Investigating the Performance Effects of Diversity Faultlines in IT Project Teams

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Abstract

To complete complex and knowledge-intensive tasks, IT work critically relies on the interaction of team members. While heralded as a contribution to performance, diversity is also linked to negative team outcomes. Given the critical role of team collaboration, we investigate the effects of diversity on performance in IT projects. Drawing on faultline theory as a measure of diversity, we develop and test hypotheses on the performance effects of the strength of identity- and knowledge-based faultlines and the number of resulting factions in 424 IT projects. While insignificant, knowledge-based faultlines positively relate to performance. The number of potential group divisions has a positive effect if identity-based and a negative effect if knowledge-based. Unexpectedly, we find identity-based faultlines to significantly improve performance. Findings are of value to research by furthering knowledge on the specifics of IT work and effects of diversity. For practice, we provide important considerations for how teams can be designed to achieve superior outcomes.

Keywords: IT work; teams; diversity; faultlines; performance; project; collaboration

Introduction

Information Technology (IT) projects are commonly carried out by teams as collections of employees brought together to contribute their individual competences (Faraj and Sproull 2000). Working in IT exhibits specific traits: IT work is highly knowledge-intensive and critically depends on the ability of team members to coordinate work on interdependent objects, as well as to process and exchange information (Faraj and Sproull 2000; Kudaravalli et al. 2017; Malone and Crowston 1994). Consequently, constant interaction of team members is needed (Espinosa et al. 2007; Faraj and Sproull 2000; Kudaravalli et al. 2017). In addition to the task, IT work exhibits a characteristic, homogeneous workforce with a continuing minority proportion of females (Armstrong et al. 2018; Korrigane 2019). The typical worker in IT is male, 35 years old, and has a high level of education (Korrigane 2019). Further solidifying the homogeneous nature of IT workers, the rapid evolution of required technical skills implies the emergence of clusters of employees of similar ages and with similar backgrounds (Zhang et al. 2012).

To reap benefits from different competencies of employees, teams are frequently assembled specifically to draw on diverse capabilities (Tiwana and McLean 2005). Whether due to differences in education or demographics, diversity is expected to increase the pool of knowledge and experiences the team can draw upon to develop cognition, solve problems, and to come up with creative solutions (DeChurch and Mesmer-Magnus 2010; Lau and Murnighan 1998). Diversity specifically enables team members to apply their knowledge individually and then integrate their outcomes in the group (Van Knippenberg et al. 2004). Such group-level integration of knowledge is the key driver of positive effects of diversity in IT work (Tiwana and McLean 2005).

While teams seek diversity to achieve the benefits mentioned above, diversity has also been frequently found to cause negative effects, thus being called "a double-edged sword" (Milliken and Martins 1996, p. 403). While relations are complex, diversity can lead for example to conflictive behavior, which in turn may inhibit effective teamwork (De Wit et al. 2012; Pelled et al. 1999). On an affective level, diversity can reduce satisfaction and the sense of belonging to a particular group (Milliken and Martins 1996). Moreover, diversity can increase turnover intentions (Jehn et al. 1999).

Social faultlines are a popular and corroborated approach to investigating diversity. Analogously to faultlines in the crust of the earth, they are hypothetical schisms in teams created by attributes that align to form a distinct division between members on either side of the faultline (Lau and Murnighan 1998). If, for example, a team is comprised of five young male programmers and two middle-aged female managers, age, gender, and job title form a distinct faultline. Embraced by many researchers, results on the effects of diversity using the faultline concept mirror the varied findings on diversity in general. Results see faultlines causing both positive and negative outcomes, from group clashes and animosity to improved knowledge processing (Carton and Cummings 2012; Cooper et al. 2014; Thatcher and Patel 2011). Faultlines based on identity attributes such as gender and age likely lead to negative outcomes through categorization in subgroups, whereas faultlines based on differences in knowledge can propel performance by making information processing more efficient (Carton and Cummings 2012).

This recollection of results in general team research gives rise to the question how faultlines affect work in the specific context of IT projects. As outlined above, IT work is highly knowledge-intensive to conduct complex interdependent tasks, which results in a constant need for team coordination and joint interaction (Espinosa et al. 2007; Faraj and Sproull 2000; Kudaravalli et al. 2017). With communication issues being key contributors to failure of IT projects (Charette 2005), ensuring a smooth flow of communication is thus a key concern in increasing project success. We thus expect to find identity-based faultlines to disrupt teamwork based on negative categorization, whereas knowledge-based faultlines as conduits of information sharing likely increase performance (Carton and Cummings 2012).

To shed light on the effects of faultlines on the performance of IT work, we investigate the prevalence and effects of faultlines based on identity and knowledge using data on 424 IT projects. First, we present background information on IT work and faultlines in general. Based on this theoretical background, we develop hypotheses on the performance effects of the strength of identity- and knowledge-based faultlines and the number of resulting group factions. After detailing the empirical method, we present and discuss results. We end with a conclusion of our results and their contributions to research and practice.

Background

In the following, we provide background information on IT work and its critical reliance on team interaction. Secondly, we introduce the faultline concept and summarize key results on observed effects.

IT Work

Work in IT is a special context shaped by factors such as task-based work practices, organizational aspects, as well as traits of teamwork and individual characteristics. In the following, we will detail these aspects as they relate to the challenge of effective teamwork. As opposed to goods in manufacturing, tasks in IT work require knowledge as their primary input (Faraj and Sproull 2000). Since IT artifacts are in a modularized structure with interdependent elements, IT workers have to coordinate the structure of the artifact as well as the tasks and interactions needed to create it (Kraut and Streeter 1995; Malone and Crowston 1994). Given the diversity of knowledge required in IT work, the requirement to coordinate transcends to the diverse expertise of members (Faraj and Sproull 2000). In order to address these organizational issues, IT work relies on methods and intense levels of collaboration between individuals (Faraj and Sambamurthy 2006).

To bring all required competences and areas of knowledge to bear, IT work is often organized around projects, which are frequently carried out in teams (Faraj and Sproull 2000). While teams are a dominant theme of current organizational practice in general (DeChurch and Mesmer-Magnus 2010), the fast-paced and project-dependent nature of IT work has specific effects. To bring in even more diverse competencies, membership may change or external parties may be involved (Espinosa et al. 2003). The observation that

IT workers are overall highly empowered to make decisions in their work (Tessem 2014) can be readily understood since much of the complexity in IT projects stems from the underlying tasks and artifacts, which require team members to draw on their individual knowledge. As a result, members have to interact to align their work (Espinosa et al. 2007; Faraj and Sambamurthy 2006; Kudaravalli et al. 2017).

The individual knowledge and cognitive abilities of team members are a prerequisite to carrying out these complex tasks. While individual cognition is the basis for performance, integration of individual abilities is critical in achieving creative outcomes (Tiwana and McLean 2005). Preceding integration, coordinating the application of distributed knowledge is of key importance (Faraj and Sproull 2000). These considerations are also at the heart of development methods. As a prominent example from agile development, pair programming requires joint elaboration of information (Balijepally et al. 2009). Moreover, integrating different methods requires knowledge sharing (Przybilla et al. 2018a). In addition to the expected technical coordination, "softer" aspects such as the timing of activities and process issues are areas that require team members to coordinate and align (Espinosa et al. 2007). As a further complication, no single interaction mechanism is universally optimal, but IT work is always trying to dynamically strike a balance between planned structure for "getting things done" and more emergent interaction between members to foster creative outcomes (Kudaravalli et al. 2017).

Work in such a challenging context critically depends on effective team processes. As a group construct, shared cognition of the task to be conducted or who in the team possesses which knowledge is a critical success factor in IT work by enabling e.g. quick coordination (Espinosa et al. 2004; He et al. 2007). As an antecedent to shared cognition, knowledge sharing as meaningful interaction between members depends on a diverse number of drivers ranging from heterogeneity in team members to incentives (Ghobadi 2015). A further critical factor are team perceptions: For example, conflict is an important concern in achieving performance (Sawyer 2001). Paying attention to such "soft" perceptual outcomes has thus been emphasized to improve project performance (Dingsøyr et al. 2016). In addition, IT work exhibits a distinct occupational environment with a number of characteristic traits. By driving positive aspects such as affective commitment, professional conduct is an important aspect in IT work (Dinger et al. 2015). As a characteristic cultural trait, members highly value technical competence and use a specific technical jargon (Guzman et al. 2008; Jacks et al. 2018).

Proceeding to a more granular level of analysis, processes at the personal level are important antecedents of productivity as well. "People aspects," i.e. how team members interact with each other, relate to a number of work practices and are thus decisive in achieving productive outcomes. Such personal interactions complement formal means of aligning work (Espinosa et al. 2004) and enable knowledge sharing (Ghobadi 2015). Interaction as such does not, however, lead to project success. For one, the content of communication is important for its effectiveness (Marlow et al. 2018). Secondly, the alignment of communication between team members with dependencies in the underlying task has been proposed as an important indicator of effective coordination (Sosa 2008).

On the most detailed level, considering the individuals working in IT project teams is worthwhile for understanding how teams work effectively. As stated before, IT work teams have been criticized to be quite homogeneous on demographic dimensions: The recurring obsolescence of technical skills can lead to marked age clusters (Zhang et al. 2012), and female members continue to be a rarity (Korrigane 2019). This compositional view gives rise to the question which individual traits make a team member an important contributor. Historically, technical and analytic abilities have been emphasized (Balijepally et al. 2006). More recently, this narrow focus grew wider to recognize the importance of teamwork and exchanging information. While the relevant characteristics still include cognitive ability and knowledge, they now also consider concepts such as motivation and communicative abilities (Siau et al. 2010). This finding on the individual level aligns with the team-level proposition that integrating information is more important than individual cognition (Tiwana and McLean 2005).

In sum, IT work exhibits a number of characteristic traits ranging from the task to be fulfilled, to typical team organization, characteristic team processes, and lastly characteristics of team members. Emanating from the complexity of the task, continuous exchange of information and interaction between members is of key importance for productive outcomes.

Team Faultlines as Explanations of Diversity Effects

As outlined above, IT work as a knowledge-intensive endeavor heavily relies on a diverse skill set, knowledge, and abilities, which have to be brought together, coordinated, and integrated to achieve the desired outcomes (Faraj and Sproull 2000; Kudaravalli et al. 2017). Diversity in members concerning their specialized knowledge and experiences is thus expected to bolster performance by allowing for more creative problem-solving (Tiwana and McLean 2005). Translating this belief into actual results hinges on group-level integration of information (Van Knippenberg et al. 2004), which necessitates productive communication within the team.

Assessing the effects of diversity on team processes and work outcomes is a longstanding issue in general group research (Bell et al. 2011). A prominent approach to explaining the effects of diversity is the faultline concept. While in geology a faultline describes a crack in the soil, in a more general sense, the term captures "a problem that may not be obvious and could cause something to fail" (Cambridge English Dictionary 2019). In group research, faultlines are hypothetical dividing lines splitting teams into several smaller entities (Lau and Murnighan 1998). Faultlines emerge based on specific differences in one or multiple characteristics that members on one side of the faultline share but distinguish them from all others (Lau and Murnighan 1998). Faultlines and the potentially perceived subgroups (Jehn and Bezrukova 2010) affect a wide range of team processes and outcomes. For example, conflict may be exacerbated by one faction strongly acting in opposition to all others (Jehn and Bezrukova 2010; Lau and Murnighan 1998). Opposition between groups moreover reduces effective communication across group boundaries (Lau and Murnighan 2005). Considering joint problem-solving abilities, activated faultlines relate negatively to creativity (Pearsall et al. 2008). In addition, satisfaction as a key enabler of effective teamwork tends to be reduced by faultlines (Thatcher and Patel 2011). Last but not least, faultlines lead to lower overall team performance (Thatcher and Patel 2011). As a concrete example, stronger faultlines negatively affect decision-making (Rico et al. 2007). Overall, the faultline concept has been found to outperform the analysis of individual diversity characteristics by taking interaction effects of multiple dimensions into account (Thatcher and Patel 2012).

Faultlines have originally been put forth to explain negative effects of demographic diversity, e.g. based on age and gender, in work teams (Lau and Murnighan 1998). Building on social categorization and social identity theory, splits based on characteristics shaping the identity of members are likely to lead to negative processes between the resulting factions (Carton and Cummings 2012). Social identity theory describes each individual to know about and estimate the value of membership in certain groups, which in turn leads to self-categorization. Self-categorization leads members to classify others as either part of their *in*group or as a "foreigner" from an *out*group (Hogg and Terry 2000). Consequently, team members repeatedly perceive and ponder their relative (dis)similarity with others. Such considerations can lead to negative effects such as biases and stereotypes, not least because of a desire to protect the own identity (Bezrukova et al. 2009; Hogg and Terry 2000).

Since its original inception, the faultline concept has been extended to other grounds for emergence. For example, knowledge-based faultlines may emerge based on e.g. differences in training and experience (Bezrukova et al. 2009; Carton and Cummings 2012; Carton and Cummings 2013). Being due to differences in knowledge, processes between the resulting factions are likely positive and focus on objectively exchanging information instead of clashing over identity (Carton and Cummings 2012). Especially in uncertain tasks, theory describes the need for more intensive information processing (Galbraith 1974). The categorization-elaboration model proposes processing task-relevant information to be the key mechanism of positive effects of diversity (Van Knippenberg et al. 2004). Based on these theories, knowledge-based faultlines thus make different pools of knowledge accessible to the team, which engenders positive effects if the knowledge is related to the task at hand and embraced by the team (Bezrukova et al. 2009; Carton and Cummings 2012).

Given the different reasons for emergence, a single team may exhibit several faultlines based on multiple dimensions (Carton and Cummings 2012). Effects of faultlines moreover depend on the magnitude of differences in the characteristics: Large differences in age are likely more impactful than having slightly different educational backgrounds (Bezrukova et al. 2009). Additionally, the number and configuration of faultline-based factions is of relevance: If teams are split into two equal factions, clashes are likely fiercer than if there are numerous factions, which may cross-cut each other (Carton and Cummings 2012;

Homan et al. 2007). More knowledge-based factions imply that achieving shared cognition may become more effortful (Carton and Cummings 2012). At the same time, an increasing number of knowledge-based factions implies more pools of knowledge to draw upon, which based on information processing theory aids elaborating uncertain tasks (Carton and Cummings 2012; Galbraith 1974).

In addition to the reason for emergence and subsequent team dynamics, faultline effects moreover depend on the context in which teams operate (Lau and Murnighan 1998). At an abstract level, effects depend on the team setting as such. As a small, yet significant influence, the type of industry moderates effects (Thatcher and Patel 2012). Moreover, the effects of diversity depend on the relevance to the task (Bezrukova et al. 2009). High autonomy of teams in decision making moderates faultline effects (Rico et al. 2007) and high task complexity can make information-based faultlines a valuable asset (Cooper et al. 2014). In addition, team structures that foster joint achievement can help cross-cut faultlines, i.e. team members feel attached to several factions (Homan et al. 2007), which attenuates negative effects.

Additionally, team-level processes moderate faultline effects. Having a shared, overarching identity is instrumental in drawing attention away from faultline differences and thus to lessen their effects (Bezrukova et al. 2009). Similarly, a shared goal can refocus members on the task instead of personal differences (Van Knippenberg et al. 2011). Lastly, the very process of sharing information in the group and elaborating project outcomes is likely to support performance and to attenuate negative faultline effects (van der Kamp et al. 2015; Van Knippenberg et al. 2004).

Hypothesized Effects of Faultlines on the Performance of IT Projects

Integrating the preceding information on IT work and faultline effects, we derive hypotheses on the effects of identity- and knowledge-based faultlines on the performance of IT project teams. We especially seek to link characteristic traits of IT work to factors influencing faultline effects such as team context and task. As introduced before, IT work heavily depends on the integration of information and knowledge of individual team members (Faraj and Sproull 2000; Kudaravalli et al. 2017). The complex tasks and resulting dependencies in timing and processes frequently require coordination of team members (Espinosa et al. 2007; Faraj and Sproull 2000; Malone and Crowston 1994). Consequently, communication figures among the decisive factors in determining project success (Charette 2005). Misunderstandings or not talking to others in the first place are a common point of failure. Moreover, communication is a key antecedent to important team-level constructs such as shared cognition (He et al. 2007).

The need for constant interaction translates into a need for effective and smooth overall teamwork. Both positive influences such as shared cognition and professionalism (Dinger et al. 2015; Hsu et al. 2012) and negative ones such as increased levels of conflict (Sawyer 2001) are decisive. We expect changes in group processes brought about by identity- and knowledge-based faultlines to affect the team processes in IT projects, and thus their performance. While the faultline concept is applicable to multiple attribute types, we distinguish these two classes as they lead to different team processes (Carton and Cummings 2012).

Effects of Identity-based Faultlines

Starting with the original introduction of the concept, faultlines based on attributes that can stimulate perceptions of identity have been related to changes in group processes and outcomes (Lau and Murnighan 1998). In meta-analysis, such faultlines have consistently resulted in adverse consequences such as increased conflict, reduced satisfaction, and lower team performance (Thatcher and Patel 2011). Moreover, faultlines inhibit communication between the resulting team factions (Lau and Murnighan 2005). Effects are more pronounced when members are further apart on the underlying characteristics, which translates into stronger and more distant faultlines (Bezrukova et al. 2009; Rico et al. 2007).

At their core, identity-based faultlines cause negative team processes based on self-categorization and the social identity of team members (Carton and Cummings 2012). By surveying whether or not others are part of their *in*group or different based on e.g. gender and thus part of the *out*group, team members change their behavior to protect the *in*group identity (Hogg and Terry 2000). As a result, exchanging knowledge across faultline divisions, i.e. to the *outgroup*, is inhibited (Lau and Murnighan 2005). A lack of exchange of knowledge removes the basis for elaboration and integration of information from multiple

sources in the group (Van Knippenberg et al. 2004). Moreover, the ensuing hostility may strengthen group conflict, lower satisfaction, and reduce overall performance (Thatcher and Patel 2011).

The observed influences of identity-based faultlines relate directly to findings from IT work, which describe issues such as the difficulties of diversity in establishing knowledge sharing (Ghobadi 2015) or the negative effects of unmanaged group conflict on performance (Sawyer 2001). The specific context of IT work is, however, likely to influence faultline effects. IT projects are complex and usually exhibit a large degree of autonomy of members (Faraj and Sproull 2000; Tessem 2014). High autonomy emphasizes strong faultline effects (Rico et al. 2007), whereas complexity increases the need for joint work and makes knowledge-based faultlines a positive influence of team performance (Cooper et al. 2014). While the latter two observations relate to knowledge- instead of identity-based faultlines, we deem the effect transferable: Autonomy implies team members are in charge to make decisions (Tessem 2014), which implies that member interaction is needed to agree on how to proceed. Discussing how to proceed is moreover highly likely since IT work exhibits a high need for coordinating actions (Espinosa et al. 2007; Faraj and Sambamurthy 2006). Such interactions harbor potential for perceiving differences in others and thus to emphasize faultline effects (Rico et al. 2007). Analogously, complexity increases the need for communication and thus the basis for faultline effects. Given the relatively homogeneous workforce in IT (Korrigane 2019), differences in demographics may be especially salient and thus trigger negative effects. This expectation is bolstered by findings that revealing additional information on team members critically changes outcomes (Windeler et al. 2015). Moreover, the potential for cross-cutting and thus attenuating faultline effects may be limited if attributes of individual "outliers" align, which likely exacerbates effects. Considering the consistently corroborated negative effects of identity-based faultlines on team outcomes and the reliance of IT work on team-based information exchange, we put forth:

H1a: The strength of identity-based faultlines negatively relates to performance in IT project teams.

As introduced above, the configuration of faultlines is an important consideration for their effects (O'Leary and Mortensen 2010). For identity-based faultlines, negative categorization is expected to be less pronounced when the number of potential factions increases since there is less direct opposition and threat to one's own *in*group (Carton and Cummings 2012). If factions based on identity clash, teams with two factions effectively opposing each other perform worse than teams with any other number (Carton and Cummings 2013). If there are multiple factions, members may perceive similarities with others that allow cross-cutting faultlines, which in turn reduces the likelihood of coalitions (Homan et al. 2007). At the same time, more potential factions may reduce the perception of the team as a coherent whole (Carton and Cummings 2012), which could lessen overall team identity. Since having one identity-based faction corresponds to having no faultline, we exclude this case and build our hypothesis on the case of two opposing factions as a minimum number, which implies a positive relative effect of additional factions:

H1b: The number of team factions due to identity-based faultlines positively relates to performance in IT project teams.

Effects of Knowledge-based Faultlines

Drawing on the proposition that the reason for the formation of faultlines critically influences the direction of effects (Bezrukova et al. 2009; Cooper et al. 2014), we seek to investigate the effects of knowledge-based faultlines. As opposed to differences in identity, knowledge-based faultlines engender positive team dynamics (Carton and Cummings 2012). The group processes emerging from differences in knowledge help efficient information processing by enabling teams to consider more sources of knowledge (Carton and Cummings 2012). This proposition of positive effects of diversity in knowledge draws on the categorization-elaboration model, which proposes an increase in task-relevant information to bolster team performance (Van Knippenberg et al. 2004). According to information processing theory such increased processing is especially important in uncertain environments (Galbraith 1974).

Considering an overall dearth of research on knowledge-based compared to identity-based faultlines (Cooper et al. 2014), empirical results have validated claims of positive effects to some extent. Knowledge-based faultlines are positive under the conditions that distance on the underlying attributes is not excessive and team identification is high (Bezrukova et al. 2009). In addition, knowledge-based faultlines are positive for performance in complex tasks, especially if much information has to be processed, and without dynamism in the environment (Cooper et al. 2014).

The preceding description of the theoretical and empirical findings on when knowledge-based faultlines are positive readily relates to the specifics of IT work. Considering the work context, the high autonomy in IT teams (Tessem 2014) is likely to strengthen effects since more direct interaction is required (Rico et al. 2007). The complexity and interdependence of artifacts, uncertain tasks, and knowledge in IT work require much coordination and interaction (Espinosa et al. 2007; Faraj and Sambamurthy 2006; Faraj and Sproull 2000; Malone and Crowston 1994). A large extent of interaction provides a broad basis for perceiving other's competences and thus to enable the efficient information-processing aided by knowledge-based faultlines. The most suitable form of such interaction is not static and clearly defined but may well depend on the specific task conducted (Kudaravalli et al. 2017). This implies that not only the content discussed but also meta-coordination concerning expertise, as well as the process and timing of activities is crucial (Espinosa et al. 2007; Kudaravalli et al. 2017).

In this sense, the value of shared cognition for conducting IT work (He et al. 2007) needs to be emphasized: The dimension of knowing who holds which knowledge effectively provides the foundation for the efficient knowledge processing enabled by knowledge-based faultlines. Given the large amount of information to be processed and since IT work is inherently complex (Faraj and Sproull 2000), the findings on positive aspects of knowledge-based faultlines in complex tasks (Cooper et al. 2014) are directly applicable. Considering the breadth of expertise required in IT work (Faraj and Sproull 2000), we expect strong knowledge-based faultlines to help with integrating more diverse knowledge. According to the categorization-elaboration model, integrating diverse task-relevant knowledge leads to productive team outcomes (Van Knippenberg et al. 2004). Considering extant knowledge on the effects of faultlines and the specific characteristics of IT work, we hypothesize:

> **H2a**: The strength of knowledge-based faultlines positively relates to performance in IT project teams.

Analogously to the considerations on the number of identity-based factions, we also expect the number of knowledge-based faultlines to influence team performance. A larger number of knowledge-based factions is proposed to improve information-processing since more diverse pools of knowledge can be accessed (Carton and Cummings 2012), which add to the productive elaboration of information (Van Knippenberg et al. 2004). At the same time, an increasing number of individual knowledge pools may provide obstacles to reaching a shared mental model (Carton and Cummings 2012), which given its importance in IT work (Hsu et al. 2012) is likely to negatively affect team performance. This proposition relates to the frequently discussed issue of transaction costs incurred by considering alternative sources of knowledge (Ghobadi and Mathiassen 2016). If there is an abundance of different knowledge sources, considering different sources may be too costly and thus lead to team members not considering any outside sources. However, it does not seem logical to assume that having three or four specialized knowledge-based factions would exclude them from consideration, especially since IT work relies on heterogeneous knowledge with communicating results and knowledge being a key trait of effective team members (Siau et al. 2010). Empirically, a larger number of knowledge-based factions has been found to positively affect performance (Carton and Cummings 2013). We thus expect positive effects of the number of knowledge-based faultlines within reasonable bounds. Taking extant knowledge on the number of knowledge-based faultlines into account, we posit:

> **H2b**: The number of team factions due to knowledge-based faultlines positively relates to performance in IT project teams.

Method

To investigate the proposed hypotheses on the effects of identity- and knowledge-based faultlines, we conducted an empirical analysis of the performance of IT project teams. We have chosen a quantitative approach using archival data, which we analyzed in multiple stages: First, we acquired the raw data, on which we secondly calculated the faultline measures. Lastly, we used the faultline information to calculate the effect of identity- and knowledge-based faultlines on project performance.

Data Acquisition and Operationalization of Faultline Measures

As a data source, we have been given access to the project records of a large IT service provider, here named ALPHA, that conducts projects of different scopes for customers in various industries. This dataset provides fine-grained information on the involvement of employees in particular projects as well as general project information. For the current analysis, we limited the dataset to projects beginning in the timeframe 2009-2012. In addition, we excluded any projects for which at least one employee had data missing on any of the dimensions used to operationalize faultlines. Checking for unreasonable extreme values and outliers, we excluded five projects with durations of less than 15 days. Since faultline and group dynamics may change over time (Thatcher and Patel 2012), these projects may behave quite differently. Moreover, 15 projects had to be excluded for computational reasons as the faultline algorithm could not establish a faultline measure. Applying this strict filtering criteria, we obtained a sample of 424 projects.

To operationalize identity- and knowledge-based faultlines, we followed extant research, which draws on general literature on diversity and social identity. We operationalized identity-based faultlines using the demographic attributes *gender*, coded as male or female, and *age* (Bezrukova et al. 2009; Carton and Cummings 2013). *Age* has been assessed at the beginning of the project using the birthdate and the project start date. Knowledge-based faultlines are meant to capture differences in knowledge and expertise. While previous research has used tenure at a company (Bezrukova et al. 2009), we deem this measure somewhat imprecise given its likely high correlation with age. We thus operationalize the grounds for knowledge-based faultlines using two measures of work experience: The sum of hours an employee had worked at ALPHA when the project under consideration started, and the sum of hours an employee had worked on projects in the same industry as the project under consideration. In both sums, we considered projects completed before the project under consideration started. These measures should capture both general knowledge acquired by working at ALPHA and industry-specific knowledge.

Calculation of Faultline Measures

The data on identity- and knowledge-based characteristics provides the foundation for calculating faultlines in the project teams. An early form of measuring faultlines is assessing strength using Thatcher's Fau as the percentage of group variation accounted for by the strongest division (Thatcher et al. 2003). As an extension, the additional measure of faultline distance captures the extent of differences within characteristics (Bezrukova et al. 2009). These measures are, however, not suitable for identifying more than one potential division (Meyer and Glenz 2013). Since we hypothesize the number of resulting factions to affect performance, we employ the cluster-based Average Silhouette Width (ASW) approach (Meyer and Glenz 2013), which is deemed applicable to all potential faultline configurations (Meyer et al. 2014). Moreover, the ASW algorithm is proposed as especially robust in cases of missing or incorrect data (Meyer et al. 2014), which increases our confidence in the results.

We calculated the strength of faultlines and the likely number of resulting factions based on the ASW algorithm using the accompanying R package asw.cluster. Since we expect differential effects, we calculated identity- and knowledge-based faultlines separately using automatic rescaling of values. Since experience at ALPHA may correlate with experience in the project industry, we chose mahalanobis distance, which can be applied to correlated characteristics (Meyer and Glenz 2013), for calculating knowledge-based faultlines.

Dependent and Control Variables

As dependent variable and operationalization of performance, we use data on the profitability of projects. Due to reasons of confidentiality, the data has been anonymized but enables a true-to-reality comparison between projects. Defining how performance of a project can be assessed is a topic of debate (Neely et al. 2005). Companies may value a host of project outcomes such as quality, yet profitability arguably is the key deciding factor (Gopal and Koka 2012; Hoermann et al. 2015). Not least, project profitability provides a proxy for firm profitability (Ethiraj et al. 2005). Influences on such highly valued outcomes are thus more likely to trigger actions or decisions that allow for improvements (Gopal and Koka 2012). Given this argumentation, we deem overall profitability apt for expressing the interests of ALPHA. Since the dataset contains projects for the same customer at different points in time, we chose a panel-corrected multiple regression analysis. A Hausman test determined a fixed effects model to be appropriate.

Beyond the four faultline variables, strength and number of likely factions based on identity and knowledge, we included control variables to account for systematic differences in projects. To control for the potential of more group splits, we added *team size*. Team size is frequently discussed as an important factor for performance since the coordination of larger teams may constitute an impediment (Ethiraj et al. 2005). To control for outliers, we logged *team size*. Moreover, we include *project volume* as a control since previous research has established it to significantly increase profitability (Gopal and Koka 2012). We operationalize *project volume* as the overall revenue generated by the project. To control for outliers, we logged the variable. In addition, we controlled for *project duration* since prolonged projects make forecasts and planning more difficult (Ethiraj et al. 2005), and changes in between are more likely (Gefen et al. 2008). Projects with a longer duration thus exhibit lower performance (Sauer et al. 2007). We operationalize *project duration* as the number of days a project has been marked as active. To control for outliers, we logged the variable.

In addition, the project setting has to be controlled for. The overall business confidence is likely to affect project outcomes. We control for this influencing factor by including the current value of the ifo business climate index (CESifo 2019), which is applicable since ALPHA is mostly based in Germany.

With the expectation of employees building knowledge for ALPHA in industry projects, we control for overall learning effects at ALPHA by including the *project start year* as a control variable. In addition to learning effects, this variable controls for other general influences (Ethiraj et al. 2005).

Results

To judge the overall sample of projects and employees, we provide descriptive statistics in Table 1. Following guidance on checking for multicollinearity in fixed effects panel models, we calculated variance inflation factors (VIFs) on linear regression equivalents of the model. *Strength of knowledge-based faultlines* exhibited the highest value of 8.09, followed by the logged *team size* at 5.17. Since both values are below the recommended threshold value of 10 (Chatterjee and Hadi 2012), we kept them in our model. All other variables exhibited VIFs of 3.52 or less. Moreover, we observe typical traits of IT work in the sample: A large majority of 81.73% of employee observations indicated gender as male. The average project duration of 176.26 days justifies our operationalization of knowledge and age since intervals of less than a year are not likely to have much influence on overall experience.

In Table 2, we detail results of the panel-corrected multi-level regressions. We used Arellano-type robust standard errors to control for any potential issues with heteroskedasticity. The first model including control variables yields an R^2 value of .142. Adding the strength and number of potential factions due to identity-based faultlines increases the amount of variance explained slightly to 15.9%. Similarly, adding the variables related to knowledge-based faultlines increases the variance explained. Model four combining the control variables and both types of faultlines achieves the highest R^2 value of 16.9%. As expected, adding the faultline variables explains additional variance. In all of the models, the control variables *project volume*, *project duration*, and *team size* are significant. As expected, *project volume* is positively related, whereas *project duration* and *team size* show negative relations.

Of our four hypotheses on the effects of identity- and knowledge-based faultlines on the performance of IT projects, only one, H1b, is supported statistically in all models. For two, the direction of effects is as expected, whereas the other two show a reversed direction.

Hypothesis 1a on the negative effect of the strength of identity-based faultlines in IT projects could not be supported. To the contrary, both in the individual model and when considered jointly with knowledge-based faultlines, the strength of identity-based faultlines is significantly positively related to project performance.

Hypothesis 1b on the positive effect of the number of identity-based faultlines could be supported. We observe a significant positive weight both in the individual and joint model.

Hypothesis 2a on the positive effect of the strength of knowledge-based faultlines in IT projects could be supported to some extent. The direction of the effect is positive, as expected, albeit insignificant.

Hypothesis 2b on the expected positive effect of the number of knowledge-based factions could not be supported. The direction of the effect is, contrary to our expectations, negative and insignificant.

Descriptive Statistics					
Projects [n=424]	**Min**	**Mean**	**Median**	**Max**	**sd**
Team Size [persons]	3	3.86	3	9	1.18
IFO Index	84.5	102.77	103.55	115	7.35
Project Volume	445.00	41289.84	17371.50	835459.56	77203.94
Project Duration [days]	15	176.26	134.50	1024	148.34
Strength of Identity-Based Faultlines	0.17	0.49	0.50	0.90	0.16
# of Identity-based Faultlines	2	2.07	2	5	0.30
Strength of Knowledge-Based Faultlines	0.00	0.17	0.00	0.79	0.21
# of Knowledge-based Faultlines	1	2.35	2	4	0.57
Project Members [n=1637]					
Age [years]	20.49	41.18	41.13	63.47	9.06
Experience at ALPHA [h]	1	9331.47	7979.75	32187.40	7647.75
Experience in Industry [h]	1	7969.60	5672.44	32105.15	7503.18
Male	81.73%		Female		18.27%

Correlations	T. Size	IFO	P. Vol.	P. Dur.	Str. ID	# ID	Str. KN	# KN	Prof.
Team Size	1	0.01	**0.11***	**0.24*****	**0.48*****	**0.47*****	**0.82*****	**0.62*****	-0.01
IFO Index		1	0.03	-0.05	0.07	0.01	0.03	-0.01	0.01
Project Volume			1	**0.29*****	0.09.	**0.12****	0.05	0.01	0.09.
Project Duration				1	**0.16*****	**0.18*****	**0.21*****	**0.14****	0.01
Str. Identity Faultlines					1	**0.16*****	**0.46*****	**0.34*****	**0.10***
# Identity Factions						1	**0.33*****	**0.27*****	0.04
Str. Knowledge Faultlines							1	**0.83*****	-0.05
# Knowledge Factions								1	**-0.11***
Profitability									1

Table 1 Descriptive Statistics and Correlations of Sample

Discussion

IT projects as endeavors of knowledge work conduct complex, dynamic tasks and critically depend on the coordination of the work and expertise of team members (Espinosa et al. 2007; Faraj and Sproull 2000; Kudaravalli et al. 2017). Smooth teamwork is thus a prerequisite to effective work. Based on this assertion, we have investigated the effects of faultlines, a widely-applied concept to explain effects of diversity in groups (Lau and Murnighan 1998), in IT project teams using panel-corrected multiple regression. Contrary to expectations, we have found the strength of identity-based faultlines due to age and gender to have significant positive relations with performance. As expected, the number of group factions due to identity-based faultlines has a positive effect. In addition, the expected positive effect of the strength of knowledge-based faultlines on performance has been insignificant. Lastly, the number of knowledge-based factions has negative, insignificant relations with performance.

Multiple Panel-corrected Regression (Fixed Effects) with Arellano-type robust standard errors								
Model	**1**		**2**		**3**		**4**	
Team Size (log)	**-0.482**	**0.000*****	**-0.713**	**0.000*****	**-0.639**	**0.002****	**-0.862**	**0.000*****
IFO Index	0.001	0.774	0.000	0.917	0.001	0.859	-0.000	0.998
Project Volume (log)	**0.323**	**0.000*****	**0.320**	**0.000*****	**0.326**	**0.000*****	**0.323**	**0.000*****
Project Duration (log)	**-0.170**	**0.001*****	**-0.180**	**0.000*****	**-0.170**	**0.001*****	**-0.180**	**0.000*****
Strength of Identity-Based Faultlines			**0.744**	**0.043***			**0.749**	**0.036***
Number of Identity-based Factions			**0.108**	**0.027***			**0.121**	**0.000*****
Strength of Knowledge-Based Faultlines					0.719	0.192	0.713	0.167
Number of Knowledge-based Factions					-0.228	0.177	-0.236	0.123
Year 2012	**0.165**	**0.019***	**0.168**	**0.033***	**0.147**	**0.043***	0.149	0.067.
R^2	0.142		0.159		0.151		0.169	

Table 2 Results of Multiple Regression Models

In the following, we discuss these findings, starting with characteristics of the dataset and analysis. Next, we elaborate on the effects of knowledge-based faultlines before turning to identity-based ones. We especially highlight how the special context of IT work may have contributed to the observed positive effects of identity-based faultlines.

Characteristics of Dataset and Analysis

As objective archival data from the field, our measures capture faultlines as such as opposed to subgroups perceived by members (Jehn and Bezrukova 2010). While we relied on data from a single company, we leveraged a real-world context compared to much extant analysis of faultlines, which has been conducted in laboratory settings with the ability to create strongly aligned faultlines and larger overall effect sizes (Thatcher and Patel 2011). This finding implies that we may be under- instead of overestimating effects, which strengthens our confidence in our results.

We analyzed data using the ASW method to calculate faultlines and used a panel-corrected regression analysis since there may be more than one project per customer. The choices made in operationalization and analysis naturally influence results. Using different operationalizations may have changed results and improved some statistical properties. Investigating the effects of faultlines on other dependent variables of interest in IT projects, e.g. quality (Gopal and Koka 2012), is a fruitful avenue for future research. Different combinations of parameters in operationalizing faultlines and the effects of calculation methods are important open questions (Meyer and Glenz 2013), which we encourage as future research.

Effects of Knowledge-based Faultlines on Performance

While the regression weight of the strength of knowledge-based faultlines is positive as expected, it is insignificant, which leads us to reject the corresponding hypothesis on statistical grounds. Unexpectedly, the number of potential knowledge-based factions is not positively but insignificantly negatively related to

performance. Previous studies have found knowledge-based faultlines to improve performance, especially if there are many factions and complexity is high (Carton and Cummings 2013; Cooper et al. 2014).

We have expected faultlines based on differences in knowledge to engender positive effects since different areas of expertise in teams likely stimulate team members to consider alternative knowledge repositories (Carton and Cummings 2012). The categorization-elaboration model predicts the amount of task-relevant information processing to be a key driver of positive effects of diversity (Van Knippenberg et al. 2004). Considering the proposition in information processing theory that especially large amounts of information are to be processed in uncertain contexts, and the key characteristic of IT work as processing complex uncertain tasks (Faraj and Sambamurthy 2006), our result is even more surprising.

A possible explanation lies in the work characteristics: In the dynamic context of IT work, the specific need to exchange information and to coordinate expertise, task- and process-related information very much depends on the task at hand (Espinosa et al. 2007; Kudaravalli et al. 2017). However, dynamic environments inhibit positive effects of knowledge-based faultlines (Cooper et al. 2014), which in our observed cases may have reduced positive effects to insignificance. Additionally, our operationalization of knowledge as working experience at ALPHA and within the industry of the project may not have captured enough differences in knowledge to become a significant influence.

In addition, given the average group size of 3.86, drawing on the number of potential group splits may have limits. This proposition is supported by the significant negative effect of team size on performance and findings in extant literature. Akin to geographic distribution, splitting a group into factions increases the effort needed for coordination (Espinosa et al. 2007) and may exceed the benefits of additional sources of knowledge. Additional factions may thus inhibit the emergence of a shared cognitive model of the task and transactive memory of who holds which expertise, which are influential factors in IT work (Carton and Cummings 2012; He et al. 2007; Hsu et al. 2012). Moreover, specific mechanisms of knowledge sharing may overpower the influence of knowledge-based faultlines as indicators where knowledge can be obtained (Carton and Cummings 2012). By using methodical approaches (Faraj and Sambamurthy 2006), IT work institutionalizes knowledge sharing in, for example, practices such as pair programming (Balijepally et al. 2009). It would thus be interesting for future research to consider knowledge-based faultlines interacting with development methods and shared cognition.

Understanding the Positive Effects of Identity-based Faultlines

Contrary to our hypothesis, the strength of identity-based faultlines has shown positive relations with performance. This finding is in opposition to extant literature, which has found negative relations to several team outcomes including performance (Thatcher and Patel 2011). While more recent works on the faultline concept have proposed to differentiate group factions based on the characteristics underlying their emergence, they have still made the case for negative effects of identity-based faultlines (Carton and Cummings 2012). Such a proposition rests on the expectation of negative categorization leading to perceived threats to each group's social identity (Carton and Cummings 2012; Hogg and Terry 2000). This gives a possible explanation to why we observed positive effects: Following self-categorization theory (Hogg and Terry 2000), there may have been no perceived threat to the identity of members' perceived *in*group and thus no negative repercussions. Differences may have been perceived as valuable task-relevant information, which can drive positive team performance (Van Knippenberg et al. 2004).

To understand this lack of identity threat, we have to consider the context-dependent nature of faultline effects. Starting with the initial proposition of the concept, faultlines are expected to have different effects based on the context and its moderating factors (Lau and Murnighan 1998). Subsequent research has analyzed a number of moderating factors such as team identification (Bezrukova et al. 2009) or task autonomy and complexity (Cooper et al. 2014; Rico et al. 2007). Many of these moderators are conceptually similar or at least closely related to known characteristics of IT work, which we expect to have been present in the project teams at ALPHA, and discuss in the next section.

Characteristics of IT Work Turning Demographic Diversity into Positive Influence

Given the dependence of faultline effects on context factors, assessing the characteristics of IT work as shaping forces seems worthwhile to interpret our results. While IT work is a broad concept without clear-

cut boundaries (Guzman et al. 2008), there are several characteristics that shape the working context. We argue that characteristics related to tasks, composition of the workforce, and teamwork explain how identity-based faultlines can engender the positive effects of a repertoire of diverse knowledge.

Key task-related aspects of IT work are complexity and knowledge-intensity (Faraj and Sproull 2000), as well as constant change in the underlying technology and skills required (Gallivan et al. 2004). These characteristics require close and dynamic coordination of tasks, timing, processes, and expertise held by team members (Espinosa et al. 2007; Kudaravalli et al. 2017). While investigated specifically for information-based faultlines, the high complexity of IT work may drive positive effects of diversity (Cooper et al. 2014). The multitude of content-based foci relating to expertise and complex decision-making provides an explanation to the positive effects of identity-based faultlines: The effect of diversity in work contexts depends on the degree to which differences are related to the task (Bezrukova et al. 2009). Since tasks in IT work do not relate to age and gender, there may be no negative repercussions on these dimensions. Moreover, since exchanging knowledge is a prerequisite in IT work (Ghobadi 2015; Kudaravalli et al. 2017), members have to interact, which implies negative perceptions may be cross-cut and thus rendered ineffective (Lau and Murnighan 1998). Drawing on social identity and self-categorization theory, team members thus might not perceive differences in identity as threats to their group identification (Hogg and Terry 2000) but come to embrace the different viewpoints in information processing. This interpretation draws attention to how perceived diversity can act as an important explanatory variable (Shemla et al. 2016). The uncertainty of tasks in IT work (Faraj and Sambamurthy 2006) strengthens this mechanism since information processing theory implies a heightened need for deliberation (Galbraith 1974). Supporting this interpretation, pronounced faultlines have been shown to be positive for team learning when interaction is high (Rupert et al. 2016).

Beyond task-related characteristics, the workforce stands out as a special factor. The IT workforce has been frequently described to be mostly composed of male members (Armstrong et al. 2018; Korrigane 2019). With 18.27% of employees in the projects we analyzed identified as 'female,' our sample is comparable with the overall representation of women in IT, which is at 17.2% (Korrigane 2019). Moreover, based on changes in technology and skill, distinct age clusters may emerge (Zhang et al. 2012). Considering these observations, differences in either age or gender should markedly stand out and may seem excessive in a typical IT project team. The resulting strong faultline is likely to engender direct opposition and conflict (Lau and Murnighan 1998). On the other hand, the minority status of those of different age or gender may inhibit the emergence of marked splits among or open conflict within the team (Carton and Cummings 2012; Lau and Murnighan 1998). In this peculiar case, the marked difference in characteristics might not lead to negative self-categorization as the resulting opposing party is too small to be perceived as a threat.

Lastly, the teamwork typical in IT warrants discussion. IT work is characterized by high levels of work autonomy (Tessem 2014), which implies much exchange of information through interaction and thus strengthens faultline effects (Rico et al. 2007). In addition, IT work draws on a set of shared professional attitudes and behaviors, that in turn significantly influence employee behavior, perceptions, and performance (Dinger et al. 2015). In addition to fostering professionalism, IT work has a distinct occupational culture, which comprises for example the use of technical jargon (Guzman et al. 2008) and much appreciation of technical knowledge (Jacks et al. 2018). These characteristics imply that any difference in characteristics of teammates might not be perceived as negative as long as they adhere to the IT occupational culture by e.g. exhibiting domain knowledge. In the context of self-categorization theory, this proposition implies that adhering to the ruleset of IT occupational culture may suffice to be perceived as part of the *in*group of team members (Hogg and Terry 2000), which starves off negative consequences. Going one step further, the value of technical knowledge (Jacks et al. 2018) and reliance on knowledge exchange (Ghobadi 2015; Kudaravalli et al. 2017) make a realistic case for perceiving any difference as a potential further source of information, which can help elaborating task-relevant information (Van Knippenberg et al. 2004). Our explanation thus describes a self-reinforcing circle: Bringing diverse knowledge helps in elaborating information, which in turn leads to perceptions of knowledge, which lead team members to welcome contributions. The possibility of such an "objective" approach to identity-based faultlines is supported by findings that gender diversity relates positively to performance through creating shared mental models in an IT context (He et al. 2007).

Contributions and Conclusion

To complete knowledge-intensive and complex tasks, IT work requires the constant exchange of information and coordination between team members. Since diversity critically influences such team processes, we investigated the effects of diversity related to identity and knowledge on the performance of 424 IT projects. We drew upon extant knowledge in IT work and faultlines as a widely discussed measure of diversity to develop hypotheses on the effects due to the strength of faultlines and the resulting number of factions. Contrary to our expectations, identity-based faultlines exhibited significant positive effects on performance. Conversely, the expected positive effect of knowledge-based faultlines was insignificant. Increasing the number of resulting factions showed significant positive effects for identity-based and negative effects for knowledge-based faultlines. We proposed an explanation to how the specific context of IT work may engender positive effects of identity-based faultlines by providing a common identity.

These results contribute to research in IT work and group diversity in general. For IT work, we contribute to the body of knowledge on contingency factors that are beyond directly visible elements such as development methodologies, yet critically influence outcomes. By integrating corroborated theory from general group research with the specifics of IT work, we particularly contribute to understanding the frequently described "people aspects" in IT work (Faraj and Sambamurthy 2006), which are a prerequisite to building a healthy workforce. Our surprising result of a positive influence of identity-based faultlines is testament to the specific work context in IT. Specifics of IT work such as agile practices may influence work characteristics (Prommegger et al. 2019), including those related to faultlines (Lassak et al. 2017; Pflügler et al. 2018; Przybilla et al. 2018b). Combining these factors provides interesting avenues for future research. By investigating the effects of team composition on outcomes, we add to the discussion of collaboration and coordination in IT work. Specifically, we added initial insight to an antecedent to how teams can optimally coordinate knowledge and tasks (Espinosa et al. 2004; Kudaravalli et al. 2017).

Moreover, our results based on a large sample of project data contributes to the body of research on faultlines. First, we added to research distinguishing faultlines based on their grounds for emergence (Carton and Cummings 2012; Carton and Cummings 2013), which helps in further teasing apart the complex phenomenon of group diversity. Contrary to extant findings (Bezrukova et al. 2009), we observed the strength of faultlines to positively affect outcomes. Our explanations of the surprising findings draw attention to the criterion of whether faultlines are perceived (Jehn and Bezrukova 2010). The present results thus provide a basis to further develop the proposed field of perceived diversity (Shemla et al. 2016). Future analysis could also benefit from combining our results on diversity with other (emergent) factors shaping teamwork such as the use of digital intelligent systems (Przybilla et al. 2019). Furthering our work while considering both characteristics of IT work and general team research can help to develop an in-depth understanding of how faultlines as measures of diversity shape IT work. While we see much potential in further empirical analysis, we see the long-term goal in developing a theory of faultlines in IT work.

For practitioners, our results are of interest by providing insights into an aspect of the dynamics underlying IT project work. Our results imply that it may be good practice to pay close attention to team composition in terms of the potential for faultlines based on either identity or knowledge. If the context is appropriate, staffing teams to draw on identity-based faultlines may provide another tool for success in IT project management. The observed effects can thus help with making precise staffing decisions and contribute to the governance of IT projects as a work endeavor characterized by very unique traits.

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