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How gender differences in informal networking result in unequal access to interorganizational R&D projects

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Women are underrepresented in interorganizational research & development (R&D) projects. This affects the innovativeness of such projects, the representation of female perspectives in the design of innovations and the career opportunities of women. Such projects often emerge from preceding interorganizational R&D projects and are particularly successful when they do so. We argue that instrumental networking in ongoing projects is constitutive for the formation of such follow-up collaborations and, further, that stereotypical gender roles hinder women's participation in instrumental interactions with their current project partners. Hence, we assume that unequal opportunities to participate in follow-up projects can be attributed to women's lesser involvement in instrumental networks. Empirically, we test our argument using data on 2746 directed and weighted personal relationships across 24 interorganizational R&D projects. We show that instrumental interactions are crucial for who initiates follow-up projects with which current partner. Furthermore, we can show that the low participation of women in these activities can be better explained by gender roles than by gender homophily. In doing so, we reveal an important cause of women's under-representation in R&D.

Keywords: gender; inequality; collaboration; innovation; instrumental ties; social networks; role theory

1. Introduction

Women still face inferior career chances compared to men (Pal et al. 2022). This also applies to the field of research and development (R&D), which is particularly prestigious and strongly influences social developments (Mickey and Smith-Doerr 2022). A particularly important mode of collaboration in this field is interorganizational R&D projects. In such projects, partners from academia and industry combine their heterogeneous resources to produce innovations and scientific knowledge. For the engaged individuals, such interorganizational R&D projects provide the opportunity to participate in shaping societal developments through innovations and to advance their own careers in research and development by benefiting from the project's successes (Pinch and Bijker 1984;

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Whittington 2018). Women are underrepresented in R&D projects with a share of 30% (Mickey and Smith-Doerr 2022; UNESCO 2019). In consequence, innovations are more strongly oriented toward male needs and women have poorer chances for career success in research and development (Pecis 2016; Whittington 2018; Xie et al. 2020). Better understanding the causes of women's underrepresentation in interorganizational R&D projects is therefore an important step toward gender equity.

An important access to interorganizational R&D projects is participating in their initiation through ongoing R&D projects (Bruneel, D'Este, and Salter 2010; Dahlander and McFarland 2013; Mannak et al. 2019). Such follow-up projects are particularly promising because they can build on established relationships between partners and jointly produce results (Hewitt-Dundas, Gkypali, and Roper 2019; Mannak et al. 2019). Research on project initiation indicates that follow-up projects are typically not initiated in formal meetings and do not include all partners of ongoing projects (Mannak et al. 2019; Manning 2010). Rather, informal instrumental interactions between selected partners are key (Berends, van Burg, and van Raaij 2011; Dahlander and McFarland 2013). Instrumental interactions are characterized by their focus on work-related tasks (Ibarra 1993; Methot and Rosado-Solomon 2020). They are constitutive of instrumental ties, and bundles of these can be summarized as instrumental networks (Crossley 2012; Fuhse 2022). Accordingly, who is involved in initiatives on follow-up projects depends on who is involved in instrumental networks. The literature on gender inequality in informal networks indicates that women are often less well integrated into instrumental networks in the work context and offers two theories to explain this: gender homophily and gender roles (Brands et al. 2022; Woehler et al. 2021).

Gender Homophily describes a higher probability for the formation of relationships between individuals with the same gender (Ertug et al. 2022; McPherson, Smith-Lovin, and Cook 2001). Since women are underrepresented in interorganizational R&D projects, the pool of gender-homogeneous interaction partners is smaller for them than it is for men. Although instrumental interactions between men and women do occur, homophily would result in women's instrumental networks being smaller because their informal networks tend to focus on the minority of other women (Burt 2019; Hofstra et al. 2022; Ibarra 1993).

Gender roles are socially shared, largely implicit ideas about how men and women behave. People internalize role expectations in the course of their socialization, orient their own actions to them, and set corresponding expectations for others (Mead 1934; Turner 1975). Role-inconsistent behavior tends to feel wrong and is more likely to be socially sanctioned (Biddle 1979). Instrumental interactions for initiating follow-up projects include openly articulating one's own competencies and interests. Role expectations for women, however, imply that they be modest, put their own interests aside, and take care of others (Eagly and Wood 1991; McClean et al. 2018; Nelson et al. 2023). Instrumental interactions are therefore more compatible with the agentic roles attributed to men. Following stereotypical gender role expectations, men are more prone to interact instrumentally (Berger, Benschop, and van den Brink 2015; Gray et al. 2024; Greguletz, Diehl, and Kreutzer 2019). Gender roles accordingly induce men to interact more instrumentally and thus to expand their instrumental networks more than women.

In this paper, we unfold three arguments. We first argue that initiatives on follow-up projects can be explained by the involvement in instrumental networks among partners in ongoing interorganizational R&D projects. Second, we argue that women are less likely to be involved in these instrumental networks and therefore less likely to participate in initiatives on follow-up projects. Third, we argue that women's weaker embeddedness in instrumental networks is driven more by stereotypical gender roles and less by homophily in interorganizational R&D projects.

Subsequently, we review the state of research on gender inequality and the key role of interorganizational R&D projects in this context. We then turn to theories explaining differences between men's and women's informal networks and unfold our arguments. Empirically, we examine the nexus between stereotypical gender roles, instrumental networking, and the engagement in initiatives on follow-up projects using data on 2746 directed and weighted personal relationships across 24 interorganizational R&D projects. For each relationship, we collected data on the strength of instrumental interaction relationships as well as the extent to which concrete initiatives on follow-up projects existed. Our statistical analysis of the data confirms our arguments. We thus conclude that stereotypical gender roles better explain gender differences in instrumental networks in R&D projects than homophily, and that the unequal likelihood of participating in follow-up projects can be explained by these differences.

2. Conceptual framework: gender, instrumental ties and follow-up collaborations

In interorganizational R&D projects, independent partners temporarily collaborate in order to creatively combine their heterogeneous resources (Spanos, Vonortas, and Voudouris 2015). Typically, the project partners work on their own work packages spatially separated from each other in their home organizations and coordinate their activities at regular meetings or in bilateral interactions between specific partners (Roth and Mattes 2023). Because interorganizational R&D projects have proven to be particularly productive for research and innovation, many countries offer public funding programs (Spanos, Vonortas, and Voudouris 2015). For partners in academia, interorganizational R&D projects are an important vehicle for implementing multi-year research projects with complementary partners. These are particularly fruitful for scientists, as they enable high-quality research and corresponding publications. Participation in interorganizational R&D projects therefore favors careers in academia (Lutter 2015; Whittington 2018). For partners from industry, the projects offer the opportunity to exploit recent scientific knowledge to develop innovations. By participating in the projects, employees from the industry have the opportunity to develop their expertise, to participate in shaping innovations and to benefit from successful innovations for their careers (Hewitt-Dundas, Gkypali, and Roper 2019; Spanos, Vonortas, and Voudouris 2015).

Follow-up projects are significantly more productive for both sides, which build on existing relationships, shared knowledge and jointly elaborated achievements (Bruneel, D'Este, and Salter 2010; Mannak et al. 2019). In such follow-up projects, selected partners continue their collaboration. At the same time, new partners are integrated in order to achieve new goals. The initiation of follow-up projects is an important access to (highly rewarding) R&D projects and the engagement in such initiatives is accordingly crucial for the career opportunities of the individual partners (Dahlander and McFarland 2013; Lutter 2015). We argue below that instrumental interactions in ongoing R&D projects are key for the involvement in follow-up project initiatives.

In organizational research, two types of informal interactions are distinguished (Methot and Rosado-Solomon 2020). Instrumental interactions are characterized by informally pursuing work- and career-related self-interests (Casciaro, Gino, and Kouchaki 2014; Ibarra 1993; Lincoln and Miller 1979). This includes information and advice sharing, self-promotion, and coordination of activities. These instrumental interactions are distinguished from expressive interactions (Kilduff and Tsai 2003; Methot and Rosado-Solomon 2020). Such are more effective and involve the informal exchange of

friendship and emotional support (Lincoln and Miller 1979; Methot and Rosado-Solomon 2020). Analytically, instrumental and expressive interactions are also addressed as instrumental and expressive – relationships or – networks. This is based on the assumption that relationships between individuals are formed by interacting with each other and forming expectations about future interactions based on past interactions (Crossley 2012; Fuhse 2022). Accordingly, having instrumental ties with each other means having performed instrumental interactions in the past and being likely to do so in the future based on this experience.

Two findings from research on the formation of interorganizational R&D projects indicate that instrumental interactions in ongoing R&D projects are crucial for participation in follow-up projects. First, research shows that instrumental interactions are the most important driver for the initiation of interorganizational R&D projects (Berends, van Burg, and van Raaij 2011; Brennecke and Rank 2016; Dahlander and McFarland 2013). Expressive interactions are beneficial because they create sympathy and closeness. However, instrumental interactions are key because in such interactions the specific resources and interests of partners are articulated and possible synergies can be found (Dahlander and McFarland 2013; Manning 2010). Second, follow-up projects are typically initiated while joint R&D projects are ongoing and only rarely afterwards (Bruneel, D'Este, and Salter 2010; Mannak et al. 2019). Joint R&D projects favor initiating follow-up projects through instrumental interactions because partners' awareness of each other is particularly high during projects (Gulati 1995; Manning 2010) and projects provide opportunities for instrumental interactions during informal encounters occurring around formal meetings (Roth and Mattes 2023; Schüßler and Sydow 2015). We therefore hypothesize that instrumental interactions among selected partners of ongoing R&D projects are critical in determining who is involved in initiatives on follow-up projects.

H1: Instrumental interactions in current projects explain joint initiatives to follow-up collaborations.

Furthermore, we argue that women have lower odds of participating in follow-up project initiatives because they are less connected in instrumental networks. The literature on gender inequality within social networks in the work context offers two explanations for this: stereotypical gender roles and gender homophily (Brands et al. 2022; Woehler et al. 2021). We argue that instrumental interactions in interorganizational R&D projects can be better explained by stereotypical gender roles than by gender homophily.

Gender homophily describes the tendency of men and women to prefer same-gender interaction partners (Ertug et al. 2022; McPherson, Smith-Lovin, and Cook 2001). This tendency is explained by differences in men's and women's socialization with respect to, for example, interests or communication styles. As a result, interactions among same-sex partners unfold more fluidly and more easily result in mutual understanding (Ertug et al. 2022; Lincoln and Miller 1979; McPherson, Smith-Lovin, and Cook 2001). In addition, same-gender individuals more easily develop trust and solidarity with each other (Ahlf et al. 2019; Tsui and O'Reilly 1989). Instrumental relationships among individuals of the same gender accordingly arise more readily because shared gender makes mutual interest in a relationship more likely and facilitates mutual understanding. Following these assumptions, strong instrumental relationships in interorganizational R&D projects are expected to be primarily found between men and between women, whereas instrumental relationships between men and women are less prevalent. Gender homophily leads to gender inequality in networks when men and women are

disproportionately represented in a context (Brands et al. 2022; Ibarra 1993). The supply of same-gender partners, with whom instrumental relationships are easier to develop, is then greater for the majority. As women are significantly underrepresented in interorganizational R&D projects, homophily grounds the expectation that they are weaker embedded in instrumental networks among project partners.

Stereotypical gender roles are also attributed to socialization-related differences between men and women. However, the gender role concept goes deeper than homophily in that it does not only focus on the fact that social roles are unequal, but instead examines more closely what the role differences are (Blackstone 2003; Eagly and Steffen 1984). It assumes that social roles such as man or woman are assigned to individuals according to social rules and are associated with role-specific behavioral expectations (Biddle 1979). Social roles and role expectations are subtly taught in the course of socialization and influence actions primarily in two ways (Goffman 1959; Mead 1934). On the one hand, individuals routinely conform to role expectations, and deviating behavior feels unnatural and wrong. On the other hand, expectations for others are routinely formed based on the social roles ascribed to them. If individuals deviate from these expectations, the disappointed individuals tend to evaluate this deviation negatively. Role-inconsistent behavior is thus socially sanctioned and role-consistent behavior socially incentivized (Heilman and Okimoto 2007; Rudman and Phelan 2008).

The network literature informed by role theory highlights that men's roles favor the formation of instrumental networks (Brands et al. 2022; Woehler et al. 2021). According to stereotypical gender roles, women are expected to be modest and to care altruistically for the needs of their community while men are expected to behave agentic and, accordingly, to pursue their own interests independently and competent against external opposition (Eagly et al. 2020; Heilman and Okimoto 2007; Spencer, Logel, and Davies 2016). Role expectations for men drive them to communicate their own achievements, abilities, and interests more openly than women, and thereby to pursue instrumental interactions (Exley and Kessler 2022; Rudman and Phelan 2008; Spencer, Logel, and Davies 2016). In contrast, when women behave in the same way, role expectations make them feel less comfortable, make it more likely that they will be socially sanctioned, and in consequence, make them more reluctant to engage in instrumental interactions (Benschop 2009; Greguletz, Diehl, and Kreutzer 2019; Rudman and Phelan 2008). Stereotypical gender roles accordingly drive men and restrain women in building instrumental networks (Brands et al. 2022; Gray et al. 2024; Woehler et al. 2021). Further, Brands and Kilduff (2014) show that women are expected to focus on interactions in their immediate social environment, whereas men are expected to engage in more brokerage and relationship building outside of their immediate social environment. In the application of stereotypical gender role expectations, women are accordingly more likely than men to feel uncomfortable and more likely to be socially sanctioned if they develop independent relationships with individuals outside of their own social environment (Brands and Mehra 2019; Zhang, Aven, and Kleinbaum 2024). Conversely, role expectations for men trigger them to form such relationships. Because partners in interorganizational R&D projects come from different organizations or even societal domains, instrumental interactions among partners can be interpreted as brokerage. Women who engage in (instrumental) networking with project partners thus risk violating this role expectation as well. Taken together, stereotypical gender roles disadvantage women in the formation of instrumental networks in interorganizational R&D projects because both instrumental interactions and brokerage are less compatible with roles of women. Considering stereotypical gender roles, we expect the strongest instrumental relationships in interorganizational R&D projects between

men (male dyads), since in this constellation both interaction partners are prone to seek instrumental interactions following gender roles. In contrast, we expect the weakest instrumental ties among women (female dyads), since here both interaction partners are restrained by gender roles to interact instrumentally, and moderately strong ties in gender-mixed dyads, since the different tendencies balance out here.

These role theory-based expectations contrast with the pattern that would emerge if homophily would significantly structure the formation of instrumental ties and intentions for joint follow-up projects. Homophily would explain that women, if they are the minority, are less involved in instrumental networks and (assuming H1 applies) in initiatives for follow-up projects. However, it would be expected that instrumental ties are equally strong in both female and male dyads. We subsequently argue that gender inequality in instrumental networks among partners in interorganizational R&D projects is driven more by stereotypical gender roles and less by gender homophily, because individuals in this context are more strongly defined by their professional expertise and are less familiar with each other.

Research on the salience of social categories shows that interaction partners are less likely to be perceived as men and women when their professional expertise is emphasized in a context (Bosak, Sczesny, and Eagly 2008; Brashears, Hoagland, and Quintane 2016; Spencer, Logel, and Davies 2016). The effects of gender homophily have been found in contexts where many individuals occupy similar formal positions (Hofstra et al. 2022; Ibarra 1992). In contrast, partners in interorganizational R&D projects are composed to complement their expertise, and collaboration is divided along the specific areas of knowledge. We therefore suspect that partners in interorganizational R&D projects categorize each other more on the basis of their expertise and less on the basis of their gender. Since the application of gender categories is fundamental to homophily, we suspect that the formation of instrumental ties in R&D projects is only weakly structured by homophily because gender is less salient in this context.

The effectiveness of gender roles can also vary between social contexts (Bosak, Asbrock, and Meyer 2021; Fiske and Neuberg 1990). However, while characteristics of individuals can easily be emphasized or concealed by contextual conditions (and can then trigger corresponding homophily more or less), routines habitualized through socialization, in which gender role-specific behavior is anchored, are less sensitive to contextual conditions. We therefore assume that in contexts that suppress gender homophily, gender roles are generally more prominent in the formation of networks.

Furthermore, we argue that the context of interorganizational R&D projects is particularly conducive to gender-role-conforming behavior. Gender roles provide orientation especially when interaction partners are less familiar with each other (Berger and Calabrese 1975; Fuhse and Gondal 2024). Partners in interorganizational R&D projects typically meet each other for the first time in the projects and work most of the time rather autonomously and spatially separated. Accordingly, when they meet sporadically, they are less familiar with each other than, for example, members of organizations that have met on a daily basis for years. We hypothesize that the lower familiarity with each other makes partners in interorganizational R&D projects more likely to orient their interactional behavior toward social roles than individuals in more permanent work contexts.

Given the more pronounced expertise categorization, the greater context independence of routinized gender roles, and the stronger social role orientation, we hypothesize that instrumental interactions in the context of interorganizational R&D projects are less structured by gender homophily and more significantly by gender roles. We explained above that gender homophily and gender roles give rise to different expectations about which gender constellations are more or less conducive to instrumental interactions.

Gender role theory implies that men are more inclined to engage in instrumental interactions when they behave in a gender role-conforming manner, while gender roles for women rather cause them to be reluctant to engage in instrumental interactions. Accordingly, we expected that instrumental interactions and resulting follow-up collaborations occur most frequently between men, less frequently in mixed-gender dyads and least frequently among women. In contrast, if homophily would structure the interaction behavior significantly, we would expect a similarly high level of instrumental interaction among men and among women.

H2: Engagement in instrumental interactions is highest in male dyads, lower in mixed dyads, and lowest in female dyads, and these differences explain corresponding gender inequalities regarding participation in follow-up project initiation.

3. Methods

3.1. *Research setting*

Our data are based on information about interorganizational R&D projects from [a funding program], which funded 26 projects. Each individual project was funded with an average of about 1.6 million euros. Of these 26 government-funded projects, we can use data from 24 projects for the purpose of this study. Each project involves an average of seven independent organizations, half of which are academic (universities and non-university research institutes) and half of which are in industry (companies with a maximum of 1000 employees and a maximum annual turnover of 100 million euros). The focus of the funding line is the virtualization of organizations (BMBF 2016). In line with the focus of the funding line, the academic partners are primarily based in the social sciences and engineering. The participating companies represent a broad spectrum of industries. The most strongly represented is the construction industry. For the industry partners the projects aim to leverage the innovation potential of firms in the area of work design and organization through digitization projects. For the academic partners, the project goals are to investigate digitization processes based on the current state of research and to disseminate related findings in the form of publications. In all cases, the projects are scheduled to run for three years and are largely decentralized. In practice, this means that the various partners work on independent tasks at separate locations (due to funding conditions all in Germany, on average 122 km away from each other) and only meet physically or virtually on specific occasions and in different partner constellations for joint workshops. These meetings offer all partners opportunities for informal interactions, which can be instrumental or expressive.

Furthermore, the partners involved in current projects are particularly suitable as partners for future projects. In order to be funded, all projects had to submit detailed applications justifying how the competencies of the individual partners complement each other in a meaningful way with regard to the project goals. Since this requirement was communicated in the call, the selection of partners by the project initiators is already highly selective. In addition, the composition of the consortium is an important criterion in the evaluation of the projects for funding. The 24 projects under consideration are a selection of more than 100 project applications that were submitted, which are characterized, among other things, by particularly promising consortia. As a result of this double selection process, we assume that the partners in the consortia are particularly suitable as partners for future projects. Even if follow-up collaborations might not become

obvious for all partners, considering that in each project on average seven organizations and 12 persons are involved, we assume that all individuals have the opportunity to find potential partners for follow-up projects within the consortium. Accordingly, the projects provide both a reason and an opportunity for project partners to initiate follow-up projects through instrumental interactions. The projects in the selected funding line are therefore suitable for the investigation of the research question being focused on here.

Finally, the projects in the funding line are suitable for comparative analysis of the patterns of interaction of men and women because the proportion of women in the funding line is representative of interorganizational R&D projects. Overall, 30% of those engaged in the 24 projects are women. This corresponds to the proportion reported by UNESCO for interorganizational R&D projects worldwide and to that reported for Germany. Furthermore, it is favorable for the intended comparison that the share of women is almost identical when partners from academia and industry are considered separately. Among the representatives of academia, the share of women is 31%, while in industry it is 29%. This symmetrical distribution favors a comparison between men and women.

3.2. *Data collection*

Data collection was carried out for all 24 projects after one year of project duration using a relationship questionnaire (Wasserman and Faust 2014, 42). In the questionnaire, each individual engaged in one of the project teams was asked about the strength of different forms of relationships and interactions with all other team members outside their own organization. In order to identify the individuals engaged in the projects, we consulted with the project leaders about this in advance. In the questionnaires, all names of project partners (excluding direct colleagues) were listed for each question, and a seven-point Likert scale, ranging from *not at all* to *a great extent*, was offered after each name (Joshi et al. 2015; Marsden 2005). Three questions were asked to capture the constructs that are central here. To elicit the extent of instrumental interactions the following question was asked:

1. *To what extent did you discuss professional issues beyond the scope of the project with ... ?*

In the literature, instrumental ties are defined, in addition to the focus on professional topics, by the ability to acquire resources that are of instrumental value (Ibarra 1993; Methot and Rosado-Solomon 2020). In the question, we excluded interaction outcomes in order to be able to survey these independently. Analogously, to capture expressive interactions, we asked the following question:

2. *To what extent did you discuss private issues with ... ?*

Finally, to capture concrete initiatives relating to joint follow-up initiatives, we asked about the extent of these:

3. *To what extent do you have concrete plans to continue the collaboration with ... beyond the current project?*

Responses were again provided using the seven-point scale (*not at all* to *a great extent*) for each project partner. The data collection was announced by the project leaders. In each case,

it was pointed out that the survey was supported by the institution funding the projects. Subsequently, all participants were invited by personal emails to complete the questionnaire within one week. Afterwards, reminders were sent up to two times.

The projects started in a staggered manner and consequently the data collection, which was oriented to the respective project lifetime, was also carried out in a staggered manner between the end of 2019 and the beginning of 2021. In early 2020, the Covid-19 pandemic prompted the German government to severely restrict personal contact through corresponding regulations. In 15 of the 24 projects, data collection was completed before then. The remaining 9 projects were strongly affected by the restrictions. Research on the consequences of the pandemic indicates that women were more stressed than men by young children who were not allowed to go to school or kindergarten during this time (Fodor et al. 2021). To include data from the 9 projects could be biasing then, because it could reinforce the inequality between men and women that we are interested in examining here. However, our data show that men and women in the 9 affected projects are even more similarly engaged in interactions with project partners (at lower levels) than in the 15 projects not affected by the pandemic and furthermore, that the explanations we will present here also apply to them. We will therefore draw on the entire data set from 24 projects in the analysis.

Our explanation of inequality focuses on instrumental ties. To control for alternative explanations in the empirical analysis, we collected some additional variables. Besides the expressive dimension of ties, the literature suggests that other dimensions of relationships can influence instrumental interactions and the initiation of follow-up projects, which could also be related to gender. Specifically, we consider the degree of familiarity between individuals as a possible confounder of the relationship of gender, instrumental ties, and follow-up collaborations (Berends, van Burg, and van Raaij 2011; Faems, Janssens, and van Looy 2007). As for the variables discussed above, we use a seven-point Likert response scale on the question 'How well do you know … ?'. Furthermore, the literature suggests that men and women may be unequally attractive in relation to follow-up projects because their resources differ in quantity and quality (Lutter, Habicht, and Schröder 2022; Woehler et al. 2021). To control for this, we coded what type of organization the individuals in the project represent and what formal status they hold in the respective organization. To capture formal status, we assigned each person to one of three status levels (low: graduate researcher/employee without managerial responsibilities; medium: doctoral researcher/employee with managerial responsibilities; high: manager/professor). The participating organizations were classified as Scientific institutions, Small and Medium sized Enterprises (SME), Consultancies, and Technology suppliers.

A total of 272 out of 276 invited individuals participated in the survey (85 women and 187 men), resulting in a 98.5% response rate. We can therefore rule out bias due to self-selection. In total, we collected 2746 directed relationships between project partners from different organizations for all of the three questions. The data include a small share of item non-response. Our analytical sample thus consists of 2373 directed and weighted ties.

3.3. *Data analysis*

We use each of the 2373 ties as a single observation in regression analyses and decompositions. Since these observations are not independent from each other, we report clustered standard errors with respondents as clusters.

With the multivariate OLS-models we test how much the willingness to engage in future collaboration depends directly on instrumental ties – everything else equal (H1).

If our claim is in line with the data, we should observe an *independent* influence of both on the willingness to engage in future collaborations after isolating these influences from each other and further influences, like social status.

We furthermore theorized that both genders engage differently in the corresponding interactions, and that this explains gender differences in initiatives for follow-up collaborations (H2). In order to test this claim, we estimate Kitagawa-Oaxaca–Blinder-decompositions using Jann's (2008) Stata implementation. Such decompositions estimate how much a difference between two groups rests on different distributions of characteristics between them or on different influences of characteristics for each group. For example, on the one hand, the overall difference in the willingness to engage in future collaborations could be a result of women's lower levels of instrumental ties in comparison to men. We refer to that as a *level effect*. On the other hand, instrumental ties could increase the willingness to engage in future collaboration more for men compared to women. In such a case, the overall gender difference in collaboration willingness would still appear even if men and women had the same level of instrumental ties. We refer to this as a *return effect*.

One challenge of decompositions is that they can only be calculated between two groups, like men and women. In our case, we have *three* groups based on different gender-compositions of dyads: male, mixed, and female. We use male dyads as reference (M/M) and calculate two group differences in average willingness to engage in future collaborations: the difference between male dyads and mixed gender ties as well as the difference between male dyads and female dyads. The formal decomposition model can be expressed as follows (with G as either a mixed or female tie):

$$\underbrace{\overline{C_{M/M}} - \overline{C_G}}_{\text{overall difference}} = \underbrace{(\hat{\boldsymbol{\beta}}_{M/M} - \hat{\boldsymbol{\beta}}_G)\bar{\mathbf{X}}_G}_{\substack{\text{contributions due to} \\ \text{different returns}}} + \underbrace{(\bar{\mathbf{X}}_{M/M} - \bar{\mathbf{X}}_G)\hat{\boldsymbol{\beta}}_{M/M}}_{\substack{\text{contributions due to} \\ \text{different levels}}}$$

The $\hat{\beta}$-coefficients for this calculation result from linear regression models for each type of tie. The coefficients are then multiplied with the average values of the type of tie ($\bar{\mathbf{X}}$)**.** The first part of the right-hand side refers to the *return effect*. For the case of the difference between male dyads and mixed gender dyads, it calculates the counterfactual if mixed both type of ties had the *same levels* in all tie-characteristics but would only differ in their returns. The second part refers to the *level effect* and calculates the counterfactual if male dyads and mixed gender ties had different levels of characteristics but would yield the same returns from all of them.

4. Findings

4.1. *Bivariate results*

In line with our expectations about gendered patterns in intentions to follow-up collaborations (H2), we calculate the highest scores for future collaboration intentions for male dyads, the lowest ones for female dyads, and intermediate scores for mixed-gender dyads (Figure 1(A)). Compared to male dyads, mixed ones have 0.54 lower future collaboration ratings and female dyads 0.69 lower ratings on average on a seven-point scale. Furthermore, we calculate a difference between mixed and female dyads of about −0.16, which is statistically not significant (s.e. = 0.151).

As for the case of intentions to follow-up projects, we observe strong gendered patterns regarding instrumental ties (Figure 1(B)). This is in line with our claim that men engage more in instrumental interactions (H2). Men form the strongest instrumental ties with each other. Compared to them, the average instrumental tie strength of mixed-gender dyads is 0.68 points lower and that of female dyads 0.75 points lower. Again, the difference between mixed-gender and female dyads is not statistically significant.

For expressive ties, we observe very similar patterns as those observed for instrumental ties (Figure 1(C)): men form the strongest expressive ties with each other. The average score of expressive ties in female dyads ranks second. Mixed-gender dyads have the lowest average score.

In sum, these patterns deviate from expectations of gender homophily. Male dyads score significantly higher in any tie characteristic compared to female dyads. This pattern is a first hint that gender role expectations may play a strong role in the formation of instrumental networks in interorganizational R&D projects.

The strength of instrumental ties correlates strongly with future collaboration intentions (Figure 2). Across all dyads, we calculate a linear correlation of 0.66. Within male dyads, both aspects seem to be more linked ($r = 0.71$) compared to mixed-gender dyads ($r = 0.61$) and female dyads ($r = 0.51$). This tentatively speaks in favor of gendered-specific returns of instrumental ties, which seem to be more rewarding for men than for women.

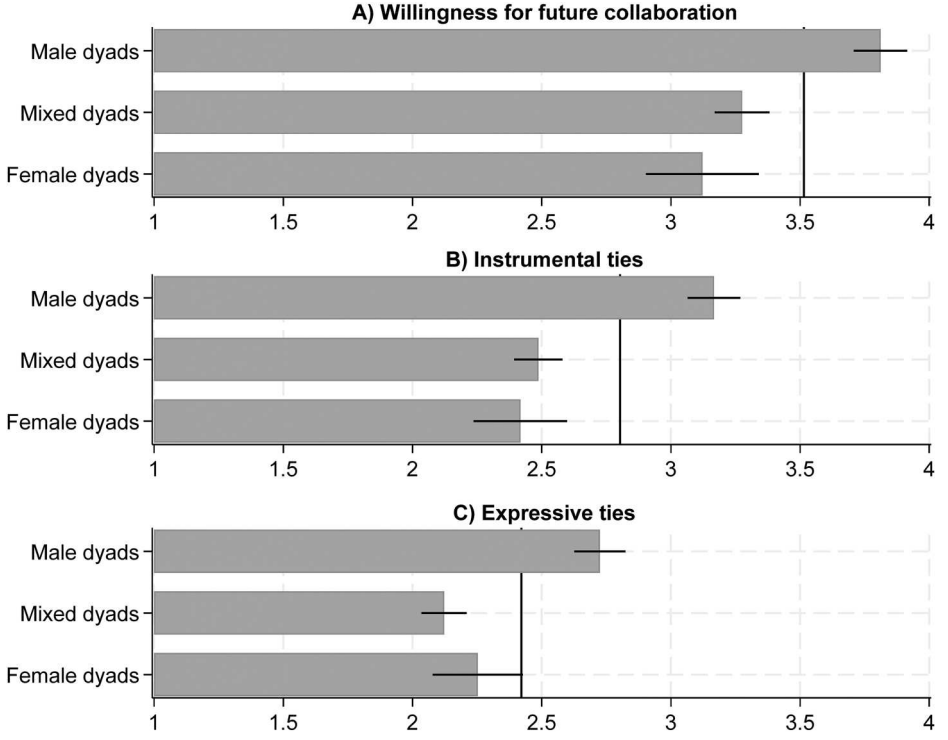

Figure 1. Average assessments of the strength of interactions across gender relations within exchange networks. Gray lines refer to 90% confidence intervals. Horizontal lines refer to the overall averages for the variable. All items used a seven-point Likert response scale.

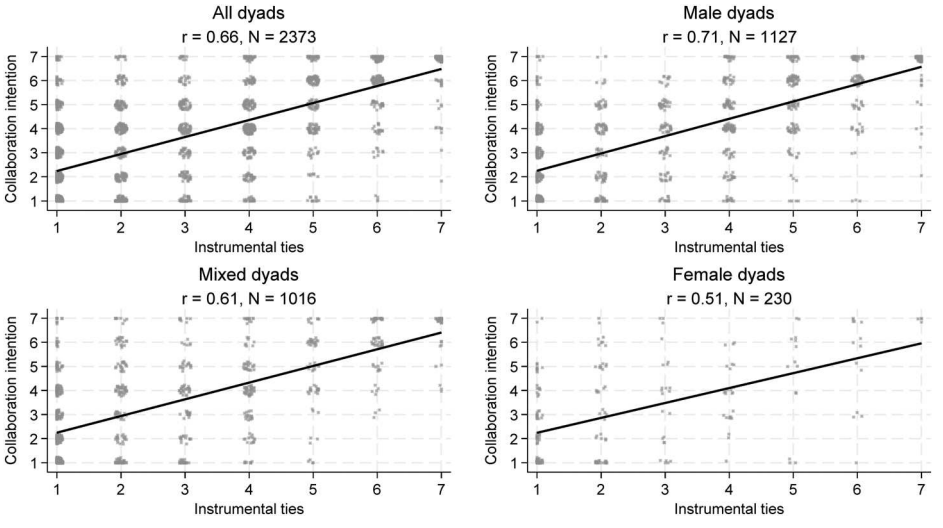

Figure 2. Correlation between instrumental tie strength and future collaboration intentions for all ties and conditional on the alter/ego gender composition. Jittered data points with linear fit.

We do not calculate such large gender-specific differences for the correlation of instrumental and expressive ties. Overall, this association is quite strong ($r = 0.68$). Again, we calculate a marginally stronger association within male dyads ($r = 0.70$) compared to mixed-gender dyads ($r = 0.64$) and female dyads ($r = 0.68$). These results are in line with previous research showing that expressive and instrumental ties are not separate dimensions but are closely linked (Casciaro and Lobo 2015; Ibarra 1992).

4.2. *Multivariate results*

Our multivariate results show a sizable gender gap in collaboration intentions, which mostly vanish after controlling for the strength of instrumental ties (Table 2). The first model shows the raw gender gaps between male dyads vs. mixed-gender and female dyads. Controlling for the type of the organization, the status of the source and target, as well as how well both parts of the dyad know each other, leads to a reduced gap in collaboration intentions between male vs. mixed-gender dyads (Table 1, M2). The gap between male and female dyads remains basically the same size. Thus, it is very unlikely that the estimated disadvantage of female as against male dyads is based on organizational differences. It is also notable that most organization-level covariates are statistically not significant for explaining differences in the willingness to engage in future collaboration, adding further credence to our claim that organizational contexts play a minor role in such project settings.

In models 3–5 within Table 1, we assess whether the disadvantage of female dyads in regard to future collaboration remains if we compare dyads that have the same strength of instrumental and expressive ties. In model 3, we compare ties with different gender compositions and the same level of instrumental ties (holding all other controls constant). This reduces the gender gaps substantially and each gap is no longer statistically significant. Model 4 compares ties with the same level of expressive ties, which also reduces the estimated gaps between ties of different gender composition but not as strongly as does the instrumental ties. Thus, overall, these results do not speak in favor of a direct

Table 1. Multivariate results for the willingness to engage in future cooperation.

	M1	M2	M3	M4	M5
Gender composition (R.: male)					
Mixed	−0.54***	−0.28*	−0.06	−0.10	−0.02
	(0.15)	(0.12)	(0.11)	(0.11)	(0.11)
Female	−0.69**	−0.60**	−0.21	−0.38^{+}	−0.19
	(0.24)	(0.21)	(0.20)	(0.21)	(0.20)
Instrumental ties			0.52***		0.40***
			(0.04)		(0.05)
Expressive ties				0.39***	0.19***
				(0.05)	(0.05)
Controls	No	Yes	Yes	Yes	Yes
Constant	3.81***	1.24***	1.00***	0.92***	0.90***
	(0.13)	(0.25)	(0.21)	(0.23)	(0.21)
Observations (ties)	2373	2373	2373	2373	2373

Notes: Standard errors in parentheses. Controls: organization type for alter and ego, social status of alter and ego, mutual knowledge of each other.
$^{+}p < 0.10$.
$^{*}p < 0.05$.
$^{**}p < 0.01$.
$^{***}p < 0.001$.

gender influence on collaboration intentions *independent* of the level of instrumental and expressive ties (H2).

Lastly, model 5 reveals that instrumental ties are more important for differences in the willingness to collaborate in the future compared to expressive ties, which is in line with our expectations (H1). According to model 5, an increase of one unit in instrumental tie strength is almost twice as important as a one-unit increase in expressive tie strength.[1]

In sum, the linear models show a consistent, reduced willingness to engage in future collaborations in women-only dyads – independent of the strength of instrumental and expressive ties as well as a large set of organizational characteristics. Furthermore, the strength of instrumental ties is the single most important predictor for the willingness to engage in future collaborations.

We furthermore claimed that both genders engage differently in the corresponding interactions, and that this explains gender differences in initiatives for follow-up collaborations (H2). That is, we expect that different returns to instrumental ties play a minor role for the overall gap in comparison to the gender-specific engagement in them. In order to analyze this question, we calculated decompositions in addition to the models presented above. It is not only important to know whether gender gaps appear even if dyads are otherwise comparable, it is also crucial to know which characteristics contribute how much to the observable gap.

For the previous results, we compared ties conditional on various characteristics. In a second step, we assess whether the overall gaps in the willingness to engage future collaborations across ties with different gender compositions, as shown in model 1, are mainly driven by different levels of instrumental ties or their returns. It is not only important to know whether gender gaps appear even if dyads are otherwise comparable: for organizations, it might also be crucial to know which characteristics contribute how much to the observable gap.

The results of the decompositions reveal that different levels of instrumental ties are the most important explanation of the disadvantage of female dyads compared to male dyads,

Table 2. Contributions to differences in the willingness to collaborate in the future for women as the target and the source.

	M6: Male vs female dyads		M7: Male vs mixed-gender dyads	
Difference	−0.69**		−0.54***	
	(0.24)		(0.14)	
Overall levels	−0.56**		−0.54***	
	(0.26)		(0.11)	
Overall returns	−0.13		0.00	
	(0.24)		(0.12)	
	Levels	**Returns**	**Levels**	**Returns**
Instrumental ties	−0.31*	−0.07	−0.24***	−0.25
	(0.13)	(0.47)	(0.06)	(0.24)
Expressive ties	−0.02	−0.40	−0.13	0.07
	(0.06)	(0.38)	(0.07)	(0.29)
Ego: organization type	0.03	−0.05	0.01	0.05
	(0.04)	(0.15)	(0.02)	(0.08)
Alter: organization Type	0.07	−0.13	−0.01	−0.03
	(0.03)	(0.10)	(0.01)	(0.07)
Ego: social status	−0.26	0.10	−0.04	0.02
	(0.14)	(0.06)	(0.03)	(0.03)
Alter: social status	−0.06	0.03	−0.03	0.02
	(0.09)	(0.03)	(0.02)	(0.02)
Mutual knowledge of each other	−0.01	0.07	−0.11*	0.39
	(0.05)	(0.47)	(0.04)	(0.27)
Constant		0.32		−0.25
		(0.36)		(0.23)
N (ties)		1357		2143

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

which is in line with our expectations (H1). Different levels of strength of instrumental ties explain almost half of the gap (−0.31 of −0.69 points). All other variables are statistically not significant in this decomposition, including the level of, and returns on, expressive ties. Overall, we do not estimate any significant role of different returns on characteristics or ties for the gap in the willingness to engage in future collaboration across gender-specific types of ties. This suggests that the forming of instrumental ties is the single most important driver of gender gaps in follow-ups to interorganizational R&D projects.

In a second step, we assess whether the overall gaps in the willingness to engage future collaborations across dyads with different gender compositions, as shown in model 1, are mainly driven by different levels of instrumental ties or their returns (Table 2). This second decomposition explains the gap between the collaboration intentions of male and mixed-gender dyads. The results are largely comparable to the first decomposition. Again, different levels of instrumental ties explain half of the overall gap between groups (−0.24 out of −0.54 points). We also estimate a negative contribution of lower levels of mutual knowledge in mixed-gender dyads.

In sum, the decomposition results underscore our claim that the level of instrumental ties is the most important contribution for the intention to collaborate in the future. They also show that women have sizably lower levels of instrumental ties but do *not* suffer from different returns on them.

5. Discussion and conclusion

Women are underrepresented in interorganizational R&D projects worldwide. This is problematic since women's career opportunities suffer from their absence (Hofstra et al. 2022; Lutter, Habicht, and Schröder 2022), the unequal involvement of men and women has a negative impact on project performance (Wu et al. 2021; Xie et al. 2020), and women consequently have less influence on the design of innovations, with the result that the shaping of the world through innovation is primarily driven by and based on the unquestioned assumptions of men (Mickey and Smith-Doerr 2022; Pecis 2016; Pinch and Bijker 1984). Hence, how the underrepresentation of women in interorganizational R&D projects occurs is a pivotal question. Prior research suggested that initiating follow-up projects during current collaborations is an important pathway to access (Hewitt-Dundas, Gkypali, and Roper 2019; Mannak et al. 2019). Following on from this, in our paper we analyzed 2376 ties from 24 interorganizational R&D projects to show that women are engaged in the initiation of follow-up projects significantly less often than men. Furthermore, we were able to explain this disparity by reference to the less intense involvement of women in instrumental networks between collaborators. The paper thereby contributes to the state of research in three ways.

The first contribution lies in having identified the initiation of follow-up collaborations during current projects as a critical practice for the production of gender inequality in research and development. Previous research has already identified a number of causes for the underrepresentation of women in this area (Jadidi et al. 2018; Mickey and Smith-Doerr 2022). Among these is the poorer inclusion of women in collaborative networks that can be used to initiate interorganizational R&D projects (Greguletz, Diehl, and Kreutzer 2019; Whittington 2018). However, research on the origins of interorganizational R&D projects indicates that such relationships are especially leveraged when opportunities exist. Current interorganizational R&D projects provide such opportunities and are therefore an important source for the emergence of further interorganizational R&D projects (Berends, van Burg, and van Raaij 2011; Mannak et al. 2019). Our analysis shows that women are less likely to take advantage of these opportunities. Assuming that the initiatives observed here translate into follow-up projects, our findings suggest that instrumental interactions in ongoing R&D projects are an important driver of gender inequality in research and development as a whole. Further research should accordingly continue to focus on this crucial but so far poorly analyzed cause of inequality in this field.

The second contribution is that we were able to explain women's poorer involvement in follow-up initiatives based on women's lower engagement in instrumental interactions with project partners. The central role of instrumental interactions in the initiation of follow-up projects and the emergence of inequality in this context contrasts with resource-based explanations of inequality. The resource-based perspective assumes that women are less likely to be considered as potential project partners because their resources are not recognized (devaluation) or because they lack resources (Lutter, Habicht, and Schröder 2022; Ochsenfeld 2014). Our findings challenge these assumptions. First, our data shows that individuals' status (which we interpret as a proxy for their resources) does not explain their involvement in initiatives to follow-up projects, but instrumental interactions do. Second, our analysis shows that women would be preferred as partners for future interorganizational R&D projects if they had the same instrumental ties (resources in the sense of social capital) as men. Our findings thus imply that neither unequally distributed resources nor the devaluation of women's resources account for unequal chances as regards engaging in follow-up projects, but rather engagement in

instrumental interactions does. In addition to showing which characteristics are important in the selection of partners, our findings help to more adequately conceptualize the social process of initiating follow-up projects. Resource-based approaches assume that individuals attribute resources to each other and seek or reject partnerships in light of the expected benefits of those resources (Eisner, Rahman, and Korn 2009). However, our findings suggest that the occurrence of instrumental interactions is crucial. The occurrence of instrumental interactions is strongly driven by opportunities, which are structured by the spatial and social structures of everyday life (Roth 2023; Toker and Gray 2008). Accordingly, it seems appropriate to focus more systematically on constitutive everyday practices and their structural preconditions, in addition to the cognitive process of partner selection, in order to explain the formation logic of follow-up collaborations.

Our third contribution concerns this very emergence of instrumental interactions. Previous research has attributed differences in men's and women's instrumental networks to gender homophily (Hofstra et al. 2022; Ibarra 1993). We argued that gender homophily is less powerful in interorganizational R&D projects, because individuals here are defined more by their expertise and less by gender, and contact among partners tends to be sporadic. Under these conditions, we propose, stereotypical gender roles are a major driver of gender differences in instrumental networks. Following this theory, we hypothesized that women are both less likely to seek instrumental interactions (with men or women) and less likely to be sought out for instrumental interactions (by men or women). Our results clearly support this conjecture. Contrary to homophily theory, instrumental relationships are not weakest in mixed relationships but are weakest between women. At the same time, instrumental relationships are strongest between men. However, this picture is fully consistent with expectations based on gender role theory (Eagly et al. 2020; Gray et al. 2024). Accordingly, our study provides evidence for the utility of gender role theory for this context. Furthermore, it provides clues as to the conditions in which one of the two explanations carry more weight: in contexts where individuals with similar job profiles work in copresence, gender homophily tends to come to the fore, whereas in more transient contexts with a strong profile differentiation, stereotypical gender roles structure interactions more strongly.

5.1. *Practical implications*

Women's unequal participation in interorganizational R&D projects is a key societal challenge. Our findings offer some indications regarding practical measures that can be taken to combat this inequality. First, given the high importance of interactions, we believe it is appropriate to focus measures on creating interaction opportunities that make it easier for women to engage in instrumental interactions. Specifically, formal interaction situations that explicitly focus on instrumental interaction and the initiation of follow-up projects could be created. Second, given their lower propensity to interact instrumentally, measures that promote women-only networks would appear to be less beneficial. Rather, mixed-gender dyads should be promoted or complementary measures should be implemented to promote instrumental interactions between women.

5.2. *Limitations and future research directions*

The first limitation of our paper is that we only explain initiatives relating to follow-up projects. It is conceivable that while men are significantly more likely to be involved in such initiatives, the initiatives in which women are involved are more likely to be realized.

Further research should investigate to what extent the chances of men and women also differ in regard to the realization process.

Second, we have empirically focused on a specific context: digitization projects in Germany. Gender role expectations are culturally shaped (Eagly 2009). It is therefore an important question whether their characteristics produce different patterns in other cultural contexts. Furthermore, we assume that the content of the initiated projects also has an effect on how far interactions directed toward them are compatible with gender role expectations. For example, the focus on digitization may be less in line with the role expectations for women than projects that aim to improve care, so that the inequality here could be lower.

Our data clearly indicate differences in interaction behavior. However, on the basis of the mixed relationships, it can also be shown that women evaluate the same relationships less strongly than men. This observation is consistent with research on cognitive social structures and the assumption that role expectations influence not only actions but also perceptions (Brands 2013; Brands and Mehra 2019; Zhang, Aven, and Kleinbaum 2024). Following on from this, it seems possible that women exploit relationships less because they undervalue their own networks. Therefore, in further research it would be productive to examine valuation differences and their consequences in more detail.

Note

1. Note that we use the same response scale across all tie items. This allows us to compare the size of the coefficients without standardizing them.

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Ethics declarations

All participants provided written informed consent prior to enrollment in the study. The study did not require the approval of an ethics committee as it was carried out strictly on the basis of the German Data Protection Regulation.

Data availability statement

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data is not available.

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