female directors.

More specific to female management, in 2013 the Abe Cabinet introduced "Womanomics"(4) policies that aimed to increase female labour supply and promote more women to leadership positions. This policy is a pillar of Abe's economic growth strategy. Japan's working population is shrinking rapidly and increases in female labour supply are essential for reinvigorating and

(2) Hybrid firms have been defined by authors as firms that have significantly changed their external governance systems to market-based systems and combined these with traditional relationship-based internal governance mechanisms (Jackson and Miyajima, 2007; Miyajima and Saito, 2021).

(3) "Abenomics" refers to the policy packages implemented by the government of Shinzo Abe, consisting of a series of economic reforms that were designed to reinvigorate Japan's economy. The policy mix consists of bold monetary policy, flexible fiscal policy, and a growth strategy often referred to as "three arrows".

(4) The term "Womanomics" was first introduced by Kathy Matsui and her team when they prepared the Japan Portfolio Strategy report, which was published by Goldman Sachs in 1999. Womanomics is the concept that the advancement of women will provide a much-needed economic boost to an ageing Japan. The authors suggested that encouraging more women into the workforce and investing in them would help boost Japan's gross domestic product. This spurred Prime Minister Shinzo Abe to launch measures promoting the role of women.
https://www.goldmansachs.com/our-firm/history/moments/1999-womenomics.html

boosting the economy. The Abe administration often emphasized the importance of female leadership; “Women bring to corporate management certain perspectives that only women can provide. Diversified organizations are able to provide society with new types of added value”(5).

Many countries try to increase the female representation on board (Adams, 2017; Terjesen et al., 2014). In many cases, these countries try to promote board diversity by setting a quota(6) on female representation. In contrast, Japanese government tries to promote female leadership not by setting a quota, but through 'Womanomics', by encouraging large corporations to promote policies on gender and employment. In particular, firms are advised to devise and disclose their action plans to improve gender equality and to disclose the data on gender and employment. It would be interesting to examine how effective this approach is.

The continuous legal reforms of Japanese corporate governance, especially relating to more female empowerment, are catalysts for academia to examine the effects of corporate governance changes on board structure and firm value (Tanaka, 2019; Sako and Kubo, 2019; Morikawa, 2016, 2020). There is less evidence about the effects of board gender diversity on firm investment and value. As more female directors have been appointed to boards in recent years, the analysis of female representation on corporate boards is important. Why do some firms have female directors, whereas others do not? Do firms with female directors behave differently from the firms without them? Do female directors eventually increase firm value? Answering these questions will extend the literature and inform policy-makers and business leaders regarding the appointment and empowerment of female directors.

Using an unbalanced panel of non-financial listed firms in Japan from 2009 to 2015, I find that only 10% of the firm-year observations have at least one female board director. The number of female directors increases gradu-

(5) https://japan.kantei.go.jp/96_abe/statement/201409/waw140912.html

(6) e.g., 40% female board membership quota in Norway; 25% women board membership target in the UK.

ally year-on-year in my sample and increases sharply in 2015. When I compare firm characteristics between firms with female directors and those without, the firms with female directors are larger in terms of assets; the board size is also larger, with younger directors and more outside directors.

Regarding the effects of female directors on firm investment behaviour, I find that the presence of female directors is not associated with risk-averse behaviours. The estimation results from my event study show that firms without female directors earn better cumulative abnormal returns (CARs) from M&A announcements compared with those of firms with female directors. When I separate female directors into outside female directors and inside female directors, I find weak evidence on the differences between the two groups. Regarding high-risk investments such as R&D and M&A, firms with inside female directors are less likely to invest in R&D, whereas firms with outside female directors are more likely to undertake R&D. In terms of investment efficiency, firms with inside female directors earn better CARs from M&A announcements compared with those of firms with outside female directors.

Next, I examine the effects of female directors on firm performance using OLS, fixed effects (FE), and instrumental variable two-stage least squared (IV 2SLS) regressions and propensity score matching method. Overall, I found no relation between female directors and firm performance as proxied by ROA and Tobin's Q after having addressed all potential endogeneities. The performance of firms with outside female directors is negatively related with ROA and Tobin's Q in several analyses.

I examine the effects of "Womanomics" from 2013 to 2015, and in particular whether firms were more likely to have female directors during this three-year period compared with earlier periods. Indeed, firms were more likely to have a female director during this three-year period and the marginal effect is 25.3 percentage points. This result suggests that "Womanomics" may have had the effect of increasing the number of female directors.

My research contributes to the related literature in several aspects.

First, it is the first research to examine the relation between firm investment behaviour and female director presence, using data of Japanese listed firms. Second, the paper also shows a link between firm behaviour and firm performance, which may explain the difference in the performance of the firms with female directors compared to the firms without. As the recent appointments of female directors may not change the behaviour of Japanese listed firms, I do not find evidence on the significant impact of female directors on firm value.

The remainder of this paper is organized as follows. In the next section, I review the related literature. Section 3 describes the data and methodology. Section 4 presents the main empirical results. Section 5 presents a robustness check with additional analyses and Section 6 concludes the paper.

2. Literature review

The impact of female directors on firm performance has been explained in several theories. The most popular one is agency theory, which emphasizes the role of the board in monitoring the management (Fama and Jensen, 1983; Jensen and Meckling, 1976). If the directors on the board do their job well, they can prevent managers from pursuing their own interests which might harm the firm's stakeholders. But how can directors enhance monitoring efficiency? Ferreira (2010) showed that managerial monitoring can be improved if the board directors are varied in their professions, experiences and skills. Regarding female directors, indeed, they are more diligent monitors as they do not belong to the "old boy network" (Adams and Ferreira, 2009). They are more likely to raise questions(7) than the other directors and demand greater audit effort than male directors. Therefore, through efficient monitoring, female directors can create value for stakeholders and increase

(7) The recent scandal of Yoshiro Mori, Tokyo Olympics Chief and also a former Japanese Prime Minister, is a lively illustration of how female board members operate as he had complained that women talk too much during meetings.
https://www.nytimes.com/2021/02/11/world/asia/yoshiro-mori-tokyo-olympics-resigns.html

firm value.

Another related theory, the resource dependence theory developed by Pfeffer and Salancik (1978), can also explain the positive impact of female directors. Firms, over their business cycles, often face uncertainties and, in order to survive, they need various resources provided by its board members. Female directors may bring different skills, knowledge, experiences and personal competencies to the firms and enhance firm value via advice and counsel or connecting firms to their external networks and resources. Improved monitoring and superior resources are two reasons for the positive effects of female directors on firm performance.

According to board diversity theory (Forbes and Milliken, 1999; Milliken and Martins, 1996), the effects of board diversity can be both positive and negative. A positive aspect is that diverse boards can make better decisions as the diversity brings more ideas, more innovation and various perspectives. However, a diverse board sometimes has intense and conflictual discussions, thus slowing down decision making and damaging firm value.

As the board diversity perspective predicts a contingent effect of board gender diversity, the empirical literature on this topic presents mixed results. Carter et al. (2003) examined the data of Fortune 1,000 firms and found a positive relation between board gender diversity and Tobin's Q. However, in a latter paper, they found no effect of board diversity using a panel data of S&P 500 firms from 1998 to 2002 (Carter et al., 2010). Adams and Ferreira (2009) used panel data of S&P 500, MidCaps and SmallCaps from 1996 to 2003 and documented that the average effect of gender diversity on firm performance is negative. The negative effect comes from a reduction in takeover defences.

In addition, regarding the effects of female directors on firm behaviour, women are more risk averse than men in making important corporate decisions (Huang and Kisgen, 2013; Doan and Iskandar-Datta, 2020; Perryman et al., 2016; Sila et al., 2016). However, several researchers have found a positive relation between female directors and innovation in the case of a specific

type of innovation or in the case of firms with more than one woman on their board (Miller and Triana, 2009; Torchia et al., 2011).

Regarding mergers, Kirsch (2018) reviewed more than 300 articles about board composition and found that there is a limited number of studies on the effect of women directors on firm strategy, including mergers. Furthermore, previous studies have shown that firms with female board members are less likely to make acquisitions. However, when they do, they tend to pay lower bid premia and help create shareholder value through their influence on acquisition decisions (Chen et al., 2016; Levi et al., 2014).

Boards often consist of inside and outside directors. Outsiders are either independent directors who have no business, family or interlock connections to the firm, while insiders are executive directors (Adams, 2017). Although the literature on boards often mentions the dual function of monitoring and advising by every board director, outside directors are often indicated to be more effective monitors (Adams et al., 2010; Morikawa, 2020). Insiders, however, provide valuable information to the board. Klein (1998) found that a greater number of insiders on finance and investment committees is associated with better firm performance. In Japan, since the mid-2010s, the Japanese government has enforced policies to promote corporate governance reforms by increasing the number of outside directors, expecting that outside directors will improve firm performance through the "provision of advice on business policies and business improvement" and "monitoring of the management through important decision-making at the board" (Principle 4.7 of the Corporate Governance Code, 2015; Morikawa, 2020)

Although there exists a large body of literature investigating the impact of female directors on firm behaviour and firm performance, most female directors are outside directors (Farrell and Hersch, 2005; Adams and Ferreira, 2009), and few prior studies analyse the effects of inside and outside directors simultaneously (Levi et al., 2014; Niikura and Seko, 2020; Tanaka, 2019)

Levi et al. (2014) separated female directors into independent directors(8)

and dependent directors[9]. They found that both types of female directors negatively affect the number of M&As. However, the fraction of independent female directors on the bidder board is negatively and significantly associated with the bid premium size, but there is no significant association between the fraction of dependent female directors and the size of the bid premium. This finding is consistent with studies indicating that boards dominated by independent directors or outside directors are more likely to make decisions that are in the interest of shareholders (Shivdasani, 1993; Hermalin and Weisbach, 1998).

There is little research on female directors in Japan. Morikawa (2016) used a dataset of about 3,000 firms in 2011, covering both listed and unlisted firms, and found that listed and old firms, subsidiaries or firms with labour unions tend not to have female directors, while owner-managed or family-controlled firms tend to have female directors and CEOs.

Tanaka (2019) expanded the analysis using panel data of about 2,000 listed firms over the period 2006–2015 and found differences in firm characteristics regarding inside and outside female directors. That is, firms with outside female directors are often larger firms, with younger boards and more outside directors, greater foreign ownership and lower growth prospects. However, firms with inside female directors are often younger and smaller firms but have large boards, higher managerial ownership and smaller foreign operations. Moreover, Tanaka (2019) found that firms with outside female directors outperform firms without them in terms of Tobin's Q.

Niikura and Seko (2020) addressed a similar question and found that

(8) They defined independent female directors as female directors who are neither corporate executives nor have any kinship or business relationship with the firm. Independent female directors in their sample are similar to outside female directors in Japan, while dependent female directors are similar to inside female directors in Japan.

(9) They defined dependent female directors as female directors who are also corporate executives and/or have family/ business relationships with the firm. Dependent female directors are therefore similar to inside female directors in Japan.

female directors, including both inside and outside female directors, have a positive effect on ROE for firms on the First Section of the Tokyo Stock Exchange.

So far, prior studies focusing on Japanese firms have found a significant relation between female directors and firm performance, but these studies do not fully address or investigate the channels through which female directors affect firm performance. Furthermore, no study has examined the effects of female directors on firm behaviour; however, I expect that there is a link between firm behaviour and firm performance, which may explain the difference in the performance of firms with female directors compared with other firms. This study makes several contributions to the extant literature by carrying out a comprehensive analysis of gender diversity on Japanese corporate boards and investigating the effects of female directors on firm investment behaviour and firm performance. Considering the difference between outside and inside directors, I also examine the effects of inside and outside female directors on behaviour and firm performance.

3. Data and methodology

I use data from several main databases. Data on directors are collected from the Directory of Directors provided by Toyo Keizai Inc., including information about the name, age, position title, gender, place of birth, education and previous experience of each director. Data on firm characteristics, including financial health and ownership structure, are taken from NEEDS CGES (Corporate Governance Evaluation System) provided by Nikkei Inc. and the Corporate Financial Databank provided by Development Bank of Japan. Following previous studies on boards of directors in Japan (Saito, 2008; Tanaka, 2019; Morikawa, 2016), I excluded financial firms and public utility firms(10). After merging the databases together, the final sample consists of an unbal-

(10) The reason for excluding these firms is that it is difficult to calculate Tobin's Q in the financial sector or to separate the effects of various government regulations on public utility firms (Saito, 2008).

anced panel of about 23,600 firm-year observations from 2009 to 2015.

I also collected data on mergers and acquisitions from Capital IQ provided by Standard & Poor's. My transaction screening criteria are to collect all merger or acquisition transactions by Japanese listed acquirers from 2009 to 2015. The total transaction value is greater than 0 and the percent sought is greater than 50%. Overall, I have 1,750 M&A deals in which the acquirers are listed Japanese firms in my panel data. Next, I create firm-year level observations by summing all M&A transactions made by a firm in a year and merge the M&A data set with my panel data. Therefore, I have the variable named *number of M&A deals*, which is the total M&A transactions carried out by firm i in year t. Regarding information about stock prices and the market index, I obtain data from Astra Manager and Speeda.

Table 1 presents the summary statistics of all variables used in this research. The definitions of the variables are provided in Appendix 1. In general, I divide the variables in two groups. The first group of variables represents the board characteristics, including *female director dummy*, *female director ratio*, *outside female director dummy*, *inside female director dummy*[(11)], *board size*, *board age*, *outside director ratio*, *CEO tenure* and *CEO gender*. The second group of variables represent firm characteristics, including *sales growth rate*, *listing duration*, *total assets*, *ROA*, *Tobin's Q*, *ROE*, *foreign sales ratio*, *number of M&A deals*, *R&D expenses ratio*, *leverage*, *free cash flow ratio*, *volatility*, *managerial ownership ratio* and *foreign ownership ratio*.

Columns 1, 2, 3 and 4 present the statistics of the full firm sample. There are 23,646 firm-year observations from 2009 to 2015, of which 2,352 firm-year observations have at least one female board director. On average, corporate boards in Japan have about seven members. Firms with at least one female director account for about 10% of the firm-year observations, while the ratio of female directors to total board members is 1.66%; the ratio of outside direc-

(11) In several model estimations, instead of using dummy variables, I use outside female director ratio and inside female director ratio based on the model requirements.

tors is 12.9%. Among the firms with female directors, 34% have outside female directors only; 63% of firms have inside female directors only; very few firms have both outside and inside female directors. Board members have a mean age of 57 years and CEO tenure is about seven years with very few female CEOs.

Columns 5, 6, 7 and 8 present the statistics of the firms with at least one female board director, while columns 9, 10, 11 and 12 present the statistics of the firms without a female director. The last two columns show the results of a univariate comparison. When I compare the means and medians of various firm characteristics between the two groups for the years in which the firms had a female director, the firms are larger in terms of total assets, the board size is larger with younger directors and there are more outside directors. Regarding performance, firms with female directors have better performance in terms of ROA and Tobin's Q, higher managerial ownership ratio and foreign ownership ratio.

Overall, Table 1 shows that there are several firm characteristics that might influence firms' decision to appoint female directors and I control for these characteristics in all analyses.

Table 2 details the distribution of female directors for each year of my sample. This figure increases gradually each year and rises sharply in 2015 such that among the 3,369 listed firms, 577 firms have at least one female board director. In terms of directorships, there are about 25,000 directorships per year, but only 400 of these were held by females, accounting for 1.6% of the boardroom. In the data set of Morikawa (2016), the share of companies with female directors in 2011 was 19% and the mean ratio of female directors is 5.4%, which is larger than those found in my data set (10% and 1.66%, correspondingly). The author examined both listed and non-listed firms in the analysis, so it might be likely that non-listed firms have more female board directors than listed firms. Faccio et al. (2016) also suggested that unlisted firms might have more female directors than listed firms.

Table 2 also shows that more firms have appointed female board direc-

Table 1: Summary statistics

The sample consists of nonfinancial listed firms from 2009 to 2015. Definitions of variables are provided in Appendix 1. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

	All firms				Firms with female directors				Firms without female directors				Statistic for difference	
Variables	Obs	Mean	Standard deviation	Median	Obs	Mean	Standard deviation	Median	Obs	Mean	Standard deviation	Median	t-Statistic	Z-Statistic
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Female director (dummy)	23,646	0.10	0.30	0.00	2,352	1.00	0.00	1.00						
Female director ratio (%)	23,646	1.66	5.43	0.00	2,352	16.02	6.98	14.29						
Outside female director	23,646	0.03	0.18	0.00	2,395	0.34	0.47	0						
Inside female director	23,646	0.07	0.25	0.00	2,395	0.63	0.48	1						
Board size (n)	23,646	7.51	3.01	7.00	2,352	7.88	3.03	7.00	21,294	7.47	3.00	7.00	6.31***	7.15***
Board age (year)	23,637	57.48	5.61	59.00	2,351	55.91	6.37	57.00	21,286	57.65	5.49	59.00	14.31***	13.51***
Outside director ratio (%)	23,645	12.90	15.17	10.00	2,352	18.50	17.68	16.67	21,293	12.28	14.74	10.00	19.01***	17.70***
CEO tenure (year)	23,646	7.05	8.31	4.00	2,352	8.89	10.11	5.00	21,294	6.84	8.07	4.00	11.35***	6.59***
CEO gender	23,646	0.007	0.09	0.00	2395	0.017	0.13	0	21251	0.006	0.08	0	6.02***	6.01***
Sales growth rate (%)	23,198	3.75	50.45	1.54	2,279	8.31	81.95	3.34	20,919	3.26	45.70	1.34	4.54***	8.56***
Listing duration (year)	23,646	26.29	20.11	19.00	2,352	19.90	18.85	12.50	21,294	27.00	20.12	20.00	16.34***	18.27***
Total assets (millions yen)	23,599	194,484	1,035,675	25,864	2,349	392,307	1,524,384	21,897	21,250	172,617	964,168	26,318	9.77***	3.44***
ROA	23,463	5.06	7.53	4.29	2,329	6.70	8.95	5.78	21,134	4.88	7.33	4.16	11.14***	12.69***
Tobin's Q	23,501	1.11	0.76	0.94	2,325	1.31	0.92	1.05	21,176	1.08	0.73	0.92	13.64***	20.73***
ROE	23,391	4.13	17.72	5.14	2,320	6.09	19.27	7.08	21,071	3.92	17.52	4.97	5.59***	11.02***
Foreign sales ratio (%)	2,286	0.04	0.02	0.03	128	0.04	0.02	0.03	2,158	0.04	0.02	0.03	0.41	0.88
Number of M&A deals	23,646	0.07	0.32	0.00	2,395	0.12	0.39	0.00	21,251	0.07	0.32	0.00	6.70***	7.43***
R&D expenses (%)	12,528	2.02	2.40	1.19	946	2.19	2.63	1.33	11,582	2.01	2.37	1.18	2.29***	1.90*
Leverage (%)	23,599	49.36	27.30	49.38	2,349	48.43	22.19	49.71	21,250	49.46	27.81	49.37	1.74*	1.56
Free cash flow ratio (%)	23,519	1.12	96.24	2.38	2,342	−4.50	302.00	2.47	21,177	1.75	14.13	2.38	2.98***	1.35
Volatility (%)	22,346	2.80	1.32	2.53	2,130	2.74	1.44	2.33	20,216	2.81	1.31	2.55	2.22**	6.18***
Managerial ownership ratio	23,500	8.76	13.58	2.14	2,326	14.44	17.52	6.31	21,174	8.13	12.93	1.94	21.45***	12.92***
Foreign ownership ratio	23,619	8.44	11.70	3.22	2,350	11.64	14.65	5.04	21,269	8.08	11.28	3.10	14.02***	9.75***

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Table 2: Summary statistics on female directors

This table shows the summary statistics of female directors. The sample consists of nonfinancial listed firms from 2009 to 2015. The definitions of the variables are provided in Appendix 1.

	Total firms (firm)	Total firms having female directors (firm)	Total firms having outside female directors (firm)	Percentage of firms having outside female directors (over total firms having a female director)	Total board members (persons)	Total female directors (persons)	Total outside female directors (persons)	Percentage of outside female directors (over total female directors)
Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total/Mean	23,646	2,352	884	Mean=38%	177,042	2,887	951	Mean=33%
2009	3,540	258	61	24	26,822	318	66	21
2010	3,424	266	66	25	25,736	326	70	21
2011	3,363	277	72	26	25,096	337	77	23
2012	3,316	283	84	30	24,497	353	91	26
2013	3,302	313	106	34	24,147	391	114	29
2014	3,332	378	156	41	24,597	464	167	36
2015	3,369	577	339	59	26,147	698	366	52

tors in recent years, with the percentage of firms having at least one female director rising from 7.2% in 2009 to 17.12% in 2015.

In addition, separating female directors into outside and inside directors, the number of firms that appointed an outside board director increased from 61 firms in 2009 (about 24% of all firms with a female director) to 339 firms in 2015 (about 59% of all firms with a female director).

The increase in the number of firms that appointed a female to their board and in the number of outside female directors can be partly explained by firms responding to a government request (Tanaka, 2019). The then Prime Minister Shinzo Abe's administration advised that firms should have at least one female board director and Tokyo Stock Exchange also requires listed firms to disclose the number of female directors on their board. Tanaka (2019) assumed that it is easier to appoint an outside female director than an inside female director as it takes time to promote a female leader in the current board's hierarchy.

4. Empirical results

4.1 Determinants of female director presence and the impact of "Womanomics"

Results from Table 1 show that there are differences in firm characteristics between the firms with female directors and the firms without them. Furthermore, the number of female directors has been increasing at a slow pace, which indicates that some firms are favourable or in need of female directors, whereas other firms are not; or at some firms, females are easier to promote to the board than at other firms. Therefore, it is interesting to identify the presence of female directors on boards by examining firm characteristics.

Following previous studies (Morikawa, 2016; Tanaka, 2019), I use a probit model to analyse the determinants of female directors. The dependent variables are *female director*, *inside female director* and *outside female director*. I use the three following sets of control variables based on related studies, as

well as the univariate tests shown in Table 1.

The first set of variables represent board characteristics, including *board size*, *board age* and *outside director ratio*. The univariate tests in Table 1 show that the firms with female directors have larger and younger boards, with more outside directors compared with other firms. Therefore, I predict that the coefficients on *board size* and *outside director ratio* will be positive, while the coefficient on *board age* will be negative. These assumptions are also consistent with previous findings that larger boards provide more seats for different types of directors (Farrell and Hersch, 2005; Tanaka, 2019); young directors or outside directors are more willing to accept diversified members.

The second set of variables represent firm characteristics, including *listing duration*, *log of total assets*, *ROA*, *volatility*, *R&D expenses ratio* and *leverage*. In addition, following Nagase (2018), I create a dummy variable called *womanomics*, which equals to one in the years 2013, 2014 and 2015 and zero otherwise. Finally, I also control for industry FE and year FE. Regarding year FE, because I use the dummy variable *womanomics*, I only include the year dummies from 2009 to 2012 to control for changes in the period before the "Womanomics" years.

Table 3 shows the results of the probit regressions for the determinants of female director presence. The figures are the marginal effects of the explanatory variables.

Column 1 shows the result for the dependent variable *female director*. I found the estimation results to be consistent with my original assumptions regarding coefficient signs. Column 1 shows that the presence of female directors is positively correlated with *board size*, *outside director ratio*, *firm size* (proxy by the *log of total assets*), *leverage*, *managerial ownership ratio*, *foreign ownership ratio* and especially, *womanomics*. All the corresponding coefficients are strongly significant at the 1% significance level, except for the coefficient of *leverage* (slightly significant at the 10% significance level). However, the coefficients of *board age*, *listing duration*, *ROA* and *volatility* are

Table 3: Determinants of female director presence

This table provides the results of probit regressions of the determinants of female director presence. The sample consists of listed firms from 2009 to 2015, whose primary industry is not financial services or utilities. Standard errors in parentheses are robust standard errors clustered at the firm level. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)
Regression model	Probit	Probit	Probit
Dependent variable	Female director	Inside female director	Outside female director
Board size	0.0516***	0.039***	0.052***
	(0.006)	(0.009)	(0.008)
Board age	–0.020***	–0.008	–0.035***
	(0.004)	(0.005)	(0.008)
Outside director ratio	0.020***	–0.002	0.038***
	(0.001)	(0.001)	(0.001)
Listing duration	–0.006***	–0.008***	–0.006***
	(0.001)	(0.001)	(0.001)
Log (total assets)	0.057***	–0.153***	0.236***
	(0.018)	(0.026)	(0.024)
ROA	–0.005*	0.003	–0.016***
	(0.003)	(0.003)	(0.005)
Volatility	–0.049*	–0.001	–0.174***
	(0.026)	(0.029)	(0.045)
R&D expenses (%)	0.010	–0.011	0.013
	(0.009)	(0.010)	(0.015)
Leverage	0.0006	–0.0008	0.001
	(0.001)	(0.001)	(0.001)
Managerial ownership ratio	0.023***	0.019***	0.0002
	(0.002)	(0.002)	(0.004)
Foreign ownership ratio	0.007***	0.015***	–0.002
	(0.002)	(0.002)	(0.002)
Womanomics	0.253***	0.106	0.438***
	(0.059)	(0.072)	(0.087)
Constant	–1.273***	0.226	–2.817***
	(0.380)	(0.460)	(0.571)
Observations	12,109	10,424	12,109
Pseudo R-squared	0.16	0.13	0.31
Industry FE	Yes	Yes	Yes
Year FE (2009–2012)	Yes	Yes	Yes

negative and statistically significant. These findings are consistent with the findings by Morikawa (2016) and Tanaka (2019), except for the coefficient sign of *ROA*.

The contribution of this analysis is that I find a positive effect of "Womanomics" in the initial years of this policy implementation. Table 3 shows that, during the three years from 2013 to 2015, other things being equal, firms were more likely to have a female director than in other years and the marginal effect is 25.3 percentage points. This result indicates that "Womanomics" may have had the effect of increasing the number of female directors.

In columns 2 and 3, I divide the firms with the female directors into two groups: firms with inside female directors and firms with outside female directors[12] and re-estimate the probit regressions. The dependent variable in column 2 is the *inside female director* dummy variable and the dependent variable in column 3 is the *outside female director* dummy variable.

I found variations in the determinants of the different types of female directors. Both firm types have larger boards and shorter listing years. However, firms with an inside female director are smaller in size and have a larger managerial ownership ratio and foreign ownership ratio compared with the remaining firms. The significant and negative coefficient of *total assets* in the log form suggests that smaller firms are more likely to have inside female directors. As the coefficient of *managerial ownership ratio* is significant and positive, the firms with inside female directors may be family firms and the board may include several family members. These findings are consistent with prior researches (Morikawa, 2016; Tanaka, 2019) that women are highly represented on the boards of Japanese firms managed and/or controlled by family members. Family members tend to serve as directors and several of them may be female.

In addition, *foreign ownership ratio* has a significant and positive coeffi-

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[12] I exclude firms with both inside and outside female directors prior to estimating the probit regressions. There are 75 firm-year observations of this type that were excluded.

cient, which suggests that firms with higher foreign ownership are more likely to have outside female directors. Foreign investors prefer a more diverse board as this enhances the quality of corporate governance (Adams and Ferreira, 2009), so they may place more pressure on the firm to increase the number of female board members. It might be faster and easier to promote firm female managers to the board than recruiting outside female directors as the market for outside female directors is not large in Japan.

Column 3 shows the results for the dependent variable *outside female director*. Firms with outside female directors are larger firms, and they have younger and more outside directors and worse financial performance with negative coefficients for *ROA* and *volatility*. In contrast to column 2, the coefficient of *total assets* in column 3 is positive and significant, which suggests that larger firms are more likely to have outside female directors. Compared with small firms, large firms are subject to more regulations, especially during corporate governance reforms, such as the Josei Katsuyaku Suisin Hou (The Act on Promotion of Women's Participation and Advancement in the Workplace), proposed in 2014, which mandates firms with more than 300 employees to use female employees in management more actively (Nagase, 2021). Moreover, outside directors may push the firm they serve to appoint outside female directors in order to enhance the quality of corporate governance (Tanaka, 2019). As *outside director ratio* has a significant and positive coefficient in column 3, suggesting that firms with more outside directors are more likely to have outside female directors, the above assumption may be suitable.

Regarding the effects of "Womanomics", the coefficients for *womanomics* are both positive in the two regressions, but the coefficient is only strongly significant for *outside female director*. This implies that outside female directors are likely to be appointed to boards during these policy years.

Overall, using probit regressions[13], I find that firms with female directors have larger and younger boards with more outside directors than firms without female directors. Firms with female directors are also younger listed

firms with high managerial and foreign ownership ratios. During the early years of the "Womanomics" policy implementation, it is likely that more female directors were introduced to the boards of directors, especially outside female directors.

4.2 Female directors and firm investment

4.2.1 Female directors and firm investment: OLS and FE regressions

In this section, I examine the relation between board gender diversity and high-risk investment behaviour, in particular, whether or not firms having female directors are more actively involved in high-risk investments. Following Morikawa (2020), I used R&D expenditure, which is generally considered to be a high-risk type of investment (Morikawa, 2020). I also use the number of M&A deals initiated during the research period. Levi et al. (2014) mentioned that the number of M&A deals are a good test of the effects of board gender diversity as these transactions involve many meetings and discussions among board members and, thus, clearly show the effects of differences between male and female behavioural traits.

The M&A sample has total 1,750 deals in which the acquirers are listed Japanese firms in my panel data. Having created firm-year level observations by summing all M&A transactions made by a firm in a year and merged the M&A data set with my panel data, the final M&A deal sample consists of 23,089 firm-year observations, in which 1,381 unique firms have carried out at least one M&A transaction from 2009 to 2015. As shown in Table 1, the average number of M&A transactions made by a firm in a year is 0.07. About 94% of the firm-years have no M&A deal, 5% have one deal and 0.7% have two deals. The maximum number of M&A deals done by a firm is seven.

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(13) Morikawa (2016) and Tanaka (2019) also used Tobit regressions to examine the determinants of female directorship to avoid bias from censoring because of the small number of firms with female directors. The authors reported that the Tobit estimation results are similar to the probit ones. I also present Tobit regression results in Table 3 using the same set of variables and found similar results as those from the probit regressions. The tables are available upon request.

Data on R&D investments are taken from the Corporate Financial Databank provided by Development Bank of Japan. The mean R&D expenditure is 2.02%. There are missing data in this database, accounting for 47% of the total firm-year observations.

Table 4 presents the estimation results for the effects of female director representation on firm investment behaviour. I estimate OLS and FE regressions, in which the dependent variables are *R&D expenses ratio* and *number of M&A deals*, which are measures of high-risk investment. The independent variable of interest is the *female director* dummy variable. Following the related literature (Morikawa, 2020; Levi et al., 2014), I control for various firm characteristics including firm size, financial health and ownership structure. Industry and year FE are also controlled in the analyses. Standard errors in parentheses are robust standard errors clustered at the firm level.

Columns 1 and 2 show the estimation results of the OLS regressions. The coefficient of *female director* is negative in relation to the R&D expenses ratio, which implies that the firms with female directors may invest less in R&D activities. The coefficient of *female director* is positive in relation to the number of M&A deals, which implies that the firms with female directors may carry out more M&A transactions in comparison with the firms without female directors. However, these findings are not statistically significant.

As OLS regressions do not address the effects of omitted variables, I also estimate FE regressions. The results of the FE regressions are shown in columns 3 and 4. The coefficients for *female director* are both negative in relation to the R&D expenses ratio and number of M&A deals in the FE regressions. However, these findings are not statistically significant.

The data on R&D expenditure contains missing data which might include firms that may not have any R&D investments. In this case, observations that take a value of zero are not used in the previous analyses, which might cause a bias in the estimation. Therefore, I do further tests by replacing all missing R&D values with zeros and run the OLS and FE regressions again for the *R&D expenses* ratio variable. Results of these regressions are

Table 4: Female director and firm investment

This table shows the correlation between female director representation and firm investment behaviour. I estimate OLS and FE regressions in which the dependent variables are *R&D expenses ratio* and *number of M&A deals*. The independent variable of interest is *female director dummy*. Standard errors in parentheses are robust standard errors clustered at the firm level. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Regression model	OLS	OLS	FE	FE
Dependent variable	R&D expenses	M&A deals	R&D expenses	M&A Deals
Female director	–0.051	0.014	–0.056	–0.011
	(0.069)	(0.010)	(0.043)	(0.012)
Log (total assets)	–0.224***	0.019***	–0.836***	–0.052***
	(0.075)	(0.003)	(0.046)	(0.011)
ROA	–0.012**	0.001	–0.008***	0.002***
	(0.005)	(0.0007)	(0.001)	(0.0003)
Sales growth rate	–0.0008	0.0001*	–0.0005***	6.97e–05
	(0.0005)	(7.40e–05)	(0.0002)	(5.02e–05)
Free cashflow ratio	–0.002	–0.0001***	–0.003***	–0.0001***
	(0.002)	(1.73e–05)	(0.0008)	(2.30e–05)
Leverage	–0.008***	0.0004***	–0.005***	–0.001***
	(0.002)	(0.0001)	(0.001)	(0.0003)
CEO gender	–0.739	–0.014	–0.770***	0.022
	(0.506)	(0.023)	(0.271)	(0.051)
Managerial ownership ratio	0.004	0.0005*	0.006***	–0.0005
	(0.004)	(0.0002)	(0.002)	(0.0004)
Foreign ownership ratio	0.003	0.001***	–0.001	0.001***
	(0.004)	(0.000378)	(0.002)	(0.0005)
Listing duration	0.005*	–0.000236	0.179	0.051
	(0.003)	(0.000180)	(0.556)	(0.076)
Constant	4.241***	–0.228***	5.292	–0.580
	(0.819)	(0.0430)	(16.45)	(1.829)
Observations	12,369	23,089	23,089	23,089
R-squared	0.31	0.01	0.13	0.01
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes

reported in Appendix 2. The coefficients of *female director* are both negative in relation to the R&D expenses ratio, which again imply that the firms with female directors may invest less in R&D activities in comparison with the firms without female directors but the findings are not statistically significant.

To summarize, using R&D expenditure and M&A deals as the dependent variables representing firm investment behaviour, the coefficients with female directors are found almost negative but statistically insignificant. I find no causal evidence that the female representation in the board prevents or promotes risk-taking behaviours.

4.2.2 Female directors and firm investment: Event study

In this subsection, I analyse the wealth effects of M&A performance on Japanese listed firms focusing on comparing the CAR of the firm group with female directors to that of the firm group without. Following the related literature (Dodd and Ruback, 1977; Brown and Warner, 1985; Franks et al., 1991), I use an event study methodology to measure the effects of M&A announcements on stock returns.

My data range is from 2009 to 2015 and includes 1,439 firm-year observations having M&A transactions, involving 1,750 M&A deals' initiations. Around 85% of firm-year observations have only one deal. Although several firms have more than one M&A transaction per year, to prepare the data for the event study, I limit the sample to one M&A deal per firm per year by choosing the deal with the largest transaction value of that year. To identify the announcement date of the M&A deals, I use Capital IQ provided by S&P and confirm the dates using Nikkei Value Search and the firm's homepage if available.

The requirement that firms have adjusted closing stock prices around the announcement date[14] (at least 170 days before and five days after the

[14] The adjusted closing price is the amended price prior to the next day's opening, accounting for firm actions such as stock splits, dividend distributions or rights offerings.

announcement), means that several firms were excluded from event study because of a lack of historical stock price data. After fulfilling this requirement, I obtained the event dates and stock data of 1,148 M&A deals, where 176 deals were made by firms having female board directors. The remaining 972 deals were done by firms without female directors.

I adopt the market model to calculate CARs received by shareholders of listed firms over three event windows [–1, +1], [–2 +2] and [–3, +3]. The estimation window is defined as 170 to 20 days before the transaction announcement. I use returns on the Tokyo Stock Exchange TOPIX index as the market return.

Results of the market reactions to the announcement of M&A deals are shown in Table 5. Panel A shows the CAR results for the total deals qualified for the event study. The mean CARs over the [–1, +1], [–2, +2] and [–3, +3] event windows are 1.42%, 1.28% and 1.49%, respectively, statistically signifi-

Table 5: CARs for the M&A announcements

This table shows the CARs for the M&A announcements by listed firms for the 2009–2015 period. Market model CARs are computed using days –170 to –20 as the estimation period for the market model parameters. *, ** and *** indicate significance at the 10, 5 and 1% levels, respectively.

Window	Mean CAR (%)	t-statistic for mean CAR	Median CAR (%)	Number of positive: negative	Sign test for median CAR (p-value)
Panel A: Full sample (1,148 events)					
[–1, +1]	1.42	3.06***	0.61	667:482	0.000***
[–2, +2]	1.28	2.03*	0.55	645:504	0.000***
[–3, +3]	1.49	2.14**	0.58	632:516	0.000***
Panel B: Firms with female directors (176 events)					
[–1, +1]	1.44	1.74*	0.28	96:80	0.258
[–2, +2]	–0.39	0.27	0.48	94:82	0.407
[–3, +3]	–0.01	0.85	0.47	95:81	0.327
Panel C: Firms without female directors (972 events)					
[–1, +1]	1.41	2.67***	0.62	570:402	0.000***
[–2, +2]	1.58	2.26**	0.57	550:422	0.000***
[–3, +3]	2.002	2.57***	0.63	537:435	0.001***

cantly different from zero. The median CARs over the [–1, +1], [–2, +2] and [–3, +3] windows are also positive and strongly significant.

The key contribution of Table 5 lies in panel B and panel C where I attempted to estimate the CARs for the two specific groups of acquirers. Panel B presents the CARs for the firm group with female directors. The mean CAR of window [–1, 1] is 1.44% and slightly significant at the 10% significance level; the mean CARs of the other windows are both negative and not statistically significant. The median CARs over the three event windows [–1, +1], [–2, +2] and [–3, +3] are positive but not statistically significant.

Panel C shows the CARs for the firm group without female directors. Compared with the firm group with female directors, the M&A performance of the firms without female directors tends to be better. The mean CARs of the three event windows [–1, +1], [–2, +2] and [–3, +3] are all positive, equal to 1.41%, 1.58% and 2%, respectively. The estimated mean CARs are statistically significantly different from zero. The median CARs over the [–1, +1], [–2, +2] and [–3, +3] windows are also positive and strongly significant.

In short, the estimation results from the event study show that the firms without female directors achieve better CARs from M&A announcements compared with those of the firms with female directors.

4.3 Female directors and firm performance

4.3.1 Female directors and firm performance: OLS and FE regressions

In this subsection, I examine the effects of female directors on firm performance, proxied by ROA and Tobin's Q, using OLS and FE regressions. Table 6 presents the results of the OLS and FE regressions. The dependent variables are *ROA* and *Tobin's Q*, while the key independent variable is *female director* dummy. I also control for board and firm characteristics, as well as industry and year FE.

Columns 1 and 2 present the estimation results for the dependent variable *ROA*, where the standard errors in parentheses are robust standard errors. The OLS and FE regression coefficients for the *female director*

Table 6: Female directors and firm performance: OLS and FE regressions

The table presents OLS and FE regression estimates of the effects of female directors on firm performance. *ROA* and *Tobin's Q* are the two dependent variables, while the independent variable of interest is the *female director* dummy. I control for board and firm characteristics as well as industry FE and year FE in all regressions. Standard errors in parentheses are robust standard errors clustered at the firm level. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Regression model	OLS	FE	OLS	FE
Dependent variable	ROA	ROA	Tobin's Q	Tobin's Q
Female director	−0.093	−0.374**	−0.006	−0.069***
	(0.321)	(0.185)	(0.029)	(0.016)
Board size	0.048*	0.070***	0.010***	0.009***
	(0.028)	(0.025)	(0.002)	(0.002)
Outside director ratio	−0.023***	−0.0004	0.003***	−0.0007*
	(0.007)	(0.004)	(0.0006)	(0.0003)
Log (total assets)	0.811***	2.578***	−0.105***	−0.127***
	(0.123)	(0.159)	(0.011)	(0.014)
Leverage	−0.053***	−0.017***	0.003***	0.002***
	(0.018)	(0.001)	(0.0005)	(0.0001)
Sales growth rate	0.018***	0.023***	0.001***	0.0007***
	(0.004)	(0.0006)	(0.0003)	(6.06e−05)
Listing duration	−0.041***	0.762	−0.001**	0.045
	(0.005)	(1.131)	(0.0004)	(0.103)
Managerial ownership ratio	0.081***	0.005	0.003***	−0.007***
	(0.009)	(0.006)	(0.0009)	(0.0005)
Foreign ownership ratio	0.071***	0.052***	0.016***	0.011***
	(0.016)	(0.008)	(0.001)	(0.0007)
Constant	−3.374**	−42.05	1.578***	0.743
	(1.483)	(27.05)	(0.114)	(2.459)
Observations	23,108	23,108	23,161	23,161
R-squared	0.19	0.13	0.22	0.14
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes

dummy variable are negative, which indicates the negative correlation between ROA and the presence of female director. In the FE regression, the coefficient of the female director variable is statistically significant at the 5% significance level; firms with female directors have an ROA that is 0.37 percentage points smaller than that of firms without female directors.

Columns 3 and 4 present the estimation results for Tobin's Q. Similar to ROA, the presence of female directors is negatively correlated with Tobin's Q in both the OLS and FE regressions. Firms with female directors have a Tobin's Q that is 0.07 smaller than that of firms without female directors in fixed regressions and this difference is strongly statistically significant at the 1% significance level.

In brief, using OLS and FE regressions, I find that the firms with female directors perform worse than the firms without female directors in terms of ROA and Tobin's Q.

4.3.2 Female directors and firm performance: IV 2SLS regression

Our results indicate negative effects of female directors on firm performance using OLS and FE regressions. Although the FE regression can address omitted variable problems, another concern is the effects of reverse causality. Reverse causality can arise from the potential sorting of male and female directors to firms based on performance (Adams and Ferreira, 2009), which can confuse the issue of whether female directors actually improve performance or whether firms with good performance choose female directors. To deal with this concern, Adams and Ferreira (2009) developed an instrument called "the fraction of male directors on the board who sit on other boards on which there are female directors". The assumption behind this instrument is the social network linking directors. If firms have more male directors connected to women, there are more female directors to be introduced to the firm.

I follow Adams and Ferreira (2009) by developing a similar instrument called *ratio of connected male directors* and use an IV 2SLS regression to examine the effect of female directors. The dependent variables are still *ROA*

and *Tobin's Q*. The independent variable of interest is *female director ratio*. I control for board and firm characteristics as well as industry and year FE in all regressions.

Table 7 presents the results of the IV 2SLS regressions. The first stage is reported in columns 1 and 3. In the first stage regressions, the dependent variable is *female director ratio* and the key independent variable is the instrument *ratio of connected male directors*. The coefficients of *ratio of connected male directors* are both positive and strongly significant at the 1% significance level, clearing the relevance condition for the IV that the ratio of connected male directors is correlated with the female director ratio.

To examine the exogeneity condition for a valid instrument, I conduct an endogeneity test and F test for excluded instruments in the first-stage regressions. The Chi squared-statistics has a p-value of 0.0007, which is less than 5% and the F-test is 11.44 in the first-stage regression for ROA. In the first-stage regression for Tobin's Q, the chi-squared statistic has a p-value of 0.0009, which is less than 5% and the F-test is 11.01. These statistics confirm the relative strength of our IV as well as the compatibility of the instrumental variable technique.

Columns 2 and 4 present the results of the second stage regressions. The coefficient for *female director ratio* in column 2 is negative in relation to ROA but not statistically significant. In contrast, the coefficient for *female director ratio* in column 4 is positive for Tobin's Q, yet it is also not significant. Having addressed the issue of reverse causality, I find no correlation between female directors and firm performance.

4.3.3 Female directors and firm performance: Propensity score matching estimation

In this subsection, I use a propensity score matching (PSM) method (Rosenbaum and Rubin, 1983; Rosenbaum and Rubin, 1985) to create a control group for the firms having female directors based on observable firm characteristics. The reason for creating a good control group is to address the sample selection bias (Tanaka, 2019). My results are possibly being affected

Table 7: Effect of female directors on firm performance: IV 2SLS regressions

The table shows the effects of female directors on firm performance. I estimate IV 2SLS regressions where the dependent variables are ROA and Tobin's Q in the IV regressions with FE. An industry dummy and year dummy are also included. Standard errors in parentheses are robust standard errors clustered at the firm level. *, ** and *** indicate significance at the 10, 5 and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Regression model	First-stage IV with FE	IV with FE	First-stage IV with FE	IV with FE
Dependent variable	Female director ratio	ROA	Female director ratio	Tobin's Q
Female director ratio		–0.026		0.055
		(0.469)		(0.047)
Board size	0.031*	0.063**	0.031*	0.006*
	(0.017)	(0.031)	(0.017)	(0.003)
Outside director ratio	0.024***	0.005	0.025***	–0.002*
	(0.003)	(0.013)	(0.003)	(0.001)
Log (total assets)	0.097	2.590***	0.087	–0.104***
	(0.111)	(0.184)	(0.111)	(0.018)
Leverage	0.000	–0.013***	0.000	0.002***
	(0.001)	(0.002)	(0.001)	(0.000)
Sales growth rate	0.001***	0.023***	0.001***	0.001***
	(0.000)	(0.001)	(0.000)	(0.000)
Listing duration	1.163	–0.436	1.162	–0.145
	(2.223)	(3.565)	(2.224)	(0.352)
Managerial ownership ratio	0.010**	–0.003	0.010**	–0.008***
	(0.004)	(0.008)	(0.004)	(0.001)
Foreign ownership ratio	0.023***	0.053***	0.023***	0.011***
	(0.006)	(0.014)	(0.006)	(0.001)
Ratio of connected male directors	1.884***		1.846***	
	(0.557)		(0.556)	
Observations	19,771	19,771	19,821	19,821
R-squared	0.03	0.13	0.03	0.004
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes

Table 8: Female directors and firm performance: PSM method

This table shows the results of propensity score matching estimation on the effects of female directors on firm performance, proxied by ROA and Tobin's Q. *, ** and *** indicate significance at the 10, 5 and 1% levels, respectively.

Panel A: Propensity Score matching estimation results

Propensity score matching: ROA		Propensity score matching: Tobin's Q	
Nearest-neighbour matching (n=50)		Nearest-neighbour matching (n=50)	
ATT	–0.075	ATT	–0.020
	(0.191)		(0.018)

Panel B: Mean *ex post* firm characteristics: Treated firms vs. Control firms

Main outcome =	ROA			Tobin's Q		
	Firms with female directors	Firms without female directors	Statistic for difference between treated and control group	Firms with female directors	Firms without female directors	Statistic for difference between treated and control group
Variables	Mean	Mean	t-Statistic	Mean	Mean	t-Statistic
Board size	7.903	7.814	0.93	7.904	7.809	1
Outside director ratio	18.555	18.450	0.2	18.526	18.448	0.15
Log (total assets)	10.320	10.249	1.23	10.321	10.249	1.24
Leverage	48.427	48.268	0.18	48.46	48.243	0.25
Sales growth rate	8.294	7.934	0.16	8.244	7.588	0.31
Listing duration	20.214	19.515	1.32	20.241	19.55	1.3
Managerial ownership (%)	14.367	14.412	–0.09	14.331	14.409	–0.15
Foreign ownership (%)	11.620	11.209	0.95	11.645	11.239	0.94

by sample selection bias because I compared the firm group with female directors with all remaining firms without female directors, which may have a large heterogeneity in firm idiosyncratic characteristics because of the large number of observations. I follow Tanaka (2019) to implement a propensity score matching estimator to match each treated firm with a control firm having the closest propensity score to the treated firm. The firm pair is also from the same year.

Table 8 shows the results of the propensity score matching estimation. I estimate a probit regression, in which the dependent variable is the *female director* dummy, and the two outcomes are *ROA* and *Tobin's Q*. Panel A of Table 8 reports the average treatment effect on the treated (ATT) by nearest-neighbour matching with 50 neighbours and the caliper is set equal to 0.01. Panel B reports mean comparisons of *ex post* firm characteristics and the test results for statistical difference. The *ex post* variables of the two groups in the regressions are well balanced in both cases of outcomes, ROA and Tobin's Q. There are no statistically significant differences in any variables used, which shows that the two groups are well matched.

The most important finding from Table 8 is that the ATT values are both negative for the outcomes *ROA* and *Tobin's Q*, but not statistically significant. The results of the propensity score matching estimation, which are consistent with the IV 2SLS regression, indicate no correlation between female director representation and firm performance in terms of ROA and Tobin's Q.

5. Robustness checks and additional tests

5.1 Outside and inside female directors in relation to firm investment

In this subsection, I divide female directors into inside directors and outside directors and examine whether there are differences in investment behaviour between the two director groups. Table 9A shows the OLS and FE regression results. The dependent variables are *R&D expenses ratio* and *number of M&A deals*. I use the same set of control variables as in Table 4,

Table 9A: Different types of female directors and firm investment: OLS and FE regressions

This table examines the effects of different types of female directors on firm investment behaviour. I estimate OLS and FE regressions in which the dependent variables are *R&D expenses ratio* and *number of M&A deals*. The independent variables of interest are *inside female director dummy* and *outside female director dummy*. Standard errors in parentheses are robust standard errors clustered at the firm level. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Regression model	OLS	OLS	FE	FE
Dependent variable	R&D expenses	M&A deals	R&D expenses	M&A Deals
Inside female director	–0.230	0.007	–0.247***	–0.012
	(0.169)	(0.011)	(0.072)	(0.018)
Outside female director	0.100*	0.022	0.097*	–0.016
	(0.060)	(0.017)	(0.052)	(0.016)
Log (total assets)	–0.228***	0.019***	–0.840***	–0.052***
	(0.075)	(0.003)	(0.046)	(0.011)
ROA	–0.012**	0.001	–0.008***	0.002***
	(0.005)	(0.0007)	(0.001)	(0.0003)
Sales growth rate	–0.0008	0.0001*	–0.0005***	6.98e–05
	(0.0005)	(7.39e–05)	(0.0002)	(5.02e–05)
Free cash flow ratio	–0.002	–0.0001***	–0.003***	–0.0001***
	(0.002)	(1.74e–05)	(0.0008)	(2.30e–05)
Leverage	–0.008***	0.0004***	–0.005***	–0.001***
	(0.002)	(0.0001)	(0.001)	(0.0003)
CEO gender	–0.601	–0.020	–0.635**	0.033
	(0.483)	(0.025)	(0.271)	(0.050)
Managerial ownership ratio	0.004	0.0005*	0.006***	–0.0005
	(0.004)	(0.0002)	(0.002)	(0.0004)
Foreign ownership ratio	0.003	0.001***	–0.002	0.001***
	(0.004)	(0.0003)	(0.002)	(0.0005)
Listing duration	0.005*	–0.0002	0.152	0.051
	(0.003)	(0.0001)	(0.555)	(0.076)
Constant	4.300***	–0.226***	6.136	–0.580
	(0.828)	(0.043)	(16.44)	(1.829)
Observations	12,369	23,089	12,369	23,089
R-squared	0.08	0.01	0.13	0.01
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes

but with the independent variables being the *inside female director* and *outside female director* dummy variables.

The OLS regression results are shown in columns 1 and 2, while FE regression results are shown in columns 3 and 4. The coefficient of *inside female director* is negative and significant at the 1% level on *R&D expenses* in FE regression, implying that firms with inside female directors spend 0.247 percentage points less on R&D compared with other firms. However, in the OLS and FE regressions, the coefficients on *outside female director* are both positive and slightly statistically significant at the 10% level in relation to *R&D expenses*. The results indicate that firms with outside female directors spend 0.1%pt more on R&D than other types of firms.

The data on R&D expenditure contains missing data which might include firms that may not have any R&D investments. I do further tests by replacing all missing R&D values with zeros and run the OLS and FE regressions in Table 9A again for the *R&D expenses ratio* variable. Results of these regressions are reported in Appendix 3. The total firm-year observations now increase up to 23,089, much higher than 12,369 firm-year observations in Table 9A. The coefficients of *outside female director* are both positive in relation to the *R&D expenses ratio*, while the coefficients of *inside female director* are mixed in relation to the *R&D expenses ratio*. However, the findings are not statistically significant.

Regarding the number of M&A deals, I find no correlation between M&A activity and different types of female directors. The coefficients for *inside female director* and *outside female director* are both positive in the OLS regression but turn negative in the FE regression. However, the finding is not statistically significant.

In brief, I find that there are differences in investment behaviour between the two firm groups regarding high-risk investments. Firms with inside female directors are less likely to invest in R&D, while firms with outside female directors are more likely to spend on R&D.

In Table 9B, I compare the M&A performance of firms with outside

female directors and those with inside female directors. Overall, I find that firms with inside female directors make 77 M&A transactions, while firms with outside female directors make 95 M&A transactions. There were four M&A events in which the board had both outside and inside female directors; to avoid bias and conflicting assumptions, I exclude these events from the analysis.

Panel A of Table 9B shows the CAR results for the total M&A deals carried out by firms having inside female directors. The mean and median CARs over the [–1, +1] event window is 3.41% and 1.44%, respectively, and both are statistically significantly different from zero. The mean and median CARs over the [–2, +2] and [–3, +3] windows are not significant.

Panel B presents the CARs for the firm group with outside female directors. The mean and mean CARs over the three event windows [–1, +1], [–2, +2] and [–3, +3] are mostly negative but not statistically significant. In short, among the firms having female directors, the firms with inside female directors seem to make better returns from M&A transactions than the firms

Table 9B: Different types of female directors and firm investment: M&A performance

This table shows the CARs for the M&A announcements for two firm groups, firms with inside female directors and firms with outside female directors, during the period 2009 to 2015. Market model CARs are computed using days –170 to –20 as the estimation period for the market model parameters. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Window	Mean CAR (%)	t-statistic for mean CAR	Median CAR (%)	Number of positive: negative	Sign test for median CAR (p-value)
Panel A: Firms with inside female directors (77 events)					
[–1, +1]	3.41	2.11**	1.44	49:28	0.02**
[–2, +2]	1.40	0.49	1.51	46:31	0.11
[–3, +3]	–1.22	0.39	1.93	45:32	0.327
Panel B: Firms with outside female directors (95 events)					
[–1, +1]	–0.15	0.20	–0.09	45:50	0.681
[–2, +2]	–1.78	1.23	–0.07	47:48	1.00
[–3, +3]	–1.37	1.20	0.10	47:48	1.00

with outside female directors.

5.2 Outside and inside female directors in relation to firm performance

In this subsection, I examine the effects of different types of female directors on firm performance as proxied by ROA and Tobin's Q, using OLS and FE regressions. I use the same set of control variables as in Table 6 and the key independent variables of interest are *outside female director* and *inside female dummies*. I also control for board and firm characteristics as well as industry and year FE.

Columns 1 and 2 of Table 10A show the estimation results for the dependent variable *ROA*, where the standard errors in parentheses are robust standard errors. Both coefficients for the *outside female director* dummy variable in the OLS and FE regressions are negative at the 1% significance level, which indicates a negative correlation between ROA and the presence of outside female directors. For inside female directors, I find no correlation between their presence and firm performance.

Columns 3 and 4 of Table 10A present the estimation results for Tobin's Q. Similar to ROA, I found that the presence of outside female directors is negatively correlated with Tobin's Q in the FE regressions. Firms with outside female directors have Tobin's Q that are around 0.05 smaller than those of firms without female directors and this difference is statistically significant at the 5% level. Similarly, firms with inside female directors have Tobin's Q that are 0.08 smaller than those of firms without female directors and this difference is statistically significant at the 1% significance level.

Table 10B presents the results of the IV 2SLS regressions examining the effects of inside and outside female directors on ROA and Tobin's Q. In the first stage regressions, the dependent variables are *outside female director ratio* and *inside female director ratio* and the key independent variable is the instrument *ratio of connected male directors*. The coefficients for *ratio of connected male directors* are only strongly significant in relation to *inside female director* at the 1% significance level, indicating that the relevance condition

Table 10A: Different types of female directors and firm performance: OLS and FE regressions

The table provides OLS and FE regression estimates of the effects of inside female directors and outside female directors on firm performance. The dependent variables are *ROA* and *Tobin's Q*. The independent variables of interest are *inside female director* and *outside female director*. Board and firm characteristics as well as industry FE and year FE are controlled in all regressions. Standard errors in parentheses are robust standard errors clustered at the firm level. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)	(4)
Regression model	OLS	FE	OLS	FE
Dependent variable	ROA	ROA	Tobin's Q	Tobin's Q
Outside female director	–1.005***	–0.895***	–0.036	–0.054**
	(0.328)	(0.241)	(0.0308)	(0.022)
Inside female director	0.329	–0.399	0.011	–0.085***
	(0.442)	(0.266)	(0.039)	(0.024)
Board size	0.048*	0.072***	0.010***	0.009***
	(0.02)	(0.025)	(0.002)	(0.002)
Outside director ratio	–0.02***	0.0008	0.003***	–0.0007**
	(0.007)	(0.004)	(0.0007)	(0.0003)
Total assets (log)	0.830***	2.579***	–0.104***	–0.128***
	(0.123)	(0.158)	(0.011)	(0.014)
Leverage	–0.053***	–0.017***	0.003***	0.002***
	(0.018)	(0.001)	(0.0005)	(0.0001)
Sales growth rate	0.018***	0.023***	0.001***	0.0007***
	(0.004)	(0.0006)	(0.0003)	(6.06e–05)
Listing duration	–0.041***	0.767	–0.001**	0.045
	(0.005)	(1.131)	(0.0004)	(0.103)
Managerial ownership ratio	0.080***	0.005	0.003***	–0.007***
	(0.009)	(0.006)	(0.0009)	(0.0005)
Foreign ownership ratio	0.071***	0.053***	0.016***	0.011***
	(0.016)	(0.008)	(0.001)	(0.0007)
Constant	–3.589**	–42.11	1.570***	0.758
	(1.505)	(27.05)	(0.115)	(2.459)
Observations	23,108	23,108	23,161	23,161
R-squared	0.19	0.13	0.22	0.14
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes

Table 10B: Different types of female directors and firm performance: IV 2SLS regression

The table shows the effects of inside female directors and outside female directors on firm performance. I estimate IV 2SLS regressions where the dependent variables are ROA and Tobin's Q in the IV regressions with FE. An industry dummy and year dummy are also included. Standard errors in parentheses are robust standard errors clustered at the firm level. *, ** and *** indicate significance at the 10, 5 and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Regression model	First-stage IV with FE	IV with FE	First-stage IV with FE	IV with FE	First-stage IV with FE	IV with FE	First-stage IV with FE	IV with FE
Dependent variable	Outside female ratio	ROA	Outside female ratio	Tobin's Q	Inside female ratio	ROA	Inside female ratio	Tobin's Q
Outside female ratio		–0.141		0.320				
		(2.504)		(0.477)				
Inside female ratio						–0.033		0.067
						(0.585)		(0.057)
Board size	–0.004	0.062**	–0.005	0.009*	0.046***	0.064*	0.048***	0.004
	(0.012)	(0.030)	(0.012)	(0.005)	(0.014)	(0.038)	(0.014)	(0.004)
Outside director ratio	0.044***	0.010	0.044***	–0.015	–0.015***	0.003	–0.015***	0.000
	(0.002)	(0.111)	(0.002)	(0.021)	(0.002)	(0.010)	(0.002)	(0.001)
Log (total assets)	0.044	2.594***	0.039	–0.111***	–0.051	2.586***	–0.055	–0.095***
	(0.079)	(0.212)	(0.078)	(0.036)	(0.088)	(0.178)	(0.088)	(0.017)
Leverage	–0.000	–0.013***	–0.000	0.002***	0.001	–0.013***	0.001	0.002***
	(0.001)	(0.002)	(0.001)	(0.000)	(0.001)	(0.002)	(0.001)	(0.000)
Sales growth rate	0.001*	0.023***	0.001*	0.001*	0.001**	0.023***	0.001**	0.001***
	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Listing duration	1.048	–0.319	1.053	–0.419	0.048	–0.465	0.044	–0.084
	(1.569)	(4.391)	(1.568)	(0.781)	(1.764)	(3.525)	(1.766)	(0.345)
Managerial ownership ratio	0.001	–0.003	0.001	–0.008***	0.004	–0.003	0.004	–0.007***
	(0.003)	(0.007)	(0.003)	(0.001)	(0.003)	(0.007)	(0.003)	(0.001)
Foreign ownership ratio	0.022***	0.056	0.023***	0.005	0.000	0.052***	–0.000	0.012***
	(0.004)	(0.056)	(0.004)	(0.011)	(0.005)	(0.009)	(0.005)	(0.001)
Ratio of connected male directors	0.353		0.315		1.509***		1.511***	
	(0.393)		(0.392)		(0.442)		(0.442)	
Observations	19,771	19,771	19,821	19,821	19,771	19,771	19,821	19,821
R-squared		0.13		–1.95		0.13		0.02
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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for the IV, that the ratio of connected male directors is correlated with the inside female director ratio, is satisfied. However, I do not find similar relevance for the IV for the outside female director ratio.

Columns 2, 4, 6, 8 present the results of the second stage regressions. The coefficient for *inside female director ratio* in column 6 is negative in relation to ROA but not statistically significant. In contrast, the coefficient for *inside female director ratio* in column 8 is positive in relation to Tobin's Q, yet these findings are not statistically significant. Having addressed the issue of reverse causality, I find no correlation between inside and outside female directors and firm performance, which is similar to the findings in Section 4.2.2.

Finally, I use the propensity score matching method to examine the effects of inside and outside female directors on firm performance, using a similar procedure and control variables to those used in Section 4.2.3. I use probit regressions, in which the dependent variables are *outside female director* dummy and *inside female director* dummy, and the two outcomes are *ROA* and *Tobin's Q*.

Panel A of Table 10C reports the ATT by nearest-neighbour matching for firms with outside female directors, while panel B reports the ATT by nearest-neighbour matching for firms with inside female directors. The most important finding from Table 10C is that the ATT values are negative for the outcomes *ROA* and *Tobin's Q* and strongly statistically significant for the firm group with outside female directors(15). However, I find no correlation between inside female directors and firm performance using the PSM method.

I have conducted additional tests by dividing the firms with female directors into two groups—firms with outside female directors and firms with

(15) Although not reported in Table 10C, I carried out a mean comparison of ex post firm characteristics and the test results for statistical difference. The ex post variables of the two treated and control groups in each regressions are well balanced in both cases of outcomes, ROA and Tobin's Q.

Table 10C: Female directors and firm performance: PSM method

This table shows the results of propensity score matching estimation for the effects of female directors on firm performance, proxied by ROA and Tobin's Q. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Panel A: Propensity score matching estimation results for *outside female director*			
Propensity score matching: ROA		Propensity score matching: Tobin's Q	
Nearest-neighbour matching (n=50)		Nearest-neighbour matching (n=50)	
ATT	–0.695***	ATT	–0.063***
	(0.253)		(0.026)
Panel B: Propensity Score matching estimation results for *inside female director*			
Propensity score matching: ROA		Propensity score matching: Tobin's Q	
Nearest-neighbour matching (n=50)		Nearest-neighbour matching (n=50)	
ATT	0.342	ATT	–0.032
	(0.256)		(0.023)

inside female directors—and I find differences between the two firm groups in terms of investment and financial performance. Regarding high-risk investments such as R&D and M&A, firms with inside female directors are less likely to invest in R&D, while firms with outside female directors are more likely to spend for R&D. Regarding investment efficiency and overall financial performance, firms with outside female directors have worse returns from M&A and negative correlation with ROA and Tobin's Q. Causality between firm investment behaviour and financial performance is more obvious when I separate female directors into different types.

6. Conclusion

More females are appointed to Japanese corporate boards in recent years but empirical studies on the impact of female directors on firm behaviour and performance are scant. Using panel data of more than 3,000 unique listed firms in Japan from 2009 to 2015, I fill this gap by providing empirical evidence on this research topic.

The results are summarized as follows. First, I find that only 10% of some 23,000 firm-year observations have female board directors. During the "Womanomics" policy years, there were more female directors, especially outside female directors appointed to the boards compared with the years before the policy period.

Second, I find no empirical evidence that firms having female directors are more risk-averse than firms without. However, when I examine different types of female directors, I find that firms with inside female directors are less likely to invest in R&D, while firms with outside female directors are more likely to spend on R&D.

Third, when I analyse the wealth effects of M&A performance on Japanese listed firms focusing on comparing the CARs of the firm group with female directors to that of the firm group without, I find that the firms without female directors achieve better CARs from M&A announcements compared with those of the firms with female directors.

Finally, female directors have no significant effects on firm performance measured by ROA and Tobin's Q. My research findings suggest that corporate investment behaviour might explain the relation between female directors and firm performance. As the recent appointments of female directors may not change the behaviour of Japanese listed firms significantly, I do not find evidence on the impact of female directors on firm value.

Although the research provides several contributions to the related literature and implications to policy makers regarding corporate governance reforms and Womanomics, it has some limitations. First, it has the sample size limitation. Female directors only cover a small part of the board room of Japanese listed firms. At firms having female directors on board, the number of female directors is few, often there is only one female director per board. Future research can explore the board of unlisted firms as Morikawa (2016) shows that there are more female directors at unlisted firms.

Second, this study has methodological limitations. Regarding investment measures, the *number of M&A deals* is an over-dispersed count variable and

the proportion of zeros is very large; the *R&D expenses ratio* variable has large missing data and lacks zero observations. In this case, it may be difficult to obtain consistent estimation results with linear models so there exists several possible biases in our current estimations. This presents the opportunity for further development in this research area by using more appropriate methods to address the estimation bias.

Furthermore, this study examines the effects of female directors on firm investment and financial performance. The impact of board gender diversity should not be measured in terms of financial performance only. Future research can focus on the non-financial impacts of female directors, such as the empowerment of women below board level, corporate social responsibility or the success of female CEOs. There is still a lack of empirical studies about these research topics, especially for Japanese firms.

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Appendix 1: Variable definitions and data sources

Variable	Definition	Source
Female director	Equals one if a firm has at least one female director and zero otherwise	Directory of Directors
Female director ratio	Number of female directors divided by the total number of board members	Authors
Outside female director	Equals one if a firm has outside female directors only and zero otherwise	Authors
Inside female director	Equals one if a firm has inside female directors only and zero otherwise	Authors
Board size	Number of board members	Nikkei Needs CGES
Board age	Average age of board members	Nikkei Needs CGES
Outside director ratio	Number of outside directors divided by total number of board members	Nikkei Needs CGES
CEO tenure	Number of years CEO has served as CEO of the firm	Nikkei Needs CGES
CEO gender	Equals one if a firm is run by a female CEO and zero otherwise	Directory of Directors
Sales growth ratio	Sales growth divided by sales growth in last fiscal year	Nikkei Needs CGES
Listing duration	Number of years since firm listed	Nikkei Needs CGES
Total assets (thousand yen)	Total consolidated assets	Nikkei Needs CGES
ROA	Return on assets	Nikkei Needs CGES
Tobin's Q	Fair market value plus total liabilities divided by total assets	Nikkei Needs CGES
ROE	Return on equity	Nikkei Needs CGES
Foreign sales ratio (%)	Ratio of foreign sales to total consolidated sales	Corporate Financial Databank
Number of M&A deals	Total M&A deals done by firm i in year t	Capital IQ
R&D expenses (%)	R&D expenditure divided by total assets	Corporate Financial Databank
Leverage (%)	Total liabilities divided by total assets	Nikkei Needs CGES
Industry dummy	Tokyo Stock Exchange classification of 33 industries	Nikkei Needs CGES
Free cash flow ratio (%)	Free cash flow divided by total assets	Nikkei Needs CGES
Volatility (%)	Standard deviation of total return in the last three accounting periods where total return is the daily average of total returns	Nikkei Needs CGES
Managerial ownership ratio (%)	Shareholding by managers divided by total share ownership	Nikkei Needs CGES
Foreign ownership (%)	Foreign investor share ownership divided by total share ownership	Nikkei Needs CGES

Appendix 2: Female director and R&D investment

This table examines the effects of female director representation on R&D investment. I estimate OLS and FE regressions in which the dependent variable is *R&D expenses ratio*. The data on R&D expenditure contains missing data. In this table, I replace all missing R&D values with zeros before running the regressions. The independent variable of interest is *female director dummy*. Standard errors in parentheses are robust standard errors clustered at the firm level. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)
Regression model	OLS	FE
Dependent variable	R&D expenses	R&D expenses
Female director	–0.009	–0.003
	(0.052)	(0.029)
Log (total assets)	–0.011	–0.286***
	(0.035)	(0.025)
ROA	–0.008***	–0.006***
	(0.002)	(0.0007)
Sales growth rate	–0.0006**	–0.0005***
	(0.0003)	(0.0001)
Free cash flow ratio	–7.36e–05	–9.07e–05*
	(6.07e–05)	(5.41e–05)
Leverage	–0.003**	–0.002***
	(0.001)	(0.0008)
CEO gender	–0.252	–0.241**
	(0.156)	(0.120)
Managerial ownership ratio	0.0003	0.001
	(0.001)	(0.001)
Foreign ownership ratio	0.0001	–0.003***
	(0.002)	(0.001)
Listing duration	0.003**	0.074
	(0.002)	(0.180)
Constant	1.523***	2.297
	(0.477)	(4.306)
Observations	23,089	23,089
R-squared	0.02	0.05
Industry dummies	Yes	Yes
Year dummies	Yes	Yes

Appendix 3: Different types of female directors and R&D investment

This table examines the effects of different types of female directors on R&D investment. I estimate OLS and FE regressions in which the dependent variable is R&D expenses ratio. The data on R&D expenditure contains missing data. In this table, I replace all missing R&D values with zeros before running the regressions. The independent variables of interest are *inside female director dummy* and *outside female director dummy*. Standard errors in parentheses are robust standard errors clustered at the firm level. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

	(1)	(3)
Regression model	OLS	FE
Dependent variable	R&D expenses	R&D expenses
Inside female director	–0.018	0.001
	(0.056)	(0.042)
Outside female director	0.027	0.020
	(0.081)	(0.038)
Log (total assets)	–0.011	–0.287***
	(0.035)	(0.025)
ROA	–0.008***	–0.006***
	(0.002)	(0.0007)
Sales growth rate	–0.0006**	–0.0005***
	(0.0003)	(0.0001)
Free cash flow ratio	–7.12e–05	–8.92e–05*
	(6.02e–05)	(5.41e–05)
Leverage	–0.003**	–0.002***
	(0.001)	(0.0008)
CEO gender	–0.240*	–0.239**
	(0.144)	(0.120)
Managerial ownership ratio	0.0003	0.001
	(0.001)	(0.001)
Foreign ownership ratio	0.0001	–0.004***
	(0.00280)	(0.001)
Listing duration	0.003**	0.074
	(0.001)	(0.180)
Constant	1.529***	2.303
	(0.479)	(4.306)
Observations	23,089	23,089
R-squared	0.02	0.05
Industry dummies	Yes	Yes
Year dummies	Yes	Yes