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Gender equality and innovation: evidence from UK companies

Paweł Bukowski
Hannah Yi Wei

The London School of Economics and Political Science

Economic and Social Research Council

Abstract
We investigate the effect of intra-firm gender disparities on innovation using a unique longitudinal dataset of UK companies from 1996 to 2019. Utilising within-industry and within-firm variation, as well as an instrumental variable approach, we examine the effect of gender pay gap and female representation at the top, on patenting activity - measured by their headcount, number of citations, and economic value. In general, our findings indicate that gender parity does not negatively impact patenting. However, in more recent data, we uncover evidence suggesting that a lack of gender parity adversely affects both the quantity and quality of patents.

Keywords: firm diversity; innovation; gender equality; gender wage gap
JEL codes: J16; J31; O32; J71

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Paweł Bukowski, School of Slavonic and East European Studies at University College London, Institute of Economics at the Polish Academy of Sciences and Centre for Economic Performance at the London School of Economics. Hannah Yi Wei, International Monetary Fund.

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1 Introduction

Despite significant advancements in reducing gender discrimination, women remain underrepresented in leadership roles across both business and policy (Blau and Kahn, 2017; Guvenen et al., 2014). For example, women constitute about 41% of the workforce in large UK firms but only 31% of those in the top wage quartile (Figure 1) and 18% of board positions (Table 3). Moreover, the gender pay gap persists, with median earnings differing by 12% in the UK and 11% in the OECD countries (OECD, 2025). This has prompted many governments to implement policies such as gender quotas or pay transparency to improve women's pay and increase their presence in senior positions within companies.

Because innovation is a "massive social process" (Usher, 1951; Schumpeter, 1942), it crucially depends on who is involved in its creation (e.g., Lee, 2025). Therefore, gender diversity might affect innovation; however, the theory is ambiguous about the direction of this effect. On the one hand, talent misallocation (e.g., Becker, 1957) and information environment (e.g., Perryman et al., 2016) suggest a positive association. On the other hand, gender differences in risk avoidance (e.g., Faccio et al., 2016) suggest a negative effect. While there has been extensive literature indicating that gender disparities can adversely affect firms' financial performance (Hellerstein et al., 2002; Kawaguchi, 2007; Christiansen et al., 2016; Perryman et al., 2016), labour productivity (Flabbi et al., 2019), and overall survival (Weber and Zulehner, 2014), empirical research investigating the direct consequences for firm innovation is limited to a handful of studies (Griffin et al., 2021; Na and Shin, 2019).

This paper contributes to the literature by estimating the effect of within-firm gender diversity at the top and the gender pay gap on firm innovation outputs. To achieve this, we construct two unique firm-level datasets: 1) a short panel of large UK companies from 2017 to 2019 with information on patenting activities, the gender pay gap, and female representation at various levels of the within-firm wage structure; 2) a long panel of mid- and large-sized UK firms from 1996 to 2017, containing data on patenting activity and female representation on boards. Our first empirical strategy is to aggregate the short panel data from 2017 to 2019 to obtain cross-sectional evidence on the relationship between patenting, gender pay gaps, and representation. We then examine the second dataset and analyse within-firm longitudinal variation in innovation and female representation at the top levels of corporate hierarchy.

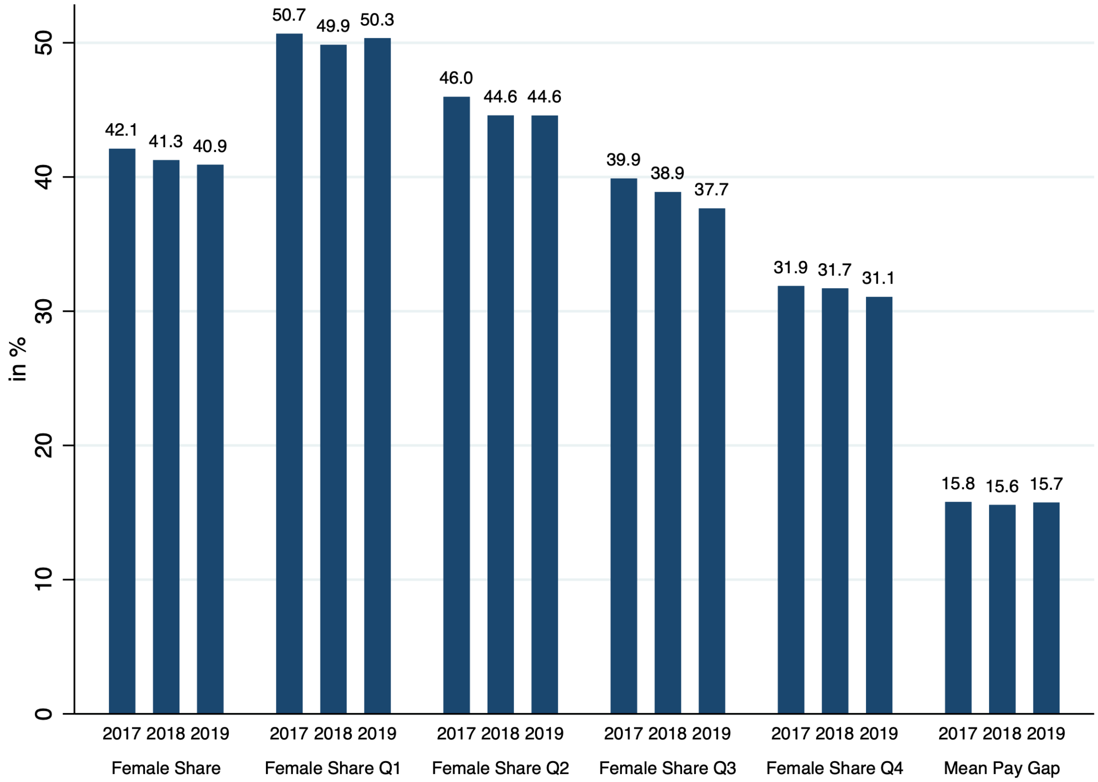
Our cross-sectional analysis of UK firms using the averaged data from the short panel 2017-2019 indicates that firms engaged in patenting tend to have lower female representation and larger gender pay gaps compared to non-innovative firms. However, these correlations are mainly explained by other firm-level characteristics. After controlling for a comprehensive set of factors, including the overall female share in the firm's workforce, firm size, average wages, value added per worker, capital per worker, and one-digit industry fixed effects, we find that a one-percentage-point increase in the share of females in the top quartile of the within-firm wage distribution is associated with a 3.1% *increase* in granted patents and a 5% rise in forward citations. Similarly, a one-percentage-point decrease in the within-firm gender pay gap has no effect on the number of patents but increases forward citations by 1.8%.

These results are broadly supported by two models that address potential endogeneity issues. First, we instrument our measures of gender disparities using the local supply of women in the relevant talent pool. The coefficients become larger and are statistically significant. Second, we utilise the short time span (2017-2019) and add firm fixed effects. While the effect of female representation at the top on the number of patents becomes zero, we find a statistically significant positive effect of reducing the gender pay gap. In addition, to isolate the extensive and intensive margin, we also run the baseline OLS models on a sample of patenting firms only. The results suggest that the effect of gender inequality on innovation operates through the intensive margin - how much firms innovate once they are active in patenting.

The longitudinal evidence from the long panel (1996-2017) shows, however, that female representation in the very top echelons of firms — boards and senior management — does not significantly affect the number of patents, their citations, or stock market value (ESMR value of patents, Kogan et al. (2017)). While simple correlations suggest an innovation penalty associated with female leadership, the inclusion of industry or firm fixed effects renders the coefficients indistinguishable from zero. An event-study around the first appointment of a woman to the board or to senior management points to the same conclusion, with no evidence of differential pre-trends and no discernible response of innovation outcomes after the transition.

The contribution of this paper to the literature is threefold. First, we estimate

Figure 1. Within-Firm Gender Disparities in the UK, 2017-2019



Notes: The figure presents employment-weighted measures of within-firm gender disparities: overall female share of employees and in quarters of within-firm wage distribution, as well as the firm-level mean gender pay gap. The sample is the Short Panel described in Section 3.4. The total sample size is 11,581. Source of the variables: Office for National Statistics, BvD FAME.

the reduced-form effect of gender disparities on patents using a large and consistent sample of UK firms spanning more than two decades, enabling us to apply several identification strategies, such as IV and Firm Fixed Effects. In general, our findings indicate that gender parity does not negatively impact innovation. Furthermore, in more recent data, we find evidence suggesting that a lack of gender parity harms both the quantity and quality of patents. Second, we examine how various forms of gender disparities - female representation at the top of wage hierarchy, on company boards, and the overall gender pay gap—affect innovation as measured by patents. We demonstrate that this distinction is important, as the impact of female representation at the top of the wage hierarchy has a greater effect on innovation than other measures. Finally, we present novel evidence on the effect of gender disparities not only on the number of patents but also on their scientific and economic stock market values. We show that the influence of gender disparities on these additional measures generally aligns with their effect on the number of patents.

The findings of this paper have important implications for policies aimed at reducing discrimination and increasing female representation, such as gender quotas, equal pay mandates, or pay gap transparency initiatives. Although there has been ongoing debate about the effect of gender quotas on corporate boards - with empirical evidence providing mixed results, and some even suggesting negative short-run effects on firm returns (Pande and Ford, 2012; Smith, 2018) - our study shows that increasing female representation in the upper ranks of firms generally does not harm innovation. In fact, our data suggest that firms with fewer women may face a disadvantage in terms of innovation. Similarly, policies intended to narrow the gender pay gap within firms are unlikely to harm innovation. Specifically, our findings support gender pay gap transparency regulations, which have been shown to effectively reduce pay disparities in firms that disclose their data (Blundell et al., 2025; Bennedsen et al., 2023).

This paper is organised as follows. Section 2 discusses the relevant literature and states our contributions. Section 3 explores in depth the firm-level data used in this project, provides definitions of the key variables and shows basic descriptive statistics. Next, Section 4 presents the empirical strategy and results for the analysis using the short panel of firms; and Section 5 shows the empirical strategy and results for the long panel analysis. Section 6 concludes.

2 Theoretical Considerations and Literature

2.1 Theoretical Considerations

Within-firm gender inequality and under-representation of women in top positions may influence innovation through various channels and is theoretically ambiguous. The first is the misallocation of talents. In the Becker (1957) seminal model of taste-based discrimination, discrimination distorts hiring, promotion, and pay, suggesting that firms do not assign workers to roles solely based on productivity.[1] This mechanism is particularly relevant for innovative output, which

[1] Becker (1957) predicts that due to inferior performance, discriminatory practices should decline thanks to competitive forces. However, gender equality may not be fully realised in the presence of information asymmetries (Phelps, 1972; Arrow, 1974) or when the absence of female

relies heavily on the identification, reward, and retention of highly productive employees, especially in the upper tiers of the hierarchy (e.g., Acemoglu et al., 2022; Zucker and Darby, 1998, 2007; Blomkvist et al., 2014; Chen et al., 2016). Innovation is seldom generated evenly across all roles within a firm; it is more likely to depend on employees in senior technical, scientific, managerial, and idea-screening positions. From this perspective, female representation at the top of the wage distribution should be particularly relevant, perhaps more than overall female employment (Flabbi et al., 2019).

A second channel operates through decision-making and the information environment at the top of the firm. Management literature argues that gender diversity in senior teams can improve the variety of perspectives brought into strategic decisions, especially in uncertain or novel environments (e.g., Perryman et al., 2016; Upadhyay and Zeng, 2014; Gul et al., 2011).[2] Conversely, the lack of gender diversity, particularly at senior levels, can lead to homogeneous decision-making and overlapping information sets, thereby diminishing decision quality (McLeod and Lobel, 1992; Ellison and Mullin, 2014). For innovative activity, this mechanism is relevant because patenting requires not only idea generation but also evaluation, coordination, and selection under uncertainty (e.g., Salerno et al., 2015; Maniak and Midler, 2014; Martinsuo and Anttila, 2022). This is particularly important in the case of patents, whose technological and economic value is highly uneven and often only becomes clear ex post (e.g., Trajtenberg, 1990; Griliches, 1990; Hall et al., 2005).

Finally, the relationship between female representation and innovation may also depend on risk-taking. Since innovation is inherently risky, a potential concern is that increased female presence in leadership could decrease patenting if women are, on average, more cautious in corporate decision-making. Meta-analyses of experiments from both economics and psychology suggest that women are generally more risk-averse and less inclined to invest (Byrnes et al., 1999; Charness and Gneezy, 2012). This concern also appears in parts of the finance literature, for example in Faccio et al. (2016), which present evidence that female CEOs are less prone to risk-taking, potentially affecting optimal capital allocation within firms.

leaders reinforces negative stereotypes regarding gender roles and attitudes (Beaman et al., 2009; Kunze and Miller, 2017).

[2]Moreover, perceptions of unfair treatment can negatively impact worker morale and effort (Breza et al., 2018).

To conclude, innovation is a ”massive social process” (Usher, 1951) and thus the composition and diversity of people responsible for it matter. This paper does not aim to separately identify the specific mechanisms through which within-firm gender disparities affect innovation. Instead, it aims to find the overall (reduced-form) relationship, which is of interest given that the theory is ambiguous and many implemented or proposed policies aim at the overall increase in the representation of females in the top positions.

We focus on patents. While not being able to measure R&D is a limitation of this study, the patents are closer to realised innovative output, whereas R&D spending is an input measure and may be used inefficiently or shaped by policy rules and accounting choices rather than by successful innovation itself (e.g., Taylor, 2016; Lee, 2025). This makes patents a more informative outcome when the aim is to study whether gender disparities are associated with the actual production of innovation rather than with resources allocated to innovative activity. An additional advantage is that patent data allow us to go beyond the extensive margin. We can examine not only the number of patent families, but also forward citations and stock market value of patents, which provide information on the quality and economic significance of innovation (e.g., Trajtenberg, 1990; Griliches, 1990; Hall et al., 2005).

Finally, our empirical design considers two complementary dimensions of gender inequality within firms. We study female representation at the top of the firm, including among the company boards, because theory suggests that these positions are particularly relevant for innovation. At the same time, we analyse the gender pay gap as a broader measure of inequality within the organisation, capturing more general disparities in pay-setting, promotion, and the valuation of female labour.

2.2 Empirical Literature

Women are underrepresented in scientific and innovation output. Frietsch et al. (2009) analyse patent data and show that in the UK, women constituted 6.7% of inventors in 2005, 2.7 percentage points higher than in 1991. This is relatively low compared to other developed countries. In terms of fields, women in the UK are the most frequently found in the pharmaceutical (16.2%) and basic chemicals (12%), and the least in general machinery (1.3%). Using the US data, Bell et al. (2019) show that 82% of middle-aged inventors in the US are male and argue that improving the allocation of female talents may boost aggregate innovation. However, the key question of how the underrepresentation of women affects innovation remains largely unanswered.

There is a small literature in the management sciences investigating the impact of gender diversity on firm innovation.[3] Arun and Rojers (2021) and Agnete Alsos et al. (2013) offer comprehensive reviews of these studies. Existing qualitative and quantitative empirical research suggests a positive effect of gender-diverse management (or R&D teams) on R&D investment and innovation output (Østergaard et al., 2011; Horbach and Jacob, 2018; Bass, 2019; Ritter-Hayashi et al., 2019; Biga-Diambeidou et al., 2021; Parrotta et al., 2014). However, much of the quantitative empirical evidence is descriptive, primarily based on cross-sectional firm surveys.

A handful of studies use longitudinal firm-level data and, overall, find no evidence of a detrimental effect of female representation on innovation. A study by Griffin et al. (2021) employs firm-level panel data from 43 countries to estimate the effect of gender board composition on the number and quality of patents submitted to the US Patent Office. The results from the long-run changes-on-changes model show a positive effect of the top female representation on firm innovation. Another study, by Na and Shin (2019), shows a positive effect of female ownership, and no effect of female share in the management or workforce, on various types of survey-measured innovation in a sample of firms from emerging economies. Finally, Dezsö and Ross (2012) employ panel data on US firms to estimate fixed-effect and Arellano-Bond regressions of Tobin's Q on the representation of women in top management, interacted with the level of R&D investment. Their results indicate that, on average, female representation does not affect firm performance, but in innovation-intensive companies, this effect is positive.

More broadly, the relationship between gender discrimination and firm performance has been a subject of extensive research. While the existing empirical literature on firm-level outcomes and gender diversity remains inconclusive (Rhode and Packel, 2014), a substantial body of work find that greater female representation, particularly in executive roles, has a positive impact on a range of measures of firm performance, including profits (Hellerstein et al., 2002; Kawaguchi, 2007), return on assets (Erhardt et al., 2003; Christiansen et al., 2016), and various mea-

[3] A converse relationship, the effect of patents on the gender gap, is explored in Masso and Vahter (2020) using Estonian matched employee-employer data. Their findings suggest that innovations tend to benefit males more than females, thereby exacerbating the pay gap in innovative firms.

sures of stock market performance (e.g., Tobin's Q, informativeness of stock prices, financial risk) (Perryman et al., 2016; Gul et al., 2011; Upadhyay and Zeng, 2014; Krishnan and Parsons, 2008). Moreover, firms with a higher share of women in management positions often exhibit better workplace management practices, such as more effective communication channels (Melero, 2011), which correlate with enhanced labour productivity (Flabbi et al., 2019) and firm survival (Weber and Zulehner, 2014; Faccio et al., 2016). Flabbi et al. (2019) show that gender differences in leadership affect how accurately firms assess workers' abilities and how efficiently workers are allocated across simple and complex tasks.

In contrast, another set of studies has found negative or non-significant impacts of gender diversity on firm outcomes. Women entrepreneurs were shown to be less innovative than males (e.g., Link and van Hasselt, 2020). Additionally, studies examining the implementation of gender quotas often find adverse effects on firms' outcomes. Noteworthy studies in this context include those by Ahern and Dittmar (2012) and Matsa and Miller (2013), which report negative effects of implementing gender quotas on companies' boards in Norway on measures such as stock prices, Tobin's Q, and overall profits.

This paper enriches the literature by providing direct evidence on the relationship between within-firm gender disparities and firm innovation using a large and comprehensive panel of British companies. Our rich data enable us to explore various novel aspects of gender disparities and innovative outcomes, employing several identification strategies to minimise endogeneity issues. Finally, by focusing solely on UK-active firms, we may address some limitations present in Griffin et al. (2021), which examines firms from 43 countries but considers patents only filed with the US Patent Office. Focusing on one country might be a better approach than cross-country comparisons, as in some countries (e.g., in China) firms might have not only economic, but also administrative incentives to patent (Lee, 2025).

Some of our findings align with the literature, particularly the lack of effect of female representation on boards on patents. However, our more novel results indicate that there could be a significant and negative impact of the under-representation of women among high-wage employees and the substantial gender pay gap on the innovation process.

3 Data

We construct two panels of British companies to explore various dimensions of within-firm gender disparities. The first, named the *Short Panel*, includes data on gender pay gaps and the representation of women at different levels of wage distribution within UK companies employing more than 250 people from 2017 to 2019. The second, called the *Long Panel*, focuses on female executives at the top of the corporate hierarchy in a broad sample of UK companies from 1996 to 2017. Both panels are linked to data on firm innovation (measured through firm-level patenting activity) and various indicators of firm performance and characteristics. In this section, we provide details about the data sources, the definitions of variables, and the process of constructing the panels.

3.1 Gender Disparities

The measures for gender discrimination in the *Short Panel* derive from data published by the UK Office for National Statistics. This data is an outcome of the 2017 legislation that requires the public reporting of within-firm average and median gender pay disparities, along with the proportion of female employees in the total workforce and across the wage quartiles, for all UK-based organisations with 250 or more employees. The gender pay gap is the percentage difference in earnings between male and female employees, without adjusting for differences in the characteristics of the workers or the jobs. This approach is an example of a broad definition of discrimination (Altonji and Blank, 1999). For instance, due to potential biases in hiring practices, the presence of a glass ceiling, or inadequate maternity leave policies, women may be underrepresented in higher-level positions within a company's hierarchy. Consequently, the broad definition of the pay gap aims to reflect not merely the wage disparities between male and female employees with similar roles but also the discrepancies in career advancement opportunities.

The *Long Panel* focuses on the female representation on the board of directors and among senior management. The data come from the Bureau van Dijk's (BvD) Historical Orbis files (DMC).

3.2 Firm Innovation

We measure firm innovation using patent data, obtained from two primary sources: the Bureau van Dijk (BvD) Orbis IP and PATSTAT. The BvD Orbis IP dataset links patents to firms and provides detailed information on firm characteristics and patenting activities. However, the linkage quality is only satisfactory in recent years. Therefore, we use Orbis IP exclusively for the *Short Panel*, which spans years from 2017 to 2019. To identify firm-level inventions in the *Long Panel*, commencing in 1996, we utilise the PATSTAT database alongside a cross-walk between BvD firm ID and PATSTAT patent ID from Martin and Verhoeven (2019).[4] The crosswalk provided by Martin and Verhoeven (2019) covers firms and patents only up to 2017; therefore, we restrict our analysis of *Long Panel* to the period 1996 to 2017.

Unlike BvD Orbis IP, which directly associates patent records with UK firms, PATSTAT is a global patent database that includes patents filed by individuals, governments, and universities worldwide, not just by UK firms. To identify patents belonging to UK firms, we restrict the PATSTAT sample to UK-related patents — those where at least one application in the patent family[5] was filed in the UK or where at least one inventor in the patent family is based in the UK. We then match these patents to firms using the crosswalk provided by Martin and Verhoeven (2019). This matching process successfully linked 65% of UK patents to British firms, resulting in 365,084 unique links between 1996 and 2017. The 65% linkage rate is reasonable, as company inventors account for 53% of all UK patents (Figure A.1), with the remainder attributed to individuals, governments, and universities. From both patent databases, for each patent family, we retrieve information on patent grant status, citation, country and date of filing, the number of patent applications, and inventor addresses.

We construct three measures of innovation, using patents as proxies. The first measure is the number of granted patents, which represents a firm's overall successful patenting activity. Recognising that not every patent holds equal scientific or economic significance, we differentiate further. For scientific relevance, we utilise the number of granted patent forward citations (Trajtenberg, 1990), captur-

[4] Maintained by the European Patent Office, PATSTAT provides the most comprehensive information on patents filed globally (Guillard et al., 2021).

[5] Following the literature on firm-level patents (Kogan et al., 2017; Kline et al., 2019), a patent is conceptualised not as an individual application but as a family of applications. This family consists of multiple applications that pertain to the same invention but may be filed separately to address specific components of the invention or to seek protection in various patent offices.

ing the influence of a patent on future innovations. Our third measure, Excess Stock Market Return (ESMR) of granted patents (Kogan et al., 2017), assesses the economic value of innovation using information on share prices of publicly listed companies.[6] ESMR is based on the premise that a granted patent boosts the company's value by the expected value of the patent, which is internalised by the market. Thus, changes in the company's stock market valuation post-patent announcement are used to estimate the patent's economic value. The ESMR for patents is calculated using daily stock market data from Compustat.[7] The primary limitation of ESMR is that it applies only to publicly listed companies. Hence, in analysing the economic value of patents, our focus is solely on these firms. In practice, due to the small number of listed companies in the *Short Panel*, our analysis of ESMR is only for the *Long Panel*.

3.3 Firm Characteristics

To account for time-variant firm-level characteristics that could correlate with gender disparity measures and firm innovation metrics, we incorporate several control variables into our regression analyses. These include the logarithm of employment (serving as a proxy for firm size), the logarithm of the average wage (acting as a proxy for skill intensity), the logarithm of value added per worker (reflecting productivity), and, in the *Short Panel* only, the logarithm of net tangible assets per worker (indicating capital intensity). For the *Short Panel*, we source these variables from the online version of BvD Fame. For the *Long Panel*, we use the Historical Files of BvD Orbis.

3.4 Data Linkage and Sample Definitions

The major undertaking of this project was to create consistent firm-level panels containing information on gender disparities, patenting activity and firm characteristics. In this sub-section, we describe in detail the linkage between the data sources and the sample selection procedure.

[6] The literature also used alternative measures, including patent renewal behaviour (Pakes, 1985; Bessen, 2008); patent ownership reassignment (Serrano, 2010); patent litigation (Harhoff et al., 2003); submission of patent applications to multiple countries (Putnam, 1996); or patent claims (Lanjouw and Schankerman, 2001).

[7] We follow Kogan et al. (2017) in our estimation of ESMR. In particular, we use the 3-day window around the patent-granting day and estimate the value of γ (.0274) and δ (.027) parameters.

Short Panel. The panel comprises UK firms employing more than 250 people from 2017 to 2019. The Office for National Statistics (ONS) provides data on gender pay gaps and female representation for 10,362 entities, resulting in 24,210 entity-by-year observations. We use the official firm registry ID to link 932 entities (1,797 entity-by-year observations) with patenting activity data from BvD Orbis IP. We assume that entities that are not linked did not patent during the analysed period. Next, by employing the same firm ID, we merge information on firm characteristics from BvD Fame for nearly all entity-year records, with the exception of 288 cases. Furthermore, we restrict our sample to observations with complete data on employment, employment cost, value added, and tangible assets. To limit measurement error, we trim the bottom and top one per cent of the distribution of average firm-level wages for each year.[8] We also exclude entities from public administration, education, health, and care services (NACE Rev 2. 2-digit codes 77-88). Finally, we drop observations with negative value added. After these steps, the final number of firms with non-missing information on all variables is 4,581.

Long Panel. The starting point in constructing the panel is firm-level financial data from the Historical Files of BvD Orbis. The sample collection in this database is not random; therefore, we followed the procedure from De Loecker et al. (2022) to create a consistent and representative panel of UK firms spanning from 1996 to 2017. We first select firms that employ ten or more individuals and exclude entities from the public sector, financial services, and the oil industry. In instances where consolidated accounts are available, we disregard the unconsolidated counterparts. Additionally, we eliminate subsidiaries from our dataset when the parent company, or global ultimate owner, is already included in our sample. Finally, we drop observations that do not contain complete data on wage bills and pretax profits. This initial selection process yields a sample comprising 109,573 firms, amounting to approximately 31,000 observations annually and totalling 720,115 firm-years.

Next, we link the data on gender composition within boards and senior management, sourced from separate files in the Historical Files of BvD Orbis (DMC files). We can do this for 69,094 firms (529,389 firm-year observations). In the final

[8] The average wage is defined as the total annual wage cost divided by the number of employees. The former is reported as an annual total, whereas employment refers to a snapshot on a particular day. Measurement error might thus arise if a firm experienced significant changes in employment throughout the year.

step, we link patent information from PATSTAT. As in the *Short Panel*, we assume that there was no patenting activity in unmatched firm-years.

3.5 Descriptive Statistics

Short Panel. Figure 1 illustrates the employment-weighted average of female representation across all firm workplaces and within quartiles of the firm-level wage distribution, as well as the mean gender pay gap at the firm level. Women in the UK labour market are not on equal terms with men. Approximately 40% of workers in the sampled firms are women, but they are over-represented in the lower half of the within-firm pay distribution and under-represented in the higher half (around 31% of workers in the fourth quartile are women). This is reflected in the gender pay gap, which indicates that, on average, women earn nearly 16% less than men.

Descriptive statistics for all firms in the *Short Panel* for 2018 are shown in Table 1. The unweighted average of the mean wage pay gap is 15%, although there is a considerable variation across firms with the standard deviation of 14% and the range from -65% (women earn more) to 79%. The average company in the sample has 1724 workers, the majority of them males. Most companies in the sample do not patent. Only 6% of firms received at least one patent in 2018, and the average number of granted patents was less than 2.

Table 2 compares firms that patented and those that did not, using pooled data from 2017 to 2019. Conditional on patenting, the average number of granted patents per firm was almost 30. Firms that do patent tend to be more masculine, larger, more profitable, and more capital-intensive. The gender pay gap is almost 1.8 percentage points higher in firms that patented compared to those that did not. Additionally, the share of females is around eight percentage points lower. Patenting firms also have, on average, three times more employees, three times higher value-added per employee, pay 30% higher wages, and possess 130% higher net tangible assets per worker.

Table 1. Descriptive Statistics, the *Short Panel* in 2018

	Mean	Median	SD	Min	Max
Gender mean pay gap (in %)	15.06	14.50	13.97	-65	79
Gender median pay gap (in %)	11.77	10.00	14.52	-72	79
Female share (in %)	35.59	31.75	20.99	0	99
Female share, lower quart. (in %)	43.18	42.70	22.16	0	100
Female share, lower-middle quart. (in %)	38.00	35.30	24.10	0	100
Female share, upper-middle quart. (in %)	33.33	28.00	23.51	0	100
Female share, top quart. (in %)	27.83	23.00	20.23	0	98
Employment	1724.52	532.00	7696.62	250	275143
Turnover per worker (in th £2021)	279.28	154.05	599.27	2	13,933
Average firm wage (in th £2021)	37.24	32.71	21.65	8	181
Value added per worker (in th £2021)	60.30	39.81	94.27	1	1,923
Net tangible assets per worker (in th £2021)	211.05	50.99	893.23	0	20,166
Number of granted patents per year	1.88	0.00	24.76	0	1,145
Number of forward citations	0.61	0.00	18.52	0	1,165
Has patenting activity (=1 if patented)	0.06	0.00	0.23	0	1

Notes: The table presents the unweighted descriptive statistics for the *Short Panel*. The numbers are for 2018. The sample size is 4521. Source: Office for National Statistics, BvD FAME, BvD ORBIS IP.

Table 2. Comparison between Patenting and Non-Patenting Firms, the *Short Panel*, 2017-2019

	Patenting	Not-Patenting	Difference
Gender mean pay gap (in %)	16.875	15.109	-1.766***
Gender median pay gap (in %)	14.630	11.742	-2.887***
Female share (in %)	27.526	35.939	8.413***
Female share, lower quart. (in %)	37.683	43.546	5.863***
Female share, lower-middle quart. (in %)	28.990	38.427	9.437***
Female share, upper-middle quart. (in %)	23.726	33.649	9.923***
Female share, top quart. (in %)	19.704	28.132	8.428***
Employment	5055.076	1632.207	-3422.869***
Turnover per worker (in th £2021)	432.580	276.510	-156.069***
Average firm wage (in th £2021)	48.940	37.158	-11.783***
Profit before taxation per worker (in th £2021)	70.715	21.136	-49.578***
Net tangible assets per worker (in th £2021)	519.081	207.078	-312.003***
Observations	669	10564	11233

Notes: The table presents the unweighted descriptive statistics by the patenting activity for the *Short Panel*. The years 2017-2019 are polled. Source: Office for National Statistics, BvD FAME, BvD ORBIS IP.

Long Panel. The unweighted descriptive statistics for the 2015 snapshot of the *Long Panel* are presented in Table 3. On average, nearly 18% of the board members and nearly 20% of senior management are female, but with sizable variation as the standard deviation is 24% for both. Notably, the median firm in the sample has no women on its board.[9] The firms in the *Long Panel* are significantly smaller than those in the *Short Panel* - the average of 557 workers vs. 1724 - but tend to pay higher wages - 48 thousand pounds on average vs. 37 thousand. While only 1% of the sampled firms in 2015 patented, 4.6% of firms in the *Long Panel* received at least one patent from 1996 until 2017.[10] As shown in Table 4, over the entire period, the patenting firms had an average of 27 granted patents and 36 citations per year.[11] The difference between firms that patented and those that did not is similar to that in the *Short Panel*. Specifically, firms that patent tend to be larger, more profitable, and offer higher wages.

Table 3. Descriptive Statistics, the *Long Panel* in 2015

	Mean	Median	SD	Min	Max
Female share in the board (%)	17.82	0.00	23.84	0	100
Female share in senior management (%)	19.68	12.50	24.23	0	100
Employment	557.20	74.00	7,617.00	10	611366
Average firm wage (in th £2021)	48.09	42.11	28.20	8	198
EBITDA per worker (in th £2021)	22.83	12.06	41.26	-112	320
Number of granted patents per year	0.26	0.00	9.32	0	1,209
Forward Citations per year	7.48	1.00	33.46	0	506
Has patenting activity (=1 if patented)	0.01	0.00	0.11	0	1

Notes: The table presents the unweighted descriptive statistics for the *Long Panel*. The numbers are for 2015. The sample size is 21539. Source: BvD ORBIS Historical Files and PATSTAT.

[9] We also study how female leadership evolves within firms over time. Figure A.2 plots the fraction of UK firms that experienced a change in the share of female leaders over horizons of 1, 3, and 5 years. Overall, female leadership composition appears relatively persistent: around 20 percent of firms experience a change within one year, 30–35 percent within three years, and 40–45 percent within five years. These patterns highlight that, while leadership composition is far from fully fluid, there is meaningful variation over time within firms.

[10] As reported in Figure A.3, there was an overall decline in the number of patenting firms between 1995 and 2017 in the UK. However, the average number of patents per patenting firm was growing.

[11] Some firms, which did not patent between 1996 and 2017, patented before 1996, and thus the average number of forward citations for non-patenting firms is positive.

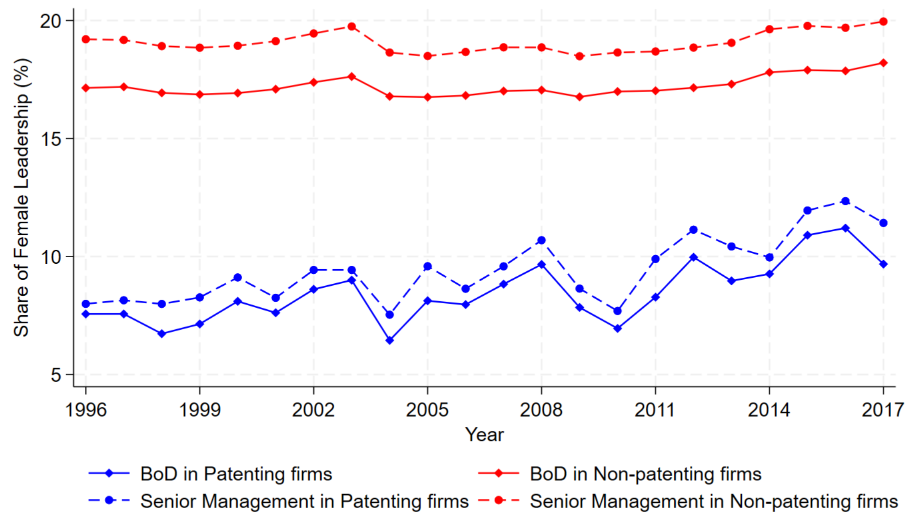
Table 4. Comparison between Patenting and Non-Patenting Firms, the *Long Panel*, 1996-2017

	Patenting	Not-Patenting	Difference
Female share in the board (%)	8.226	17.135	8.909***
Female share in senior management (%)	9.150	19.025	9.874***
Employment	2535.217	376.191	-2159.027***
Average firm wage (in th £2021)	35.237	29.963	-5.274***
EBITDA per worker (in th £2021)	11.476	8.976	-2.500***
Number of granted patents per year	27.251	0.000	-27.251***
Forward Citations per year	37.880	2.671	-35.209***
Observations	6144	426371	432515

Notes: The table presents the unweighted descriptive statistics for the *Long Panel*. The years 1996-2017 are polled. Source: BvD ORBIS Historical Files and PATSTAT.

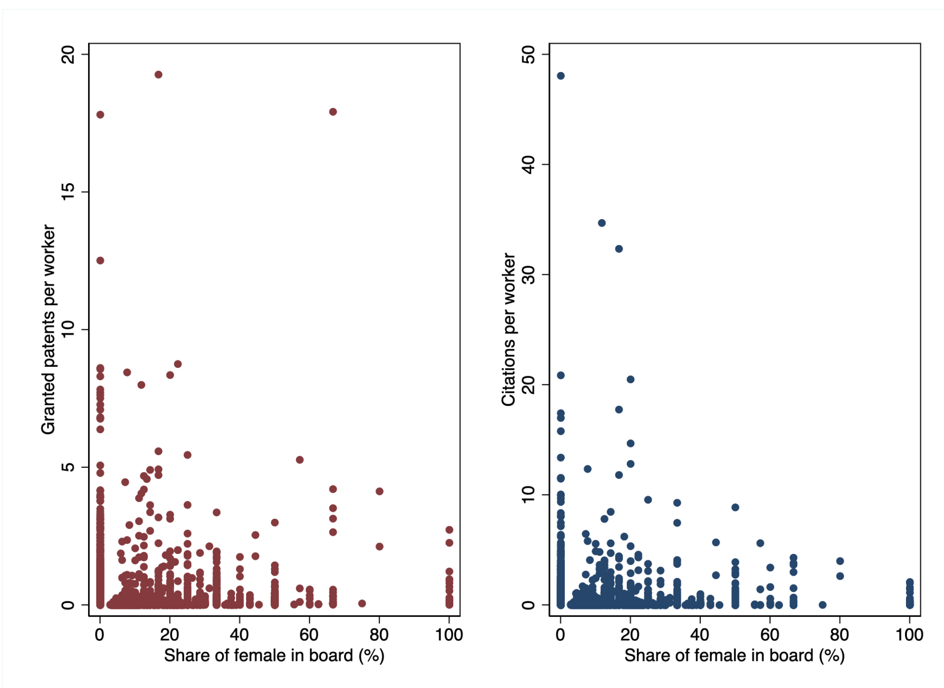
The management of patenting firms is more masculine - on average across 1996 and 2017, 8% of their boards and 9% of senior management were female, compared to 17% and 19% respectively for non-patenting firms. Figure 2 shows that in the entire period, a low representation of females on boards and senior management was a domain of patenting firms. However, from the mid-2000s, the gap narrowed from nearly 10 percentage points to 7. The increase in the female representation at boards and senior management for patenting companies mirrors (but at much smaller level) a similar increase reported for all firms in the Historical Orbis database (Figure A.4). Next, Figure 3 explores the relationship between the share of females on boards and the number of patents and citations per worker (averaged over 1996-2017) for firms that have patented at least once. While there is a considerable variation across firms in those outcomes, patent and citation intensity are larger for firms with fewer females at the top.

Figure 2. The Female Leadership Share, Patenting versus Non-Patenting Firms



Notes: The figure presents the average female share of UK firms' board of directors (BoD) and senior management for firms which are patenting and those which are not.

Figure 3. The Female Share of Companies' Boards, 1996 - 2017



Notes: The figure presents the average female share of companies' boards for firms which patented at least once.

4 Evidence from the Short Panel

The analysis using the short panel is based on a cross-sectional sample of firms from 2017 to 2019. We utilise the Poisson Pseudo-Maximum Likelihood (PPML)[12] to estimate a firm-level relationship between patenting activity and the share of females among the top 25 percent best-paid worker or the gender pay gap. All the variables in the following model are firm-level averages over the period 2017-2019:

$$P_{ij} = \exp\left(\beta_0 + \beta_1 GI_{ij} + \gamma X_{ij} + \mu_j\right) + \epsilon_{ij} \tag{1}$$

, where P_{ij} measures the patenting activity of firm i in industry j. We consider two metrics: the number of granted patents and the number of forward citations.[13] Our variables of interest are measures of within-firm gender disparities, GI. The first measures the female share in the top quartile of the within-firm wage distribution. The second uses the mean gender pay gap within the firm.[14] Our variables of interest are correlated with the overall number of employed females, which might influence a firm's innovation through, for example, local labour market conditions. Therefore, in all specifications, we control for the overall firm-level share of females[15] as well as the 2011 Travel-to-Work-Area-level female share among university graduates (sourced from the census). Additionally, we include a set of control variables, X, such as employment (a proxy for firm size); average wage (a proxy for skill intensity); value-added per worker (a proxy for productivity); and net tangible assets per worker (a proxy for capital intensity). We account for unobserved, time-invariant 1-digit industry characteristics through industry fixed effects.

The descriptive statistics presented in Section 3.5 show that, consistently over the years, patenting firms tend to be more masculine and exhibit greater gender disparities. In line with that, the first column of Table 5 reveals that in a simple bivariate Poisson regression of the number of patents on the female share at the top, there is a negative and statistically significant correlation between these

[12]This approach is chosen to appropriately handle the count data nature of patents, which includes a substantial number of zero observations.

[13]In the short panel, we do not report results using the excess stock market return (ESMR) value of patents, as the number of patenting public firms in the short panel is too small.

[14]Because the firm-level gender pay gap is determined by the share of females across different parts of the wage distribution, we do not include these variables in one model. Otherwise, one would need to consider, for instance, the effect of a change in the gender pay gap while holding the female representation at the top fixed.

[15]The coefficient on the female share in the top quartile should therefore be interpreted as the effect of increasing the female share in the top quartile while decreasing it elsewhere.

variables. However, when controlling for labour productivity, capital intensity, average wage, and employment in Column 2, the coefficient on the female share becomes positive and significant - a one percentage point increase in the share corresponds to a 5.7% increase in the number of patents. Incorporating the 1-digit industry fixed effects in Column 3 reduces the coefficient to 3.1%, but it remains significant at the 10% level. The effect is substantial, as a one standard deviation increase in the share of females in the top quartile (20 percentage points) is associated with a 62% rise in the number of patents.

The female share at the top has a stronger effect on the number of forward patent citations, which measure the scientific importance of innovations. As shown in Column 5 of Table 5, there is a negative and significant link between the female share and the number of citations. However, adding control variables reverses this effect - a one percentage point rise in the share is associated with more than a 7% increase in citations. Similar to previous findings, including industry fixed effects reduces the effect to 5%, but it remains large and significant.

The results for the gender pay gap, reported in Table 6, present a similar picture. While there is no relationship between the number of patents and the pay gap in a bivariate regression (Column 1), adding the covariates results in a negative and significant coefficient - a one percentage point (one standard deviation) increase in the gap corresponds to a 2% (28%) decrease in the number of patents. However, this effect disappears once 1-digit industry effects are included (Column 3).

Similar to the female share at the top, the impact of the gender pay gap is more significant when analysing patent quality. A one percentage point increase in the gender pay gap is linked to a 1.8% decrease in the number of forward citations in a specification that includes a full set of control variables and industry fixed effects (Column 7).

Table 5. Female representation at the top and innovation outcomes, Cross-Section, Average 2017-2019

	Patent families (headcount)				Forward citations (headcount)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Female share, top quart. (in %)	-0.029***	0.057***	0.031*	0.714*	-0.055***	0.072**	0.050*
	(0.006)	(0.021)	(0.019)	(0.423)	(0.006)	(0.029)	(0.026)
Female share (in %)		-0.087***	-0.042**	-0.638*		-0.148***	-0.105***
		(0.021)	(0.019)	(0.347)		(0.034)	(0.028)
Log value added per worker (in th £2021)		0.681*	0.487**	0.251		-0.906*	-0.604*
		(0.407)	(0.209)	(0.202)		(0.479)	(0.325)
Log net tangible assets per worker (in th £2021)		0.182*	0.304**	0.305***		0.342***	0.410***
		(0.102)	(0.142)	(0.102)		(0.049)	(0.096)
Log average firm wage (in th £2021)		0.584*	0.678***	4.036**		2.336***	1.817***
		(0.344)	(0.164)	(1.585)		(0.712)	(0.343)
Log employment		1.087***	1.155***	1.425***		1.225***	1.190***
		(0.049)	(0.063)	(0.173)		(0.049)	(0.067)
TTWA female share in higher edu. (2011)		-0.140	-0.017	0.012		-0.102	0.027
		(0.150)	(0.108)	(0.128)		(0.186)	(0.156)
Observations	4,920	4,581	4,581	4,581	4,920	4,581	4,581
Industry FE	No	No	Yes	Yes	No	No	Yes
Estimator	Poisson	Poisson	Poisson	IV	Poisson	Poisson	Poisson

Notes: Poisson and IV Poisson (control-function) estimates. Industry fixed effects are NACE Rev.2 1-digit (when included). In the IV specification for patent families, the endogenous regressor is the female share in the top quartile of the within-firm wage distribution instrumented by gender ratio (SOC3). We were unable to estimate the IV Poisson model for forward citations. The data is from *Short Panel* and the variables are aggregated at the firm level over the 2017-2019 period. Standard errors clustered at TTWA. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6. Gender pay gap and innovation outcomes, Cross-Section, Average 2017-2019

	Patent families (headcount)				Forward citations (headcount)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Gender mean pay gap (in %)	0.001	-0.021**	-0.008	-0.532*	-0.023*	-0.021**	-0.018*
	(0.005)	(0.009)	(0.008)	(0.314)	(0.012)	(0.010)	(0.011)
Female share (in %)		-0.039***	-0.015**	0.076		-0.091***	-0.063***
		(0.011)	(0.007)	(0.074)		(0.017)	(0.015)
Log value added per worker (in th £2021)		0.663	0.459**	0.064		-0.945*	-0.628*
		(0.412)	(0.223)	(0.262)		(0.493)	(0.322)
Log net tangible assets per worker (in th £2021)		0.179*	0.312**	0.218		0.329***	0.420***
		(0.101)	(0.147)	(0.149)		(0.055)	(0.098)
Log average firm wage (in th £2021)		0.620*	0.673***	7.220**		2.430***	1.849***
		(0.357)	(0.168)	(3.482)		(0.788)	(0.360)
Log employment		1.071***	1.157***	1.221***		1.223***	1.192***
		(0.048)	(0.061)	(0.150)		(0.053)	(0.066)
TTWA female share in higher edu. (2011)		-0.129	-0.014	0.015		-0.086	0.041
		(0.150)	(0.109)	(0.154)		(0.186)	(0.156)
Observations	4,920	4,581	4,581	4,581	4,920	4,581	4,581
Industry FE	No	No	Yes	Yes	No	No	Yes
Estimator	Poisson	Poisson	Poisson	IV	Poisson	Poisson	Poisson

Notes: Poisson and IV Poisson (control-function) estimates. Industry fixed effects are NACE Rev.2 1-digit (when included). In the IV specification for patent families, the endogenous regressor is the gender mean pay gap instrumented by gender ratio (SOC3). We were unable to estimate the IV Poisson model for forward citations. The data is from *Short Panel* and the variables are aggregated at the firm level over the 2017-2019 period. Standard errors clustered at TTWA. *** p<0.01, ** p<0.05, * p<0.1

4.1 IV Estimates

One concern with the cross-sectional estimates is that they may still reflect unobserved differences across firms and local labour markets. To address this issue, we instrument either the gender pay gap or the share of females in the top quartile with the female share in the TTWA-level SOC3 occupational group in 2011. The idea is that associate professional and technical occupations constitute an important pool of future managers, engineers, and other high-wage employees. Hence, firms located in travel-to-work areas with a larger female presence in this occupational tier are more likely to draw, several years later, on a deeper pool of women who can move into top-paid positions within the firm.

The exclusion restriction is supported by several features of our design. First, the instrument is measured in 2011, well before the firm-level outcomes and endogenous regressors observed over 2017–2019, which reduces the scope for reverse causality. Second, SOC3 workers are not themselves the highest-paid employees, so the instrument should not be mechanically linked to either the firm's contemporaneous gender pay gap or the female share in the top quartile. Third, the female share in SOC3 may partly capture the overall female presence in the local labour market and local differences in women's educational attainment, but we control directly for female representation within the firm and for the TTWA-level female share among university graduates in 2011 (addition of this control variable does not affect the results). This identification strategy is also consistent with a broader literature that instruments female leadership using the local or regional supply of women in the relevant talent pool. Ongsakul et al. (2022); Chatjuthamard et al. (2021); Mobbs et al. (2021) exploit variants of the idea that the local pool of female directors shapes board gender composition, while Flabbi et al. (2019) use instruments based on regional trends in female executives when studying the effects of female leadership on wage gaps and firm performance.

The first-stage evidence, reported in Appendix Table B.1, shows that the instrument is relevant for the share of women in the top wage quartile: the Kleibergen–Paap rk Wald F-statistic is 8.08 in the full sample and 13.28 in the sample of patenting firms (discussed below in Section 4.3). For the gender pay gap, the corresponding first-stage statistic is 7.74 in the full sample, but only 1.77 in the patenting-firm sample. This last result indicates a clearly weak first stage for the pay-gap specification in the restricted patenting sample, and we do not report IV estimates for this specification.

We estimate the IV Poisson model (using control function approach) for the headcount of patents only. For the forward citation outcome, the IV Poisson model does not converge, likely due to the heavy concentration of zeros in this variable. The IV estimates broadly confirm the OLS pattern, although they are less precise. In Table 5, Column 4, instrumenting the female share in the top wage quartile yields a positive and statistically significant coefficient for patent families. The estimate is substantially larger than in the corresponding OLS specifications, but its direction is the same, suggesting that greater female representation at the top of the within-firm wage distribution is associated with stronger patenting activity. Likewise, in Table 6, Column 4, the IV estimate for the gender pay gap in the full sample remains negative, in line with the OLS results. Thus, the IV analysis does not alter the main message from the cross-sectional regressions. At the same time, the IV coefficients are estimated less precisely and should be interpreted with caution.

4.2 Firm Fixed Effect Estimates

Our second identification strategy relies on firm fixed effects. The OLS correlations might be biased due to unobservable firm effects. For example, companies with a low gender pay gap and high female representation may have an open, nondiscriminatory corporate culture, which could also positively influence innovativeness. This can be addressed by leveraging the time dimension of the panel and adding firm fixed effects. The analysis of the *Long Panel*, discussed in the next section, is based on such an approach. In the case of *Short Panel*, this is also feasible, but limited data makes the estimation particularly noisy. The reason is that, in the Poisson model, the fixed effect panel model can only be estimated for firms that have at least one episode of patenting or citation. In the *Short Panel*, we only have 560 companies (out of 5267) that patented and 160 that were cited.

Keeping these caveats in mind, we estimate the following model for the years 2017-2019:

$$P_{ijt} = \exp\left(\beta_0 + \beta_1 GI_{ijt} + \gamma X_{ijt} + \mu_t + \mu_i\right) + \epsilon_{ijt} \tag{2}$$

, where the notation remains the same as before, except that t represents time, μ_t indicates year fixed effects, and μ_i refers to firm fixed effects.

Table 7, Columns 1 and 2 show that, although there is no significant effect of female share at the top on the number of patents after controlling for individual firm fixed effects, a significant relationship exists between the gender pay gap and patenting. A one-percentage-point increase in the gap is, on average, associated with a 1.2% decrease in the number of granted patents, and the coefficient is significant at the 5% level. The opposite effects are reported when forward citations are considered (Columns 3 and 4). There is a negative effect of female representation and an insignificant effect of the gender pay gap. However, these results are based on a very small sample of 166 firms that patented and were cited, and thus the coefficient should be interpreted with a grain of salt.

Table 7. Gender diversity and innovation outcomes, Short Panel, 2017-2019

	Patent families		Forward citations	
	(1)	(2)	(3)	(4)
Female share, top quart. (in %)	0.002		-0.061*	
	(0.009)		(0.037)	
Gender mean pay gap (in %)		-0.012**		-0.003
		(0.005)		(0.026)
Female share (in %)	0.001	0.008	0.067	0.047
	(0.011)	(0.012)	(0.061)	(0.073)
Log value added per worker (in th £2021)	0.046**	0.044**	0.112**	0.142***
	(0.019)	(0.021)	(0.056)	(0.050)
Log net tangible assets per worker (in th £2021)	-0.030	-0.032	0.750*	0.623
	(0.080)	(0.082)	(0.415)	(0.419)
Log average firm wage (in th £2021)	-0.244	-0.139	-0.417	0.068
	(0.266)	(0.290)	(0.490)	(0.532)
Log employment	-0.289	-0.301	0.172	0.298
	(0.200)	(0.202)	(0.562)	(0.566)
Observations	1,475	1,475	439	439
Firms	560	560	166	166
Firm FE	Yes	Yes	Yes	Yes

Notes: Poisson Fixed Effect estimates. The data is from *Short Panel* and the variables are aggregated at the firm level over the 2017-2019 period. Standard errors clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1

4.3 Restricting the Sample to Patenting Firms

Finally, in the Appendix Tables B.2 and B.3 we report the OLS and IV estimates on the sample restricted to firms with positive patenting activity. Focusing on this subsample is useful because it isolates variation among firms that already innovate and therefore speaks more directly to the intensive margin of innovation, that is, the number and quality of patents conditional on patenting at all. In Appendix Table B.2, the OLS estimates for the female share in the top quartile remain positive for both patent families and forward citations. With the full set of controls and industry fixed effects, a one percentage point increase in the female share in the top quartile is associated with around 3.9% more patent families and 7.2% more forward citations. These magnitudes are similar to those in the full sample. By contrast, the IV estimate for patent families is positive but imprecisely estimated and no longer statistically significant. This is in sharp contrast to the full-sample IV coefficient, which is much larger. One interpretation is that the large IV coefficient in the full sample partly reflects a particularly strong effect of female representation at the top on the decision to patent in the first place, that is, on the extensive margin. Once the sample is restricted to firms that already patent, this extensive-margin channel is shut down, and the remaining effect on patent intensity appears more modest.

A similar pattern emerges for the gender pay gap. In Appendix Table B.3, among patenting firms, the coefficient on the gender pay gap is negative and statistically significant for both patent families and forward citations in the OLS specifications. With controls and industry fixed effects, a one percentage point increase in the pay gap is associated with around 1.3% fewer patent families and 2.5% fewer forward citations. These estimates are similar to the corresponding full-sample specifications. We do not report IV estimates for the gender pay gap in this patenting-firm sample because, as shown in Appendix Table B.1, the first stage is too weak to support reliable inference.

Overall, a conservative interpretation of the results presented in this section is that increasing the representation of females at the top of a firm's hierarchy and closing the gender pay gap might increase the number of patents and their quality. In addition, the OLS results suggest that the effect of gender inequality on innovation operates through the intensive margin - how much firms innovate once they are active in patenting.

5 Evidence from the Long Panel

5.1 Baseline PPML Estimates

We now turn to the *Long Panel* analysis, which provides complementary evidence on the effect of the female representation at the very top of the corporate hierarchy - the board of directors and senior managers. We estimate a Poisson Pseudo Maximum Likelihood (PPML) model with a one-period lag structure on all independent variables, which mitigates concerns about reverse causality. This approach allows us to better isolate the effect of prior gender disparities on subsequent innovation outcomes.[16] We consider the following specification:

$$P_{ijt} = \exp\left(\beta_0 + \beta_1 GI_{ijt-1} + \gamma X_{ijt-1} + \mu_t + \mu_j\right) + \epsilon_{ijt} \tag{3}$$

, where P_{ijt} is a measure of patenting activity for firm i, from industry j at time t. We not only consider the previous two innovation measures - the number of granted patents and forward citations, but also examine the ESMR value of patents (Kogan et al., 2017). Our variable of interest is a lagged measure of within-firm gender imbalance, GI. In the *Long Panel*, we examine the female representation on companies' boards of directors and senior management. As in the *Short Panel* analysis, we include a vector of lagged, time-varying, firm-level controls, X_{ijt-1}, comprising employment (a proxy for firm size), average wage (skill intensity), and value-added per worker (productivity).

We also include firm fixed effects μ_i, effectively exploiting variation within firms. However, in the Poisson model, the fixed effect panel model can only be estimated for firms that have at least one episode of patenting. In the *Long Panel*, we have 2243 such companies (out of 69,094). Consequently, the results from the fixed-effects model are noisier than those from the simpler models.

The *Long Panel* presents a more nuanced picture of the link between female leadership and innovation. Table 8 shows that female board representation is significantly and negatively associated with both the number of patents and forward citations in raw specifications. A one percentage point increase in board-level female representation corresponds to a 1.8% decline in granted patents, a 2.3% decline in forward citations. However, these effects attenuate and become statistically insignificant once firm-level controls and fixed effects are added. This pattern sug-

[16] Results using additional lags are available upon request and yield similar findings.

gests that the observed baseline correlation is not causal but is likely driven by selection effects and underlying heterogeneity across firms. The effect of board-level female representation on the market value of patents, capturing the economic importance of innovation, is positive but statistically insignificant. Column 9, without controls or fixed effects, and subsequent specifications (Columns 10 to 12) with firm characteristics and firm or industry fixed effects, all yield similar results.

A similar pattern emerges for female representation in senior management (Table 9). In the baseline specification, the share of female managers is negatively and significantly associated with both patent grants and citation counts. However, once firm-level controls and fixed effects are introduced, the coefficients shrink markedly and lose significance (Columns 2 to 4). In fact, once the firm fixed effects are added (Column 4), the point estimate for patent counts turns positive, indicating that within-firm increases in female managerial representation are not detrimental to innovation. For the market value of patents, the baseline specification shows a significant positive coefficient of 1.5%. Yet, the relationship disappears once firm characteristics and firm and industry fixed effects are included.

The above results could be influenced by the fact that firms with high female representation on boards and senior management may also have a higher proportion of females in the workforce, which (as shown in Section 4) negatively impacts innovation. We lack data on the overall share of females, and although firm fixed effects should partly address this issue, some potential omitted variable bias might remain. To examine whether this affects the results, we run a model including both female representation on boards and in senior management. In this model, the coefficient for female board representation reflects the effect of having more women on boards, while keeping the female share in senior management constant.

The findings, presented in Appendix Table B.4, show that in specifications with industry fixed effects and control variables, the effect of the female share on boards on all outcomes is positive and, except for the number of patents, statistically significant (Columns 3, 7, 11). This suggests that increasing the female share on boards, without changing the management structure, positively influences innovation. Conversely, the coefficient for the female share in senior management is negative, implying that innovation may decline if the share of females in management rises without altering the gender composition of the board. However, once firm fixed effects are included, both effects become statistically indistinguishable from zero (Columns 4, 8, 12).

Table 8. Female Board Members and Patenting Activity, the *Long Panel*, 1996-2017

VARIABLES	(1) #P	(2) #P	(3) #P	(4) #P	(5) #FC	(6) #FC	(7) #FC	(8) #FC	(9) #MV	(10) #MV	(11) #MV	(12) #MV
Female Board Representation (in %)	-0.0176***	-0.0111***	-0.0055	-0.0109	-0.0234***	-0.0126**	-0.0064	-0.0031	0.0185	-0.0047	0.0072	0.0001
	(0.0054)	(0.0099)	(0.0113)	(0.3086)	(0.0046)	(0.0087)	(0.0083)	(0.4954)	(0.0052)	(0.0162)	(0.0165)	(0.0063)
Ln VA per worker (in th £2021)		0.2834***	0.3036***	0.1396		0.1853**	0.29422***	0.1496		1.2060	0.5169***	0.0113
		(0.0848)	(0.0834)	(1.4495)		(0.1019)	(0.0836)	(2.1770)		(0.2848)	(0.1827)	(0.0652)
Ln average firm wage (in th £2021)		1.2216***	0.9141***	14.7242		1.4885***	1.1191***	16.2091		-0.1751	-0.5744	-0.2648
		(0.2106)	(0.2866)	(12.7315)		(0.2296)	(0.2348)	(21.6739)		(0.4626)	(0.4945)	(0.2539)
Ln employment (in th £2021)		0.7653***	0.7666***	13.8632**		0.8103***	0 .8187***	3.4939		1.2014	1.1160***	0.1106
		(0.0542)	(0.0601)	(5.6650)		(0.0772)	(0.0794)	(8.4800)		(0.1564)	(0.1428)	(0.0849)
Observations	269,943	269,943	269,943	3,616	269,943	269,943	269,943	3,616	4,060	3,834	3,834	3,834
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No
Firm FE	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: The table shows the results from PPML fixed effect regression of the number of granted patents (#P, Columns 1-4), the number of forward citations (#FC, Columns 5-8) or the ESMR value of granted patents (#MV, Columns 9-12) on the female share of the boards of directors. Control variables include 1-digit industry (Columns 3,7,11) and firm (Columns 4,8,12) fixed effects. The data is from *Long Panel*. Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 9. Female Managers and Patenting Activity, the *Long Panel*, 1996-2017

VARIABLES	(1) #P	(2) #P	(3) #P	(4) #P	(5) #FC	(6) #FC	(7) #FC	(8) #FC	(9) #MV	(10) #MV	(11) #MV	(12) #MV
Share of Female Senior Managers (in %)	-0.0205***	-.01125*	-0.0070	0.0478	-0.0239***	-0.0149*	-0.0081	0.0281	0.0145***	-0.0213	-0.0008	-0.0014
	(0.0060)	(0.0098)	(0.0121)	(0.2837)	(0.0054)	(0.0097)	(0.0090)	(0.5384)	(0.0048)	(0.0199)	(0.0197)	(0.0050)
Ln VA per worker (in th £2021)		0.2709***	0.2809***	-0.3033		0.1511	0.2500***	1.4595		1.2120***	0.5406***	0.0119
		(0.0938)	(0.0917)	(1.7486)		(0.1170)	(0.0881)	(2.2826)		(0.2661)	(0.1763)	(0.0655)
Ln average firm wage (in th £2021)		1.2538***	0.9322***	16.8499		1.5580***	1.1615***	19.2913		-0.1391	-0.4815	-0.2586
		(0.2316)	(0.3263)	(14.8545)		(0.2632)	(0.2730)	(25.0634)		(0.4388)	(0.4865)	(0.2538)
Ln employment (in th £2021)		0.7643***	0.7701***	13.6442*		0.8183***	0.8289***	5.6543		1.2204***	1.1162***	0.1125
		(0.0567)	(0.0624)	(6.1822)		(0.0822)	(0.0823)	(8.7872)		(0.1585)	(0.1458)	(0.0863)
Observations	271,780	271,780	271,780	3,618	271,780	271,780	271,780	3,618	4,056	3,831	3,831	3,831
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No
Firm FE	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: The table shows the results from PPML fixed effect regression of the number of granted patents (#P, Columns 1-4), the number of forward citations (#FC, Columns 5-8) or the ESMR value of granted patents (#MV, Columns 9-12) on the female share of the senior management. Control variables include 1-digit industry (Columns 3,7,11) and firm (Columns 4,8,12) fixed effects. The data is from *Long Panel*. Clustered robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$

5.2 Long-Difference Estimates

Next, we employ a long-difference specification (equation 4) over the period 2000–2015 to verify the robustness of our findings. As before, P_{ij} denotes the measure of patenting activity for firm i in industry j, while GI_{ij} captures the share of females on the board or in senior management positions. X_{ij} represents the same set of control variables as in the baseline specification, and μ_j denotes industry fixed effects:

$$\Delta P_{ij} = \beta_0 + \beta_1 \, \Delta GI_{ij} + \boldsymbol{\gamma} \, \Delta X_{ij} + \mu_j + \varepsilon_{ij}, \tag{4}$$

The results indicate that changes in female leadership representation, both on boards and in senior management, are uncorrelated with changes in innovation outcomes. As shown in Table 10, across all three innovation measures, the estimated effects are small and statistically insignificant.

Table 10. Female Representation and Patenting Activity, Long Differences (2000-2015)

VARIABLES	(1) #P	(2) #FC	(3) #MV	(4) #P	(5) #FC	(6) #MV
Δ Female Board Representation (in %)	-0.0040	0.0029	0.0005			
	(0.0099)	(0.0098)	(0.0046)			
Δ Female Senior Management (in %)				-0.0048	0.0042	0.0017
				(0.0096)	(0.0095)	(0.0048)
Δ Ln VA per worker (in th £2021)	-0.1645	-0.1067	-0.0414	-0.1642	-0.1064	-0.0440
	(0.1507)	(0.1492)	(0.0981)	(0.1502)	(0.1487)	(0.0982)
Δ Ln average firm wage (in th £2021)	0.7280	2.8571***	-0.7702***	0.7200	2.8456***	-0.7755***
	(0.5627)	(0.5571)	(0.1664)	(0.5606)	(0.5549)	(0.1668)
Δ Ln employment	-0.1172	0.6088**	-0.0705	-0.1221	0.6043	-0.0780
	(0.2406)	(0.2383)	(0.0878)	(0.2400)	(0.2375)	(0.0896)
Adjusted R-squared	0.0005	0.0033	0.1907	0.0003	0.0033	0.1923
Observations	4,910	4,910	90	4,910	4,910	90
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table shows the results from OLS regression of the number of granted patents (#P, Columns 1 and 4), the number of forward citations (#FC, Columns 2 and 5) or the ESMR value of granted patents (#MV, Columns 3 and 6) on the female share of the boards of directors (Columns 1-3) or the female share in senior management (Columns 4-6). Control variables include 1-digit industry fixed effects. The data is from *Long Panel*. Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5.3 Event-study design: female leadership appointments

Finally, to examine the timing of innovation responses to changes in firm female leadership composition, we implement an event - study design around the first entry of women into senior leadership among the sampled firms. The panel is at the firm - year level. We focus on two event definitions: (i) the first year a firm moves from having no women on the board to having a positive share of women on the board, and (ii) the first year a firm moves from having no women in senior management to having a positive share of women in senior management. We concentrate on the first female leadership appointment because it represents a clear and discrete shift from zero to positive female representation, whereas subsequent appointments reflect more gradual changes in composition and often occur in closer succession, making dynamic effects harder to interpret.

Let i index firms and t index years. For a given leadership margin $\ell \in \{\text{bod}, \text{sen}\}$, denote the treatment indicator as

$$D_{it}^{\ell} \equiv 1\{\textit{female\_}\ell_{it} > 0\}, \tag{5}$$

where $\ell = \text{bod}$ refers to board membership and $\ell = \text{sen}$ to senior management. The corresponding event year (cohort) is defined as the first year in which the firm becomes treated,

$$G_i^{\ell} \equiv \min\{t : D_{it}^{\ell} = 1\}, \tag{6}$$

with G_i^{ℓ} undefined for never-treated firms. Relative event time is defined as $k = t - G_i^{\ell}$. For each event type, we construct event-time indicators over a window of five years before and seven years after the event, omitting the year immediately preceding the appointment ($k = -1$) as the reference period. Never-treated firms serve as the comparison group.

For each outcome y_{it} and each leadership margin ℓ, we estimate the following dynamic specification:

$$y_{it} = \alpha_i + \lambda_t + \sum_{\substack{k=-5 \\ k \neq -1}}^{7} \beta_k^{\ell} \cdot 1\{t - G_i^{\ell} = k\} + \varepsilon_{it}, \tag{7}$$

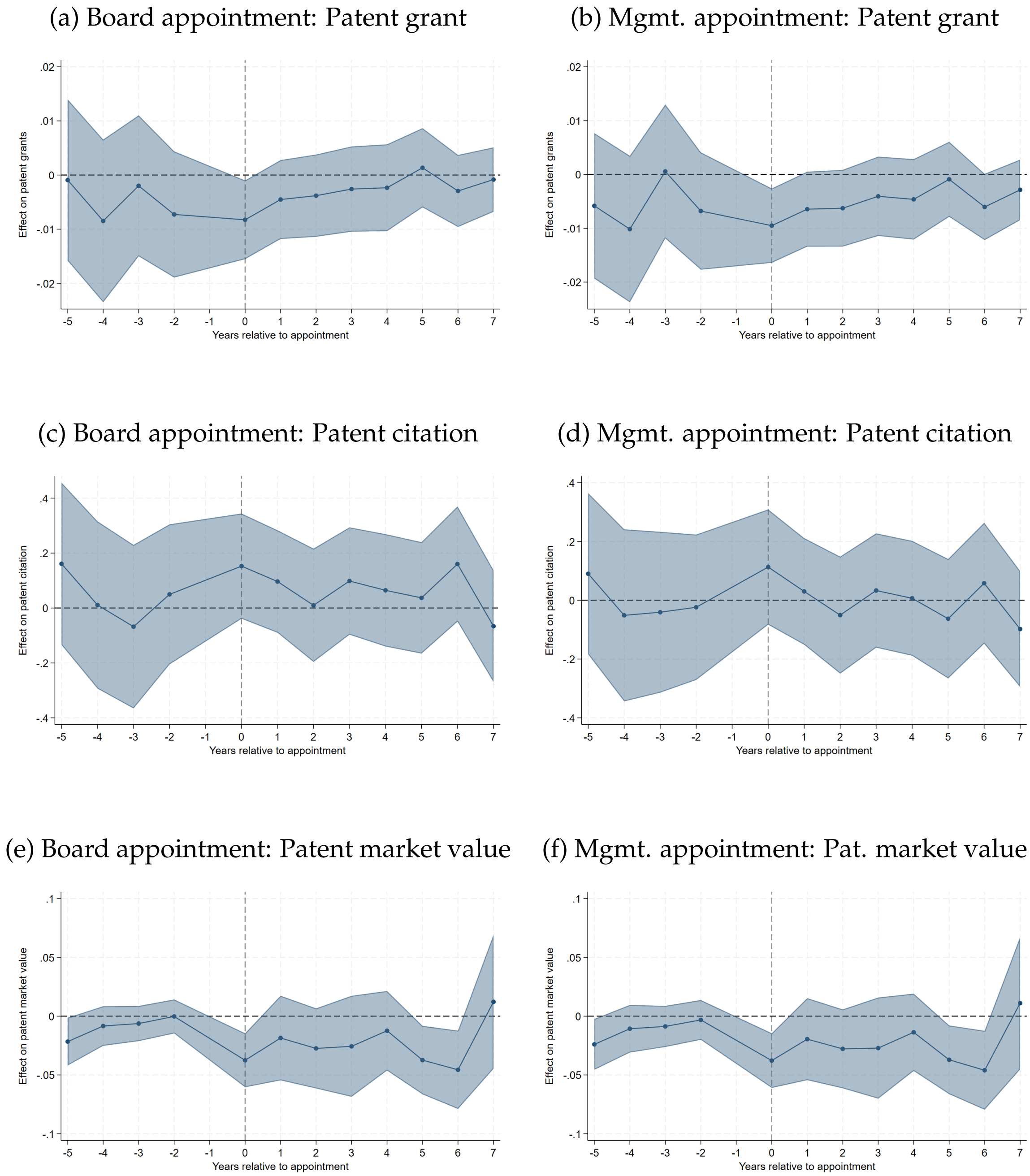
where α_i are firm fixed effects and λ_t are year fixed effects. The coefficients $\{\beta_k^{\ell}\}$ trace the evolution of innovation outcomes in event time relative to the year before the leadership appointment. Coefficients for $k < 0$ provide a diagnostic for differential pre-trends, while coefficients for $k \geq 0$ capture post-appointment dynamics. The specification captures reduced-form responses to leadership transition events – the entry of women into top positions, which may coincide with broader changes in governance, management practices, or organizational composition within firms.

Because firms adopt female leadership at different points in time and treatment effects may vary across cohorts, we estimate equation (7) using the interaction-weighted event-study estimator of Sun and Abraham (2021). This approach is designed for staggered adoption settings and yields event-time estimates that remain interpretable under heterogeneous treatment timing. Standard errors are clustered at the firm level, and never-treated firms form the control cohort.

Figure 4 presents the event-study estimates for innovation outcomes around female leadership appointments, separately for board and senior management transitions. Across all specifications and outcome measures, the estimated coefficients are close to zero and statistically indistinguishable from zero at conventional levels throughout the event window. In particular, the pre-event coefficients are small and display no systematic pattern, providing no evidence of differential pre-trends in innovation prior to female leadership entry. Likewise, we find no discernible changes in patent grants, patent citations, or patent-based market value following the appointment of women to boards or senior management.

Together, these dynamic findings are in line with the previous regressions - increasing gender diversity in corporate leadership does not come at the cost of reduced innovation, nor does it generate systematic innovation gains on average. Once firm-specific factors and time trends are accounted for, female leadership appears to have neither a large negative nor positive effect on innovation.

Figure 4. Event-study effects of female leadership appointments on firm innovation



Notes: The figure reports interaction weighted event-study estimates around the first appointment of a female leader ($k = 0$) across UK companies from 1996 to 2017, on innovation measures proxied by granted patents, patent citation, and patent market value. The event studies are plotted separately for board of directors in the left column, and senior management (Mgmt.) transitions in the right column. The omitted category is $k = -1$. All specifications include firm and year fixed effects; standard errors are clustered at the firm level. Shaded areas indicate 95% confidence intervals.

6 Conclusion

This paper explores how gender disparities within firms—both in pay and in leadership representation—relate to innovation, using detailed panel data on UK companies from 1996 to 2019. We contribute to the literature by combining a short panel capturing detailed workforce composition and pay gaps with a long panel focusing on female representation in top management and patenting outcomes over more than two decades. Our identification combines within-industry and within-firm variation with an instrumental variable strategy that exploits the local supply of women in associate professional and technical occupations.

Our findings are threefold. First, gender pay gaps are negatively associated with firm innovation. Firms with larger pay disparities between men and women produce fewer patents and receive fewer citations, suggesting that discriminatory pay practices may impair innovative capacity. This effect remains robust after controlling for firm size, capital intensity, skill levels, industry-specific factors, and firm fixed effects. The IV estimates broadly confirm this pattern, although they are less precise.

Second, the link between female representation and innovation is more complex. Female presence in the top wage quartile of the workforce is positively associated with innovation outcomes, while higher female representation in lower pay grades (but holding the share of women at the top fixed) seems to have a negative impact on patenting. The IV estimates indicate that part of this effect operates through the extensive margin—the decision to patent at all—since the coefficient becomes more modest once the sample is restricted to firms already active in patenting. These patterns emphasise the importance of equal gender representation at the upper echelons. Simply increasing the number of women in the company, without changing the composition of management, could potentially hinder company performance.

Third, our longitudinal analysis indicates that female leadership, as measured by board and senior management representation, has at most a weak and statistically insignificant impact on innovation once firm-level characteristics and unobserved heterogeneity are taken into account. Long-difference estimates over 2000–2015 confirm this picture: changes in female leadership are uncorrelated with changes in patent grants, citations, or patent market value. An event-study around the first appointment of a woman to the board or to senior management points to the same conclusion, with no evidence of differential pre-trends and no discernible response of innovation outcomes after the transition. This implies that worries about a potential innovation penalty from gender quotas or diversity mandates in leadership are largely unfounded.

Taken together, these results show that while increasing female representation at the top does not reduce innovation, ongoing gender pay gaps may hinder firms' ability to innovate. Policies aimed at promoting gender equality, especially those focusing on pay transparency and access to leadership, are unlikely to harm innovation and could potentially improve it. By tackling structural inequalities, firms may unlock untapped innovative potential within their workforce.

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During the preparation of this work the author(s) used Grammarly and Claude in order to proof-read the paper. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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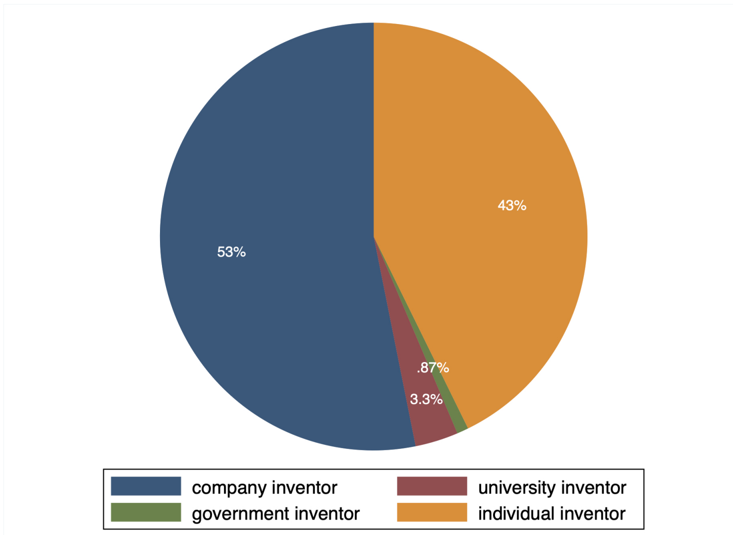
_ **and** _ , "Star Scientists, Innovation and Regional and National Immigration," NBER Working Paper 13547, National Bureau of Economic Research 2007.

Appendix

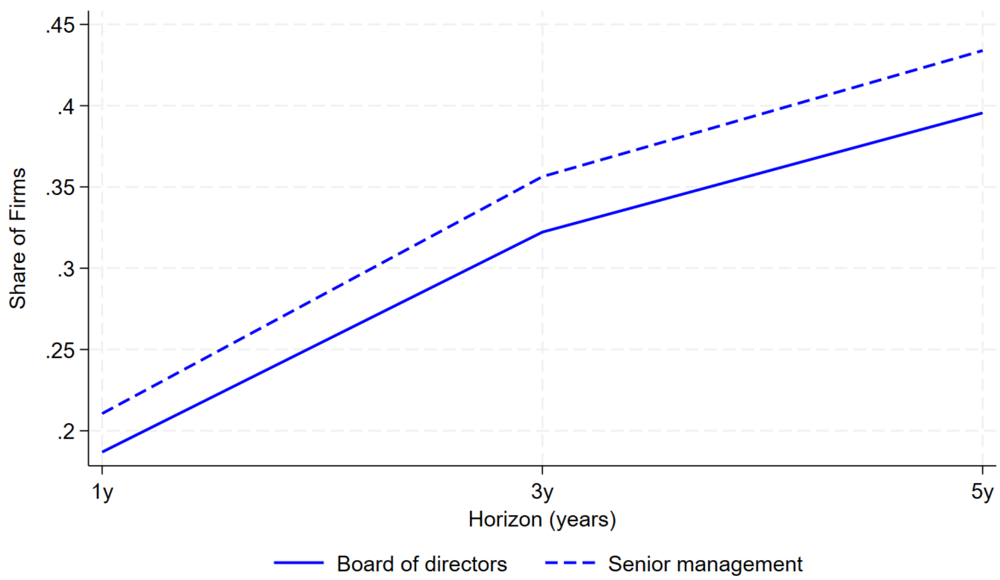
A Appendix Figures

Figure A.1. The Composition of the Major Patent Inventors in the UK, 1996 - 2020



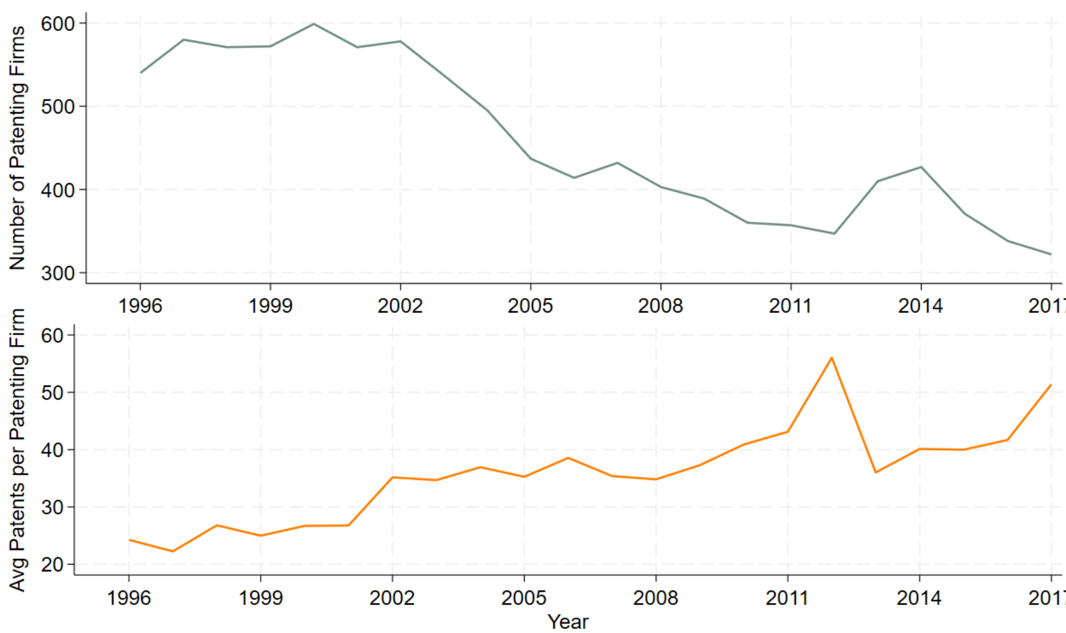
Source: PATSTAT data.

Figure A.2. The Share of UK Firms Changing Female Leadership, 1996 - 2017



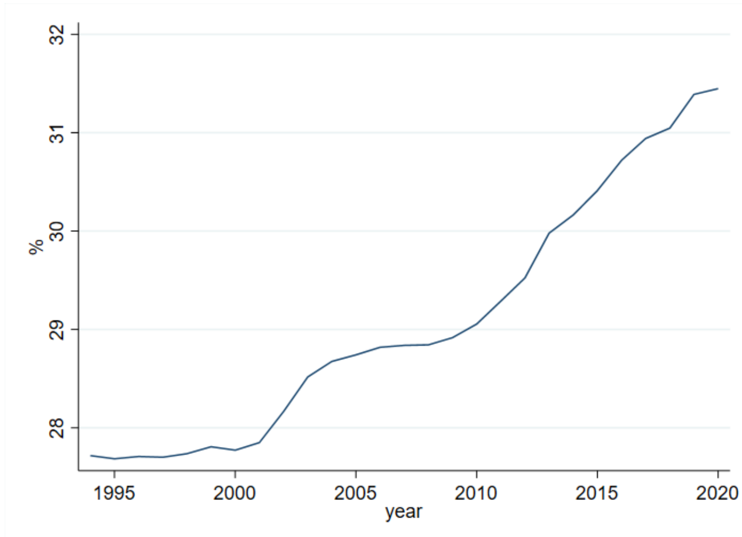
Notes: The figure presents the share of UK firms changing female leadership composition in Board of Directors and Senior Management after 1 year, 3 years, and 5 years.

Figure A.3. Patenting Firms and Average Number of Patents, 1996-2017



Notes: The figure presents the year-firm observations described in the *Long Panel*, from 1996 to 2017, for firms that had at least 1 patent application.

Figure A.4. The Share of Female Board Members in BvD Historical Orbis, UK 1994-2020



B Appendix Tables

Table B.1. First-stage regressions

	Top quartile	Pay Gap	Top quartile	Pay Gap
Instrument: female share (SOC3)	0.250***	-0.334***	0.413***	-0.271
	(0.087)	(0.116)	(0.117)	(0.201)
Female share (in %)	0.847***	0.209***	0.780***	0.209***
	(0.017)	(0.018)	(0.023)	(0.042)
Log value added per worker (in th £2021)	-0.278	0.003	-0.247	0.194
	(0.215)	(0.388)	(0.379)	(0.610)
Log net tangible assets per worker (in th £2021)	-0.083	-0.052	-0.034	0.046
	(0.075)	(0.138)	(0.150)	(0.274)
Log average firm wage (in th £2021)	-3.236***	10.274***	-1.947***	4.805***
	(0.296)	(0.748)	(0.419)	(0.864)
Log employment	-0.300**	0.026	0.340	-0.444
	(0.149)	(0.179)	(0.345)	(0.347)
TTWA female share in higher edu. (2011)	-0.064	0.091	-0.020	0.063
	(0.106)	(0.181)	(0.232)	(0.372)
Observations	4,581	4,581	631	631
Kleibergen-Paap rk Wald F	8.08	7.74	13.28	1.77
Sample	All	All	Patenting	Patenting

Notes: First-stage OLS regressions from with standard errors clustered at the TTWA level The instrument is the TTWA-level share of females in SOC3 occupation group from the 2011 census. *** p<0.01, ** p<0.05, * p<0.1.

Table B.2. Female representation at the top and innovation outcomes, Cross-Section, Patenting Firms, Average 2017-2019

	Patent families (headcount)				Forward citations (headcount)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female share, top quart. (in %)	-0.005	0.062***	0.039**	0.094	-0.040***	0.090**	0.072***	-0.018
	(0.007)	(0.022)	(0.017)	(0.086)	(0.007)	(0.037)	(0.025)	(0.206)
Female share (in %)		-0.078***	-0.046***	-0.082		-0.151***	-0.128***	-0.010
		(0.023)	(0.017)	(0.066)		(0.039)	(0.024)	(0.159)
Log value added per worker (in th £2021)		0.481	0.316	0.251**		-0.927*	-0.720**	0.459**
		(0.311)	(0.242)	(0.107)		(0.496)	(0.342)	(0.223)
Log net tangible assets per worker (in th £2021)		0.121	0.256	0.104		0.218***	0.422***	0.265***
		(0.114)	(0.166)	(0.074)		(0.059)	(0.105)	(0.066)
Log average firm wage (in th £2021)		0.528	0.562**	0.897***		2.270**	1.769***	1.696***
		(0.394)	(0.223)	(0.226)		(0.886)	(0.457)	(0.617)
Log employment		0.739***	0.869***	0.532***		0.881***	0.938***	0.714***
		(0.043)	(0.062)	(0.083)		(0.046)	(0.072)	(0.114)
TTWA female share in higher edu. (2011)		-0.130	-0.048	-0.035		-0.110	-0.005	-0.184
		(0.118)	(0.107)	(0.047)		(0.197)	(0.166)	(0.165)
Observations	669	631	631	631	669	631	631	631
Industry FE	No	No	Yes	Yes	No	No	Yes	Yes
Estimator	Poisson	Poisson	Poisson	IV	Poisson	Poisson	Poisson	IV

Notes: Poisson and IV Poisson (control-function) estimates on the sample of patenting firms. Industry fixed effects are NACE Rev.2 1-digit (when included). In the IV specification for patent families, the endogenous regressor is the female share in the top quartile of the within-firm wage distribution instrumented by gender ratio (SOC3). The data is from *Short Panel* and the variables are aggregated at the firm level over the 2017-2019 period. Standard errors clustered at TTWA. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table B.3. Gender pay gap and innovation outcomes, Cross-Section, Patenting Firms Average 2017-2019

	Patent families (headcount)			Forward citations (headcount)		
	(1)	(2)	(3)	(4)	(5)	(6)
Gender mean pay gap (in %)	-0.011*	-0.022**	-0.013*	-0.044***	-0.028*	-0.025**
	(0.006)	(0.009)	(0.008)	(0.016)	(0.015)	(0.011)
Female share (in %)		-0.024**	-0.011		-0.078***	-0.067***
		(0.011)	(0.008)		(0.017)	(0.017)
Log value added per worker (in th £2021)		0.464	0.296		-1.002*	-0.753**
		(0.328)	(0.258)		(0.555)	(0.350)
Log net tangible assets per worker (in th £2021)		0.118	0.263		0.220***	0.432***
		(0.115)	(0.172)		(0.056)	(0.109)
Log average firm wage (in th £2021)		0.488	0.534**		2.301**	1.771***
		(0.389)	(0.223)		(0.955)	(0.486)
Log employment		0.728***	0.877***		0.876***	0.943***
		(0.044)	(0.062)		(0.050)	(0.075)
TTWA female share in higher edu. (2011)		-0.118	-0.036		-0.090	0.018
		(0.120)	(0.108)		(0.191)	(0.164)
Observations	669	631	631	669	631	631
Industry FE	No	No	Yes	No	No	Yes
Estimator	Poisson	Poisson	Poisson	Poisson	Poisson	Poisson

Notes: Poisson estimates on the sample of patenting firms. Industry fixed effects are NACE Rev.2 1-digit (when included). The data is from *Short Panel* and the variables are aggregated at the firm level over the 2017-2019 period. Standard errors clustered at TTWA. *** p<0.01, ** p<0.05, * p<0.1

Table B.4. Female Representation at the Top and Patenting, the *Long Panel*, 1996 - 2017

VARIABLES	(1) #P	(2) #P	(3) #P	(4) #P	(5) #FC	(6) #FC	(7) #FC	(8) #FC	(9) #MV	(10) #MV	(11) #MV	(12) #MV
Female Board Representation (in%)	0.0203***	0.0090***	0.0067	-0.4487	0.0222***	0.0120***	0.0085**	-0.0634	0.2600***	0.1373***	0.0879*	0.0114
	(0.0062)	(0.0103)	(0.0133)	(0.8070)	(0.0058)	(0.0110)	(0.0122)	(0.9473)	(0.0418)	(0.0382)	(0.0465)	(0.0199)
Share of Female Senior Managers (in%)	-0.0396***	-0.0208	-0.0131*	0.4624	-0.0449***	-0.0264	-0.0161	0.0830	-0.2503***	-0.1867***	-0.1059*	-0.1239
	(0.0068)	(0.0081)	(0.0073)	(0.5333)	(0.0076)	(0.0109)	(0.0093)	(0.8489)	(0.0423)	(0.0523)	(0.0602)	(0.0166)
Ln VA per worker (in th £2021)		0.2687***	0.2784***	-0.2943		0.1488	0.2465***	1.4785		1.1623***	0.4606**	0.0106
		(0.0941)	(0.0916)	(1.7460)		(0.1170)	(0.0881)	(2.2780)		(0.2385)	(0.2185)	(0.0649)
Ln average firm wage (in th £2021)		1.2573***	0.9338***	16.8558		1.5575***	1.1601***	19.2662		0.0458	-0.4600	-0.2638
		(0.2323)	(0.3273)	(14.8216)		(0.2635)	(0.2736)	(25.1244)		(0.3868)	(0.4625)	(0.2536)
Ln employment (in th £2021)		0.7632***	0.7688***	13.7676		0.8172***	0.8277***	5.5646		1.1795***	1.1075***	0.1126
		(0.7632)	(0.0632)	(6.2742)		(0.0827)	(0.0830)	(8.8602)		(0.1337)	(0.1477)	(0.0861)
Observations	235,653	235,653	235,653	3,609	235,653	235,653	235,653	3,609	4,056	3,831	3,831	3,831
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No
Firm FE	No	No	No	Yes	No	No	No	Yes	No	No	Yes	No

Notes: The table shows the results from PPML fixed effect regression of the number of granted patents (#P, Columns 1-4), the number of forward citations (#FC, Columns 5-8) or the ESMR value of granted patents (#MV, Columns 9-12) on the female share of directors' boards and of the senior management. Control variables include 1-digit industry (Columns 3,7,11) and firm (Columns 4,8,12) fixed effects. The data is from *Long Panel*. Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1