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Impact of women on corporate boards of directors on product quality

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Abstract

We analyze the impact of women on corporate boards of directors on product quality. We innovate firstly by integrating the broad but fragmented research on the topic, offering a first simultaneously testing of a larger set of variables identified to be significant in earlier studies. Second, we add alternative indicators of female representation in board of directors as a potential determinant of product quality. Third, we use evaluation scores of goods by the nonprofit foundation “Stiftung Warentest” as a quality indicator, thus adding to a regionally diversified evidence. We find a significant positive effect of female board directors on product quality.

Keywords Gender equality · Women ratio · Women on boards of directors · Product quality · Product reliability · Consumer reports

JEL Classification C30 · L21 · L25 · C13 · J16

1 Introduction

Around the world, policymakers, legislators, large institutional investors, and certain stock exchanges have called to diversify boards of directors to increase board independence. Having women on boards sends a positive signal to both internal and external constituents, regarding whether man and women in a firm have similar educational backgrounds and the overall labor market in a particular economy is balanced (Dunn, 2012; Terjesen et al., 2016).

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On average, women constituted 30% of corporate boards of directors in Europe's largest publicly listed companies in 2020 (Gender Statistics Database, 2021), with the highest representation in France (45.1%), Iceland (44.4%), and Norway (40.4%), but other European countries lagged in this regard (e.g., Estonia, 8.8%). Although the female share of boards within European companies has almost tripled since 2010, it remains distant from the European Commission's recommendation of 40% (Jourova, 2016). The global picture is similar, with females holding only 26.2% of corporate directorships among the Morgan Stanley Capital International World Index companies in 2020, and a declining growth rate in female board positions (Emelianova, 2020). Rohner and Dougan (2012) report that more than 15% of publicly listed companies in the US and Europe still did not have even one female board member appointed, with the gender gap particularly visible in IT, industrial goods, materials, and telecom sectors. The authors find an underrepresentation of women in consumer-related sectors in the European markets and for large-cap stocks. Adams and Kirchmaier (2016) confirm that women are underrepresented in science and engineering professions as well as all academic levels in academia. According to Hillman et al. (2007), only large firms are more inclined to employ a more gender-balanced directors' cadre to strive for more legitimacy in the corporate hierarchy, as structural barriers still exist for female board candidates, and the actual circumstances are determined by individual firm and industry specific characteristics (Brieger et al., 2019). Young female human capital has overtaken young men in many countries in enrollment and exam passes at schools and universities, but women do not appear to succeed in corporate governance for complex reasons (Walby, 2011). Higher academic achievements are often required for female nominees to be considered for a board nomination. Women also feel that they are more frequently discouraged from aspiring to high-profile positions due to modest self-image, discriminating stereotypes, or lack of networking opportunities among the higher echelons of corporate power. Furthermore, firm size and masculine corporate culture may impede women's election to governance bodies. In contrast, opportunities for female directors are higher in public and nonprofit enterprises. Greater economic and political empowerment accompanied by countries' shared cultural values, beliefs, and attitudes has successively helped women overcome the "glass ceiling" of corporate elites (Lewellyn & Muller-Kahle, 2020). However, corporate boardrooms' gender democratization proceeds slowly, with the first wave of feminization based on political background, the second facilitated by female board candidates' academic achievements, and the third attributed to exceptional and company-grown female talent (Heemskerk & Fennema, 2014).

Sabatier (2015) confirms that existing quotas have prompted French companies to engage more female directors, which positively impacted companies' performance, while Comi et al. (2020) elicit mixed results, finding positive effects only on firm labor productivity in Italy, negative effects in France, and an insignificant impact on the profitability of Spanish companies. The Norwegian board of directors' quota reform of 2003 only applied to publicly listed companies in Norway, which to a larger extent accumulated capital that was financed by debt or a combination of debt and existing capital. The short-run impact of the reform on company performance measured by a return on assets was negligible (Dale-Olsen et al., 2013). Yang et al.

(2019a, b) determine that the Norwegian quota adversely affects treated firms' performance and reduces risk.

Researchers continue to investigate the business case for a higher proportion of female directors on boards, predominantly focusing on financial (e.g., firms' profitability, market returns, stock prices, liquidity, enterprise value, profits dividends, and risk) or organizational effects (e.g., corporate innovativeness, entrepreneurship, relationships with stakeholders, organizational and team performance, or inter-departmental dynamics and transparency). The scientific evidence for these associations is mixed, as board diversity can become "a double-edged sword," including a "value-in-diversity" proposition and counterarguments; for instance, regarding social categorization processes that lead to in-group favoritism and out-group discrimination and subsequent team fragmentation and negative behavioral dynamics or group outcomes (Kaczmarek & Nyuur, 2021). Numerous scholars have provided empirical evidence that differences in boards or firms with enhanced female participation may lead to differences in key company figures. Companies with more diversified boards may achieve increased patent activities (Griffin et al., 2021), improved stock liquidity (Ammad & Searat, 2017), better accounting performance (Dang & Nguyen, 2016; Lückerath-Rovers, 2013; Post & Byron, 2015), higher market valuation (Ntim, 2015), larger returns (Duppatti et al., 2020; Johnstone-Louis, 2017; Kang et al., 2010), higher share price and earnings per share (van Dunk et al., 2005), a larger price/book value, and a larger average growth (Rohner & Dougan, 2012), particularly firms with a higher market value, as expressed by superior Tobin's Q performance (Conyon & He, 2017). Rossi et al. (2018) determine that more women on boards of directors increase companies' indebtedness level, but invested capital is used more efficiently.

However, the positive impact of female directors could also depend on external circumstances. Dezső and Ross (2012) suggest that women in executive management improve company performance only if female representation is moderated by high innovation intensity, measured as the ratio of research and development (R&D) expenses to assets from the prior year. Sarhan et al. (2019) determine that the positive impact of diversity on firms' financial performance is stronger in companies that are better governed and can enhance the pay-for-performance sensitivity. Hsu et al. (2019) used a composite diversity index, including board members' gender, age, tenure, and professional background, demonstrating that boardroom diversity positively affects operating performance, however firms with larger strategic change tend to present a negative correlation between boardroom diversity and operating performance. The probability of women on a board increases with firm performance, defined as return on assets and family ownership, but diminishes with corporate ownership and firm risk (Martin-Ugedo & Minguez-Vera, 2014). Farrell and Hersch (2005) find that the likelihood of electing a woman to a corporate board negatively depends on the number of females appointed in the past, suggesting that firms may add female directors only as a defensive reaction to outside pressure and scarce female top performers could proactively prefer stronger and better-positioned companies. Turban et al. (2019) rule out this reverse causality, confirming the positive effect of gender diversity (measured using Blau's index) on firms' market valuation (e.g., Tobin's Q or turnover ratio), but only in national contexts where gender

diversity is normatively accepted and not in economies where it is regulated (e.g., Western Europe vs. Japan).

Positive evaluations of the greater participation of women on business performance are not without opposition. Other scholars do not find significant effects; for example, on returns (Francoeur et al., 2008; Ramadhanian et al., 2021), Tobin's Q (Rose, 2007), IPO pricing (Mohan & Chen, 2004), or dividend payouts (Arora, 2021; Pucheta-Martinez & Bel-Oms, 2016). Some even reveal negative effects of female directors; for example, on companies' share price (Ryan & Haslan, 2005), profitability (Shrader, 1997), or firm performance (Dang & Nguyen, 2016; Triana et al., 2013). Ferreira (2015) criticizes research that seeks to prove the positive effects of female directors on firms' profitability, encouraging focus on female directors' potential benefits to society.

Since no consensus has emerged regarding the favorable effect of females on boards of directors, this study seeks to make four primary contributions to this controversial topic. First, our study complements the existing spectrum of academic research demonstrating the positive effects of boardroom diversity. We analyze the effect of increased female representation on boards of directors on product quality (PQ),¹ which we consider to be a socially responsible measure of corporate success and an aspect of sustainable economic development, which is contemporarily deserving of more attention. We examine whether companies with a higher proportion of female directors produce higher quality goods than competitors that are governed by fewer women in boardrooms. Second, we review the relevant literature and methodologies applied to examine the effects of increased female participation in corporate governance. Third, we systematically extend the literature on Product Quality (PQ) in the light of our research. Our study enhances the partially fragmented research on the determinants of PQ (as described in the next section) by conducting the first simultaneous test of a larger set of variables identified to be significant in earlier studies. Finally, we add to research in the economics and management literature regarding the potential effects of gender diversity in leading positions in business enterprises.

2 Background

High PQ is an instrumental component of sustainable corporate policies, as increased quality standards indicate corporations' high social responsibility, which is a crucial management strategy (Kytle & Ruggie, 2005). Moreover, contemporary firms are expected to manage non-economic business results and fulfill social and ecological responsibilities to stakeholders and clients. Effective corporate social responsibility (CSR) is a tool for successful firm and product differentiation, since internal and external CSR can enhance products' quality (Calveras & Ganuza, 2016). Social role theory considers women to be more moral, diligent, compassionate, inclusive, and

¹ For summaries of the evolution of the definition of PQ, see (Reeves & Bednar, 1994) & Golder, Mitra, & Moorman (2012).

stakeholder oriented. The proportion of females on boards of directors is positively proportional to their influence on CSR decisions (Elstad & Ladegard, 2012). The more highly educated a female senior manager, the more sensitive she is in terms of the quality and commitment of the environment, and the more attention she pays to the community (Yang et al., 2019a, b). A larger proportion of women and female labor representatives at the board level are positively related to CSR and environmental performance (Lopatta et al., 2020), which may subsequently favorably affect PQ.

PQ is also a key consumer decision criterion and has long been a “strategic weapon” in management practice (Garvin, 2001) that can impact several company performance indicators, such as outgoing defect rates and on-time delivery rates (Nagar & Rajan, 2001). Phillips et al. (1983) demonstrate that PQ also has a significant positive influence on return on investment (ROI), particularly for enterprises operating consumer goods non-durables, capital goods, and components businesses. Jacobson & Aacker (1987) observe a highly significant association between quality and product price (for four of six defined business segments), suggesting that buyers are inclined to reward premium goods with higher prices in these markets. Lakhali & Pasin (2008) summarize the literature finding a positive impact of PQ on financial performance, although they do not find a direct significant association linking PQ and financials for a sample of 133 Tunisian companies. Nevertheless, they detect a favorable correlation between PQ and customer satisfaction and internal processes. Table 1 presents the major determinants of PQ studied empirically. For a summary on the evolution of the definition of PQ, see Reeves and Bednar (1994), Golder et al. (2012), and Suchanek et al. (2014).

3 Theoretical framework

Despite substantial empirical literature devoted to the matter, the impact of boardroom diversity on firm performance is not a unanimously held business case. Note that diverging empirical results find their counterparts in diverging theoretical considerations. Three key theories support the positive aspects of greater gender meritocracy on corporate boards, including agency, resource dependence, and stakeholder theories (Ntim, 2015), whereas social identity theory emphasizes a more critical approach (Luis-Carnicer et al., 2008).

Agency theory implies that female directors can more effectively resolve agency problems between shareholders and company managers. Female directors are particularly valued for ex-ante (visionary) strategic company control related to long-term strategy and monitoring of the environment (e.g., benchmarking qualitative indices). They may apply a higher sensitivity to internal compliance policies or acts of discrimination and are considered as more independent board members.

The resource-based perspective argues that firms can develop a competitive advantage by employing a complementary pool of female talent, skills, capabilities, and networks. Corporate boards maintain essential links between companies and their environment. A firm’s effective linkage to its ecosystem, provides an organization with useful information, maintains a channel for communication purposes, is

Table 1 Literature review of the determinants of product quality

Independent variables tested																				
No	Authors (Year)	Research period	Research method	Industry sample	Dependent variable	Advertising spend	Sales, General and Admin (SG&A)	% of sales on new prod- ucts	Return on Invest- ment	Rela- tive price (t-1)	Relative quality (t-1)	Cost of Goods Sold (COGS)	Mar- ket share	Com- pany brand	Co- man- age- ment	Firm size	Down- sizing	Capital expen- diture	Unions	Market Fixed size cost indus- try
1	Phillips et al. (1983)	1974– 1975; 1980– 1981	OLS	Consumer durables	Relative product quality (t)	(+)** (-)	(+)** (-)	(+)** (-)	(+)** (-)											
				Consumer non-dura- bles																
2	Jacobson & Aker (1987)	1970– 1983	Vector autore- gression models	Consumer durables	Relative product quality (t)			(+)	(+)	(+)**	(+)	(-)								
				Consumer non-dura- bles				(-)**	(+)	(+)**	(-)	(-)								
3	Erden & Swait (1998)	Pre 1998	General- ized Least Squares	Consumer non-dura- bles	Perceived quality								(+)**							
4	Cooke, W.N (2010)	1981– 1987	Ordered probit estimates	Industrial goods	Perceived extent of change in product quality									(+)**	(-)**	(-)**	(-)**	(+)	(+)	
5	Berry & Waldfogel (2010)	2009	OLS, Tobits	Newspapers restaurants	Product quality															(+)** (+)**

***p < 0.01; **p < 0.05; *p < 0.1

an important step in obtaining commitments of support from important elements of the environment, and helps legitimize organizations (Lückerath-Rovers, 2013). The increased presence of high-profile women in corporate governance could enhance the level of quality assurance, as they may be more responsive to sustainable market trends and technologies. Female leaders can passionately contribute cutting-edge managerial, engineering, and product development skills. They may also be more motivated and determined than their male counterparts to organize and manage publicly transparent internal sustainability and quality reporting, and more proactively network across and beyond corporate hierarchies to anticipate, detect, and navigate quality issues within organization (e.g., product recalls, warranty policy, and customer service).

Stakeholder theory indicates that heterogeneous boards may be more creative, although it may take longer to negotiate and achieve consensus. By recruiting female directors, firms can benefit from links with stakeholders, particularly when determining business purpose and customer orientation, which can become major aspects of the superior PQ of delivered goods. Adams and Ferreira (2004, p. 14) suggest that gender diversity on boards may also have a political dimension, as “companies may care more about diversity when they are concerned about their public image.”

In contrast, Luis-Carnicer et al. (2008, p. 588) examine social identity theory in context, revealing “demographic dissimilarity and these outcomes may vary among negative, neutral and even positive, depending on the extent to which employees’ social identities are built among their demographic characteristics” (Chattopadhyay et al., 2004). Tsui et al. (1992) demonstrate that greater cohesion in homogenous groups results from easier communication and low relational conflict, while higher gender diversity leads to more absences and less organizational commitment for men and more organizational commitment for women (with no effect on absences). These considerations imply that the impact of female directors may depend on the settings and general conditions in the relevant societies and firms. Board gender diversity may primarily affect firm performance positively in countries with high national governance quality (Nguyen et al., 2021), in national contexts where gender diversity is normatively accepted (Turban et al., 2019), and in firms with a high rate of innovation (Dezsö & Ross, 2012). According to social identity theory, male and female management styles differ as well. Women and men in the same organizational roles may behave somewhat differently (Eagly & Johanessen-Schmidt, 2001) and women may be more effective in performing certain tasks over others (Eagly et al., 1995). Although social scientists and organizational scholars argue that gender differences in managerial positions are minimal, they can become impactful when applied in a long-term repetitive mode (Martel et al., 1996). These arguments suggest that gender differences in approach and management of PQ on a strategic company level may result in different PQ outcomes over time.

While diversity fosters change and evolution, the aggregate results of contemporary research in this topic remain inconclusive regarding whether it hinders or improves organizational performance. Fulton (2021) asserts that while social bridging theories argue in favor of diverse organizations, social bonding theories argue against it. The author’s study specifies these concepts as two distinct mechanisms, indicating that both can positively impact organizations, but their respective benefits

depend on the task being performed. The study demonstrates that social diversity facilitates performance related to accessing external resources and social interaction facilitates performance related to internal coordination.

4 Literature review and hypothesis development

Koutoupis et al. (2022) systematically scrutinize 140 board diversity studies published from 2015 to 2021, determining that this topic has primarily been empirically investigated in developed countries. The research analyzed predominantly concentrates on the effect of board diversity on firms' (financial and sustainability) performance; however, no conclusive results have emerged regarding the extent to which diversity facilitates firms' operations. Nguyen et al. (2020) conducted a comprehensive systematic literature review of the existing research on women on corporate boards and financial and non-financial performance, reviewing 634 mixed, qualitative, quantitative, and theoretical studies conducted in over 100 countries from more than 10 disciplines (e.g., accounting, finance, economics, and governance) from 1981 to 2019 and published in 270 top-ranked journals. The authors find that many existing studies are descriptive and/or draw on single rather than multi-theoretical perspectives and focus on firm-level rather than country-level effects. The observable methodological limitations include a dearth of qualitative, mixed-methods, and cross-cultural/country studies. The study concludes by outlining opportunities for future research regarding women on boards of directors.

The upper echelons theory stipulates that senior management's quality and traits are reflected in organizations and systematically cascade down the hierarchical ladder to achieve strategic importance (Finkelstein et al., 2008; Hambrick & Mason, 1984; Pfeffer, 1983). The ratio of female directors represents a certain tendency of team (board) composition; hence, gender diversity can be a predictor of board level processes and effectiveness. Amin et al. (2021) indicate that female board presence significantly reduces agency costs (defined as the sum of monitoring expenditures by the principal, bonding expenditures by the agent, and residual losses), hence reduces the principal-agent conflict, particularly when a critical mass of women is achieved. Demographically balanced boards may tend to pursue long-term policies focused on high quality assurance, as female directors holding monitoring roles can mitigate managerial opportunism focused on earnings (Saona et al., 2019). Gyapong et al. (2019) reveal that gender mixed boards may alleviate principal-agent conflicts around the dividend payout in hard times for a company (e.g., during an economic crisis), although they generally favorably affect dividend payouts, particularly when female directors have a critical mass; however, when ownership concentration is high, board gender diversity reduces dividend payments. Corporate funds not spent on dividends could be theoretically invested in advancing a sustainable product portfolio of superior quality. Female directors with financial backgrounds improve earning's quality more than their female counterparts without relevant financial expertise (Zalata et al., 2021).

We assume that female directors are more effective as PQ agents for companies, staying more vigilant to customer feedback and corporate risks. Oliver (1996)

notes that while men tend to measure performance quantitatively in financial terms, women do not hesitate to use either customer service ratings or diverse satisfaction scores. Female directors report higher concerns regarding product risk, supply chain, and reputational issues (Groysberg et al., 2016), mitigate such issues more decisively, and may have less tolerance for ethical lapses (Eagly et al., 2004; Franke et al., 1997; Lunsford, 2000; McCarthy, 2017), which can prevent ambiguous PQ and sustainability hazards. Female directors may monitor internal quality control mechanisms more diligently. They may be more inclined to promote targeted internal quality guidelines and sustainable corporate policies (e.g., product recycling, six sigma programs, and ecologically friendly supply chains). Furthermore, female directors could generally limit firms' risk performance,² measured by the volatility of equity returns (Zalata et al., 2019 and Yang et al., 2019a, b). Shahab et al. (2020) confirm that CEO's power to increase the likelihood of stock price crash risk is significantly mitigated when a company's proportion of female directors is high. Adhikari et al. (2019) determine that female executives have more power to avoid lawsuits, partially by avoiding risky but value-increasing firm policies, such as more aggressive R&D, intensive advertising, and policies inimical to other parties.

Since organizations depend on external resources to survive (Pfeffer & Salancik, 1978), increased female board representation can significantly extend the number of relationships and resources available to a corporation. Because of this, and beyond any soft skills, female directors may be expected to bring a high level of competence to the table (Pesonen et al., 2009, Freeman and Varey, 1997), and new female directors contribute more additional expertise in boardrooms than newly selected male counterparts, on average (Kim & Starks, 2016), frequently advancing capacities for professional achievement (Pace, 2009). Nielsen and Huse (2010, p. 16–17) propose “that it is not the gender per se, but the different values and professional experiences that women may possess that enable them to make a difference to actual board work and influence board decision-making.” The authors conclude that a female board member equivalent with similar (board relevant) professional experiences and different values can enhance board decision-making. The apparent higher quality of female corporate governors may positively affect quality strategy and management of the corporation, as female directors could be more educated, vigilant, and committed to quality management issues.

Board members' statistics by gender contrast with contemporary research results, confirming that females' characteristics may complement or ameliorate the input of male directors in multiple business management aspects. Solakoglu and Demir (2016) argue that an increased portion of female directors alters boards' supervisory behavior. Female managers are less likely to practice “management-by-exception” than males (Burke & Collins, 2002). Women may prefer to engage as transformational and servant leaders (Duff, 2013; Eagly & Carli, 2003). Servant leadership style involves behavioral dimensions, such as empowerment and development, building trust, humility, altruism, authenticity, responsibility, and interpersonal acceptance, and competence in this approach can add significant value to

² For opposing findings, see Iqbal, Sewon, & Back (2006) and Bruna et al. (2019).

high quality organizations (Su et al., 2020, Amah, 2018; Erdurmazli, 2019). Less tolerance for inconsistent PQ management and high commitment to interdisciplinary teamwork across the organizations could cause more diverse boards to compromise less on the quality of goods and services produced against other factors.

Kochan et al. (2003) and Burgess and Tharenou (2002) describe female managers as consensus seekers who focus on team building, democratic values, and long-term relationships, and Johansen (2007) suggests that female managers tend to prioritize the process by which an outcome is achieved, and are more likely to act as business defenders. Women tend to prefer an inclusive, “power sharing” management style more so than their male counterparts (Burgess & Tharenou, 2002), assuming a more personal approach toward employees and customers (Allen & Truman, 1993). A gender-sensitive board setting may lead to a more transparent information environment (Upadhyay & Zeng, 2014), a higher quality of corporate sustainability reporting (Al-Shaer & Zaman, 2016), and improved adoption of sustainability reporting and external assurance (Girón et al., 2021). However, critical voices suggest that the influence of female directors on the promotion of CSR disclosure practices could be attributable to reputational motivations, and some studies have found mixed results in this regard (Amorelli & Garcia-Sanchez, 2019). Women show more interest in corporate philanthropy (Selma et al., 2020) as well as utilitarian and altruistic endeavors (Mukhtar, 2002; Simmons & Emanuele, 2007). A qualitative management survey by Adams and Funk (2012) finds female directors to be not only more risk-loving but also more benevolent and caring for universalism and stimulation. The authors find that women in the boardroom are less concerned about power, security, conformity, and tradition, which can be beneficial when any problematic status quo in PQ is being questioned. Dobson and White (1995) argue that “feminine firms,” in which soft-skilled persuasion and trust become contractual enforcement mechanisms, establish cooperative environments supporting communal objectives.

Based on the above arguments it can be argued that enterprises with a higher proportion of female directors on the board may be able to pursue a corporate strategy and respectively manage operations to achieve a higher quality output than their competition with fewer women represented in corporate governance.

5 Research design

Since different sets of determinants of PQ have been tested independently of one another, we propose an integrated approach to elicit a comprehensive analysis of the determinants of PQ for investigating the effect of women on boards. We aim to introduce (a) an integrated analysis of the bespoke determinants and (b) a novel approach, adding gender related variables. We apply a three-stage methodology. First, we replicate earlier studies on PQ; second, we estimate models including all the variables identified as significant in earlier studies; third, we add gender-specific variables to test our hypothesis of the favorable impact of women directors on PQ. We find a positive relationship between a higher female board ratio and companies’ PQ scores, which we discuss along with other results.

We use firm-attested PQ as a dependent variable, obtained from the goods' evaluation scores published regularly by the German nonprofit foundation, Stiftung Warentest (SW). This institution, which tests consumer goods and services from various industry sectors, publishes a monthly journal with a series of tests. All products inspected by the organization are described in the magazine (including price, producer, sample, and other factors), which are evaluated using a reverse point scale per item, from 1 (very good) to 5.5 (very bad).

We also draw on the theoretical considerations of previous studies from the past four decades of related research, including independent determinants that different studies find to have an impact on PQ, which are presented in Table 2.

Table 2 Descriptive statistics

Variables	Mean	Median	Std. Dev	Min	Max
Dependent					
Median product quality score (PQ) [1–5.5]	2.74	2.60	0.67	1.65	5.50
Independent					
Advertising expenses [in % of sales]	0.06	0.03	0.08	0.00	0.32
SG&A [in % of sales]	0.23	0.21	0.12	0.01	0.68
Innovative company*	0.20	0.00	0.40	0.00	1.00
R&D [in % of sales]	0.04	0.03	0.03	0.00	0.14
Return on investment (ROI) [%]	7.25	6.31	8.11	– 24.63	32.79
Relative product price	1.03	1.03	0.35	0.34	2.94
COGS [in %]	0.65	0.68	0.16	0.22	0.93
Best brand*	0.23	0.00	0.42	0.00	1.00
Firm size [1000 persons]	74.21	34.00	89.03	0.09	385
Best company*	0.20	0.00	0.4	0.00	1.00
Downsizing [YoY in %]	0.03	0.01	0.24	– 0.64	2.50
Capital expenditures (CAPEX) [in % of sales]	0.04	0.03	0.03	0.00	0.19
Market size [in €B]	17.20	11.30	26.70	0.24	158
Female directors count	1.32	1.00	1.55	0	8.00
Women on board share [%]	0.11	0.09	0.11	0.00	0.50
Zero women on board*	0.37	0.00	0.49	0.00	1.00
Women share on board_1-10 PC*	0.18	0.00	0.38	0.00	1.00
Women share on board_11-20 PC*	0.26	0.00	0.44	0.00	1.00
Women share on board_21-30 PC*	0.15	0.00	0.36	0.00	1.00
Women share on board_31-50 PC*	0.04	0.00	0.20	0.00	1.00
Control					
Board size	11	11	5	3	22
Fixed cost industry*	0.94	1.00	0.23	0.00	1.00
Consumer durables*	0.75	1.00	0.44	0.00	1.00

Authors' calculations based on the data from annual reports and product quality evaluations in Stiftung Warentest's consumer reports (2009 & 2010)

*Dummy variable; Data from 2009 to 2010, N = 142

Phillips et al. (1983) analyze factor correlations of *advertising expenditure*, sales, general and administrative costs, and R&D expenditure with PQ, finding a positive relationship between all three categories and PQ, particularly in the consumer durables industry sector.³ We re-estimate these factors using the variables *advertising expenses* in percentage of sales (ADDS), *sales, general and administrative costs* in percentage of sales (SG&A), *research and development expenses* in percentage of sales (R&D), and a dummy variable for an *innovative firm* (INNOV) if a company is listed by the *Business Week* journal as one of the top 50 most innovative companies in the world in respective years. All financial data are sourced from companies' public annual reports. The advertisement cost ratios are sourced from Schonfeld & Associates (2010).

Jacobson & Acker (1987) use a vector autoregressive model for relative PQ (t) as a dependent variable. The authors' model equation considers one year lagged ROI, market share, relative product price, relative costs, and relative PQ as independent variables, revealing the positive impact of an established PQ and product price and mixed effects of ROI and costs in consumer durables and non-durables sectors. We use a *return on investment* ratio as a percentage per anno (ROI), a *relative product price* level⁴ of a firm (REL_PRC) to control for companies' pricing position (expensive or low-cost products), and *cost of goods sold* as a percentage of sales (COGS) as independent factors possibly impacting PQ. Due to the lack of publicly and readily available information on market share, we are unable to test the exogenous variables of Jacobson & Acker (1987), which are based on a proprietary dataset. Note that market share is not found to be significant in the results for the industry sectors in our study. We alternatively assign two separate dummy parameters; one for corporations active in the *consumer durables* (IND_CD) sector, and the second for firms in the *consumer nondurable* (IND_NON_CD) sector, examining them separately in our regressions.

Erdem and Swait (1998) use proprietary questionnaires and ordinary least squares (OLS) regressions to find that brand investments may positively affect a (perceived) quality of goods. We replicate their study by using a BEST BRAND dummy, if a company was ranked among the Global Best Brands in 2010 and in 2009 (Interbrand, 2010).

Cooke (1992) uses ordered probit estimates to investigate the effectiveness of an employee participation program on PQ improvement, determining that investments and a well-established workforce friendly employee participation program positively

³ For an older rank correlation study on promotional expenses and the quality of diverse consumer goods, see Rotfeld and Rotzoll (1976); for a test on the reverse causality of PQ on advertising expenditure, see Tellis and Fornell (1988); and for an analysis of perceived PQ, see Moorthy and Zhao (2000).

⁴ SW documents publish the prices for all reviewed goods and firms, allowing us to calculate the average price of a particular product within each single test sample (e.g., TV sets). We then analyze the price ratio (in percentage) that a particular test item per company (e.g., a TV set unit) has in comparison to the average reference price estimated for this type of product within each test sample. Finally, we determine an average value of the relative product price levels per company in all test samples scrutinized for a particular company.

affect PQ improvement, while downsizing measures significantly deteriorate PQ. Firm size may impact quality endeavors slightly negatively, but the outcome value is rather minimal. Devaro (2008) finds that autonomous production teams can most probably contribute to "*a lot higher*" than industry average product quality". Likewise, we test *capital investments* in percentage of sales (CAPEX) as a potential driver of PQ, the numbers for which are taken from the company annual reports (sourced from the corporate investor relations websites). We also deploy the standard test variable of *FIRM SIZE* based on absolute employee headcount values, supplemented by parameters approximating corporate human resource policies, such as *organizational downsizing* (DOWNSIZE), if a year-on-year personnel reduction had exceeded 10%, as well as a BEST EMPLOYER dummy variable, if a company was awarded this title in 2010 and/or 2009 by The Great Place to Work Institute(<http://www.greatplacetowork.net/>).

Finally, we reference Berry and Waldfogel (2010), who use OLS regressions and Tobin's Q to find a positive impact of market size on PQ in newspaper and restaurant sectors in the US. The authors also demonstrate that markets competing primarily through variable costs (like restaurants) allow for more rapid development of broader market variety, including high-end products, than markets ruled by fixed costs (like newspapers). We use a binary variable indicating whether a company operates within a *fixed costs industry* (FIX_COST_IND) and consider MARKET SIZE values for Germany, which were taken in absolute numbers from the national value-added tax statistics published by the German Statistical Office (Destatis, 2012).

To test our hypothesis regarding the positive impact of women on boards of directors on PQ, we use several control parameters, such as the number of women on the board of directors (FEMALE DIRECTORS), the size of the board (BOARD SIZE), and the share of female directors (in percentage) per firm (WBOARD). We also include dummy variables for the companies (and years) with a female share of 0%, 1–10%, 11–20%, 21–30%, and 31–50%. Only six of the observations in our data set (N = 142) have more than a 31% female share. The average female directors' share in our sample increased from 10% in 2009 to 11% in 2010, on average, along with the average female count. In 2010, 26 boards had exclusively male representation, compared to 27 boards in 2009, with a 1% increase of the board size.

SW initially evaluated products from 173 companies in 2009 and 175 firms in 2010, including financial services corporations. We exclude banking and insurance corporations from our analysis due to the effect of the financial crisis on this sector in the respective years; hence, we review 759 product tests for 151 enterprises profiled in 2010 and 682 product tests for 154 firms in 2009 from the SW foundation. We include companies evaluated in two consecutive years reducing our sample to 93 companies evaluated in both years. Finally, we establish our research sample with 71 publicly listed companies for which we are able to obtain consistent financials for our 16 independent variables simultaneously that are consistently reported each year. Therefore, our sample includes a balanced panel data set of 142 observations for which a corresponding set of comprehensive financial details and testing samples is consistently available the two consecutive years of study. Data consistency is a challenging aspect of multi-year quality studies, as the SW foundation's

Table 3 Tabulated selection process of the research sample

Selection step	Sample size	
	2009	2010
Total companies evaluated p.a	175	173
whereof financial service firms	21	22
Total companies reviewed	154	151
Total companies with consecutive scores p.a	93	93
Total companies with consistent financial data p.a	71	71
Total observed panel sample for two consecutive years of study	142	

Authors' calculations based on the data from annual reports and product quality evaluations in Stiftung Warentest's consumer reports (2009 & 2010)

tested product portfolio changes every year and respective firm financials may vary due to market factors such as mergers and acquisitions, altered reporting structure of business units and accounts, subsidiary business branching, and other changes. The tabulated sample selection process is presented in Table 3.

For the final research sample, we consider a final number of 555 product evaluations in 2010 and 558 in 2009. The included firms reported a cumulative revenue of 2.150 billion US\$ in 2010, jointly employing over 5.4 million people worldwide. On average, we collect approximately eight product evaluations per company per year. We calculate $PQ(t)$ approximated by a (log) median product evaluation score per company (MED_PQS) in 2010 and in 2009 as an endogenous variable, based on the product reliability marks achieved per company in the respective year, leading to $N=142$. The composition of the data sample in terms of firms' industry affiliation and geographic origin (including calculated average PQ values) is presented in Table 4.

The reliability of consumer reports is criticized by Hjorth-Andersen (1984), who claims that the mathematical averaging process and some arbitrary product cue weights used for a creation of quality indices could be misleading. However, in an empirical study of consumer reports, Curry and Faulds (1986) come to conflicting conclusions regarding the efficacy of published quality indices. Tellis and Johnson (2007) find product evaluations in the Wall Street Journal to be a reliable source of information that impacts capital markets and increases abnormal returns of product manufacturers' stock prices for five days from the date of the quality test disclosure Table 4.

We begin by quasi-replicating the previously mentioned PQ studies, study by study. In the next step, we simultaneously test all variables using an OLS regression, referencing Jacobson & Acker (1987).

Equation 1: Regression model for impact of women directors on PQ :

$$V_{c,t,t} = g(X_{1-p, c,t}) + h(WBOARD_{c,t}) + i(c) + k(t) + \varepsilon_{it} \quad (1)$$

where V is the logarithm of c th firm's median PQ score in year t . All model variables are indexed by firm c and time period t . X_{1-p} is the set of firm-level control

Table 4 Sample composition of the dependent variable and median/average quality scores

Company sample	No. of companies	No. of product quality tests 2010	Median product quality score 2010	Average product quality score 2010
Total (consumer durables and nondurables)	71	555	2.5	2.7
Consumer durables	53	461	2.6	2.8
Automotive	8	19	2.7	3.2
Consumer electronics	41	425	2.5	2.7
Consumer goods	4	17	2.3	2.6
Non-Durables	18	94	2.3	2.5
Cosmetics & Chemicals	9	64	2.1	2.3
Food & Beverage	2	13	2.0	2.4
Retail	4	10	3.3	3.3
Telecommunication	3	7	2.5	2.3
By headquarter region				
Europe	31	189	2.5	2.8
Asia	24	268	2.8	2.7
US	16	98	2.4	2.6

Source: Authors' calculations based on the data from annual reports and product quality evaluations in Stiftung Warentest's consumer reports (2009 & 2010)

variables described above and the term WBOARD represents the variables related to gender.

For robustness testing, we analyze the same data pool using a robust LS regression function by applying the M-, S-, and MM-estimation methods to mitigate the impact of outliers. We also run stepwise regressions; being aware of the criticisms of the last method (Whittingham et al., 2006, p. 1), we use a “hands-off” approach to test our data selection.

6 Empirical findings

Table 5 presents the re-estimation results of the effects of variables on PQ as individually considered by various studies. We first re-estimate the model of Phillips et al. (1983) in column (1). For consumer durables, we confirm a positive impact of sales force expenditure and company innovative power on PQ. In contrast, we do not find a positive relationship between advertising spending and PQ when using the variable specifications of Phillips et al. (1983).

Column (2) confirms the findings of Jacobson and Aaker (1987), indicating a significant impact of higher relative product prices. Although Jacobson and Aaker (1987) find a significant negative impact of ROI on PQ within nondurable businesses, they generally doubt any larger association between these two parameters. Our results do not find a significant relationship between ROI and PQ. Jacobson and

Table 5 Determinants of product quality (OLS): quasi-replication of earlier studies

Columns Model	1 Phillips et al. (1983)	2 Jacobson and Acker (1987)	3 Erdem and Swait (1998)	4 Cooke (1992)	5 Berry and Waldvo- gel (2010)	6 Integrative approach
Constant	0.836*** 0.067	1.039*** 0.072	1.009*** 0.020	1.356*** 0.159	1.354*** 0.324	1.173*** 0.373
Advertising expenses	0.330 0.277					0.689** 0.306
SG&A**	- 0.112 0.035					- 0.081** 0.037
Innovative company*	- 0.082* 0.046					0.021 0.054
R&D	- 0.630 0.547					0.144 0.564
Return on investment		0.001 0.002				- 0.001 0.002
Relative product price**		- 0.141** 0.056				- 0.096* 0.056
COGS**		0.110 0.086				
Best brand*			- 0.110** 0.042			- 0.073 0.052
Firm size**				- 0.039*** 0.011		- 0.028** 0.013
Best company*				- 0.044 0.046		0.034 0.049

Table 5 (continued)

Columns	1	2	3	4	5	6
Model	Phillips et al. (1983)	Jacobson and Aker (1987)	Erdem and Swait (1998)	Cooke (1992)	Berry and Waldvo-gel (2010)	Integrative approach
Downsizing				0.083		0.065
CAPEX**				0.072		0.072
				– 0.010		0.010
Market size**				0.021		0.023
					– 0.009	0.005
					0.014	0.017
					– 0.163**	– 0.183*
					0.078	0.098
Fixed cost industry*(c)						Yes
Industry fixed effects	Yes	Yes				Yes
Time fixed effects						Yes
Adj. R ²	0.069	0.045	0.039	0.112	0.022	0.170
AIC	– 0.272	– 0.253	– 0.268	– 0.326	– 0.244	– 0.328

Standard deviation values in italics

FE Fixed Effects, $N = 142$

(c) Control variable * Dummy variable. ** Logarithm

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Aaker (1987) find no significant effect of COGS on PQ, which is confirmed in our replication. As the COGS variable is multilinear with industry dummy variables, we only test for COGS.

Column (3) confirms the results of Erdem and Swait (1998) of a positive impact of brand names on the quality of goods, indicating that membership in the global group of “best brand” can favorably impact attested PQ.

Cooke (1992) finds that firms’ size negatively, but marginally, impacts quality, while unionized and nonunionized companies, if empowered with an employee participation program, can improve product reliability. Model (4) shows a significant positive relationship between firm size and PQ but does not reveal any significant positive effects from an employee friendly human resource policy or effective employee participation. In addition, the results do not indicate any significantly negative effect of downsizing measures or capital expenditures on PQ. The author also finds a positive impact of capital investments on PQ, whereas the impacts of these variables are not significantly different from zero in our estimations.

Model (5) quasi-replicates the finding of Berry and Waldfogel (2010) that fixed costs industries may have a significantly positive PQ advantage, but in contrast, we do not find a significant association between market size and PQ.

Finally, Model (6) in Table 5 presents the results of our estimation model including all previously used exogenous determinants. Note that the goodness of fit of our integrated approach is comparatively better. We find that sales, general and administrative expenses, relative product price, firm size, being part of a fixed cost industry, and advertising expenditures significantly impact PQ.

In Table 6, column (1) we simultaneously test all variables significantly associated with PQ in estimation (6) of Table 5. Note that adjusted R^2 increases. Variables such as advertising expenses, sales, general and administrative expenditures, product price, firm size, and fixed cost industry remain significant, while company innovativeness and best brand status lose significance. The coefficients of relative price and fixed cost industry increase in value, while other significant factors decrease. In column (2) we add our focus variables featuring the number and the proportion of females on boards of directors and the control parameter of board size. While we find an insignificant impact of board size on PQ, the absolute number of women directors significantly positively affects PQ. Increasing the female director count by one woman (ca. 10%) improves the average PQ score by 2.5%. Accordingly, in column (5) we find a significant positive association of the proportion of females on boards of directors on PQ. Columns (4) and (7) test the quadratic polynomial values of gender-specific variables and remain insignificant. We also confirm that PQ is positively impacted by sales, general and administrative expenses, the relative product price, best brand status, and by being in a fixed cost industry. Conversely, there is an inverse relationship between higher advertising expenses and goods’ quality.

The models in Table 7 adopt the idea of a nonlinear relationship between female participation and PQ due to minimum critical mass (Kanter, 1993; Rosener, 1995; Konrad et al., 2008; Torchia et al., 2011; Elstad & Ladegard, 2012; Joecks et al., 2013; Schwartz-Ziv, 2017; Amorelli & Garcia-Sanchez, 2019; Gyapong et al., 2019; Saggese et al., 2020; Nguyen et al., 2021; Amin et al., 2021). Column (1) of Table 7 indicates that a complete lack of females on a board of directors does

Table 6 Effects of women on boards of directors on product quality (OLS)

Columns Model	1	2	3	4	5	6	7
	All significant ^{FE}	Number of female directors ^{FE}	Number of female directors ^{FE}	Number of female directors ^{FE}	Female board share [in %] ^{FE}	Female board share [in %] ^{FE}	Female board share ² [in %] ^{FE}
Constant	1.218*** 0.143	1.214*** 0.142	1.210*** 0.143	1.213*** 0.144	1.211*** 0.141	1.209*** 0.142	1.207*** 0.143
Advertising expenses	0.693** 0.283	0.781*** 0.253	0.830*** 0.290	0.821*** 0.294	0.799*** 0.248	0.828*** 0.287	0.830*** 0.289
SG&A**	-0.076** 0.033	-0.083*** 0.030	-0.079** 0.033	-0.080** 0.033	-0.084*** 0.030	-0.082** 0.033	-0.081** 0.033
Innovative company*	0.021 0.051	0.008 0.050	0.013 0.052	0.013 0.052	0.009 0.050	0.012 0.052	0.012 0.052
Relative product price**	-0.107** 0.047	-0.130** 0.054	-0.130** 0.054	-0.129** 0.055	-0.128** 0.053	-0.128** 0.054	-0.128** 0.054
Best brand*	-0.078 0.047	-0.080* 0.047	-0.081* 0.047	-0.079* 0.048	-0.072 0.047	-0.073 0.047	-0.073 0.047
Firm size**	-0.025** 0.011	-0.017 0.014	-0.017 0.014	-0.017 0.014	-0.015 0.014	-0.015 0.014	-0.015 0.014
Fixed cost industry*(c)	-0.190** 0.086	-0.183** 0.077	-0.197** 0.087	-0.196** 0.088	-0.181** 0.076	-0.190** 0.087	-0.189** 0.088
Board size (c)		-0.001 0.005	-0.001 0.005	-0.001 0.005	-0.003 0.005	-0.003 0.005	-0.003 0.005
Female directors count		-0.025* 0.013	-0.024* 0.014	-0.031 0.030			
Female directors count ²				0.001 0.005			

Table 6 (continued)

Columns	1	2	3	4	5	6	7
Model	All significant ^{FE}	Number of female directors ^{FE}	Number of female directors ^{FE}	Number of female directors ² ^{FE}	Female board share [in %] ^{FE}	Female board share [in %] ^{FE}	Female board share ² [in %] ^{FE}
Women on board share					-0.383**	-0.373**	-0.343
					0.167	0.175	0.390
Women on board share ²							-0.084
							0.992
Industry fixed effects	Yes	No	Yes	Yes	No	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R ²	0.209	0.224	0.219	0.214	0.233	0.227	0.221
AIC	- 0.409	- 0.422	- 0.409	- 0.395	- 0.433	- 0.419	- 0.405

Standard deviation values in italics

FE Fixed Effects. N = 142

(c) Control variable * Dummy variable. **Logarithm

***p < 0.01; **p < 0.05; *p < 0.1

Table 7 Effects of female directors on product quality: non-linear effects

Columns Model	1 Zero women ^{FE}	2 Female board intervals [in %] ^{FE}	3 Female board intervals [in %]FE_M-estimation	4 Female board inter- vals [in %]_M-esti- mation	5 Female board inter- vals [in %]_S-esti- mation	6 Female board intervals [in %]_MM-estimation
Constant	1.169*** 0.146	1.187*** 0.143	0.960*** 0.124	0.972*** 0.124	1.082*** 0.070	1.084*** 0.101
Advertising expenses	0.708** 0.285	0.945*** 0.292	1.056*** 0.254	1.011*** 0.225	-0.985*** 0.142	0.300 0.203
SG&A**	-0.085** 0.033	-0.083** 0.033	-0.072** 0.029	-0.084*** 0.026	0.054*** 0.017	0.022 0.024
Innovative company*	0.018 0.053	-0.006 0.053	-0.037 0.046	-0.046 0.045		
Relative product price**	-0.112** 0.054	-0.123** 0.054	-0.163*** 0.047	-0.164*** 0.047	-0.220*** 0.029	-0.265*** 0.042
Best brand*	-0.078 0.047	-0.067 0.047	-0.065 0.045	-0.060 0.041		
Firm size**	-0.018 0.014	-0.012 0.014	0.015 0.012	0.013 0.012	0.001 0.007	-0.006 0.010
Fixed cost industry*(c)	-0.198** 0.088	-0.182** 0.088	-0.235*** 0.076	-0.216*** 0.070		
Board size (c)	-0.002 0.005	-0.004 0.005	-0.006 0.004	-0.006 0.004	-0.002 0.002	-0.003 0.004
Zero women on board*	0.053 0.040					
Women share on board_1-10 PC*		-0.029 0.051	-0.012 0.044	-0.017 0.044		

Table 7 (continued)

Columns Model	1	2	3	4	5	6
	Zero women ^{FE}	Female board intervals [in %] ^{FE}	Female board intervals [in %]FE_M-estimation	Female board inter- vals [in %]_M-esti- mation	Female board inter- vals [in %]_S-esti- mation	Female board intervals [in %]_MM-estimation
Women share on board_11-20 PC*		- 0.021 <i>0.046</i>	- 0.008 <i>0.040</i>	- 0.017 <i>0.038</i>	- 0.025 <i>0.021</i>	0.026 <i>0.031</i>
Women share on board_21-30 PC*		- 0.179*** <i>0.061</i>	- 0.199*** <i>0.053</i>	- 0.210*** <i>0.050</i>	- 0.068** <i>0.030</i>	- 0.105** <i>0.043</i>
Women share on board_31-50 PC*		- 0.132 <i>0.087</i>	- 0.150** <i>0.075</i>	- 0.157** <i>0.075</i>		
Industry fixed effects	Yes	Yes	Yes	No	No	No
Time fixed effects	Yes	Yes	No	No	No	No
Adj. R ²	0.211	0.243	0.125	0.131	0.190	0.088
AIC	- 0.399	- 0.421	180	176	NA	217

Standard deviation values in italics

FE Fixed Effects. N = 142

(c) Control variable* Dummy variable. **Logarithm

***p < 0.01; **p < 0.05; *p < 0.1

not significantly affect the PQ status quo. Column (2) shows that a positive ratio of women directors of 21–30% results in a 3.6% improvement on the PQ score in our log-leve model, also when controlling for time fixed effects. In columns (3–6), we control our model for variable outliers, obtaining similar positive results. The strongest M-estimation model is obtained excluding industry effects. These outcomes suggest that a minimum one-fifth female directors' ratio generates effective action on PQ.

7 Conclusion

We analyze the determinants of PQ, beginning by a quasi-replication of earlier quantitative studies, simultaneously testing all variables identified to be significant in the past and then adding gender-specific variables. As robustness tests, we leverage M-, S-, and MM- robust LS functions (to control for outliers' impact) and step-wise regression algorithms.

Our study confirms that optimizing certain determinants of organizational performance is relevant to increasing PQ benchmarks and that gender diversity in corporate governance could be an additional lever for improving the quality of offered goods. Our results also imply that stakeholders should discourage “tokenism” in appointing boards of directors. We confirm the finding of Phillips et al. (1983) that general sales and administrative expenses have a significant and positive effect on PQ. Our results mainly indicate a negative relationship of advertising expenses on PQ, showing a positive association only in one LS robustness test regression (S-Model). This relationship also remains unsettled in the literature. We confirm a positive association between relative product price and product reliability as demonstrated by Jacobson and Aaker's (1987) research. We also identify an insignificant impact of costs of goods sold and ROI on PQ. Like Erdem and Swait (1998), we find company brand to be a significant determinant of quality performance. Our results suggest that an employee friendly workforce policy and higher capital investments could positively affect PQ, while downsizing measures may decrease it. We find a positive and significant correlation between firm size and PQ. Our models also confirm that being part of a fixed cost industry significantly favors PQ (Berry & Waldfogel, 2010).

Finally, and as a central finding, using different multiple model variants and robustness specifications, we present evidence confirming that female directors can favorably affect PQ. Testing in more detail for further nonlinearities, we find that a critical mass of female board members—beyond a one-fifth proportion—is needed to positively influence PQ scores. Modern and high quality products demand a considerable degree of sustainability (monitoring and governance) and a respective communication style and policy, regarding which female board members appear to have an effective role as PQ agents. Advanced goods tend to already consume less energy and produce less waste and pollution in manufacturing processes. During the product life cycle, such companies usually operate with energy savvy mechanisms, assess low warranty costs, seldom experience product recalls, and maintain a low carbon footprint. Notably, business ethics and sustainability are among the top

issues considered by contemporary investors and an overall board gender diversity promotes the implementation of high ethical codes (Koutoupis et al., 2022), which presumably also includes related PQ and sustainability guidance. Ambitious governance best practices and strict monitoring procedures in corporations are company prerequisites for producing reliable and environmentally friendly goods. Diverse boards with more female directors may eventually better facilitate quality friendly policies and business ecosystems. Gender-balanced corporate governance bodies are more likely to implement quality assurance services (Liao et al., 2018). If more companies are motivated through appropriate regulations or research findings such as those found in this study to raise the number of female board appointments, a positive effect to PQ and the sustainability of national economic output could be achieved in the long run. Nongovernmental organizations could have a unique role in favorably affecting the current regulatory status quo of gender participation in corporate governance (Lindberg et al., 2014) and advance board sensitivity to the business implications of high quality goods.

We acknowledge the limitations of our analysis, being aware that researchers' intervention does not eliminate selection bias (Massaro et al., 2016). As with any empirical study, our results are based on a particular data sample that is specific to the period chosen, geography, and data availability. The regression analysis primarily used in such studies has limitations in assessing the circumstantial aspects of corporate governance. More qualitative and non-parametric analyses or survey approaches could provide adjacent observations in our context. In addition, measuring the proportion of female board members cannot fully capture the deeper traits of female directors' behavior and management attributes; hence, it only allows for binary modeling of board diversity (Koutoupis et al., 2022). Some authors argue that the proportion of women on the board is not an appropriate measure of diversity, as boards with a large female presence will exhibit a high degree of homogeneity in terms of the gender category (Campbell & Minguez-Vera, 2008). Alternatively, rather than this measure (the proportion of females on boards of directors), the Blau or Shannon index could be used to measure gender diversity, since they are more sensitive to smaller values and may be more appropriate to capture critical mass effects (Humbert & Gunther 2017). We analyze effects of critical mass in Table 7 by setting precise female share intervals. Furthermore, improved access to proprietary and consistently measured of firm characteristics and personnel-related data (e.g., board members' biographical details, female directors' experience, or granular key performance indicators on manufacturing shop floors), which are often protected by privacy policies, could presumably uncover further insights into the relationship between board member gender and PQ or other firm performance indicators. Broader data sets from other jurisdictions could consider even more factors, and conducting a similar study for a sample of companies from emerging countries could reveal further results. Notably, with broader resource inequality data that include diverse data on demographic, leadership, and formal personnel and organizational factors, an analysis of gender causality could become overly complex (Cruz-Castro & Sanz-Menendez, 2019; Mazur & Spierings, 2016). Rossignoli et al. (2021) also argue that other aspects of diversity, such as educational background, professional expertise, and other personal information (e.g., marital status, sexual orientation,

and other difficult measures that are to model due to a lack of relative disclosures) do not seem to matter for company performance. Considering such caveats, our framework could stimulate further studies, such as in B2B or public domains. Likewise, in sophisticated and transparent markets, where the public is pushing for inclusion, brand equity, and customer loyalty may especially and increasingly depend on a greater representation of female directors, executive officers, and CEOs. In addition, an examination of the impact of women's representation in the executive ranks of companies operating in markets with rapidly changing market trends, or markets with particularly creative and innovative products, may be of particular interest. We believe that our research could be a good inspiration for academics, practitioners, and policymakers to continuously discuss, pragmatically influence, and possibly further regulate the gender balance of boards of directors.

Appendix: robustness and additional analyses

As a further robustness check, we run a robust least squares regression analysis with all variables considered thus far, controlling our model estimates for the impact of outliers (in dependent, independent, and both types of variables) and respectively use the M-, S-, and MM- estimation function. Our outcomes confirm the positive impact of the number and proportion of females in boards of directors on PQ. These results are presented in Table 8.

Additionally, we run a stepwise regression analysis with all variables considered thus far (Table 9). presenting the best three models determined by the forward stepwise algorithm in columns (1), (2), and (3). The results demonstrate a significant positive effect of relative product price, firm size, general sales, and administrative expenses, being part of a fixed cost industry and a strong corporate brand. Significantly negative effects on PQ are revealed for advertising expenditure. A proportion of female directors of more than 21% significantly improves PQ.

To control for fixed effects, we also calculated models (3) and (6) in Table 6, testing a similar set of variables along with the additional consideration of industry and time fixed effects to control for events that possibly affect all companies (e.g., financial crisis) but are not specific to any company. In this case, female directors on boards and the associated proportion also indicate a positive impact on PQ. We also test our models with company fixed effects, and the results are available upon request. In this setting, all variables, apart from advertising expenditure, are insignificant, potentially indicating a shortcoming of applying the fixed effects models for panel data (Bell & Jones, 2015; Hill et al., 2020). We also test the models in Table 7 with company fixed effects, and the relationship between female share ratios and PQ remains positive (results available upon request). All other variables are insignificant, which points to the above-mentioned controversial aspect of estimation models with (too many) fixed effects.

The gender research that we examine regarding robustness tests selectively use a broad variety of analyses individually matched to a specific research question (e.g., 2SLS, GLS regressions, Heckman selection models, lagged structures, fixed

Table 8 Effects of women on the boards of directors on product quality (Robust L/S)

Columns Model	1	2	3	4	5	6
	Number of female directors_M-estima- tion	Number of female directors_S-estima- tion	Number of female directors_MM-esti- mation	Female board share [in %]_M-estimation	Female board share [in %]_S-estimation	Female board share [in %]_MM-esti- mation
Constant	1.066*** <i>0.131</i>	0.828*** <i>0.063</i>	1.067*** <i>0.099</i>	1.049*** <i>0.130</i>	0.958*** <i>0.095</i>	1.091*** <i>0.098</i>
Advertising expenses	0.739*** <i>0.234</i>	-0.134 <i>0.122</i>	0.104 <i>0.190</i>	0.754*** <i>0.228</i>	-0.012 <i>0.189</i>	0.229 <i>0.195</i>
SG&A**	-0.084*** <i>0.028</i>	0.035** <i>0.014</i>	0.022 <i>0.022</i>	-0.088*** <i>0.028</i>	0.037* <i>0.022</i>	0.013 <i>0.023</i>
Innovative company*	-0.010 <i>0.046</i>			-0.009 <i>0.046</i>		
Relative product price**	-0.177*** <i>0.050</i>	-0.194*** <i>0.026</i>	-0.331*** <i>0.040</i>	-0.174*** <i>0.049</i>	-0.299*** <i>0.040</i>	-0.316*** <i>0.041</i>
Best brand*	-0.068 <i>0.043</i>	-0.103*** <i>0.021</i>	-0.036 <i>0.032</i>	-0.057 <i>0.043</i>		
Firm size**	-0.002 <i>0.013</i>	0.025*** <i>0.006</i>	-0.003 <i>0.010</i>	0.002 <i>0.013</i>	0.006 <i>0.009</i>	-0.007 <i>0.009</i>
Fixed cost industry*(c)	-0.195*** <i>0.071</i>			-0.188*** <i>0.070</i>		
Board size (c)	-0.002 <i>0.004</i>	-0.004 <i>0.002</i>	-0.002 <i>0.003</i>	-0.004 <i>0.004</i>	0.000 <i>0.003</i>	-0.002 <i>0.003</i>
Female directors count	-0.031*** <i>0.012</i>	-0.014** <i>0.006</i>	-0.011 <i>0.010</i>			
Women on board share				-0.460*** <i>0.153</i>	-0.252** <i>0.126</i>	-0.230* <i>0.130</i>

Table 8 (continued)

Columns	1	2	3	4	5	6
Model	Number of female directors_M-estimation	Number of female directors_S-estimation	Number of female directors_MM-estimation	Female board share [in %]_M-estimation	Female board share [in %]_S-estimation	Female board share [in %]_MM-estimation
Industry fixed effects	No	No	No	No	No	No
Time fixed effects	No	No	No	No	No	No
Adj. R ²	0.102	0.259	0.087	0.110	0.166	0.087
AIC	161	NA	238	165	NA	208

Standard deviation values in italics

FE Fixed Effects. N = 142

(c) Control variable * Dummy variable. ** Logarithm

***p < 0.01; **p < 0.05; *p < 0.1

Table 9 Robustness test II: stepwise regression models (stepwise LS)

Columns	1	2	3
Model	Top 3 variables	Top 5 variables	Top 10 variables
Constant	1.379*** <i>0.102</i>	1.316*** <i>0.101</i>	0.193*** <i>0.137</i>
Relative product price**	– 0.122** <i>0.052</i>	– 0.138*** <i>0.051</i>	– 0.120** <i>0.053</i>
Firm size**	– 0.039*** <i>0.010</i>	– 0.034*** <i>0.010</i>	– 0.013 <i>0.013</i>
Women share_21_30*		– 0.149*** <i>0.052</i>	– 0.166*** <i>0.051</i>
Advertising expenses		0.584** <i>0.239</i>	0.958*** <i>0.253</i>
SG&A**			– 0.079*** <i>0.029</i>
Fixed cost industry*(c)			– 0.180** <i>0.075</i>
Women share_31_50*			– 0.127 <i>0.082</i>
Best brand*			– 0.071* <i>0.042</i>
Board size (c)			– 0.005 <i>0.004</i>
Adj. R ²	0.142	0.189	0.253
AIC	– 0.375	– 0.416	– 0.466

Standard deviation values in italics

(c) *Control variable* * Dummy variable. **Logarithm. N = 142. ***p < 0.01; **p < 0.05; *p < 0.1

effects, and other methods). In this study, we focus on robustness methods, which correspond best with our sample and data set availability, and still allow us to construct relevant approximation models in our research context. Future research efforts could apply additional robustness methodologies.

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