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Knowledge diversity and technological innovation: The moderating role of top management teams

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ABSTRACT

Knowledge diversity between a firm's groups of inventors enables recombinatory search for innovation. Yet, such diversity remains rather useless unless it is actively exchanged among inventor groups. Inventor groups, however, tend to specialize by engaging in so-called perspective-making activities, that is, in intra-group knowledge exchange and specialization. This makes them increasingly unable to communicate and understand other inventor groups and creates a risk of incommensurability, which attenuates a firm's effectiveness in its recombination for innovation. Here, we draw on transformational leadership theory to understand how TMTs are enabled to motivate and inspire their inventor groups to share information and knowledge, to mitigate incommensurability risks. For a TMT to act as an effective transformational leader, information is key, and their ability to send, receive, and process information is shaped, following classic organization theory, by their structural attributes. Hence, we study three key TMT structural attributes that underlie its information-processing capacity: Hierarchical structure, functional structure, and administrative intensity. Based on a longitudinal dataset that includes 124 pharmaceutical firms, 2815 top managers, and 34,203 inventors, we show that the positive relation between inventor group knowledge diversity and innovation performance strengthens with a functional structure yet weakens with administrative intensity. We contribute to the literature with its emphasis on how TMT compositional characteristics influence its cognitive processes and decision-making on innovation, by studying how TMT structural characteristics shape its information-processing capacity to be effective as transformational leaders in motivating and inspiring inventor groups to engage in perspective-taking and overcome incommensurability.

1. Introduction

It is well known that knowledge diversity, which exists between groups of inventors with different expertise, enables recombinatory search processes for innovation (Caner et al., 2017; Carnabuci and Operti, 2013; Fleming, 2001; Gittelman and Kogut, 2003; Maggitti et al., 2013). Yet, an important and overlooked implication is that knowledge diversity is only useful for recombinatory purposes if these various pieces of knowledge are *actively exchanged* among groups of inventors (Boland and Tenkasi, 1995; Carnabuci and Operti, 2013). In other words, whereas knowledge diversity is a necessary condition for recombinatory search, it is not sufficient (Kogut and Zander, 1992; Polanyi, 1966; Savino et al., 2017).

Diverse groups of inventors are not necessarily motivated to engage in knowledge exchange. As groups of inventors specialize, they tend to develop expert vocabularies, references, and information connections, which are difficult for others to recognize and understand (Anderson and Lewis, 2014; Fraidin, 2004). That is, groups of inventors—as communities of knowing—naturally engage in so-called *perspective-making*, that is, in in-group knowledge development and specialization. Yet, such specialization inherently limits their aptitude to engage in *perspective-taking*, that is, understanding and incorporating the perspectives of other groups (Boland and Tenkasi, 1995; Fraidin, 2004). Specifically, while perspective-making activities enable specialization within a group of

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inventors, and happens rather naturally, it also instigates, and increasingly so, between-group misunderstandings, biases, and conflict (Carlile, 2004; Milliken and Martins, 1996; Williams and O'Reilly, 1998). This leads to *incommensurability* across inventor groups, which further drives out perspective-taking (Boland and Tenkasi, 1995; Hoever et al., 2012), thereby limiting the potential for recombinatory search.

Incommensurability among inventor groups, as such, jeopardizes a firm's innovation performance and, as a consequence, its future competitiveness and viability (Ahuja and Lampert, 2001; Carnabuci and Operti, 2013; Granstrand et al., 1997; Moreira et al., 2018). Such risk makes it a key issue for TMTs to consider and act upon, through motivating and inspiring their inventor groups to overcome incommensurability and to engage in perspective-taking. In this respect, TMTs can address incommensurability among inventor groups by acting as transformational leaders. Transformational leadership 'transforms' followers to transcend their self-interest to identify needed change, creating a vision to guide the change through influence and inspiration, and through executing the change in tandem with committed members of a group (Aryee et al., 2012; Bass, 1999; Bryman, 2011; Gumusluoglu and Ilsev, 2009; Odumeru and Ogbonna, 2013). Following transformational leadership theory (Burns, 1978; Siangchokyoo et al., 2020), we argue that TMTs may seek to mitigate the risk of incommensurability by raising inventor groups' awareness of such risk, encouraging collaborations and relationships, preventing and resolving conflicts, and fostering a sense of shared purpose. This resonates strongly with Lawrence and Lorsch's (1967) seminal idea that a firm's TMT is tasked with achieving 'unity of effort' among their organization's diverse parts.

For TMTs to act as effective transformational leaders and address the risk of incommensurability, receiving and sending information as well as its processing are of key importance. Here, we draw on classic organization theory, which details that structural attributes determine information-processing capacity (Galbraith, 1973; Lawrence and Lorsch, 1967). Here, we focus on three key TMT structural attributes—covering both the richness of vertical (i.e., hierarchical structure) and horizontal (i.e., functional structure) information processes[2] as well as cognitive capacity to process this information and act on it towards the organization (i.e., administrative intensity)—and discuss how these influence a TMT's ability to act as transformational leader to address incommensurability among its inventor groups.

Based on this, we specify and test how these TMT structural attributes moderate the relationship between inventor groups' knowledge diversity and innovation performance. To test our hypotheses, we rely on a unique dataset spanning 2000–2014, which includes 124 pharmaceutical firms, 34,203 inventors, and 2815 top managers. We find that, among others, TMT functional structure *strengthens*, while TMT administrative intensity *attenuates*, the positive relationship between inventor groups' knowledge diversity and innovation performance.

We contribute to the literature on knowledge diversity and recombination. This body of literature discusses the merits of knowledge diversity as an enabler for recombinatory search for innovation (Carnabuci and Operti, 2013; Moreira et al., 2018), and emphasizes the value of different organizational measures to connect and create linkages among (groups of) inventors, such as information support tools and objects (Acharya et al., 2022; Boland and Tenkasi, 1995; Nicolini, 2011), informal exchanges (e.g., Hargadon, 2002; Chou et al., 2011; Garud et al., 2011), formal team structures (e.g., Singh and Fleming, 2010; Toh and Polidoro, 2013), effective team leadership (e.g., Currie and White, 2012) and organizational knowledge networks (Carnabucci and Diószegi, 2015; Moreira et al., 2018; Paruchuri and Awate, 2017). Yet, this literature with its emphasis on organizational measures to connect and create linkages implicitly assumes that diverse groups of inventors are naturally inclined and motivated to engage in cross-group collaboration and knowledge exchange. Whereas diverse inventor groups naturally engage in perspective-making, they do *not* in perspective-taking (Boland and Tenkasi, 1995; Hoever et al., 2012). This implies that a TMT needs to ensure it not only provides these information channels and structures for communication and knowledge exchange, but also inspires and motivates groups of inventors to overcome incommensurability and engage in perspective-taking, through transformational leadership. This motivational dimension to knowledge exchange across diverse inventor groups has remained relatively unaddressed in the literature on recombination. Whereas there is growing attention in the literature for the role of leadership in addressing individuals' motivation for creativity and knowledge exchange with others (Gardner et al., 2020; Hughes et al., 2018; Crosby and Bryson, 2010), an understanding of motivation for knowledge exchange and perspective taking by diverse groups of inventors, across disciplinary boundaries, is still missing.

We also contribute to the growing literature on how TMTs influence their firm's innovation activities and outcomes. In most of this literature, there has been a strong emphasis on how top managers' backgrounds and TMTs' compositional characteristics shape their cognitions and values, and how these influence their processing of external information and a firm's strategic decision-making process on innovation (e.g., Kashmiri & Mahajan, 2017; Kiss et al., 2018; Kiss et al., 2020; Ruiz--Jiménez et al., 2016; Talke et al., 2010; Zhang et al., 2021). This dominant focus on information-processing and decision-making carries a strong focus on the cognitive processes within a TMT, yet at the expense of a predominantly motivational process that occurs largely *between* a TMT and a firm's inventor groups. To address this, we need to look beyond cognitive processes within a TMT such as its processing of information and decision-making on innovation strategy and focus instead on its information-processing capacity to influence the organization's different inventor groups through transformational leadership, to execute on this strategy. Here, our paper contributes by showing how a TMT's structural attributes shape its capacity for receiving, processing, and sending information to be effective as transformational leaders in motivating and inspiring inventor groups to engage in perspective-taking, and overcome incommensurability, to enable innovation.

2. Theoretical background and hypotheses

2.1. Knowledge diversity, recombinatory search, and innovation

As people are cognitively bounded, inventors can specialize only in a limited number of technological domains (Gruber et al., 2013; Maggitti et al., 2013). The implication is that to solve today's complex problems, organizations need to maintain so-called communities of knowing (Boland and Tenkasi, 1995)—in this paper considered to be groups of inventors specializing in various technical knowledge domains. Especially knowledge-intensive firms are likely to consist of different communities, each holding highly specialized knowledge and associated technology (Boland and Tenkasi, 1995; Purser et al., 1992). Such inventor groups' knowledge diversity, if shared, creates the potential for innovation through recombinatory search processes (Acharya et al., 2022; Boland and Tenkasi, 1995; Nicolini, 2011; Fleming, 2001; Gittelman and Kogut, 2003)—through various mechanisms: First,

[2] We refer to vertical information processes as the flow of information within a hierarchical structure or along the chain of command in an organization. In a vertically structured organization, information typically moves up and down through different levels of management, from top to bottom or vice versa. Horizontal information processes involve the exchange of information between individuals or departments at the same hierarchical level within an organization. This type of communication is often associated with collaboration and coordination among peers rather than through a formal chain of command. Information richness refers to the depth and complexity of information that can be conveyed through a communication channel. Rich communication channels allow for the transmission of a variety of cues, such as verbal and nonverbal signals, and can convey a high level of detail and context.

knowledge diversity and exchange bring about the possibility to discover and execute new opportunities for technological innovation (Brennecke and Rank, 2017; Taylor and Greve, 2006). That is, the sharing of specialized, diverse knowledge exposes groups of inventors to different areas of expertise, approaches, and viewpoints that, in turn, result in novel knowledge associations and linkages (Brennecke and Rank, 2017; Taylor and Greve, 2006). Second, knowledge diversity and exchange, across groups of specialized inventors, also leads to novel interpretations of existing knowledge, which helps discover hitherto undiscovered opportunities or identify new ways to understand and solve existing problems (Carnabuci and Operti, 2013). Third, inventor groups' knowledge diversity and exchange also aid in interpreting and learning from the often-unexpected outcomes of experiments. That is, diverse groups of specialists are simply better equipped to make sense of such feedback (Henderson and Cockburn, 1994; Thomke et al., 1998).

As an example, in the pharmaceutical industry, the development of new products demands the integration of disciplinary knowledge from a wide array of different disciplines. Think about molecular biology, physiology, synthetic chemistry, and pharmacology (Henderson, 1994). Mark Esser, VP at AstraZeneca, once explained that their scientists explored three potential sources for antibodies against COVID-19 in the process of identifying a lead candidate, and that such exploration induced the need for groups of specialists from different disciplines to exchange their knowledge to develop a more profound understanding of new disease domains and what could form effective new molecules to combat the underlying causes of a new 'target' (Astrazeneca, 2021).

Summarizing, knowledge exchange among specialized groups of inventors is key to enable recombinatory search processes that, in turn, lead to innovation (Ahuja and Lampert, 2001; Boland and Tenkasi, 1995; Carnabuci and Operti, 2013; Fleming, 2001; Huang, 2009; Huang and Chen, 2010). Hence, and in-line with standing literature (e.g., Brennecke and Rank, 2017; Taylor and Greve, 2006), we expect that.

Hypothesis 1. Knowledge diversity among a firm's groups of inventors is positively related to firm innovation performance.

2.2. Incommensurability among inventor groups: the need for information exchange and the role of a TMT

As explained, the diverse specialized knowledge, skills, and expertise are held by a firm's various groups of inventors—and such knowledge only becomes helpful for recombinatory search when these groups, or communities of knowing, are motivated to actively exchange it (Brennecke and Rank, 2017; Kogut and Zander, 1992; Savino et al., 2017). In this respect, Henderson and Cockburn (1994) found that maintaining an extensive flow of information across different scientific disciplines and technological domains benefits innovation; but this does not mean that between-group knowledge exchange comes about by itself.

The similarity between people operating in a particular community of knowing yields cooperation, trust, and social cohesiveness (e.g., Harrison et al., 2002; Locke and Horowitz, 1990), enhancing an in-group orientation. Such an in-group orientation also means a stronger focus on the group's unique knowledge and supports *perspective-making*, implying the development of a common, yet specialized, language and shared cognition that supports information exchange *within* a community of knowing (Boland and Tenkasi, 1995; Lawrence and Lorsch, 1967).[3] However, the risk of an in-group orientation is that inventor groups increasingly start to perceive other groups as less relevant, trustworthy, or cooperative (Stephan and Stephan, 1985; Tsui et al., 1995), feeding the development of stereotypes and prejudices (Boland and Tenkasi, 1995; Milliken and Martins, 1996). As Boland and Tenkasi (1995: p. 351) describe: "Thought worlds with different funds of knowledge and systems of meaning cannot easily share ideas, and may view one another's central issues as esoteric, if not meaningless."

Perspective-making therefore brings about the risk of incommensurability, stifling communication and knowledge exchange across groups of inventors, and increasingly inhibiting *perspective-taking*—which refers to information exchange *across* communities of knowing, aimed at bringing about an understanding and incorporating the perspectives of other groups as part of a community's way of knowing (Boland and Tenkasi, 1995; Carnabuci and Operti, 2013; McGrath and Gruenfeld, 1993; Milliken and Martins, 1996). Meanwhile, there is a growing literature detailing how inventors can access and connect to other (groups of) inventors by emphasizing the use of information support tools (e.g., Acharya et al., 2022; Boland and Tenkasi, 1995; Nicolini, 2011), informal exchanges (e.g., Hargadon, 2002; Chou et al., 2011; Garud et al., 2011), formal team structures (e.g., Singh and Fleming, 2010; Toh and Polidoro, 2013), effective team leadership (e.g., Currie and White, 2012), and organizational knowledge networks (e.g., Carnabucci and Diószegi, 2015; Moreira et al., 2018; Paruchuri and Awate, 2017). This strong focus on different information channels and organization structures to connect and create linkages places an emphasis on the ability for inventors to reach out to other (groups of) inventors, under the tacit assumption that these groups are also motivated to do so. Yet, groups of inventors are naturally inclined to engage in perspective-making, but much less to also engage in perspective-taking (Boland and Tenkasi, 1995; Hoever et al., 2012; Mathieu et al., 2017). This brings about a lack of effective information exchange between inventor groups, which deteriorates the potential of knowledge recombination for innovation—ultimately jeopardizing a firm's future competitiveness and viability (Ahuja and Lampert, 2001; Granstrand, 1998; Grigoriou and Rothaermel, 2017).

Such a high risk makes the management of incommensurability a key concern for TMTs. At the same time, however, it has been well established that a rich, decentral, and horizontal information exchange is needed to overcome different frames of reference across groups (Daft and Lengel, 1984; Maitlis and Christianson, 2014; Narayanan et al., 2011). For a TMT, the implication is that it needs to enable and foster—but not necessary directly interfere in—such rich form of horizontal communication and interaction among its inventor groups (Granstrand, 1998). This demands for a TMT to act as transformational leaders. Transformational leadership theory postulates that leaders can inspire and motivate followers to achieve their full potential and surpass their own self-interests (and expectations) to the benefit of the organization (Aryee et al., 2012; Bass, 1999; Bryman, 2011; Gumusluoglu and Ilsev,

[3] Perspective taking is a cognitive process in which inventors take stock of and learn other inventors' expertise and viewpoints to understand their preferences, values, and needs (Grant and Berry, 2011). Yet, in organizations, the motivation for sharing and jointly creating knowledge tends to be limited as inventors, and people in general, often try to protect what they know and are generally not motivated to engage in perspective-taking (Hoever et al., 2012), which accentuates the need for leadership (Von Krogh et al., 2012). Whereas there is growing attention in the literature for the role of leadership in addressing individuals' motivation for creativity and innovation (Gardner et al., 2020; Hughes et al., 2018; Crosby and Bryson, 2010), how it affects the motivation for knowledge exchange and perspective-taking across disciplinary boundaries, by diverse groups of inventors, is still missing.

2009; Odumeru and Ogbonna, 2013). We argue that transformational leaders can play a crucial role in preventing incommensurability among inventor groups by: First, clear and open communication on strategy, vision, and goals, ensuring everyone understands the direction and purpose of their work, to promote alignment. Second, by actively encouraging collaboration and teamwork, between groups, by fostering and stimulating a collaborative work environment. Third, by conflict resolution, addressing conflicting viewpoints, incentives, and interpretations by different inventor groups, to prevent incommensurability from happening or escalating. And fourth, by building trust among the various groups, to ensure inventors feel safe to express their (potentially conflicting) viewpoints, which also enhances horizontal information exchange among inventor groups, further decreasing the risk of incommensurability.

For TMTs to be effective as transformational leaders in addressing the risk of incommensurability, its ability to obtain information from the organization, to interpret this, and send information to the organization, is of key importance (Daft and Weick, 1984; Maitlis and Christianson, 2014; Narayanan et al., 2011). Here, we draw on classic organization theory and consider structure to determine information-processing capacity (Galbraith, 1973; Lawrence and Lorsch, 1967). Structures, in general, serve to establish coherent connections between the various agents and functions that make up teams, groups, departments, and, ultimately, the entire organization. In this respect, Hambrick et al. (2015) describe that a TMT's structural attributes significantly influence the extent to which units or individuals affect each other by setting the basic contours of the team. In other words, how agents interact to obtain, interpret, and share information is according to classic organization theory greatly determined by structures.

Here, we focus on three key TMT structural attributes that, we argue, influence TMTs ability to act as transformational leader to address incommensurability among inventor groups. This idea is in line with research which details the link between structures—such as organizational hierarchy and centralization—and transformational leadership behavior and effectiveness (e.g., Walter and Bruch, 2010; Wright and Pandey, 2010). We concentrate on those attributes that fully emerge from structure, staying true to classical organization theory, namely: Hierarchical structure, which influences the richness of *vertical* information processes and influences, for instance, critical thinking and constructive disagreement among TMT members; functional structure, which captures diversity in functional expertise, influencing the richness of *horizontal* information processes, notably by bringing together a wider range of ideas and experiences; and administrative intensity, a measure of relative size and administrative demands, which affects the cognitive capacity of a TMT to act as transformational leader by, for instance, having the time to share compelling visions and goals, to foster a sense of shared purpose and enable collaboration.

2.2.1. The moderating role of TMT hierarchical structure

A stronger hierarchy within a TMT brings about the opportunity for TMTs, and especially the CEO, to influence and inspire others. In this respect, higher ranked officers are placed in a position of great leverage, able to (quickly) act and direct the implementation of transformational initiatives to combat, among others, incommensurability among inventor groups. Moreover, a high hierarchical position also provides greater visibility and exposure, allowing these top managers to serve as role models, potentially allowing them to spur perspective-taking among inventor groups.

At the same time, however, a strong hierarchy implies that rank designations among the TMT are more distinct and that a sort of pecking order may emerge. Consequently, TMT members will hold less salience for each other, as they will view each other less as part of the same team (Hambrick et al., 2015). In this respect, a strong hierarchy can limit a TMT's vertical information-processing capacity, thereby limiting their ability to engage in transformational leadership in several ways.

First, a status quo bias might arise, where leaders in higher hierarchical positions are more focused on preserving their authority and the stability of the organization, rather than fostering an environment conducive of collaboration and innovation (Pizzolitto et al., 2023). As a consequence, the concentration of power could discourage the participation and involvement of other, lower-ranked TMT members (Clark, 2022). That is, the top leaders (e.g., CEO and/or COO) may dominate the decision-making processes, leaving little room for input and influence from other team members, or lower-level team members may simply feel hesitant to voice their ideas or concerns to higher-ranking executives due to power differentials and fear of repercussions (Mihalache et al., 2014). This can lower a TMT's ability to signal alignment and a sense of shared purpose to the organization towards the organization, and to credibly encourage collaboration and teamwork across different groups in the organization, including inventor groups. This will limit the potential for transformational leadership by a TMT to stimulate inventor groups to overcome incommensurability and to engage in perspective-taking.

Second, TMT hierarchy can contribute to a culture where feedback flows primarily from top to bottom, rather than being encouraged in reverse. Leaders in higher hierarchical positions may be less receptive to feedback and suggestions from lower-level team members, also because there are less informal social relations among TMT members (Mihalache et al., 2014). This can suppress minority dissent (Nijstad et al., 2014) that hinders the open exchange of ideas that can impede a TMT's efforts to support trust building among various inventor groups, and to ensure a perception of safety by inventor groups to express different viewpoints. In this respect, TMT hierarchy could severely limit the upward information process of 'issue selling' by inventor groups on incommensurability issues (Dutton et al., 2001; Narayanan et al., 2011), which reduces the likelihood that (looming) conflicts between inventor groups reach a TMT and can be effectively resolved.

These negative consequences limit the richness of the vertical information flow, to and from a TMT, hindering its ability to gather diverse perspectives and ideas. This will negatively affect its ability to prevent and resolve conflicts, encourage collaborations across inventor groups, and foster a shared sense of purpose—all which reduces its effectiveness as transformational leader to address perspective-taking across inventor groups. We therefore expect a negative moderation effect of TMT hierarchy on the relationship between inventor groups' knowledge diversity and innovation.

Hypothesis 2. TMT hierarchical structure negatively moderates the relationship between knowledge diversity among a firm's groups of inventors and firm innovation performance.

2.2.2. The moderating role of TMT functional structure

In functionally structured TMTs, each executive is responsible for a specific functional part of the firm's value-creation process in a way that depends on the behavior and effectiveness of all other TMT members (Hambrick et al., 2015; Menz, 2012). A functionally structured TMT consists of different executive functions, like marketing, sales, R&D, operations, finance, and engineering. This means that a highly functionally structured TMT needs to process cross-functional information and expertise to make effective team decisions (Menz, 2012). While such a functional structure provides valuable expertise, it may also cause functional leaders to prioritize the interests and goals of their respective functions, potentially hindering the TMT's ability to take a holistic and organization-wide approach to transformational leadership.

On the other hand, the mutual dependency could also make them more aware of the presence and value of functional differences in the organization, and of diversity in general (Richard et al., 2019). In this respect, functional diversity can be advantageous for TMT's ability to process information horizontally, to enable transformational leadership, in various manners. First, each TMT member brings a unique set of skills and capabilities associated with their functional expertise. Drawing on their varied perspectives, insights, and skills enables them to synthesize from these diverse perspectives (Wang et al., 2019), which contributes to fostering a shared sense of purpose and to stimulating collaboration across inventor groups. In this respect, its functional structure enables a TMT to be effective as transformational leader as it supports the alignment of diverse viewpoints and skill sets and thereby the alignment of the organization at large, which enhances perspective-taking across inventor groups for recombination and innovation.

Second, TMT functional diversity can be effective in addressing conflicting viewpoints by offering different interpretations and in this way reduce risks of conflicts, or resolve them, between different inventor groups (Cao et al., 2010), which then also contributes to the build-up of trust among these groups. Trust between inventor groups breaks down silos, reduces risks of conflicts, and facilitates cross-functional collaboration, which enables them to engage in perspective-taking and challenge existing assumptions, identify new opportunities and develop innovative solutions.

In sum, we expect that a functionally structured TMT will provide it with a rich horizontal information flow, equipping them to act as effective transformation leaders to also address incommensurability across inventor groups. Therefore, we expect a positive moderation effect of TMT functional structure on the relationship between inventor groups' knowledge diversity and a firm's innovation performance.

Hypothesis 3. TMT functional structure positively moderates the relationship between knowledge diversity among a firm's groups of inventors and firm innovation performance.

2.2.3. *The moderating role of TMT administrative intensity*

Administrative intensity is reflected by the number of TMT members in relation to the number of inventors—and is indicative of the required level of TMT administrative tasks and oversight (see Sine et al., 2006). A high administrative intensity is sometimes found to be beneficial, notably in the context of startups, by top management extensively engaging in process and organization-building activities (Sine et al., 2006).

However, a high administrative intensity can negatively influence TMTs ability to act as a transformational leader, in two ways. First, the demands associated with high administrative intensity include tasks such as budgeting, planning, and performance monitoring, which consume a substantial portion of a TMT's time and attention. As a consequence, these administrative tasks may consume much of the TMT's cognitive resources, leaving little mental space and energy to be effective as transformational leader to notice new opportunities for innovation, and to address perspective-taking across inventor groups (Shepherd et al., 2017). More specifically, higher administrative intensity reduces a TMT's capacity for raising awareness among inventor groups of the risk of incommensurability, for encouraging collaboration among them, for preventing and resolving conflicts, and for fostering a sense of shared purpose across these groups.

Second, a high administrative intensity can nurture a culture where alignment and a shared sense of purpose as well as fostering and stimulating collaboration across inventor groups carries especially a focus on day-to-day operational tasks, routine processes, and ensuring compliance with established procedures (Cortes and Herrmann, 2021; Teece, 1999). Such focus prioritizes stability and risk mitigation, in favor of maintaining stability and operational efficiency, yet discourages risk-taking, experimenting with new ideas, and knowledge exchange across inventor groups, which augments the risk of incommensurability across inventor groups.

In sum, a high administrative intensity increases the risk of incommensurability across inventor groups while it also undermines a TMT's ability to address this risk by effective transformational leadership. Therefore, we expect a negative moderation effect of TMT administrative intensity on the relationship between inventor groups' knowledge diversity and a firm's innovation performance.

Hypothesis 4. TMT administrative intensity negatively moderates the relationship between knowledge diversity among a firm's groups of inventors and firm innovation performance.

3. Method

We drew our sample from the pharmaceutical industry for different reasons. First, many pharmaceutical firms are relatively large and known to be comprised of various communities of knowing—think of domains such as molecular biology, physiology, biochemistry, synthetic chemistry, and pharmacology (Henderson and Cockburn, 1994; Pisano, 2006), and the various specialisms that exist within these domains. This fits well with our emphasis on the creation of innovations that come from recombining unconnected elements of knowledge (e.g., Carnabuci and Operti, 2013). Second, the interdisciplinary nature of drug discovery makes the ability to exchange and combine specialized knowledge within a firm key to innovation success and, ultimately, firm survival. Third, practically speaking, pharma firms have a strong incentive to file for patents, allowing us to study inventor groups' knowledge diversity at the firm level, based on the identification of technology classes and associated inventor groups (Henderson and Cockburn, 1994), as well as to establish the overall success of a firm's innovation activities (Caner et al., 2017).

3.1. *Data collection*

We compiled an initial list of 195 public US pharmaceutical firms (SICs 2833–2836), for which data were available in the BoardEx database, and that were, according to the Compustat database, among the industry's hundred largest employers at any time during the period between 2000 and 2014. This sample ensured that we observed the vast majority of innovation activity, employment, and assets in the pharmaceutical industry. We shortened the study's time panel to 2000–2011 to reduce truncation bias in patent citations (Hall et al., 2005). By doing so, we removed two firms from the sample. Owing to the study's focus on firms that are actively engaged in pharmaceutical innovation, we omitted 29 firms because they had fewer than five active inventors over at least one five-year time window or because they were granted no patents during the period of study (Carnabuci and Operti, 2013). Listwise deletion to handle missing data removed 24 firms. Fourteen firms were deleted because of gaps in their time panel or because they had only one observation. The resulting sample consists of 124 firms, 34,203 inventors, 2815 top managers, and 917 firm-year observations.

We constructed a unique firm-level panel dataset that includes detailed information on firms' top management, R&D activities and associated technological domains, and innovation outcomes resulting from extensive data collection across different data sources. We first identified subsidiaries, joint ventures, and historical names using Securities and Exchange Commission SEC 10-K filings and company websites to construct detailed family trees of all firms (Caner et al., 2017). Next, we collected data on all firms' patenting activities through extensive name matching of the entities in the family trees. All patent documents of the US Patent and Trademark Office (USPTO) were downloaded from the official ReedTech website, which resulted in a dataset covering patents granted between 1976 and 2015. Subsequently, we matched firms to USPTO and SDC records based on company names, USPTO assignee or SDC entity name, legal form, and country data to company information contained in SEC filings. These data sources were used as they match our sample of US public firms. Eventually, we aggregated all data for our 124 focal firms and their wholly owned subsidiaries at the ultimate parent level to capture each focal firm's full patenting and external R&D activity (Arora et al., 2014). We identified firms' executives and gathered data on their backgrounds using the BoardEx, Execucomp, and Thomson Reuters Eikon databases; these data were complemented with hand-collected data from a wide variety of databases, such as company reports, SEC filings, Lexis Nexis, and Bloomberg Executive Profile and Biography. All financial data are from

Compustat, and data on firms' ownership structures are from the Thomson Reuters Institutional Holdings 13F database.

3.2. Dependent variable: innovation performance

We examined patent data to assess each firm's *innovation performance*, measured as a citation-weighted patent count (Aghion et al., 2013; Kaplan and Vakili, 2015). Our focus on patents as an indicator of technological innovation follows the idea that "without inventions there are no innovations" (Ahuja and Lampert, 2001: p. 524). These innovations can, as such, be viewed as successful when they serve as the basis for many subsequent technical developments and innovation initiatives. Specifically, we measured performance using Trajtenberg's (1990) citation weighted patent count: $\text{CWP}_t = \sum_{i=t}^{nt}(1 + C_i)$, where each patent i is weighed according to the subsequent citations C_i it receives. We took the patent application year as the observation year because this is the closest to the actual innovation activity and summed all citations received in the subsequent five years (t to $t + 5$). We only consider patents granted before 2011, as this ensures a five-year citation window to prevent right censoring. Furthermore, drug patents tend to receive the highest number of citations within three to four years after application and receive the bulk of citations within five years from the grant date (Hall et al., 2005). Also, our patent dataset allowed us to correct for patent families, as these might substantially affect patent counts.[4]

3.3. Independent variable: inventor groups' knowledge diversity

We measured *inventor groups' knowledge diversity* as the extent to which the knowledge held by a firm's inventors is dispersed across different technological domains (Carnabuci and Operti, 2013). We matched our patent dataset with the disambiguated inventor names provided by the FUNG database (see Li et al., 2014, for information on the FUNG project). In the case of multiple patent assignees, we correctly assigned unique inventors to our sampled firms using inventors' historical or future patent activity. In total, we identified 34,203 inventors. We subsequently measured knowledge diversity at the firm level, relatively, using Teachman's entropy index (Teachman, 1980): knowledge $\text{diversity}_{t\text{-}1} = \sum_{j=1}^{N} P_j \times \ln\frac{1}{Pj}$, where P$j$ is the share of the firm's inventors who filed a patent in technology class j during the previous five years, summed over the total number of patent classes N in a firm's patent stock in this period (Carnabuci and Operti, 2013). We considered both primary and secondary patent classifications at a three-digit class level. The index approaches ln(N) when the inventors are fully dispersed over distinct technological domains (i.e., no knowledge groups exist). This is a direct measure of inventor groups' knowledge diversity that considers the total number of technology classes and the distribution of inventors over these classes, or knowledge groups, within the firm.[5] This is also in-line with Harrison and Klein's (2007) notion of diversity as 'variety,' meaning that members of different groups differ from each other qualitatively, that is, on a categorical variable like for example domain of expertise, functional background or source of external information.

3.4. Moderator variables: administrative intensity, hierarchical structure, and functional structure

We measured the three structural attributes of firms' TMTs based on data about each firm's TMT. Our database includes 2815 different top managers. We operationalized each firm's TMT as consisting of executives who had an executive directorship or worked at the level of senior vice president or higher (i.e., chairperson, vice-chairperson, CEO, CFO, executive vice president, and senior vice president). Following Hambrick et al. (2015), when a team consisted of five executives or less, we also included executives with a vice president title.[6] This procedure maintains consistency across firms to identify top management as the CEO and the executives with whom (s)he regularly interacts to make and implement important strategic decisions (Williams et al., 2017), including matters such as stimulating knowledge exchange across diverse groups of inventors for innovation.

Administrative intensity was measured as the number of top managers divided by the number of inventors. This measure was adapted from Blau and Schoenherr's (1971) administrative ratio measure (i.e., the ratio of administrators to employees). Classical sociological studies first introduced the concept of administrative intensity as a reflection of the intensity of coordination issues that firms have to manage (Sine et al., 2006).

Hierarchical structure was determined by standardizing and averaging the following two indicators: (1) number of distinct hierarchical levels as indicated by the title gradations in the management team each year, always including a CEO and possibly including COO, EVPs, SVPs, and VPs; and (2) the presence of a COO; a value of 1 was given if a COO was present and 0 if one was not (Hambrick et al., 2015). Notably, the presence of a COO represents an important aspect of the hierarchical structure of TMTs, as it indicates a structural distinction between strategy formulation and implementation, adds an organizational layer to management teams, and splits the reporting structure in and to the team (see Hambrick and Cannella, 2004).

Functional structure: Each team's functional roles were coded based on Menz (2012). Functional structure was then calculated as the total number of functional roles that exist within the TMT divided by the total number of top managers.[7]

3.5. Control variables

We controlled for variables that are common in research on search, innovation, and TMTs (Aghion et al., 2013; Barney et al., 2018). These include *firm size* (log. of the number of employees), *firm age* (years since IPO or first recording in Compustat), *financial performance* (return on assets, as net income divided by total assets), *financial slack* (current ratio, as current assets divided by current liabilities), *R&D expenditure*

[4] Even after these extensive efforts and manual checks of patent data, some citation-weighted patent counts of a few big-pharma firm observations remain outliers in our dataset. The 99th percentile of the citation count variable consists of eight observations that all relate to Johnson & Johnson. The 95th percentile of this variable mainly concerns observations of other big pharma firms. However, winsorizing the dependent variable at the 99th or 95th percentiles or removing these outliers from the sample did not substantially affect our results. (See Appendix I. Note that all Appendices will be made available online after acceptance of this manuscript.)

[5] Patents typically have more than one assignee. This does not substantially influence our measure, however, as we consider the count of patent applications, in each domain, per inventor.

[6] To study if the selective inclusion of VPs did not introduce any bias, we conducted a sensitivity test (Hambrick et al., 2015). Notable, we included a dummy variable that was coded 1 in case 'vice presidents' were included in our measures on TMT structural attributes. The result obtained from this model is highly similar to the results presented here (see Appendix II).

[7] Notably, this procedure implies that TMTs that include EVPs, SVPs, or VPs that are responsible for the same functional domains *increase* our measure of functional structure. For instance, consider a team of 10, from which 1 SVP and 1 VP are responsible for innovation. Let us assume that the other 8 TMT members all have 'generic' titles. In that case, our measure would be 2/10 (and not 1/10). As an alternative measure, we adopted Hambrick et al.'s (2015) TMT horizontal interdependence structure index, which was created by standardizing and averaging two indicators: (1) functional structure, which was coded 1 if the team was based entirely on functional roles or 0 if the team consisted of multiple general managers; and (2) functional titles, which was the proportion of functional titles within the senior management team. Although this index measure resulted in a skewed distribution and troubled the interpretation of its coefficient, it resulted in similar findings (see Appendix III).

(log. of R&D dollars invested by a firm), *acquisitions* (the absolute number), *diversification* (Teachman's entropy index to calculate the proportional distribution of firm sales over business and geographical segments), and *board independence* (number of independent directors divided by board size). We also controlled for *TMT size* (number of TMT members), *TMT age* (average TMT members' age), *functional heterogeneity* (Herfindahl-Hirschman index to calculate the concentration of TMT members' primary functional backgrounds), *tenure heterogeneity* (standard deviation of each executive's number of years in the TMT), and *proportion PhDs* (proportion of executives holding a Ph.D. or M.D. before TMT appointment). We included the number of *inventors* and patent *classes* to control for size-related factors in each firm's knowledge diversity and patenting activity (Carnabuci and Operti, 2013). We also controlled for the number of granted *patents* in year *t*, dated by application year, and corrected by patent families (Caner et al., 2017)—meaning that the coefficient estimates for other independent variables capture marginal contributions to the mean impact of a firm's innovation performance. Finally, we account for variation across industry segments and time by including a full set of four-digit SIC and year dummies. All explanatory variables and controls were lagged by one year to reduce possible simultaneity biases and to allow for the influence of the explanatory variables to become observable.

3.6. Analysis

We used generalized estimating equations (GEE) models to analyze our longitudinal data because we had multiple observations for each firm that may be correlated over repeated measures. We specified a negative binomial distribution with a log-link function because the mean for innovation performance, standard deviation, and the likelihood-ratio test all indicate overdispersion of our count-based dependent variable. To control for unobserved heterogeneity between firms, we introduced fixed-effects by including the pre-sample mean-scaling estimator (Blundell et al., 1995), and we exploited our long pre-sample history on patenting behavior (up to 25 years per firm) to include a pre-sample average of citation-weighted patents. GEE makes it possible to account for firm-specific factors reflected in any remaining correlation or heteroscedasticity between the residuals within the firm, which the fixed-effects estimator does not consider. We clustered robust standard errors by firm and modeled first-order serial autocorrelation because the Wooldridge test for serial correlation in panel-data models reported a significant test statistic.

We exploited our rich panel dataset to control for endogeneity in two ways. First, the panel structure of our data enables to address the risk of simultaneity bias, as all our independent variables and controls are lagged by one year. Second, to address concerns related to omitted variable bias, our dataset enabled the use of a five-year lag of inventor groups' knowledge diversity as an instrument (Bettis et al., 2014). This instrument satisfies the exclusion criteria because it is unlikely that depreciated knowledge diversity affects firms' innovation performance directly (Caner et al., 2017). As expected, our instrument is positively and significantly correlated with our knowledge diversity variable ($r = 0.77$; $p = 0.000$). The Kleibergen-Paap rk Wald F statistic, which can be used as an indicator of instrument strength in models with robust standard errors, clearly exceeded the Stock and Yogo (2005) critical value for a maximal instrumental variable IV bias of 10 percent (i.e., $61.19 > 16.38$). This confirms that our instrument is relevant and that our IV estimates are not severely biased due to weak instruments. Also, the Davidson and MacKinnon test of endogeneity is insignificant, which shows that the parameter estimates of knowledge diversity are not biased by endogeneity. This test compares the estimated coefficient of the assumed endogenous regressor from an OLS panel regression with the estimate obtained using a two-stage instrumental variable panel regression. The null hypothesis is that the OLS regression yields consistent parameter estimates. The results of the IV regressions are consistent with the reported findings in our main analyses (see Appendix V). Based on these measures, we carefully conclude that our results are not significantly affected by endogeneity related biases.

We estimated the interaction effects by hierarchically entering their interaction terms into our models (see Table 2). Model 1 contains only control variables. Model 2 includes the main predictor, inventor groups' knowledge diversity, to assess the baseline model. Models 3, 4, and 5 each introduce one of the three interaction terms. Finally, Model 6 includes all variables and interaction terms. We report Wald chi-square statistics to test overall model significance and further include the quasi-likelihood under the independence model criterion. Notably, the QIC decreases by 16 (from 9630 to 9614) when the three TMT structure variables are added to the model with control variables and the knowledge diversity variable. The QIC further decreases by 67 (from 9632 to 9565) when all variables and all moderation terms are included (compare models 2 and 6 in Table 2). Both decreases signal that the final model, that considers a TMT's structural attributes, underlying its ability to act as transformational leader to enable knowledge diversity for innovation, is the most parsimonious one (Cui and Qian, 2007).

Table 1 provides descriptive statistics and correlations. The mean-variance inflation factor (VIF) of 4.49 indicated potential multicollinearity between the variables of patent classes inventors, firm size, and pre-sample patent stock. We kept these variables in our models because of the importance of controlling for size-related factors. We investigated the potential impact of multicollinearity in two ways. First, we estimated models with orthogonalized variables of the indicated variables using a modified Gram-Schmidt procedure (Sine et al., 2006). This technique' partials out' the common variance between collinear variables. The resulting VIF in the models was 3.61, which is well below the commonly maintained threshold of 10 (see Appendix IV) (Gururati, 2005). Second, we also specified models that include only one collinear variable as a control, followed by a model without these variables (Kalnins, 2018). The signs, significance, and magnitudes of estimates remained highly consistent in all models (see Appendix V), indicating that multicollinearity did not substantially affect our results.

4. Results

Table 2 reports our results. With respect to our baseline Hypothesis 1, models 2–5 show a significant positive relationship between inventor groups' knowledge diversity and innovation performance. However, this is not the case for model 6. And while we cannot confirm Hypothesis 1, this finding underscores our central thesis that the relationship between knowledge diversity and innovation performance can only be comprehensively understood when including TMT structural attributes—as excluding these attributes results in omitted variable bias. We now continue to discuss the results obtained from Model 6.

Model 6 reports that hierarchical structure as a moderator has a positive yet insignificant effect on the relationship between knowledge diversity and innovation performance ($\beta = 0.156$; $p = 0.211$). This finding provides no support for Hypothesis 2. Model 6 also illustrates a strong positive moderation effect of functional structure on the relation between knowledge diversity and innovation performance ($\beta = 1.279$; $p = 0.008$). This result provides support for Hypothesis 3. Furthermore, we find a negative moderation effect of administrative intensity on the relationship between inventor groups' knowledge diversity and innovation performance ($\beta = -1.483$; $p = 0.000$). This finding validates Hypothesis 4, which predicted such a negative moderation effect. Finally, Model 6 include all three interaction terms, and the signs and magnitude of the coefficients remain highly consistent to those observed in models 3–5, in which we only included one interaction term at the time. This outcome provides further support for hypotheses 3 and 4.

Since we estimated non-linear models, we tested the significance of the interaction terms by plotting marginal effects at the means (MEM) with 95 percent confidence intervals using the estimates of Model 6. The predicted values of innovation performance are calculated over the entire range of values for knowledge diversity, when the moderating

Table 1
Descriptive statistics and correlation matrix.

		Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11
1	Innovation performance	320.21	1423.39	0.00	17961.00											
2	Knowledge diversity	2.14	0.62	0.00	4.08	0.43										
3	Administrative intensity	0.22	0.23	0.00	1.60	−0.18	−0.61									
4	Hierarchical structure	0.00	0.70	−1.42	1.30	−0.24	−0.19	0.16								
5	Functional structure	0.87	0.16	0.14	1.00	−0.53	−0.45	0.13	0.13							
6	Firm size[i]	8535.15	21648.32	12.00	122200.00	0.41	0.64	−0.42	−0.22	−0.48						
7	Firm age	25.84	35.36	0.00	161.00	0.43	0.50	−0.30	−0.19	−0.42	0.74					
8	Financial performance	−0.13	0.30	−1.33	0.76	0.16	0.27	−0.07	−0.02	−0.25	0.54	0.32				
9	Financial slack	5.75	6.53	0.37	64.14	−0.11	−0.20	0.16	0.13	0.14	−0.36	−0.24	−0.05			
10	R&D expenditure[i]	0.56	1.43	0.00	12.18	0.37	0.55	−0.54	−0.18	−0.28	0.77	0.67	0.22	−0.21		
11	Acquisitions	0.45	1.02	0.00	8.00	0.45	0.40	−0.19	−0.10	−0.37	0.51	0.47	0.22	−0.16	0.44	
12	Diversification	0.68	0.85	0.00	3.66	0.31	0.54	−0.24	−0.11	−0.46	0.72	0.55	0.46	−0.32	0.41	0.45
13	Board independence	0.83	0.09	0.50	1.00	0.01	0.21	−0.15	−0.13	0.04	0.06	0.08	0.00	−0.07	0.09	0.00
14	TMT size	8.35	2.94	3.00	23.00	0.33	0.51	−0.28	0.02	−0.37	0.60	0.49	0.24	−0.17	0.63	0.40
15	TMT age	49.97	3.49	38.60	60.50	0.11	0.15	−0.20	0.01	−0.06	0.27	0.33	0.04	−0.26	0.28	0.14
16	Functional heterogeneity	0.81	0.07	0.48	0.95	0.22	0.39	−0.13	0.06	−0.29	0.54	0.39	0.26	−0.16	0.54	0.29
17	Tenure heterogeneity	3.77	1.85	0.00	11.36	0.01	0.05	−0.06	0.03	−0.07	0.13	0.11	0.13	0.01	0.05	0.03
18	Proportion PhDs	0.40	0.21	0.00	1.00	−0.20	−0.23	−0.06	0.15	0.25	−0.41	−0.31	−0.29	0.28	−0.13	−0.16
19	Inventors	238.93	536.00	5.00	3801.00	0.71	0.60	−0.35	−0.28	−0.51	0.70	0.77	0.26	−0.21	0.68	0.61
20	Classes	21.56	27.96	1.00	186.00	0.74	0.77	−0.42	−0.28	−0.60	0.73	0.71	0.30	−0.23	0.64	0.57
21	Granted patents	26.35	67.25	0.00	557.00	0.83	0.57	−0.30	−0.27	−0.54	0.62	0.65	0.24	−0.18	0.58	0.52
22	Presample patent stock	138.97	262.86	0.48	1582.67	0.72	0.62	−0.37	−0.24	−0.54	0.67	0.72	0.23	−0.20	0.64	0.54

		12	13	14	15	16	17	18	19	20	21
13	Board independence	0.09									
14	TMT size	0.42	0.12								
15	TMT age	0.18	0.05	0.13							
16	Functional heterogeneity	0.33	0.10	0.83	0.11						
17	Tenure heterogeneity	0.03	−0.16	0.00	0.27	−0.01					
18	Proportion PhDs	−0.37	−0.14	−0.19	−0.07	−0.33	0.08				
19	Inventors	0.51	0.11	0.53	0.24	0.38	0.03	−0.23			
20	Classes	0.59	0.14	0.54	0.21	0.40	0.02	−0.30	0.92		
21	Granted patents	0.45	0.09	0.46	0.19	0.32	0.01	−0.21	0.91	0.89	
22	Presample patent stock	0.48	0.10	0.53	0.20	0.38	0.01	−0.22	0.92	0.90	0.88

Note: Correlations greater than 0.06 are significant at $p < 0.05$ and those greater than 0.08 are significant at $p < 0.01$.
[i] Log-transformed variable but original values reported here (R&D expenditure in $m).

Table 2
Results.

DV: Innovation Performance	Model 1 β	se	Model 2 β	se	Model 3 β	se	Model 4 β	se	Model 5 β	se	Model 6 β	se
Knowledge diversity (KD)			0.497	0.179	0.514	0.177	−0.872	0.486	1.033	0.255	−0.170	0.572
KD*Hierarchical structure					0.057	0.120					0.156	0.124
KD*Functional structure							1.414	0.494			1.279	0.485
KD*Administrative intensity									−1.472	0.340	−1.483	0.385
Firm size[i]	0.172	0.110	0.158	0.106	0.159	0.106	0.121	0.103	0.130	0.105	0.103	0.101
Firm age	−0.005	0.003	−0.005	0.003	−0.005	0.003	−0.005	0.003	−0.004	0.003	−0.004	0.003
Financial performance	0.054	0.195	0.056	0.201	0.058	0.200	0.081	0.195	0.026	0.204	0.047	0.194
Financial slack	0.005	0.005	0.004	0.006	0.004	0.006	0.003	0.006	0.005	0.006	0.004	0.006
R&D expenditure[i]	0.219	0.059	0.221	0.058	0.221	0.058	0.233	0.059	0.174	0.060	0.181	0.060
Acquisitions	−0.022	0.030	−0.020	0.030	−0.021	0.030	−0.024	0.029	−0.012	0.031	−0.018	0.029
Diversification	−0.059	0.095	−0.069	0.098	−0.072	0.097	−0.067	0.099	−0.047	0.100	−0.054	0.100
Board independence	−0.714	0.566	−0.621	0.552	−0.614	0.548	−0.618	0.556	−0.811	0.608	−0.805	0.597
TMT size	0.050	0.028	0.046	0.027	0.044	0.027	0.051	0.027	0.053	0.026	0.050	0.026
TMT age	−0.024	0.017	−0.025	0.017	−0.025	0.017	−0.025	0.016	−0.017	0.016	−0.017	0.016
Functional heterogeneity	−1.714	1.369	−1.704	1.325	−1.648	1.347	−1.847	1.317	−1.263	1.324	−1.277	1.344
Tenure heterogeneity	0.012	0.032	0.006	0.032	0.005	0.032	0.012	0.032	0.011	0.033	0.017	0.033
Proportion PhDs	−0.169	0.351	−0.125	0.344	−0.119	0.347	−0.282	0.351	−0.066	0.350	−0.194	0.353
Administrative intensity	−0.894	0.386	−0.556	0.406	−0.522	0.409	−0.560	0.416	1.418	0.578	1.523	0.661
Hierarchical structure	−0.108	0.087	−0.104	0.088	−0.228	0.268	−0.126	0.089	−0.115	0.090	−0.474	0.294
Functional structure	−0.024	0.368	−0.028	0.366	−0.041	0.363	−3.254	1.101	−0.071	0.346	−3.022	1.088
Inventors	−0.001	0.000	−0.001	0.000	−0.001	0.000	−0.001	0.000	−0.000	0.000	−0.000	0.000
Classes	0.014	0.008	0.001	0.009	0.001	0.010	0.008	0.009	−0.012	0.010	−0.006	0.010
Granted patents	0.012	0.002	0.013	0.002	0.013	0.002	0.013	0.002	0.013	0.002	0.014	0.002
Presample patent stock	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Constant	3.360	1.369	2.427	1.365	2.354	1.364	5.716	1.890	1.770	1.364	4.606	1.972
Wald chi-square	889.8		906.0		956.8		960.9		990.4		1119.5	
QIC	9637.9		9614.3		9619.2		9610.3		9567.6		9563.7	

Note: Table shows coefficients and robust standard errors in parentheses clustered by firms. All models include SIC and time dummies.
[i] Log-transformed variable.

variable is low or high (one SD below or above its mean), while all other variables were held constant at their means. Fig. 1 shows that the positive relationship between knowledge diversity and innovation performance decreases as administrative intensity increases. The MEM effect of knowledge diversity on innovation performance decreases by 56.2 percent and 69.8 percent when administrative intensity increases from low to mean and mean to high, respectively. Fig. 2 shows that when functional structure increases from low to mean and from mean to high, the MEM effect of knowledge diversity on innovation performance increases by 42.2 percent and 26.9 percent, respectively. These findings provide further support for hypotheses 3 and 4—and are demonstrative of how TMT structural attributes influence TMT's ability to act as transformation leader, to address incommensurability among their inventor groups, to enable recombinatory search for innovation.

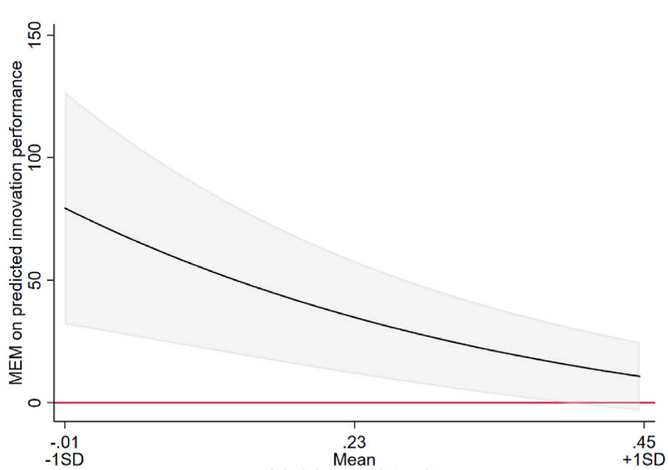

Fig. 1. Marginal effect of knowledge diversity given administrative intensity.

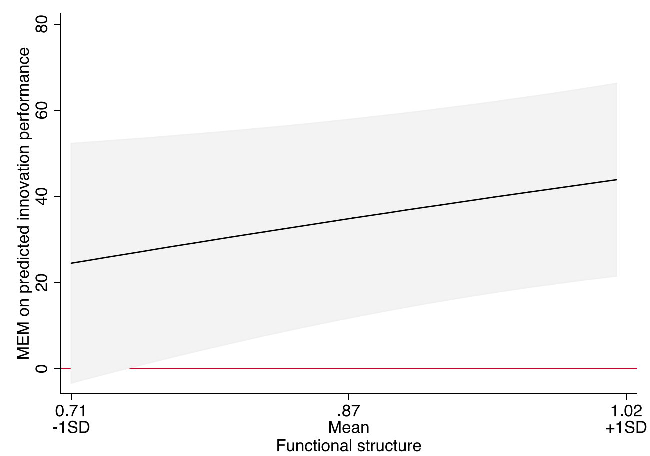

Fig. 2. Marginal effect of knowledge diversity given functional structure.

5. Discussion and conclusions

Whereas the literature has meanwhile demonstrated that organizations have a wide range of instruments and measures available to support rich knowledge exchange among groups of inventors, *perspective-taking* still does not come naturally in most firms. Whereas perspective-taking activities are essential for effective recombinatory search, they are mostly driven out by the emphasis on *perspective-making* by specialized groups of inventors, that is, in-group knowledge development and specialization activities (Boland and Tenkasi, 1995; Huang, 2009). When left unaddressed, this creates a risk of incommensurability across inventor groups, which jeopardizes a firm's innovation performance and thereby its future competitiveness and viability (Ahuja and Lampert, 2001; Granstrand, 1998; Grigoriou and Rothaermel, 2017).

This makes incommensurability among inventor groups a key concern for TMTs.

The implication for a TMT is that it not only needs to equip groups of inventors by providing them with different organizational measures to connect and create linkages among them to engage in perspective-taking, but it also needs to motivate them to execute on this. This demands for a TMT to act as a transformational leader and motivate and inspire inventor groups to transcend their self-interest to overcome incommensurability and to engage in perspective-taking (Boland and Tenkasi, 1995; Hoever et al., 2012). In our paper, we argued and showed how a TMT's structural attributes shape its information-processing capacity to be effective as transformational leaders in motivating and inspiring inventor groups to overcome incommensurability and to engage in perspective-taking. Following this, several results stand out.

We argued and found that TMT's functional structure has a *positive* moderating effect. A functionally structured TMT is well equipped to act as transformation leader, by being able to draw on the varied perspectives, insights, and skills of its members. This enables a TMT to allow for the alignment of diverse beliefs and skill sets, and thereby strengthen the alignment of the organization at large, and allow for the signaling of clear and compelling goals and vision. This then enables functionally structured TMTs to address complex challenges such as incommensurability across inventor groups, through promotion of interdisciplinary collaborations by breaking down silos and signaling of alignment, and to address and manage conflicts among these groups. This strengthens perspective-taking, which will amplify the positive relationship between knowledge diversity and innovation performance.

On the other hand, as predicted, we found that a TMT's administrative intensity has a *negative* moderating effect on the relationship between knowledge diversity and innovation performance. We argued that a high TMT administrative intensity is associated by a high administrative load that will consume a substantial portion of a TMT's time and attention, leaving less room for vision and strategy development and sharing this across the organization to stimulate organizational alignment, and to stimulate collaboration and trust-building among inventor groups. All of which is needed for inventor groups to engage in perspective-taking activities.

Overall, these findings suggest that the moderation of the relationship between inventor groups' knowledge diversity and innovation performance needs to be understood by how two key TMT's structural attributes, that is, its administrative intensity and its functional structure, influence its ability to act as transformational leader to address the risk of incommensurability, for innovation. In contrast to our expectations, we did not find that a TMT's hierarchical structure moderates the relationship between knowledge diversity and innovation performance. An interpretation of this latter non-finding may be as follows. While more hierarchy within a TMT might constrain the vertical information flow, it also allows top managers to better serve as role-models, by having great visibility and exposure. Moreover, a stronger hierarchy might possibly elevate the potential for conflict resolution and enhanced decision-making speed, also with respect to resource decisions (Henderson and Cockburn, 1994), which might have a positive effect on addressing the risk of incommensurability. As a net result, the positive and negative effects might cancel each other out, resulting in a non-significant finding for hierarchical structure in our analyses. We leave this reasoning as an interesting direction for future work.

We contribute to the literature on knowledge diversity and recombinatory search (Ahuja and Lampert, 2001; Carnabuci and Operti, 2013; Xiao et al., 2022). In this literature, there is a dominant focus on how collaboration, networks, and teams of inventors influence the relationship between knowledge diversity and innovation (Carnabuci and Operti, 2013; Moreira et al., 2018; Vakili and Kaplan, 2021). While inventor groups' knowledge diversity enables recombinatory search for innovation, it does not mean that inventor groups are motivated to collaborate and share their knowledge. On the contrary, inventors typically engage in perspective-making, limiting their collaborative processes to their direct peers. So, whereas perspective-taking is what inventors *should do* normatively, from a more behavioral perspective, this is different from what most inventors are inclined or willing to do (Boland and Tenkasi, 1995; Hoever et al., 2012; Mathieu et al., 2017). This means that the necessary configurational and structural adjustments as endorsed by this literature are likely to be less effective, or even ineffective, when this motivational side remains unaddressed. Here, we inform this field of incommensurability across diverse inventor groups, and its attendant risks of diverging interests, potential for conflict and lack of motivation, and the important role that TMTs play in addressing these risks through transformational leadership. More specifically, we argue and show how a TMT's structural attributes shape its information-processing capacity to be effective as transformational leader, and in this way moderate the relationship between knowledge diversity and a firm's innovation performance.

Moreover, these findings and conclusions also contribute to a better understanding of the role of a firm's TMT in strategy execution for innovation. In the growing literature on how TMTs influence their firm's innovation activities and outcomes, there is a major emphasis on the cognitive process *within* a TMT by studying how its compositional characteristics influence this information-processing and decision-making for innovation (e.g., Kashmiri & Mahajan, 2017; Kiss et al., 2018; Kiss et al., 2020; Zhang et al., 2021). Yet this has been largely at the expense of looking into the motivational process of strategy execution, a process that occurs largely *between* a TMT and lower-level employees, including inventor groups (Pryor et al., 2007). Here, we argued and showed that TMTs play a key role in addressing this motivational side to knowledge exchange across inventor groups by acting as transformational leader. We show that effective transformational leadership is enabled by their structural attributes as these shape their capacity to receive, process and send information to these different inventor groups, on awareness of incommensurability, encouraging collaborations and relationships, preventing and resolving conflicts, and fostering a sense of shared purpose. By means of our focus on a TMT's information-processing capacity to influence the organization's different inventor groups, through transformational leadership, our paper complements the literature with a dominant emphasis how its compositional characteristics influence cognitive processes within a TMT such as processing of external information and arriving at strategy formulation, rather than enacting strategy execution.

5.1. Managerial implications

The findings of this study have important implications for managerial practice. Attempts to create value in the modern organization through innovation have led to a recent surge in management concepts such as holacracy (Robertson, 2015), podularity (Gray and Vander Wal, 2014), teal organizations (Laloux, 2014), delayering (Ostroff, 1999), and agile management (Rigby et al., 2016). These approaches often consider structure as a burden and management as a cost. While these modern approaches can indeed enhance the swiftness, speed, and adaptiveness of organizations, it also emphasizes the use of smaller, autonomous groups. This brings along the risk of breeding an in-group out-group attitude, which feeds perspective-making at the expense of perspective-taking. Hence, an overemphasis on these novel organizational forms, without a TMT safeguarding perspective-taking, in concert with perspective-making, might undermine recombinatory search activities that are key to innovation and sustained organizational performance. As our study shows, for a TMT to be effective in enabling inventor groups' knowledge diversity for innovation, it needs to act as transformational leader. To be effective herein, we argued and showed that by lowering its administrative intensity while also placing a key emphasis on different functional roles, TMTs can strengthen their capacity for receiving, processing and sending information to and from inventor groups, in order to motivate and inspire them for perspective-taking.

5.2. Limitations and future research

One limitation of our study arises from our empirical focus on the pharmaceutical industry. This industry fits well with our interest and emphasis on the creation of innovations that stem from recombination and integration of knowledge from a broad array of different technological disciplines (Henderson and Cockburn, 1994); akin to the idea that innovation originates from recombining unconnected elements of knowledge, rather than linking these in new ways (Carnabuci and Operti, 2013). Yet, it also forms a somewhat unique type of industry given its highly science-based character (Gilsing et al., 2011; Pavitt, 1984). More work is needed to study if our findings hold true for other contexts, such as industries that are based on mechanical and electrical engineering, computer science, and mathematics (Gilsing et al., 2011; Marsili, 2001).

Another limitation is that we did not measure perspective-making, perspective-taking, transformational leadership, and incommensurability directly. Future work could be directed to open the black-box that underlies these making versus taking activities and associated group incommensurability. Moreover, despite the fact we took several remedial measures to address omitted variable bias and simultaneity bias (reverse causality), we cannot entirely rule out endogeneity in our empirical analysis. In this respect, inventor groups' knowledge diversity and innovation performance may be jointly determined. That is, while knowledge diversity serves innovation performance, innovation performance may, in turn, affect company practices or strategy formulation processes directed toward diminishing or enlarging knowledge diversity. Following performance feedback theory (Greve, 1998), for instance, negative performance generally makes a firm more inclined to adjust its strategy and become more risk-taking—which could indeed include an increase in its knowledge diversity. We leave this reasoning as an interesting suggestion for future work, but it also means that our findings should be treated with some care and best be interpreted as associations rather than be seen as causations.

Moreover, we studied three TMT structural attributes—which we argued are highly relevant to TMTs' ability to act as transformational leader. Nevertheless, various other TMT structural attributes exist, such as TMT reward interdependence (Hambrick et al., 2015). We leave it for future work to continue our work and study the effects of other attributes.

Finally, we focused on the role of top management teams to combat incommensurability by their ability to act as transformational leaders. This also implies that we did not focus on the role that individual senior executives can play in this process. Our decision to focus on at the team level follows existing research that discusses 'transformational leadership climate' — the degree to which leaders throughout an organization engage in transformational leadership behaviors (Menges et al., 2011). Future research, however, may consider the influence of R&D directors, which in concert with the TMT need to act as transformational leaders to enable knowledge recombination for innovation.

A final promising direction for future research is knowledge exchange and search *across* firm boundaries. This study adopted a *within-firm* perspective, but external knowledge is another important source of knowledge diversity that may enable innovation (Faems et al., 2005; Moreira et al., 2018). Although external collaboration for innovation will also contribute to knowledge diversity, we submit that the task of a TMT will not change qualitatively from what we have studied here. However, we leave it up to future research to ascertain whether this is the case.

CRediT authorship contribution statement

Bob Walrave: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Nino van de Wal:** Conceptualization, Data curation, Investigation, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing. **Victor Gilsing:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Appendix I. Dependent variable Winsorized at 99th percentile and 95th percentile

	Model 1			Model 2			Model 3		
Dependent: CWP <99th	*β*	*p*	*se*	*β*	*p*	*se*	*β*	*p*	*se*
Knowledge diversity (KD)				0.500	(0.005)	0.179	1.042	(0.000)	0.256
KD*Administrative intensity							−1.485	(0.000)	0.341
KD*Hierarchical structure									
KD*Functional structure									
Firm size	0.173	(0.116)	0.110	0.160	(0.132)	0.106	0.131	(0.211)	0.105
Firm age	−0.005	(0.150)	0.003	−0.004	(0.156)	0.003	−0.004	(0.175)	0.003
Financial performance	0.053	(0.786)	0.195	0.055	(0.783)	0.201	0.025	(0.901)	0.204
Financial slack	0.005	(0.353)	0.005	0.004	(0.499)	0.006	0.005	(0.436)	0.006
R&D expenditure	0.219	(0.000)	0.059	0.221	(0.000)	0.058	0.174	(0.004)	0.060
Acquisitions	−0.021	(0.477)	0.030	−0.019	(0.520)	0.030	−0.011	(0.716)	0.030
Diversification	−0.058	(0.538)	0.095	−0.068	(0.485)	0.098	−0.045	(0.649)	0.100
Board independence	−0.713	(0.208)	0.566	−0.618	(0.263)	0.552	−0.808	(0.184)	0.609
TMT size	0.050	(0.075)	0.028	0.046	(0.084)	0.027	0.053	(0.043)	0.026
TMT age	−0.024	(0.160)	0.017	−0.025	(0.133)	0.017	−0.017	(0.285)	0.016
Functional heterogeneity	−1.713	(0.212)	1.371	−1.704	(0.199)	1.326	−1.263	(0.341)	1.326
Tenure heterogeneity	0.012	(0.719)	0.032	0.005	(0.868)	0.032	0.011	(0.752)	0.033
Proportion PhDs	−0.167	(0.635)	0.351	−0.121	(0.725)	0.345	−0.061	(0.861)	0.351
Administrative intensity	−0.895	(0.020)	0.386	−0.556	(0.171)	0.407	1.434	(0.013)	0.578
Hierarchical structure	−0.108	(0.218)	0.087	−0.103	(0.241)	0.088	−0.115	(0.206)	0.091
Functional structure	−0.018	(0.960)	0.369	−0.021	(0.954)	0.367	−0.061	(0.859)	0.347
Inventors	−0.001	(0.009)	0.000	−0.001	(0.073)	0.000	−0.000	(0.348)	0.000

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	Model 1			Model 2			Model 3		
Dependent: CWP <99th	β	p	se	β	p	se	β	p	se
Classes	0.014	(0.076)	0.008	0.001	(0.924)	0.010	−0.013	(0.209)	0.010
Granted patents	0.012	(0.000)	0.002	0.012	(0.000)	0.002	0.012	(0.000)	0.002
Presample patent stock	0.001	(0.256)	0.001	0.001	(0.298)	0.001	0.001	(0.366)	0.001
Constant	3.352	(0.014)	1.370	2.413	(0.077)	1.366	1.750	(0.200)	1.366

	Model 4			Model 5			Model 6		
Dependent: CWP <99th	β	p	se	β	p	se	β	p	se
Knowledge diversity (KD)	0.517	(0.004)	0.178	−0.896	(0.066)	0.487	−0.195	(0.733)	0.571
KD*Administrative intensity							−1.502	(0.000)	0.386
KD*Hierarchical structure	0.058	(0.628)	0.120				0.160	(0.200)	0.125
KD*Functional structure				1.443	(0.004)	0.497	1.321	(0.007)	0.486
Firm size	0.160	(0.128)	0.106	0.122	(0.235)	0.103	0.104	(0.303)	0.101
Firm age	−0.004	(0.156)	0.003	−0.005	(0.135)	0.003	−0.004	(0.136)	0.003
Financial performance	0.058	(0.773)	0.200	0.081	(0.680)	0.196	0.046	(0.812)	0.194
Financial slack	0.004	(0.477)	0.006	0.003	(0.671)	0.006	0.004	(0.509)	0.006
R&D expenditure	0.221	(0.000)	0.058	0.234	(0.000)	0.059	0.181	(0.002)	0.060
Acquisitions	−0.020	(0.502)	0.030	−0.024	(0.414)	0.029	−0.017	(0.553)	0.029
Diversification	−0.071	(0.469)	0.098	−0.065	(0.510)	0.099	−0.051	(0.607)	0.100
Board independence	−0.611	(0.265)	0.548	−0.611	(0.272)	0.556	−0.797	(0.182)	0.597
TMT size	0.044	(0.107)	0.027	0.051	(0.059)	0.027	0.051	(0.054)	0.026
TMT age	−0.025	(0.136)	0.017	−0.025	(0.130)	0.016	−0.017	(0.292)	0.016
Functional heterogeneity	−1.647	(0.222)	1.349	−1.853	(0.160)	1.320	−1.283	(0.341)	1.347
Tenure heterogeneity	0.005	(0.875)	0.032	0.012	(0.705)	0.032	0.016	(0.624)	0.033
Proportion PhDs	−0.116	(0.739)	0.347	−0.281	(0.424)	0.351	−0.192	(0.587)	0.354
Administrative intensity	−0.521	(0.204)	0.410	−0.561	(0.179)	0.417	1.549	(0.019)	0.663
Hierarchical structure	−0.231	(0.389)	0.268	−0.126	(0.159)	0.089	−0.485	(0.101)	0.295
Functional structure	−0.034	(0.926)	0.364	−3.313	(0.003)	1.106	−3.110	(0.004)	1.090
Inventors	−0.001	(0.071)	0.000	−0.001	(0.032)	0.000	−0.000	(0.242)	0.000
Classes	0.001	(0.920)	0.010	0.008	(0.386)	0.009	−0.006	(0.528)	0.010
Granted patents	0.012	(0.000)	0.002	0.013	(0.000)	0.002	0.013	(0.000)	0.002
Presample patent stock	0.001	(0.287)	0.001	0.001	(0.167)	0.001	0.001	(0.191)	0.001
Constant	2.337	(0.087)	1.365	5.772	(0.002)	1.894	4.684	(0.018)	1.974

	Model 1			Model 2			Model 3		
Dependent: CWP <95th	β	p	se	β	p	se	β	p	se
Knowledge diversity (KD)				0.515	(0.004)	0.180	1.082	(0.000)	0.257
KD*Administrative intensity							−1.549	(0.000)	0.342
KD*Hierarchical structure									
KD*Functional structure									
Firm size	0.188	(0.089)	0.110	0.176	(0.097)	0.106	0.148	(0.159)	0.105
Firm age	−0.004	(0.196)	0.003	−0.004	(0.211)	0.003	−0.004	(0.246)	0.003
Financial performance	0.055	(0.778)	0.195	0.057	(0.778)	0.201	0.024	(0.907)	0.205
Financial slack	0.005	(0.337)	0.005	0.004	(0.491)	0.006	0.005	(0.427)	0.006
R&D expenditure	0.222	(0.000)	0.059	0.225	(0.000)	0.058	0.176	(0.003)	0.060
Acquisitions	−0.019	(0.511)	0.029	−0.019	(0.526)	0.029	−0.011	(0.712)	0.030
Diversification	−0.073	(0.434)	0.093	−0.085	(0.373)	0.096	−0.061	(0.533)	0.098
Board independence	−0.693	(0.221)	0.566	−0.575	(0.297)	0.551	−0.768	(0.211)	0.613
TMT size	0.048	(0.098)	0.029	0.045	(0.104)	0.027	0.052	(0.053)	0.027
TMT age	−0.024	(0.155)	0.017	−0.025	(0.125)	0.017	−0.017	(0.278)	0.016
Functional heterogeneity	−1.716	(0.213)	1.379	−1.715	(0.198)	1.332	−1.257	(0.346)	1.333
Tenure heterogeneity	0.011	(0.740)	0.032	0.004	(0.898)	0.032	0.009	(0.782)	0.033
Proportion PhDs	−0.119	(0.736)	0.353	−0.063	(0.856)	0.347	0.007	(0.984)	0.354
Administrative intensity	−0.904	(0.020)	0.389	−0.556	(0.178)	0.413	1.518	(0.009)	0.578
Hierarchical structure	−0.100	(0.262)	0.089	−0.094	(0.296)	0.090	−0.104	(0.260)	0.093
Functional structure	0.013	(0.973)	0.378	0.018	(0.961)	0.377	−0.007	(0.985)	0.356
Inventors	−0.001	(0.016)	0.000	−0.001	(0.091)	0.000	−0.000	(0.382)	0.000
Classes	0.013	(0.099)	0.008	0.000	(0.993)	0.010	−0.014	(0.169)	0.010
Granted patents	0.011	(0.000)	0.002	0.011	(0.000)	0.002	0.011	(0.000)	0.002
Presample patent stock	0.001	(0.331)	0.001	0.001	(0.387)	0.001	0.001	(0.486)	0.001
Constant	3.234	(0.019)	1.384	2.241	(0.105)	1.381	1.511	(0.275)	1.385

	Model 4			Model 5			Model 6		
Dependent: CWP <95th	β	p	se	β	p	se	β	p	se
Knowledge diversity (KD)	0.542	(0.002)	0.178	−1.020	(0.040)	0.497	−0.321	(0.574)	0.570
KD*Administrative intensity							−1.595	(0.000)	0.391
KD*Hierarchical structure	0.081	(0.503)	0.121				0.202	(0.111)	0.127
KD*Functional structure				1.589	(0.002)	0.511	1.518	(0.002)	0.491
Firm size	0.178	(0.093)	0.106	0.136	(0.187)	0.103	0.119	(0.239)	0.101
Firm age	−0.004	(0.216)	0.003	−0.004	(0.213)	0.003	−0.003	(0.228)	0.003
Financial performance	0.059	(0.766)	0.200	0.083	(0.672)	0.195	0.044	(0.820)	0.193
Financial slack	0.004	(0.463)	0.006	0.002	(0.681)	0.006	0.004	(0.506)	0.006
R&D expenditure	0.225	(0.000)	0.058	0.239	(0.000)	0.059	0.184	(0.002)	0.060
Acquisitions	−0.019	(0.500)	0.029	−0.022	(0.414)	0.027	−0.017	(0.539)	0.028

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Dependent: CWP <95th	Model 4 β	p	se	Model 5 β	p	se	Model 6 β	p	se
Diversification	−0.088	(0.354)	0.095	−0.078	(0.421)	0.097	−0.064	(0.516)	0.098
Board independence	−0.565	(0.301)	0.546	−0.568	(0.307)	0.556	−0.756	(0.207)	0.599
TMT size	0.041	(0.142)	0.028	0.049	(0.079)	0.028	0.047	(0.080)	0.027
TMT age	−0.026	(0.127)	0.017	−0.025	(0.124)	0.016	−0.017	(0.283)	0.016
Functional heterogeneity	−1.631	(0.230)	1.359	−1.844	(0.165)	1.330	−1.219	(0.369)	1.357
Tenure heterogeneity	0.004	(0.908)	0.032	0.011	(0.735)	0.032	0.015	(0.649)	0.033
Proportion PhDs	−0.053	(0.879)	0.349	−0.231	(0.516)	0.355	−0.130	(0.715)	0.356
Administrative intensity	−0.506	(0.226)	0.418	−0.564	(0.186)	0.427	1.694	(0.012)	0.671
Hierarchical structure	−0.271	(0.313)	0.269	−0.117	(0.198)	0.091	−0.566	(0.058)	0.298
Functional structure	0.003	(0.993)	0.374	−3.595	(0.001)	1.121	−3.498	(0.001)	1.091
Inventors	−0.001	(0.089)	0.000	−0.001	(0.036)	0.000	−0.000	(0.228)	0.000
Classes	0.000	(0.995)	0.010	0.008	(0.391)	0.009	−0.007	(0.477)	0.010
Granted patents	0.011	(0.000)	0.002	0.012	(0.000)	0.002	0.012	(0.000)	0.002
Presample patent stock	0.001	(0.373)	0.001	0.001	(0.248)	0.001	0.001	(0.299)	0.001
Constant	2.126	(0.124)	1.382	5.877	(0.002)	1.913	4.792	(0.016)	1.985

Note: n = 917. Table shows coefficients, p-values and robust standard errors clustered by firms. All models include SIC and time dummies.

Appendix II. Analyses that include a dummy in case 'vice presidents' were included in the measure on TMT structural attributes

Dependent: CWP	Model 1 β	p	se	Model 2 β	p	se	Model 3 β	p	se
Knowledge diversity (KD)				0.496	(0.006)	0.179	1.038	(0.000)	0.253
KD*Administrative intensity							−1.487	(0.000)	0.336
KD*Hierarchical structure									
KD*Functional structure									
VP included in TMT	**0.108**	**(0.450)**	**0.143**	**0.108**	**(0.444)**	**0.141**	**0.122**	**(0.395)**	**0.144**
Firm size	0.172	(0.113)	0.108	0.159	(0.128)	0.104	0.130	(0.204)	0.103
Firm age	−0.005	(0.134)	0.003	−0.005	(0.137)	0.003	−0.004	(0.147)	0.003
Financial performance	0.062	(0.759)	0.201	0.063	(0.759)	0.207	0.033	(0.875)	0.212
Financial slack	0.005	(0.336)	0.005	0.004	(0.484)	0.006	0.005	(0.418)	0.006
R&D expenditure	0.230	(0.000)	0.056	0.232	(0.000)	0.055	0.186	(0.001)	0.058
Acquisitions	−0.022	(0.474)	0.030	−0.020	(0.513)	0.030	−0.012	(0.696)	0.031
Diversification	−0.059	(0.522)	0.092	−0.069	(0.468)	0.095	−0.047	(0.630)	0.097
Board independence	−0.762	(0.170)	0.556	−0.669	(0.217)	0.542	−0.868	(0.148)	0.600
TMT size	0.051	(0.065)	0.028	0.047	(0.073)	0.026	0.054	(0.036)	0.026
TMT age	−0.021	(0.220)	0.017	−0.022	(0.196)	0.017	−0.013	(0.416)	0.016
Functional heterogeneity	−1.768	(0.190)	1.348	−1.761	(0.178)	1.308	−1.330	(0.309)	1.308
Tenure heterogeneity	0.011	(0.742)	0.033	0.004	(0.889)	0.032	0.010	(0.773)	0.034
Proportion PhDs	−0.181	(0.603)	0.349	−0.139	(0.684)	0.342	−0.084	(0.808)	0.347
Administrative intensity	−0.919	(0.017)	0.383	−0.580	(0.151)	0.404	1.412	(0.014)	0.575
Hierarchical structure	−0.130	(0.181)	0.097	−0.125	(0.201)	0.098	−0.140	(0.164)	0.100
Functional structure	0.038	(0.921)	0.383	0.039	(0.917)	0.376	0.010	(0.977)	0.355
Inventors	−0.001	(0.008)	0.000	−0.001	(0.069)	0.000	−0.000	(0.339)	0.000
Classes	0.014	(0.073)	0.008	0.001	(0.897)	0.010	−0.012	(0.225)	0.010
Granted patents	0.013	(0.000)	0.002	0.013	(0.000)	0.002	0.013	(0.000)	0.002
Presample patent stock	0.001	(0.275)	0.001	0.001	(0.316)	0.001	0.001	(0.388)	0.001
Constant	3.089	(0.030)	1.424	2.151	(0.132)	1.428	1.445	(0.320)	1.452

Dependent: CWP	Model 4 β	p	se	Model 5 β	p	se	Model 6 β	p	se
Knowledge diversity (KD)	0.513	(0.004)	0.178	−0.864	(0.079)	0.492	−0.150	(0.794)	0.574
KD*Administrative intensity							−1.504	(0.000)	0.379
KD*Hierarchical structure	0.061	(0.604)	0.118				0.160	(0.197)	0.124
KD*Functional structure				1.407	(0.004)	0.495	1.269	(0.009)	0.483
VP included in TMT	**0.112**	**(0.427)**	**0.141**	**0.094**	**(0.512)**	**0.143**	**0.118**	**(0.408)**	**0.143**
Firm size	0.159	(0.124)	0.104	0.121	(0.232)	0.102	0.104	(0.297)	0.099
Firm age	−0.005	(0.136)	0.003	−0.005	(0.119)	0.003	−0.005	(0.115)	0.003
Financial performance	0.066	(0.746)	0.205	0.088	(0.663)	0.201	0.055	(0.786)	0.201
Financial slack	0.004	(0.462)	0.006	0.003	(0.657)	0.006	0.004	(0.488)	0.006
R&D expenditure	0.232	(0.000)	0.055	0.243	(0.000)	0.056	0.193	(0.001)	0.058
Acquisitions	−0.021	(0.494)	0.030	−0.024	(0.408)	0.029	−0.018	(0.538)	0.029
Diversification	−0.071	(0.451)	0.095	−0.067	(0.489)	0.097	−0.054	(0.581)	0.097
Board independence	−0.663	(0.218)	0.538	−0.660	(0.224)	0.542	−0.858	(0.144)	0.586
TMT size	0.045	(0.094)	0.027	0.052	(0.052)	0.027	0.051	(0.047)	0.026
TMT age	−0.021	(0.202)	0.017	−0.022	(0.188)	0.017	−0.013	(0.433)	0.016
Functional heterogeneity	−1.703	(0.199)	1.326	−1.894	(0.147)	1.305	−1.332	(0.316)	1.328
Tenure heterogeneity	0.004	(0.897)	0.032	0.011	(0.731)	0.032	0.015	(0.651)	0.034
Proportion PhDs	−0.134	(0.696)	0.343	−0.293	(0.402)	0.349	−0.210	(0.548)	0.350
Administrative intensity	−0.544	(0.181)	0.407	−0.581	(0.163)	0.416	1.529	(0.019)	0.651
Hierarchical structure	−0.261	(0.336)	0.272	−0.144	(0.138)	0.097	−0.507	(0.092)	0.301
Functional structure	0.027	(0.941)	0.373	−3.175	(0.004)	1.112	−2.919	(0.008)	1.092

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Dependent: CWP	Model 4 β	p	se	Model 5 β	p	se	Model 6 β	p	se
Inventors	−0.001	(0.067)	0.000	−0.001	(0.029)	0.000	−0.000	(0.219)	0.000
Classes	0.001	(0.891)	0.010	0.008	(0.381)	0.009	−0.006	(0.554)	0.010
Granted patents	0.013	(0.000)	0.002	0.013	(0.000)	0.002	0.014	(0.000)	0.002
Presample patent stock	0.001	(0.304)	0.001	0.001	(0.174)	0.001	0.001	(0.197)	0.001
Constant	2.061	(0.149)	1.428	5.448	(0.006)	1.999	4.248	(0.043)	2.100

Note: n = 917. Table shows coefficients, p-values and robust standard errors clustered by firms. All models include SIC and time dummies.

Appendix III. Analysis using TMT horizontal interdependence structure index variable

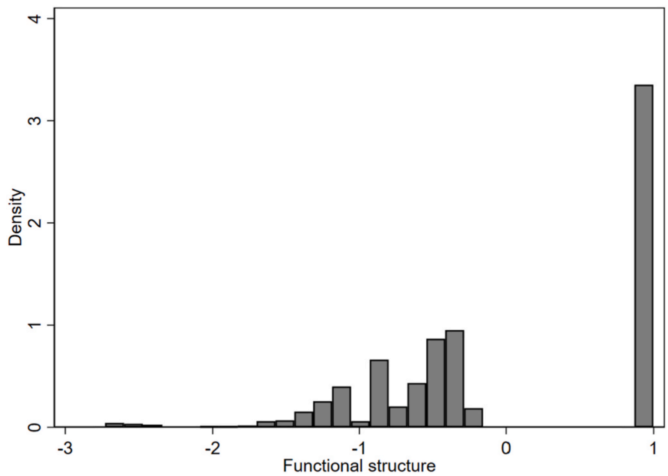

Fig. 1. Distribution of TMT horizontal interdependence structure index variable.

Dependent: CWP	Model 1 β	p	se	Model 2 β	p	se	Model 3 β	p	se
Knowledge diversity (KD)				0.480	(0.006)	0.176	1.027	(0.000)	0.254
KD*Administrative intensity							−1.505	(0.000)	0.344
KD*Hierarchical structure									
KD*Functional structure									
Firm size	0.155	(0.145)	0.106	0.144	(0.164)	0.103	0.114	(0.261)	0.101
Firm age	−0.005	(0.117)	0.003	−0.005	(0.125)	0.003	−0.004	(0.141)	0.003
Financial performance	0.076	(0.688)	0.188	0.075	(0.701)	0.194	0.045	(0.818)	0.197
Financial slack	0.005	(0.351)	0.005	0.004	(0.487)	0.006	0.005	(0.436)	0.006
R&D expenditure	0.229	(0.000)	0.058	0.230	(0.000)	0.057	0.182	(0.002)	0.059
Acquisitions	−0.019	(0.532)	0.030	−0.017	(0.577)	0.030	−0.009	(0.770)	0.030
Diversification	−0.068	(0.464)	0.093	−0.077	(0.422)	0.096	−0.055	(0.577)	0.098
Board independence	−0.669	(0.237)	0.566	−0.586	(0.292)	0.556	−0.787	(0.201)	0.615
TMT size	0.045	(0.103)	0.028	0.042	(0.116)	0.027	0.049	(0.063)	0.026
TMT age	−0.026	(0.130)	0.017	−0.026	(0.114)	0.017	−0.018	(0.259)	0.016
Functional heterogeneity	−1.758	(0.195)	1.357	−1.747	(0.184)	1.317	−1.300	(0.322)	1.312
Tenure heterogeneity	0.010	(0.741)	0.031	0.005	(0.882)	0.031	0.009	(0.771)	0.032
Proportion PhDs	−0.194	(0.570)	0.341	−0.154	(0.647)	0.336	−0.092	(0.788)	0.342
Administrative intensity	−0.915	(0.021)	0.397	−0.586	(0.157)	0.414	1.429	(0.015)	0.586
Hierarchical structure	−0.131	(0.133)	0.087	−0.124	(0.159)	0.088	−0.136	(0.135)	0.091
Functional structure	−0.106	(0.080)	0.060	−0.097	(0.108)	0.060	−0.105	(0.074)	0.059
Inventors	−0.001	(0.011)	0.000	−0.001	(0.083)	0.000	−0.000	(0.386)	0.000
Classes	0.013	(0.096)	0.008	0.001	(0.927)	0.010	−0.013	(0.206)	0.010
Granted patents	0.012	(0.000)	0.002	0.012	(0.000)	0.002	0.013	(0.000)	0.002
Presample patent stock	0.001	(0.292)	0.001	0.001	(0.326)	0.001	0.001	(0.393)	0.001
Constant	3.501	(0.008)	1.330	2.583	(0.051)	1.326	1.874	(0.159)	1.330
	Model 4			**Model 5**			**Model 6**		
Dependent: CWP	β	p	se	β	p	se	β	p	se
Knowledge diversity (KD)	0.500	(0.004)	0.174	0.376	(0.035)	0.179	0.983	(0.000)	0.270
KD*Administrative intensity							−1.555	(0.000)	0.382
KD*Hierarchical structure	0.070	(0.557)	0.119				0.167	(0.182)	0.125
KD*Functional structure				0.165	(0.119)	0.106	0.159	(0.108)	0.099
Firm size	0.145	(0.159)	0.103	0.121	(0.235)	0.102	0.098	(0.324)	0.100
Firm age	−0.005	(0.124)	0.003	−0.005	(0.141)	0.003	−0.004	(0.147)	0.003
Financial performance	0.077	(0.691)	0.193	0.093	(0.627)	0.191	0.061	(0.746)	0.189

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Dependent: CWP	Model 4 β	p	se	Model 5 β	p	se	Model 6 β	p	se
Financial slack	0.004	(0.465)	0.006	0.003	(0.615)	0.006	0.004	(0.484)	0.006
R&D expenditure	0.230	(0.000)	0.057	0.239	(0.000)	0.058	0.186	(0.002)	0.059
Acquisitions	−0.018	(0.550)	0.030	−0.020	(0.496)	0.029	−0.015	(0.613)	0.029
Diversification	−0.080	(0.405)	0.096	−0.072	(0.461)	0.098	−0.057	(0.563)	0.099
Board independence	−0.577	(0.296)	0.552	−0.606	(0.276)	0.556	−0.804	(0.182)	0.602
TMT size	0.039	(0.150)	0.027	0.046	(0.088)	0.027	0.046	(0.081)	0.026
TMT age	−0.026	(0.117)	0.017	−0.027	(0.108)	0.017	−0.018	(0.267)	0.016
Functional heterogeneity	−1.678	(0.210)	1.338	−1.834	(0.166)	1.326	−1.245	(0.353)	1.342
Tenure heterogeneity	0.004	(0.887)	0.031	0.007	(0.814)	0.031	0.012	(0.710)	0.033
Proportion PhDs	−0.147	(0.663)	0.337	−0.259	(0.455)	0.346	−0.176	(0.612)	0.348
Administrative intensity	−0.545	(0.194)	0.420	−0.602	(0.161)	0.430	1.578	(0.017)	0.661
Hierarchical structure	−0.277	(0.301)	0.268	−0.135	(0.125)	0.088	−0.509	(0.086)	0.297
Functional structure	−0.098	(0.096)	0.059	−0.443	(0.038)	0.214	−0.442	(0.027)	0.200
Inventors	−0.001	(0.081)	0.000	−0.001	(0.044)	0.000	−0.000	(0.276)	0.000
Classes	0.001	(0.920)	0.010	0.005	(0.601)	0.010	−0.009	(0.424)	0.011
Granted patents	0.013	(0.000)	0.002	0.013	(0.000)	0.002	0.013	(0.000)	0.002
Presample patent stock	0.001	(0.306)	0.001	0.001	(0.218)	0.001	0.001	(0.226)	0.001
Constant	2.479	(0.061)	1.322	2.941	(0.035)	1.398	2.010	(0.154)	1.409

Note: n = 917. Table shows coefficients, p-values and robust standard errors clustered by firms. All models include SIC and time dummies.

Appendix IV. Analysis using orthogonalized TMT structure variables

Dependent: CWP	Model 1 β	p	se	Model 2 β	p	se	Model 3 β	p	se
Knowledge diversity (KD)				0.497	(0.005)	0.179	1.033	(0.000)	0.255
KD*Administrative intensity							−1.472	(0.000)	0.340
KD*Hierarchical structure									
KD*Functional structure									
Firm size	0.226	(0.125)	0.147	0.208	(0.143)	0.142	0.170	(0.225)	0.140
Firm age	−0.005	(0.142)	0.003	−0.005	(0.147)	0.003	−0.004	(0.162)	0.003
Financial performance	0.054	(0.784)	0.195	0.056	(0.780)	0.201	0.026	(0.897)	0.204
Financial slack	0.005	(0.356)	0.005	0.004	(0.500)	0.006	0.005	(0.438)	0.006
R&D expenditure	0.219	(0.000)	0.059	0.221	(0.000)	0.058	0.174	(0.004)	0.060
Acquisitions	−0.022	(0.470)	0.030	−0.020	(0.510)	0.030	−0.012	(0.695)	0.031
Diversification	−0.059	(0.532)	0.095	−0.069	(0.478)	0.098	−0.047	(0.637)	0.100
Board independence	−0.714	(0.208)	0.566	−0.621	(0.261)	0.552	−0.811	(0.182)	0.608
TMT size	0.050	(0.074)	0.028	0.046	(0.083)	0.027	0.053	(0.043)	0.026
TMT age	−0.024	(0.161)	0.017	−0.025	(0.135)	0.017	−0.017	(0.292)	0.016
Functional heterogeneity	−1.714	(0.211)	1.369	−1.704	(0.198)	1.325	−1.263	(0.340)	1.324
Tenure heterogeneity	0.012	(0.715)	0.032	0.006	(0.861)	0.032	0.011	(0.744)	0.033
Proportion PhDs	−0.169	(0.631)	0.351	−0.125	(0.717)	0.344	−0.066	(0.850)	0.350
Administrative intensity	−0.894	(0.021)	0.386	−0.556	(0.171)	0.406	1.418	(0.014)	0.578
Hierarchical structure	−0.108	(0.216)	0.087	−0.104	(0.237)	0.088	−0.115	(0.201)	0.090
Functional structure	−0.024	(0.949)	0.368	−0.028	(0.939)	0.366	−0.071	(0.838)	0.346
Inventors	0.281	(0.124)	0.182	0.103	(0.587)	0.190	−0.146	(0.436)	0.188
Classes	0.252	(0.001)	0.079	0.109	(0.262)	0.097	−0.051	(0.610)	0.101
Granted patents	0.012	(0.000)	0.002	0.013	(0.000)	0.002	0.013	(0.000)	0.002
Presample patent stock	0.093	(0.251)	0.081	0.090	(0.288)	0.085	0.075	(0.349)	0.080
Constant	4.728	(0.002)	1.492	3.505	(0.016)	1.458	2.416	(0.098)	1.462

Dependent: CWP	Model 4 β	p	se	Model 5 β	p	se	Model 6 β	p	se
Knowledge diversity (KD)	0.514	(0.004)	0.177	−0.872	(0.073)	0.486	−0.170	(0.766)	0.572
KD*Administrative intensity							−1.483	(0.000)	0.385
KD*Hierarchical structure	0.057	(0.636)	0.120				0.156	(0.211)	0.124
KD*Functional structure				1.414	(0.004)	0.494	1.279	(0.008)	0.485
Firm size	0.209	(0.139)	0.142	0.158	(0.251)	0.138	0.135	(0.321)	0.136
Firm age	−0.005	(0.147)	0.003	−0.005	(0.125)	0.003	−0.004	(0.126)	0.003
Financial performance	0.058	(0.771)	0.200	0.081	(0.677)	0.195	0.047	(0.808)	0.194
Financial slack	0.004	(0.480)	0.006	0.003	(0.671)	0.006	0.004	(0.511)	0.006
R&D expenditure	0.221	(0.000)	0.058	0.233	(0.000)	0.059	0.181	(0.002)	0.060
Acquisitions	−0.021	(0.492)	0.030	−0.024	(0.405)	0.029	−0.018	(0.533)	0.029
Diversification	−0.072	(0.462)	0.097	−0.067	(0.499)	0.099	−0.054	(0.591)	0.100
Board independence	−0.614	(0.263)	0.548	−0.618	(0.266)	0.556	−0.805	(0.177)	0.597
TMT size	0.044	(0.105)	0.027	0.051	(0.059)	0.027	0.050	(0.055)	0.026
TMT age	−0.025	(0.138)	0.017	−0.025	(0.135)	0.016	−0.017	(0.305)	0.016
Functional heterogeneity	−1.648	(0.221)	1.347	−1.847	(0.161)	1.317	−1.277	(0.342)	1.344
Tenure heterogeneity	0.005	(0.867)	0.032	0.012	(0.699)	0.032	0.017	(0.618)	0.033
Proportion PhDs	−0.119	(0.731)	0.347	−0.282	(0.422)	0.351	−0.194	(0.583)	0.353
Administrative intensity	−0.522	(0.203)	0.409	−0.560	(0.178)	0.416	1.523	(0.021)	0.661
Hierarchical structure	−0.228	(0.394)	0.268	−0.126	(0.157)	0.089	−0.474	(0.107)	0.294

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	Model 4			Model 5			Model 6		
Dependent: CWP	*β*	*p*	*se*	*β*	*p*	*se*	*β*	*p*	*se*
Functional structure	−0.041	(0.911)	0.363	−3.254	(0.003)	1.101	−3.022	(0.005)	1.088
Inventors	0.110	(0.570)	0.194	0.213	(0.268)	0.192	−0.010	(0.962)	0.210
Classes	0.110	(0.257)	0.097	0.172	(0.055)	0.090	0.013	(0.894)	0.100
Granted patents	0.013	(0.000)	0.002	0.013	(0.000)	0.002	0.014	(0.000)	0.002
Presample patent stock	0.092	(0.277)	0.085	0.105	(0.155)	0.074	0.096	(0.170)	0.070
Constant	3.440	(0.018)	1.460	6.684	(0.001)	1.995	5.220	(0.013)	2.093

Note: n = 917. Table shows coefficients, p-values and robust standard errors clustered by firms. All models include SIC and time dummies.

Appendix V. GEE negative binomial analyses following Kalnins (2018) guidelines for mitigation of multicollinearity concerns

	Model 1			Model 2			Model 3			Model 4		
	β	*p*	*se*	*β*	*β*	*p*	*se*	*β*	*β*	*p*	*se*	*β*
Knowledge diversity (KD)				0.487	(0.007)	0.180	1.020	(0.000)	0.258	0.921	(0.004)	0.322
KD*Administrative intensity							−1.464	(0.000)	0.343	−1.431	(0.000)	0.346
KD*Hierarchical structure										−0.035	(0.375)	0.039
KD*Functional structure										0.086	(0.585)	0.158
Administrative intensity	−0.890	(0.020)	0.384	−0.567	(0.158)	0.402	1.407	(0.014)	0.574	1.353	(0.020)	0.582
Firm size	0.188	(0.091)	0.111	0.173	(0.106)	0.107	0.146	(0.169)	0.106	0.137	(0.195)	0.106
Firm age	−0.005	(0.143)	0.003	−0.004	(0.148)	0.003	−0.004	(0.159)	0.003	−0.004	(0.162)	0.003
Financial performance	0.032	(0.871)	0.198	0.035	(0.863)	0.204	0.004	(0.983)	0.208	0.019	(0.926)	0.208
Financial slack	0.005	(0.371)	0.005	0.004	(0.531)	0.006	0.004	(0.480)	0.006	0.004	(0.483)	0.006
R&D expenditure	0.222	(0.000)	0.059	0.224	(0.000)	0.058	0.178	(0.004)	0.061	0.174	(0.004)	0.061
Acquisitions	−0.026	(0.408)	0.031	−0.023	(0.446)	0.031	−0.016	(0.612)	0.031	−0.015	(0.626)	0.030
Diversification	−0.069	(0.466)	0.094	−0.078	(0.420)	0.097	−0.058	(0.557)	0.099	−0.049	(0.625)	0.101
Board independence	−0.670	(0.255)	0.588	−0.566	(0.324)	0.574	−0.750	(0.234)	0.630	−0.798	(0.197)	0.619
TMT size	0.043	(0.121)	0.027	0.040	(0.130)	0.026	0.047	(0.066)	0.025	0.055	(0.037)	0.026
TMT age	−0.027	(0.112)	0.017	−0.028	(0.093)	0.017	−0.020	(0.210)	0.016	−0.018	(0.272)	0.016
Functional heterogeneity	−1.894	(0.151)	1.319	−1.884	(0.141)	1.279	−1.487	(0.244)	1.276	−1.402	(0.280)	1.297
Tenure heterogeneity	0.006	(0.851)	0.032	0.000	(0.996)	0.032	0.005	(0.872)	0.033	0.010	(0.764)	0.033
Proportion PhDs	−0.167	(0.630)	0.347	−0.127	(0.707)	0.340	−0.074	(0.831)	0.346	−0.079	(0.822)	0.351
Inventors	−0.001	(0.010)	0.000	−0.001	(0.077)	0.000	−0.000	(0.353)	0.000	−0.000	(0.305)	0.000
Classes	0.014	(0.057)	0.007	0.001	(0.876)	0.009	−0.012	(0.215)	0.010	−0.011	(0.306)	0.011
Granted patents	0.013	(0.000)	0.002	0.013	(0.000)	0.002	0.013	(0.000)	0.002	0.013	(0.000)	0.002
Presample patent stock	0.001	(0.263)	0.001	0.001	(0.297)	0.001	0.001	(0.350)	0.001	0.001	(0.327)	0.001
Constant	3.536	(0.007)	1.317	2.609	(0.048)	1.319	1.936	(0.145)	1.327	1.853	(0.159)	1.316
	Model 5			Model 6			Model 7			Model 8		
	β	*p*	*se*	*β*	*β*	*p*	*se*	*β*	*β*	*p*	*se*	*β*
Knowledge diversity (KD)				0.642	(0.001)	0.185	0.654	(0.000)	0.185	0.575	(0.022)	0.250
KD*Administrative intensity										−0.631	(0.001)	0.183
KD*Hierarchical structure							0.097	(0.421)	0.120	0.056	(0.648)	0.123
KD*Functional structure										0.088	(0.571)	0.155
Hierarchical structure	−0.110	(0.201)	0.086	−0.104	(0.228)	0.086	−0.316	(0.232)	0.264	−0.225	(0.428)	0.283
Firm size	0.201	(0.083)	0.116	0.172	(0.108)	0.107	0.172	(0.105)	0.106	0.140	(0.180)	0.105
Firm age	−0.006	(0.118)	0.004	−0.005	(0.134)	0.003	−0.005	(0.137)	0.003	−0.004	(0.169)	0.003
Financial performance	0.032	(0.868)	0.191	0.041	(0.835)	0.198	0.047	(0.813)	0.197	0.051	(0.803)	0.204
Financial slack	0.005	(0.352)	0.005	0.004	(0.542)	0.006	0.004	(0.501)	0.006	0.004	(0.446)	0.006
R&D expenditure	0.267	(0.000)	0.054	0.248	(0.000)	0.053	0.245	(0.000)	0.054	0.181	(0.002)	0.059
Acquisitions	−0.036	(0.240)	0.030	−0.027	(0.370)	0.030	−0.028	(0.349)	0.030	−0.015	(0.615)	0.030
Diversification	−0.074	(0.437)	0.096	−0.080	(0.413)	0.098	−0.082	(0.401)	0.098	−0.052	(0.595)	0.098
Board independence	−0.692	(0.218)	0.562	−0.573	(0.295)	0.546	−0.574	(0.287)	0.540	−0.749	(0.199)	0.583
TMT size	0.045	(0.099)	0.027	0.043	(0.100)	0.026	0.039	(0.142)	0.027	0.051	(0.062)	0.027
TMT age	−0.021	(0.241)	0.018	−0.023	(0.177)	0.017	−0.022	(0.181)	0.017	−0.022	(0.191)	0.017
Functional heterogeneity	−2.176	(0.086)	1.267	−1.959	(0.115)	1.241	−1.833	(0.150)	1.275	−1.332	(0.335)	1.381
Tenure heterogeneity	0.016	(0.599)	0.031	0.006	(0.832)	0.030	0.006	(0.849)	0.031	0.008	(0.803)	0.034
Proportion PhDs	−0.089	(0.797)	0.348	−0.058	(0.866)	0.343	−0.054	(0.876)	0.345	−0.144	(0.686)	0.356
Inventors	−0.001	(0.003)	0.000	−0.001	(0.077)	0.000	−0.001	(0.074)	0.000	−0.001	(0.133)	0.000
Classes	0.017	(0.031)	0.008	−0.001	(0.914)	0.009	−0.001	(0.941)	0.009	−0.003	(0.781)	0.010
Granted patents	0.013	(0.000)	0.002	0.013	(0.000)	0.002	0.013	(0.000)	0.002	0.013	(0.000)	0.002
Presample patent stock	0.001	(0.183)	0.001	0.001	(0.261)	0.001	0.001	(0.244)	0.001	0.001	(0.291)	0.001
Constant	2.618	(0.038)	1.260	1.699	(0.178)	1.260	1.627	(0.197)	1.261	2.433	(0.056)	1.272
	Model 9			Model 10			Model 11			Model 12		
	β	p	se	β	β	p	se	β	β	p	se	β
Knowledge diversity (KD)				0.634	(0.001)	0.190	−0.601	(0.185)	0.454	−0.594	(0.214)	0.479
KD*Administrative intensity										−0.649	(0.000)	0.181
KD*Hierarchical structure										−0.045	(0.248)	0.039
KD*Functional structure							1.275	(0.008)	0.479	1.286	(0.008)	0.482
Functional structure	0.120	(0.743)	0.366	0.089	(0.804)	0.357	−2.800	(0.008)	1.058	−2.980	(0.005)	1.062
Firm size	0.219	(0.067)	0.120	0.188	(0.086)	0.109	0.159	(0.139)	0.107	0.107	(0.298)	0.102

(*continued on next page*)

(*continued*)

	Model 9			Model 10			Model 11			Model 12		
	β	p	se	β	β	p	se	β	β	p	se	β
Firm age	−0.005	(0.123)	0.004	−0.005	(0.137)	0.003	−0.005	(0.118)	0.003	−0.004	(0.142)	0.003
Financial performance	0.010	(0.960)	0.196	0.020	(0.923)	0.203	0.034	(0.866)	0.199	0.066	(0.741)	0.199
Financial slack	0.005	(0.362)	0.005	0.003	(0.574)	0.006	0.002	(0.748)	0.006	0.003	(0.629)	0.006
R&D expenditure	0.267	(0.000)	0.055	0.250	(0.000)	0.054	0.262	(0.000)	0.054	0.198	(0.001)	0.060
Acquisitions	−0.039	(0.209)	0.031	−0.031	(0.319)	0.031	−0.035	(0.239)	0.030	−0.018	(0.553)	0.030
Diversification	−0.083	(0.388)	0.096	−0.089	(0.368)	0.099	−0.090	(0.372)	0.101	−0.051	(0.606)	0.099
Board independence	−0.645	(0.270)	0.585	−0.510	(0.368)	0.567	−0.491	(0.391)	0.573	−0.739	(0.214)	0.595
TMT size	0.037	(0.161)	0.027	0.037	(0.147)	0.025	0.039	(0.119)	0.025	0.055	(0.041)	0.027
TMT age	−0.024	(0.176)	0.017	−0.025	(0.126)	0.017	−0.025	(0.120)	0.016	−0.023	(0.154)	0.016
Functional heterogeneity	−2.343	(0.053)	1.209	−2.143	(0.072)	1.193	−2.319	(0.051)	1.190	−1.625	(0.226)	1.342
Tenure heterogeneity	0.011	(0.725)	0.031	0.001	(0.966)	0.030	0.006	(0.839)	0.030	0.013	(0.697)	0.033
Proportion PhDs	−0.082	(0.813)	0.345	−0.056	(0.868)	0.340	−0.198	(0.568)	0.347	−0.288	(0.417)	0.354
Inventors	−0.001	(0.004)	0.000	−0.001	(0.083)	0.000	−0.001	(0.039)	0.000	−0.001	(0.086)	0.000
Classes	0.017	(0.031)	0.008	−0.001	(0.954)	0.010	0.006	(0.531)	0.009	0.002	(0.831)	0.009
Granted patents	0.014	(0.000)	0.002	0.013	(0.000)	0.002	0.014	(0.000)	0.002	0.013	(0.000)	0.002
Presample patent stock	0.001	(0.185)	0.001	0.001	(0.259)	0.001	0.001	(0.155)	0.001	0.001	(0.201)	0.001
Constant	2.694	(0.038)	1.298	1.801	(0.171)	1.316	4.755	(0.008)	1.797	5.655	(0.002)	1.824

Note: n = 917. Table shows coefficients, p-values and robust standard errors clustered by firms. All models include SIC and time dummies.

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