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The relevance of personal characteristics and gender diversity for (eco)-innovation activities at the firm-level: Results from a linked employer-employee database in Germany

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The relevance of personal characteristics and gender diversity for (eco) - innovation activities at the firm-level

Results from a linked employer-employee data-
base in Germany

Jens Horbach
Jojo Jacob

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The relevance of personal characteristics and gender diversity for (eco) - innovation activities at the firm-level

Results from a linked employer-employee database in Germany

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Mit der Reihe „IAB-Discussion Paper“ will das Forschungsinstitut der Bundesagentur für Arbeit den Dialog mit der externen Wissenschaft intensivieren. Durch die rasche Verbreitung von Forschungsergebnissen über das Internet soll noch vor Drucklegung Kritik angeregt und Qualität gesichert werden.

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Abstract

Up to now, the growing literature on the determinants of eco-innovation has not considered the influence of personal characteristics of the employees of a firm. The existing econometric analyses show much "noise" explaining the driving forces of eco-innovation. The paper tries to open the "black box" of unexplained heterogeneity. In fact, latent variables such as the greenness of a firm may be explained by the personal characteristics (gender, family status, geographical origin, education etc.) of the staff and the decision makers in a firm. The linked employer-employee database of the Institute for Employment Research (IAB) in Germany allows such an analysis based on data for 2010 and 2012. The results of an econometric analysis show that a high share of high qualified women and a mixed gender composition of the management board are positively correlated to eco-innovation activities. Furthermore, the results confirm that export-oriented firms are more likely to innovate, firms characterized by an over-aging of the staff innovate less and a higher competition pressure leads to more innovations.

Zusammenfassung

In der mittlerweile umfangreichen Literatur zu den Determinanten von Umweltinnovationen wurde bislang die Rolle persönlicher Charakteristika der Beschäftigten der Unternehmen noch nicht berücksichtigt. Ökonometrische Analysen zu Umweltinnovationen weisen häufig einen hohen Anteil unerklärter Streuung auf, was auch auf die fehlende Berücksichtigung personenbezogener Variablen zurückgeführt werden könnte. So lassen sich u.U. latente Variablen wie die „grüne“ Ausrichtung eines Unternehmens zumindest teilweise durch persönliche Charakteristika (Geschlecht, Familienstatus, geografische Herkunft, Ausbildungsstand) der Belegschaft und des Managements erklären. Der linked employer-employee Datensatz des Instituts für Arbeitsmarkt- und Berufsforschung erlaubt eine solche Untersuchung für 2010 bzw. 2012. Die Ergebnisse einer ökonometrischen Analyse zeigen, dass ein hoher Anteil hochqualifizierter Frauen in der Belegschaft und eine geschlechtergemischte Zusammensetzung des Managements die Durchführung von Umweltinnovationen begünstigen. Darüber hinaus bestätigen die Ergebnisse, dass exportorientierte Betriebe sowie Betriebe, die einem hohen Wettbewerbsdruck unterliegen, mehr Innovationen realisieren, während das Gegenteil für Betriebe mit überalterter Belegschaft gilt.

JEL-Klassifikation: C35, J16, Q55

Keywords: Eco-innovation, probit model, linked employer-employee data

1 Introduction

Eco-innovation is widely seen as crucial for reducing the environmental damages arising from the production and consumption of goods and services. Companies are increasingly attaching great importance to eco-innovation due to the growing environmental concerns of consumers and governments, but also because of strategic, long-run benefits. On the one hand, a lower use of energy and materials resulting from the adoption of more efficient process and practices can lead to substantial cost reductions. On the other hand, products that are environmentally benign can create additional market opportunities. Thus, eco-innovation may represent a “win-win” situation characterized by both economic and environmental benefits.

Although a rich and growing body of research has investigated factors driving eco-innovation, the focus has mainly been on the characteristics of firms and on the effectiveness of specific policy measures. Surprisingly, the literature on the determinants of eco-innovation until now has not considered the influence of personal characteristics of a firm’s staff and management. It is well established that characteristics of a firm’s personnel shape the firm’s cognitive makeup and hence the degree of creativity that propel innovation in the firm (Nielsen/Nielsen 2013, Galasso/Simcoe 2011). They affect what a firm notices, how it interprets information, and the decisions it make (Hambrick/Mason 1984). In line with these predictions, firms with otherwise similar, non-personnel related, characteristics are observed to take different decisions concerning eco-innovations. However, extant empirical analyses of eco-innovation has not accounted for differences among firms in the characteristics of their personnel and therefore suffer from substantial “noise” in explaining the forces driving this type of innovation. The current research project tries to open the “black box” of unexplained heterogeneity among firms, starting from the premise that characteristics of a firm’s personnel (gender, family status, geographical origin, education etc.) are likely to be crucial in explaining the greenness of a firm. We specifically focus on the role of gender diversity of the management and the staff for the realization of eco-innovation activities. The linked employer-employee database of the Institute for Employment Research (IAB) in Germany allows such an analysis based on data for 2010 and 2012.

The analysis links different streams of literature, both theoretical and empirical. On the one hand, the eco-innovation literature identifies the main potential drivers of this special kind of innovation. On the other hand, the social role theory attaches importance to the personal characteristics, particularly gender, of a firm’s management and staff. This theory illustrates the peculiarities of feminine leadership style that in combination with or in addition to gender mixed teams might lead to a higher openness to fresh ideas in new innovation fields such as eco-innovations. This type of innovation poses several unique challenges for firms, from the choice of a specific area, to the potential need for organizational changes, and to the establishment of linkages with a variety of external stakeholders. Gender mixed management and staff might have better capacities to respond to these challenges. We will therefore examine how the gender composition of a firm’s personnel, in addition to its direct effect on

innovation, would enhance the effectiveness of organizational changes that may precede innovation activities in the firm. Empirically, our analysis combines "traditional" determinants of eco-innovation with the personal characteristics, in particular gender, in one econometric model. In a first step, the effect of firm specific and personal characteristics is used to distinguish firms that carry out any innovation activity from those that do not innovate. In a second step, we restrict the sample to innovators only and explore the specific determinants of eco-innovations compared with non-environmentally related innovations.

The paper is organized as follows. Section 2 provides the theoretical background combining the eco-innovation literature with the social role and related theories. Furthermore, it contains an overview on the empirical literature on the effects of gender diversity on performance and innovation. In Section 3, the database and descriptive statistics are presented. Section 4 discusses the results of our econometric analysis. Section 5 concludes.

2 Drivers of eco-innovation

2.1 Prior research

The following widely adopted definition of eco-innovation distinguishes it from other types of innovation activities (Kemp/Pearson 2008: 7):

“Eco-innovation is the production, application or exploitation of a good, service, production process, organizational structure, or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resource use (including energy use) compared to relevant alternatives”.

Based on this definition, any innovation that generates positive environmental effects can be described as an eco-innovation. In this spirit, Horbach/Rammer/Rennings (2012: 113) argue that “...it does not matter if environmental improvements have been the primary goal of a new product or process, or came about as a by-product or simply by chance. Eco-innovations can thus be the result of other economic rationales such as increasing market share or reducing costs”.

In the innovation literature, factors driving innovation activities are typically grouped into technology push and market pull (or demand pull) categories (Hemmelskamp 1999, Rennings 2000, Horbach 2008). Although many of these are also highly relevant factors for eco-innovations, (environmental) policy measures and institutional factors are particularly crucial for initiating eco-innovations. This is because, as most environmental problems represent negative external effects, there may be no clear economic incentives to address these problems through developing new environmentally benign products and processes. Therefore, (environmental) policy measures and institutional factors are crucial for initiating eco-innovations. Indeed, the empirical lit-

erature on the determinants of eco-innovation underlines the high importance of government policies (e. g. Horbach/Rammer/Rennings 2012, Demirel/ Kesidou 2012, Barbieri et al. 2016 for a comprehensive literature overview).

There are further specific determinants of eco-innovations compared to “other” innovations. A demand pull explanation for eco-innovations is the increasing environmental consciousness of consumers and firms. Another market-pull determinant is cost savings arising, in particular, from reductions in material and energy use that are often linked to reduced environmental impacts through, for example, reductions in CO₂ emissions (Horbach/Oltra/Belin 2013). The empirical eco-innovation literature furthermore identifies firm specific factors, such as external sources of knowledge and information and internal innovation efforts through R&D activities (e. g. Horbach/Oltra/Belin 2013) and location-specific factors favouring eco-innovations (Cainelli/Mazzanti/Zoboli 2011, Horbach 2014).

Despite the use of a wide array of firm-specific, location-specific and institutional factors by extant firm-level studies, there may still be unexplained heterogeneity in analyses because eco-innovation decisions and their implementation may differ among firms with otherwise similar characteristics. This remaining “black box” might be opened by including the influence of personal characteristics of a firm’s personnel, such as the gender or cultural diversity – factors that have been neglected by most of the existing firm-level analyses of eco-innovation.

2.2 Importance of personal characteristics, gender mix, and organizational changes for (eco-) innovation

Personal characteristics of decision makers influence what they observe and perceive as opportunities in relation to important strategic priorities such as innovation (Hambrick/Mason 1984, Forsman 2009, Venugopal/Krishnan 2014). Personal characteristics reflect the underlying backgrounds and experiences that help create the mental frames with which a firm’s personnel view the world that shapes how they formulate and implement strategies (Knight et al. 1999, Walsh 1995).

As regards the importance of personnel characteristics, recent research points out that complex innovation activities need more collaborative than competitive behavior and that women tend to be more empathetic, change-catalyst and inspirational leaders than men. Men, on the other hand, are characterized by a higher emotional self-control and a more accurate self-assessment (Young 2016). In this regard, the social role theory of leadership provides important insights (Eagly/Johannesen-Schmidt 2001, Eagly/Johnson 1990, Eagly/Karau 2002). It uses the concepts of gender role and leader role to explain the different behavioral traits of female and male leaders. Gender roles are socially shared expectations about the attributes of men and women, with women, as noted, being associated more with communal attributes such as concern and sympathy for others, and men with agentic qualities such as independence and assertiveness (Ridgeway 2001). Gender roles may influence organizational behavior in that employees’ reaction to leaders and leaders’ response to it occur through

the prism of gender. This may lead to an internalization of gender role whereby male and female leaders form different expectations, even if subconsciously, about their own behaviors. For instance, many female leaders prefer an interactive management style reflecting behaviors associated with women's traditional roles in the society (Rosener 1990). Communal attributes of female leadership style is further reinforced by the incongruence between their gender role and their leader role. Successful leaders are expected to possess agentic qualities, such as assertiveness and self-confidence, which are typically associated with men. This creates a particular dilemma for female leaders because not displaying assertive and controlling behaviors might raise questions about their legitimacy, making them look like weak leaders. However, if they indeed try to exhibit agentic qualities, they may face backlash as such behaviors contradict stereotypical female characteristics (Sauer 2011, Ridgeway/Bourg 2004). Women leaders therefore may integrate gender role with leader role, combining agentic qualities, for gaining legitimacy as leaders, with more female-typical communal behaviors, for gaining greater social acceptance (Eagly/Johannesen-Schmidt 2001).

In line with these predictions, studies suggest a distinctive leadership style associated with women. It is less hierarchical and more interactive - a style that could be traditionally deemed inappropriate for leaders (Rosener 1990). This style of leadership is considered transformational because female leaders encourage broad participation in decision making and are willing to share information and power, thereby helping transform employees' self-interest into the goals of their organization (Helgesen 2011, Rosener 1997, Book 2009, Dezsö/Ross 2012). This ensures that decisions are based on as much information as possible and enhances employees' self-worth, their motivation, and their trust in and the decisions of their leaders (Burns 1978, Rosener, 1990, Wang et al. 2013).

Although prior research in the organizational demography literature has focused on the influence of heterogeneous management teams on firm performance (e.g. Wiersema/Bantel 1992), with the notable exception of Dezsö/Ross (2012), few studies have paid close attention to the gender diversity of the management of a firm. We discuss several reasons why female presence in management might be relevant for firms' innovation performance in general and their environmental innovation in particular. First, women's presence in the management team can generate what is described as interpretive ambiguity in the team. Interpretive ambiguity refers to a state of equivocality, or a lack of clarity, wherein members initially sense and interpret a complex and equivocal reality in different yet complementary ways (Martin 1992, Kilduff/Angelmar/Mehra 2000). Specifically, when members of a team have different backgrounds they employ different frames of reference for giving meanings to complex problems arising out of the external environment (Weick 1995). Interpretive ambiguity is important in complex environments because it allows for matching the variety needed internally to comprehend and interpret the variety that a team faces in the external environment. It is important, however, that different interpretations of complex situations do not lead to too many disagreements, which can damage performance. In fact, interpretive ambiguity presupposes that members share opinions with

each other, leading eventually to the creation of a collective frame of reference to sense and interpret the environment, ultimately enhancing the team's creativity and the quality of their decisions (Weick 1995). We extend this idea to the context of a team environment with female presence. Men and women tend to have different experiential backgrounds and therefore possess different values and intentions (Carter/Williams/Reynolds 1997). As a result, male and female executives may have different perspectives concerning environmental issues. A gender diverse staff and management team may therefore open up multiple pathways for comprehending and dealing with these issues. In that context, Dezsö/Ross (2012: 1085) state: "In general, homogenous groups may perform slightly better on simple tasks, even though heterogeneous groups do better on difficult tasks". Furthermore, given the communal attributes associated with feminine management style outlined above, female executives may create an environment that is open to and welcoming of different perspectives of a firm. This can lead, at the team level, to a clear, shared understanding of the problems arising out of the environment and to creative solutions.

Secondly, while their particular life experiences can make individual executives of either gender catalysts for their organization to pursue an environmentally-oriented innovation strategy, women might be more concerned and passionate about issues related to environment. Recent evidence demonstrates that female leaders tend to possess a peculiar strategic orientation, such as avoiding competitive environments (Datta Gupta/Poulsen/Villeval 2013, Niederle/Vesterlund 2007) and being less concerned with short-term economic goals (Brush 1992). This may suggest that female executives may be more interested than their male counterparts in pursuing environmentally orientated goals as a way to carve out unique strategic advantages for their organizations.

Finally, it is important to consider the importance of organizational changes and how a gender-mixed team of personnel may make these more effective for innovation outcomes. In fact, in many cases eco-innovation activities are very complex because they often require adaptations of the whole production process so that characteristics such as teamwork and collaboration awareness in combination with an accurate self-assessment may help realizing eco-innovation activities. Compared with other innovations, eco-innovations demand a shift in firms' organizational goals, practices, and routines due to their systemic character, complexity, potential lack of fit with firms' traditional innovation activities, and higher technological and market uncertainty (de Marchi 2012, Horbach/Oltra/Belin 2013). Such a setting may make gender diversity especially salient: On the one hand male personnel can help offer accurate assessments of the needed changes. Female personnel, on the other hand, with their unique collaborative and interpersonal skills may help win support for these changes through effective communication, thus improving teamwork and cohesion and reducing conflicts and delays. Male and female personnel thus complement each other in that the former's role may be suitable especially in choosing efficient strategies, while the lat-

ter may help the whole organization rally behind these changes, improving the effectiveness of organizational changes in the process. These arguments lead us to formulate our hypotheses H1, H2 and H3:

H1: Mixed teams with a high share of qualified women are favorable for the realization of complex eco-innovations.

H2: A high share of qualified women in the staff and the management team reinforces the role of organizational innovations for the innovative behavior of a firm.

H3: Organizational innovations are crucial for (eco-) innovations because of their systemic character.

2.3 Empirical literature of the role of mixed teams and women leadership for the greenness of a firm

A growing literature analyses the importance of personal characteristics and staff diversity on performance, employment or greenness of a firm. In particular, there are many studies analyzing the relationship between women leaders, gender diversity and firm performance (see Noland/Moran/Kotschwar 2016 or Qian 2016 as examples). A further strand of literature analyses the determinants of the greening of households. These analyses are highly relevant for our paper because they help in finding out which personal characteristics are favorable for green attitudes. De Silva/ Pownall (2014) explore the relevance of education, gender and income for sustainable behaviour and financial well-being for a sample of 1400 Dutch households. Using matching methods, the authors find that gender and education are more important for sustainable behavior compared to income. Especially educated females seem to put high values on going green. Their analysis supports earlier findings of Davidson, Freudenburg (1996) or Zeleznay/Chua/Aldrich (2000) showing that the environmental consciousness of females seems to be higher compared to that of men. Terjesen/Bosma/Stam (2016) and Estrin/Mickiewicz/Stephan (2013) show that female entrepreneurs are more interested in the realization of non-economic goals compared to men.

Kassinis et al. (2016) analyse the relationship between gender and environmental sustainability based on a sample of 296 US firms. The authors find that "...both 'demographic' and 'structural' gender diversity are significant predictors of a firm's environmental sustainability initiatives." (Kassinis et al. 2016: 1). The reasons for this result can be explained using gender theory (Kanter 1977) because "...women in top positions bring environmental sensitivity and policy-making to the table, as this is influenced by their specific characteristics. These include a greater propensity to be 'green,' more effective monitoring of agents, more stringent enforcement of ethical conduct, and greater likelihood to engage with multiple stakeholders and respond to their needs..." (Kassinis et al. 2016: 9).

A positive influence of a high proportion of women in responsible positions on corporate social performance (Walls/Berrone/Phan 2012) and environmental performance is also detected in the literature (Bear/Rahman/Post 2010). Galbreath (2010) shows that firms with larger boards and younger directors perform better with respect to climate change issues.

Glass/Cook/Ingersoll (2016) investigate the effect of women leaders on the promotion of sustainability using a dataset of CEOs and BODs of the Fortune 500 firms for the years 2001–2010. Their results on the role of women for sustainability issues are mixed showing that "Gender diversity on the board is associated with only a small positive effect on a firm's likelihood of supporting positive environmental initiatives." (Glass/Cook/Ingersoll 2016: 506). Post/Rahman/Rubow (2011) and Webb (2004) also empirically show that a higher gender diversity of boards is correlated to higher environmental ratings compared to other firms. A more socially related behavior of women is documented by Conroy/Weiler (2016) showing that female business owners are less likely to dismiss workers compared to men.

Based on a multi-level analysis, the cross-country study of Hörisch/Kollat/Brieger (2017) analyses the determinants of environmental orientation of entrepreneurial activity. Surprisingly, the authors find a negative correlation between the education and income of entrepreneurs and their environmental orientation. Furthermore, the authors reject the hypothesis that younger entrepreneurs are more likely to support environmental issues. They argue that older entrepreneurs have more children on average leading to a higher consciousness for the concerns of future generations. Concerning the gender variable, the study indicates that women have a higher environmental orientation.

3 Databases and descriptive results

The analysis of the determinants of eco-innovation activities is based on data of the establishment panel of the Institute for Employment Research in Nuremberg. This survey was founded in 1993 to obtain a representative picture of German establishments which have at least one employee subject to social security. The survey is characterized by very high response rates of more than 70 percent. The 2012 wave contains a filter question that allows determining whether the firm belongs to the environmental sector or not. The environmental sector comprises goods and services which prevent environmental damage in different fields such as air or water pollution. A share of 14.8 percent (2413 firms) of all the firms in the sample of the wave 2012 declared to belonging to the environmental sector. Furthermore, the questionnaire of this wave contains information about the innovative behaviour of the firm so that innovative firms within the environmental sector can be identified. To reduce problems with endogeneity, the data of the preceding wave of 2011 was also used for time dependent independent variables. The two waves of the establishment panel were furthermore merged with employee data from 2010. This linked employer-employee data basis of the Institute for Employment Research allows getting information about

personal characteristics of the firm such as gender, education or age (see also Alda/Bender/Gartner 2005).

Table 1
Qualification level of employees and innovativeness in the German environmental sector in 2011

Environmental technology field	Employees with university education in %	Share of "high-paid" women in %	Share of innovative establishments in %
Prevention of water pollution, waste water treatment	13.4	2.8	47.2
Waste management, recycling	8.9	3.2	53.0
Air purification	8.6	0.5	54.2
Climate protection, renewable energies, energy saving	13.4	3.6	55.2
Noise abatement	13.1	3.6	55.4
Environmental remediation, soil conservation	9.5	5.7	54.5
Nature conservation, landscape management	12.9	4.3	36.6
Measurement, analysis and control technology	16.4	1.8	66.1
Analytics, consultancy, project planning	26.8	9.5	65.3
Environmental research, development and monitoring	38.4	2.7	60.0
Other environmental fields	12.1	9.2	62.7
Environmental establishments in total	13.4	3.9	53.4
All establishments	9.9	6.1	40.4

Source: Horbach, Janser 2016, own calculations.

Compared to all establishments in the sample, the establishments offering environmental goods and services are more innovative and show a higher share of employees with university education (see Table 1). Women belonging to high wage categories are under-represented in the environmental sector especially in production-oriented fields such as air purification or measurement and control technology. In these fields, engineers where men traditionally dominate show high shares of the whole staff. On the other side, in very innovative fields like analytics, consultancy, project planning or other environmental fields the share of high-paid women is disproportionately high.

4 Estimation strategy and results

The following econometric analysis aims at detecting the main drivers for innovation activities combining firm specific factors and personal characteristics. The analysis is conducted as follows: First, the determinants of the general innovation behavior of the questioned establishments are analyzed. The variable *innovation* gets the value 1 if the firm realized a product or process innovation in 2011, otherwise 0. In a second step, the different drivers of eco-innovations and other innovations are analyzed.

Ecoinnovation gets the value 1 if an innovative firm belongs to the environmental sector and 0 if the firm innovates in non-environmentally related activities. To analyze the determinants of innovation activities and to detect differences between eco-innovations and other innovations binary probit models are estimated. According to our theoretical analysis, different factors such as the existence of gender mixed teams or competition pressure summarized by a vector \mathbf{x} or rather \mathbf{z} influence the dependent variables innovation or eco-innovation, respectively. The probabilities $prob(\text{innovation} = 1 | \mathbf{x}) = F(\mathbf{x}, \beta)$ and $prob(\text{eco-innovation} = 1 | \mathbf{z}) = F(\mathbf{z}, \gamma)$ are estimated. Marginal effects are calculated.

Description of the correlated variables (for a detailed definition see the Appendix)

The personal characteristics of the employees stem from the employee databank of the Institute for Employment Research and were matched to the establishment panel of this institute by using the means of the personal staff characteristics for each establishment. The average wage is captured by *avwage*. *German* denotes the share of German employees, *hwagegerman* interacts this variable with the highest wage category. *Women* describes the share of women with regard to the whole staff, *hwagewomen* captures the share of women in the highest wage category. Unfortunately, the data basis cuts wages exceeding the threshold for social security contribution assessment. Therefore, a further variable is required representing women in the highest management category. *Womenleader* thus denotes the share of women in the highest management level. *Lengsoccup* describes the duration of occupation life. Furthermore, the diversity of the top management is captured by *mixedlead*: This dummy variable gets the value one if the top management is mixed with respect to gender and zero if it consists only of men or exclusively women. *Highqual* denotes the share of employees with a university education. The variables *orga* to *orgj* describe organizational changes, *oergcfem* to *orgifem* the respective changes connected with high shares of high paid women. *Age* describes the age of the firm, the variable gets the value one if the firm has been founded after 1990, zero otherwise. *Competition* denotes a high competition pressure perceived by the firm. The dummy variable *export* shows if the firm exports goods or services. *Invest10* gets the value one if the firm realized any investment in 2010. *Owner* describes the situation if the owner of the firm is the chairman of the executive board. *Mentwomen* captures the existence of specific women's promotion programs in the firm. A value one of *profitsituation10* denotes a very good or a good self-perceived profit situation of the firm in 2010. *Size* denotes the number of employees of the establishment. The state of a firms' capital stock is indicated by *capitalstocknew*. The technological capabilities of the firm are also described by the existence of further education measures (*furthereducation*). *Rad* denotes the existence of R&D activities in 2010. Furthermore, dummies for the German Länder and sectors were included.

Results of the econometric analysis

The results for the general innovative behavior of establishments (see Table 2) show, contrary to our expectations, that a high share of women in the highest management level is associated with less innovation success. This may be due to the fact that

women leaders are still dominating in occupation fields that are less innovative such as social services. In fact, we controlled for sectors but the available sector structure is too rough to fully eliminate this effect. However, in line with our predictions, the existence of mixed teams, operationalized as a high percentage of *women* staff members, does seem to enhance the innovative behavior of firms confirming results from other authors (see Section 2). Furthermore, organizational changes such as more in-house production (*orga*, marginal effect (me) 15%), the re-organization of supply chains (*orgc*, me 17%) or of departments and functional areas (*orgd*, me 11%) or the introduction of group work (*orgf*, me 13%) trigger innovative activities. Interestingly, organizational innovations connected with a high share of high-paid women (interaction terms) also promote innovations supporting our Hypothesis 2: Especially moving responsibilities to lower decision levels (*orgefem*, me 0.17) triggers innovation.

Furthermore, the results confirm former firm-level oriented analyses of innovation behavior (see e. g. Horbach 2008): Export-oriented firms are more likely to innovate (*export*), a higher competition pressure leads to more innovations (*competition*). As expected, lagged R&D expenditure, investment activities, a modern capital stock and further education measures are positively correlated to more innovation success (*rad*, *invest10*, *capstocknew*, *furthereducation*). On the other side, firms with owners as chief executives (*owner*) and firms that fear an overaging of the staff (*toold*) are less likely to innovate. Bigger firms (*size*) are characterized by more innovation success. A higher average payment (*avwage*) is significantly connected with more innovation activities, which may signify the beneficial effects from the presence of high-quality human capital within a firm.

Table 2
Determinants of innovation activities in German establishments

Dependent variable: Innovation:			
1 Innovator			
0 No innovation output			
Correlates			
<i>Personal characteristics</i>		<i>Technological capabilities</i>	
Avwage	0.00 (2.21)**	Capstocknew	0.10 (7.37)***
German	-0.00 (-0.03)	Furthereducation	0.11 (7.29)***
Mixedlead	-0.02 (-0.96)	Rad	0.31 (12.98)***
Hwagegerman	0.05 (1.27)		
Hwagewomen	-0.01 (-0.29)	<i>Control variables</i>	
Highqual	0.03 (0.53)	Age	0.00 (0.28)
Lengsoccup	-0.00 (-1.04)	Competition	0.04 (3.13)***
Women	0.06 (1.83)*	Export	0.10 (5.70)***
Womenleader	-0.04 (-2.18)**	Invest10	0.06 (4.30)***
		Mentwomen	0.01 (0.16)
<i>Organisational changes</i>		Owner	-0.04 (-2.32)**
Orga	0.15 (5.46)***	Profitsituation10	0.02 (1.51)
Orgb	0.12 (4.52)***	Sizeln	0.02 (3.75)***
Orgc	0.17 (7.63)***	Toold	-0.05 (-2.45)***
Orgd	0.11 (5.02)***		
Orge	0.07 (2.74)***	<i>German Länder</i>	
Orgf	0.13 (3.70)***	Baden	0.10 (2.85)***
Orgg	0.08 (2.02)**	Bavaria	0.12 (3.65)***
Orgh	0.02 (0.71)	Berlin	0.05 (1.23)
Orgi	0.10 (5.80)***	Brandenburg	0.01 (0.31)
Orgj	0.16 (4.12)***	Bremen	0.17 (4.84)***
Orgcfem	0.12 (2.00)**	Hamburg	0.06 (1.13)
Orgdfem	-0.10 (-1.47)	Hesse	0.13 (3.72)***
Orgefem	0.17 (2.35)**	Lowsax	0.07 (2.19)**
Orgffem	-0.12 (-1.21)	Meckpom	0.12 (3.76)***
Orggfem	-0.15 (-0.97)	Northwestf	0.10 (3.08)***
Orghfem	0.13 (0.63)	Rhineland	0.04 (1.00)
Orgifem	0.11 (2.36)**	Saarland	-0.02 (-0.47)
		Saxony	0.06 (1.97)**
		Saxonyanh.	-0.04 (-1.35)
		Schleswig	0.04 (1.10)

Probit regressions. Number of observations: 8335. $\chi^2 = 2684$. Pseudo $R^2 = 0.24$. Z-statistics are given in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. Instead of coefficients, marginal effects are reported. The marginal effects for the continuous independent variables were calculated at their means. Concerning dummy variables the values report the change in probability for a discrete change of the dummy variable from 0 to 1.

Source: IAB Linked Employer-Employee database 2010, IAB Establishment Panel 2012, own estimations.

In a second step, the determinants of eco-innovation activities compared to other innovations are analyzed (see Table 3). In general, firms with a high share of women (*women*) are less likely to realize eco-innovations compared to other innovations.

Table 3
Determinants of eco-innovations compared to other innovations in Germany

Dependent variable: Ecoinnovation:			
1	Innovator in the environmental sector		
0	Innovator in other sectors		
Correlates			
<i>Personal characteristics</i>		<i>Control variables</i>	
Avwage	-0.00 (-0.90)	Age	-0.02 (-1.18)
German	0.09 (1.24)	Competition	0.02 (1.55)
Mixedlead	0.04 (1.93)**	Export	-0.02 (-0.98)
Hwagegerman	-0.07 (-1.34)	Invest10	0.02 (1.07)
Hwagewomen	0.13 (2.11)**	Mentwomen	0.06 (1.94)**
Highqual	0.05 (0.77)	Owner	-0.01 (-0.74)
Lengsoccup	0.00 (0.44)	Profitsituation10	0.02 (1.65)*
Women	-0.23 (-6.37)***	Sizeln	-0.01 (-1.80)*
Womenleader	-0.03 (-1.11)	Toold	0.03 (1.38)
<i>Organisational changes</i>		<i>German Länder</i>	
Orga	0.04 (1.85)*	Baden	0.01 (0.35)
Orgb	0.03 (1.53)	Bavaria	0.01 (0.36)
Orgc	0.05 (2.95)***	Berlin	0.07 (1.59)
Orgd	-0.00 (-0.19)	Brandenburg	0.05 (1.12)
Orge	0.03 (1.73)*	Bremen	0.06 (1.34)
Orgf	0.05 (2.06)**	Hamburg	0.02 (0.29)
Orgg	0.05 (1.58)	Hesse	-0.01 (-0.39)
Orgh	0.07 (2.78)***	Lowsax	0.04 (0.96)
Orgi	0.01 (0.53)	Meckpom	-0.03 (-0.89)
Orgj	0.03 (0.76)	Northwestf	0.03 (0.93)
<i>Technological capabilities</i>		Rhineland	0.03 (0.78)
Capstocknew	-0.01 (-0.67)	Saarland	0.04 (0.64)
Furthereducation	0.5 (2.65)***	Saxony	0.05 (1.34)
Rad	0.06 (3.09)***	Saxonyanh.	0.02 (0.43)
		Schleswig	0.07 (1.41)

Probit regressions. Number of observations: 3386. $\text{Chi}^2 = 457$. Pseudo $R^2 = 0.13$. Z-statistics are given in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. Instead of coefficients, marginal effects are reported. The marginal effects for the continuous independent variables were calculated at their means. Concerning dummy variables the values report the change in probability for a discrete change of the dummy variable from 0 to 1.

Source: IAB Linked Employer-Employee database 2010, IAB Establishment Panel 2012, own estimations.

This effect may be due to the fact that many eco-innovations are based on production-oriented activities requiring many engineers. However, the results on mixed teams suggest their key significance in complex eco-innovation activities supporting our Hypothesis 1: The variable *mixedlead* (me 4%) denoting firms characterized by gender mixed first level management board is positively significant with respect to the introduction of eco-innovations. Furthermore, a high share of high-paid women (*hwage-women*, me 13%) in the staff of the firm also triggers eco-innovations. Specific wom-

en's promotion programs seem to support the positive eco-innovation effect of gender-mixed teams (*mentwomen*, me 6%). Among other personal characteristics, the cultural diversity of the staff seems not to be important for the introduction of eco-innovations (insignificant variable *german*). This is also the case for education (*highqual*), income (*avwage*) and the age of the staff (not included in the econometric model because of insignificance and small number of observations) supporting the mixed results in the respective literature (see Section 2). Some organizational changes are more relevant for eco-innovations compared to other innovations supporting Hypothesis 3: Re-organisation of supply chains and customer relationships (*orgc*, me 5%), introduction of groupwork (*orgf*, me 5%) and, not surprisingly, environmentally related organizational measures (*orgh*, me 7%).¹ Unfortunately, a regulation variable triggering especially eco-innovations is not available in the data basis (see also Section 2). We included sector dummies that at least partially account for the influence of regulation activities on eco-innovation. Furthermore, innovation input (*rad*) is more important for eco-innovations supporting results from previous literature (e. g. Horbach/Oltra/Belin 2013). In line with this result, further education measures (*furthereducation*) also trigger eco-innovation activities.

5 Summary and conclusions

The growing literature on the determinants of eco-innovation has not yet considered the influence of personal characteristics of the employees of a firm. The existing econometric analyses therefore show much "noise" in explaining the driving forces of eco-innovation. This paper opens the "black box" of unexplained heterogeneity among firms who otherwise share similar characteristics but have often been observed to take different decisions concerning eco-innovations. In fact, latent variables such as the greenness of a firm may be explained by the personal characteristics (gender, family status, geographical origin, education etc.) of the staff and the decision makers in a firm. The linked employer-employee database of the Institute for Employment Research (IAB) in Germany allows such an analysis based on data for 2010 and 2012.

Our econometric analysis aims at detecting the main drivers for innovation activities combining firm specific factors with characteristics of firms' personnel. In a first step, the determinants of the general innovation behavior, be it process or product innovations, are analyzed. In a second step, the different drivers of eco-innovations and other innovations are explored. The results of our probit models show that a high share of high-qualified women and a mixed-gender composition of the management board are positively correlated to eco-innovation activities. This might be explained by the fact that complex innovation activities in a company need more collaborative

¹ We did not include interaction effects between organizational changes and gender variables because they were all insignificant and did not considerably change the coefficients of the other covariates.

than competitive behavior. In fact, women are known to be characterized by an empathetic, change-oriented and inspirational leadership style.

The cultural diversity of the staff seems not to be important for the introduction of eco-innovations. This is also the case for education, income and the age of the staff supporting the mixed results in the respective literature. Some organizational changes are more relevant for eco-innovations compared to other innovations: Reorganisation of supply chains and customer relationships, the introduction of group work and, not surprisingly, environmentally related organizational measures. Furthermore, the results confirm that export-oriented firms are more likely to innovate, firms with an over-aged staff innovate less and a higher competition pressure leads to more innovations.

From a policy perspective, our analysis shows that policies aiming at a better gender fairness in the sense of a higher share of women in the management boards and staff may also lead to a better eco-innovation performance. At least from an environmental perspective it pays to be gender fair.

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Appendix

Descriptive statistics and definitions of the variables

Variables	Description	Mean	St. Dev.
<i>Endogenous variables</i>			
Innovation	Process- or product innovation in 2011 (1 yes, 0 no)		
Ecoinnovation	1 Innovator in the environmental sector 0 Innovator in other sectors	0.40 0.20	0.49 0.40
<i>Personal characteristics</i>			
Avwage	Daily average wage per capita	58.7	32.4
German	Share of German employees	0.61	0.47
Hwagegerman	Share of German employees in the highest wage category with regard to the whole staff	0.12	0.24
Hwagewomen	Share of women in the highest wage category with regard to the whole staff	0.06	0.19
Highqual	Share of employees with university education	0.03	0.10
Lengsoccup	Duration of occupation life (in years)	14.4	5.27
Mixedlead	1 Gender mixed top management, 0 Only men/women in TMT	0.14	0.35
Women	Share of women with regard to the whole staff	0.48	0.33
Womenleader	Share of women in top level management	0.23	0.38
<i>Organisational changes</i>			
	1 yes, 0 no		
Orga	More in-house production	0.07	0.25
Orgb	More purchases of products and services	0.06	0.25
Orgc	Re-organisation of supply chains and customer relationships	0.11	0.32
Orgd	Re-organisation of departments or functional areas	0.17	0.38
Orge	Downward relocation of responsibilities	0.11	0.31
Orgf	Introduction of groupwork	0.05	0.22
Orgg	Establishment of units with own determination of results	0.04	0.18
Orgh	Environmentally related organizational measures	0.05	0.21
Orgi	Improvement of quality assurance	0.25	0.43
Orgj	Other organizational measures	0.03	0.16
Orgcfem	1 If orgc equals 1 and hwagewomen g.t. 0.1, 0 Otherwise	0.01	0.09
Orgdfem	1 If orgd equals 1 and hwagewomen g. t. 0.1, 0 Otherwise	0.01	0.08
Orgfefem	1 If orge equals 1 and hwagewomen g. t. 0.1, 0 Otherwise	0.01	0.08
Orgffem	1 If orgf equals 1 and hwagewomen g. t. 0.1, 0 Otherwise	0.00	0.05
Orggfem	1 If orgg equals 1 and hwagewomen g. t. 0.1, 0 Otherwise	0.00	0.03
Orghfem	1 If orgh equals 1 and hwagewomen g. t. 0.1, 0 Otherwise	0.00	0.03
Orgifem	1 If orgi equals 1 and hwagewomen g. t. 0.1, 0 Otherwise	0.01	0.12
<i>Control variables</i>			
Age	Foundation of the firm after (1) or before 1990 (0)	0.58	0.49
Competition	High competitive pressure (1), little or no comp. p. (0)	0.33	0.47
Export	Export activities (1 yes, 0 no)	0.19	0.39
Invest10	Investments carried-out in 2010 (1 yes, 0 no)	0.61	0.49
Mentwomen	1 Existence of specific women's promotion programs, 0 not	0.07	0.25
Owner	Owner of the firms as chairman of the board (1 yes, 0 no)	0.56	0.50
Profitsituation10	Good/very good profit situation in 2010 (1 yes, 0 other)	0.47	0.50
Size	Number of employees / 100 in 2011	138.9	907.3
SizeIn	Logarithm of employees/100 in 2011	3.01	1.83
<i>Technological capabilities</i>			
Capstocknew	State-of-the-art capital stock (1), older capital stock (0)	0.64	0.48
Furthereducation	Further education measures in 2011 (1 yes, 0 no)	0.66	0.47
Rad	R&D activities in 2010 (1 yes, 0 no)	0.12	0.32
<i>Sector dummies</i>			
	1 yes, 0 no (for all sector dummies)		
Sec1	Agriculture, forestry and fishery	0.02	0.15
Sec2	Mining, quarrying of stones, energy supply	0.02	0.14
Sec3	Food products, beverages and tobacco	0.02	0.15
Sec4	Textiles, leather	0.01	0.10
Sec5	Wood, paper, printing	0.02	0.14
Sec6	Chemical industry, rubber and plastics, glass	0.04	0.19

Variables	Description	Mean	St. Dev.
Sec7	Basic metals and fabricated metals	0.05	0.21
Sec8	Electrical machinery and apparatus	0.02	0.14
Sec9	Machinery	0.04	0.19
Sec10	Motor vehicles and other transport equipment	0.01	0.12
Sec11	Furniture and other products	0.02	0.13
Sec12	Construction sector	0.08	0.27
Sec13	Wholesale and retail trade	0.15	0.35
Sec14	Transport and logistics	0.04	0.19
Sec15	Information and communication	0.02	0.14
Sec16	Services: banking sector, insurance etc.	0.17	0.38
Sec17	Architectural and engineering offices	0.03	0.16
Sec18	Public sector and other services	0.25	0.43
<i>German Länder</i>	<i>1 yes, 0 other Land</i>		
Baden	Baden-Wuerttemberg	0.07	0.26
Bavaria	Bavaria	0.08	0.27
Berlin	Berlin	0.05	0.22
Brandenburg	Brandenburg	0.06	0.25
Bremen	Bremen	0.06	0.23
Hamburg	Hamburg	0.02	0.12
Hesse	Hesse	0.06	0.24
Lowsax	Lower Saxony	0.07	0.25
Meckpom	Mecklenburg-Western Pomerania	0.07	0.25
Northwestf	North Rhine-Westphalia	0.10	0.30
Rhineland	Rhineland-Palatinate	0.05	0.22
Saarland	Saarland	0.05	0.22
Saxony	Saxony	0.07	0.26
Saxonyanh.	Saxony-Anhalt	0.07	0.25
Schleswig	Schleswig-Holstein	0.06	0.23
Thuringia	Thuringia	0.07	0.25

Source: IAB Linked Employer-Employee database 2010, IAB Establishment Panel 2012, own calculations.

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