Managing Innovation in Firms

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Abstract

Most innovation occurs inside firms, yet little is known about the organizational forces that shape it. We study the role of managers in within-firm innovation using uniquely rich administrative data from a global manufacturing firm that tracks workers' ideas from invention to patenting and commercialization. Exploiting quasi-random manager switches across teams, we show that managers with prior invention experience substantially increase both the quantity and quality of workers' innovative output. Within four years, switching from a manager without invention experience to one with experience more than doubles workers' production of patented inventions. The effects emerge quickly, persist over time, and appear throughout the entire innovation pipeline. Our findings are consistent with knowledge transmission as a key mechanism: invention-experienced managers transmit innovation-related skills through close collaboration with workers, reallocating inventive effort towards managers' areas of technological expertise.

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1 Introduction

Most innovation takes place within firms,[1] yet we know surprisingly little about the organizational forces that shape how it is produced. Firms ultimately rely on individual workers to generate and develop new ideas. Unlike production involving routine tasks, however, innovation is characterized by substantial uncertainty, hard-to-observe effort, and long and noisy feedback cycles (Holmstrom 1989). These features create severe information frictions and make it difficult to evaluate performance, posing unique challenges for firms in structuring and managing the innovation process (Azoulay and Lerner 2012).

One potential response to these frictions is the deployment of managers. In many settings, firms rely on managers to monitor workers, coordinate tasks, and guide problem-solving. A growing body of empirical research outside of innovation contexts has established that managers have substantial effects on worker productivity (e.g., Lazear et al. 2015; Fenizia 2022; Cullen and Perez-Truglia 2023). Yet, it is unclear whether these insights extend to innovation, where production relies heavily on technical expertise and tacit knowledge rather than standardized tasks. While anecdotal evidence suggests that managers may influence innovation by providing technical guidance and steering resources,[2] there has been little systematic investigation, largely due to a lack of data that link the innovation process to internal organizational structures. As a result, we still have a limited understanding of whether managers can meaningfully shape innovative output within firms—and if so, through which channels their effects operate.[3]

This paper provides new evidence on the central role of middle managers in the innovation process. Using uniquely rich personnel and innovation data from a large manufacturing firm, we examine how managers affect the quantity, quality, and trajectory of workers' inventive output. Our analysis focuses on managers' hands-on invention experience, measured by their prior inventions, which captures domain-specific technical expertise and tacit knowledge that are central to the innovation process but largely absent from existing empirical work. Exploiting manager switches across teams, we use plausibly exogenous changes in workers' exposure to invention-experienced managers. We show that these changes have large and economically meaningful effects: within four years, teams exposed to the most invention-experienced managers roughly double their production of patented inventions. These effects emerge quickly, persist over time, and extend beyond patenting to upstream idea generation and downstream commercialization. By analyzing detailed collaboration patterns, information on the technological domain and novelty of inventions, and managers' leadership evaluations, we emphasize the importance of knowledge transmission as a key channel through which managers shape innovation.

We study a global manufacturing firm headquartered in Germany that ranks among Europe's leading innovators. The firm produces technologically sophisticated intermediate goods used across

[1] For example, 74% of R&D spending within the OECD is conducted by firms (OECD, 2024).

[2] See, for example, Gladwell (2011).

[3] Many influential studies on the determinants of innovation focus on individual inventors and star scientists (Azoulay et al. 2010; Waldinger 2010; Jaravel et al. 2018; Bell et al. 2019), which abstracts from the organizational environments in which these individuals operate.

a wide range of downstream industries and employs more than 200,000 workers worldwide. Consistent with its reputation as an innovation leader, the firm invests heavily in R&D and generates a high volume of inventions and patents each year. Our analysis focuses on the firm's white-collar and managerial employees in Germany, who account for the majority of inventive activity, and for whom we observe detailed longitudinal data on worker characteristics, team structures, and supervisor assignments.

Innovation at the firm involves the interaction of multiple different actors, as is typical for large firms. Corporate management sets broad technological priorities, but innovation activities occur across many different business units rather than in a centralized R&D department. The majority of inventions are generated by employees in engineering positions. Employees are legally required to disclose potentially patentable ideas through an online portal. Middle managers play a pivotal role in this process: they supervise teams, provide technical guidance, and help assess the feasibility of early-stage ideas. We find that their domain expertise is substantial—around half of managers in engineering continue to invent themselves after becoming managers and often work in multiple technological fields.

We assemble a uniquely rich dataset that allows us to observe innovation inside the firm from inventions through patenting and commercialization and to link these activities to workers' backgrounds and positions within the organization. First, we observe the entire universe of invention disclosures filed at the firm (N≈43,000 from 2008 to 2023), each time-stamped and listing all contributing inventors.[4] Second, for all disclosures that progress to patent applications, we observe detailed information on the invention, the filing strategy, and patent outcomes, including citations and technological fields, as well as whether the patented invention is ultimately implemented in a commercialized product. Third, we link these innovation measures to comprehensive personnel records that include demographics, education, pay, and position information. Because we observe workers' assignments to teams and supervisors, we are able to relate workers' innovation activities to detailed characteristics of their manager, including multiple dimensions of manager behavior, such as performance ratings and 360 degree reviews. To our knowledge, no prior work has been able to use such granular information on within-firm innovation.

Leveraging our unique data, we document several new stylized facts about how innovation unfolds within the firm. Innovation is highly concentrated among a relatively small group of employees. Only 16% of employees ever file an invention disclosure, and inventive output is extremely skewed, with a small fraction of workers accounting for a disproportionate share of disclosures and patents. Inventors are drawn primarily from technical roles: among employees who ever invent, 94% work in engineering positions, and they are substantially more educated than the broader workforce—16% hold a PhD compared with 6% among all employees. Finally, innovation at the firm is inherently

[4] As with patents, our measures reflect technical innovations rather than changes in marketing strategies or business models. This focus is appropriate for our setting—a large manufacturing firm whose competitive advantage relies on continuous technical innovation—and is shaped by the institutional environment: under the German Employee Inventions Act (*Arbeitnehmererfindungsgesetz*), employees are required to disclose all inventions to their employer, ensuring comprehensive coverage of inventive activity.

collaborative. The majority of invention disclosures in our sample (66%) involve multiple inventors, with an average of 2.5 inventors per disclosure. While most collaborations occur within relatively close organizational and geographic boundaries—typically within the same function, division, and country—inventive activity frequently spans formal team structures. These collaboration networks are persistent: in 68% of invention disclosures, at least two inventors have collaborated previously.

Managers play a particularly prominent role in this collaborative innovation process. Nearly half of all inventions in our data involve a manager as a co-inventor, indicating that managerial involvement often extends beyond oversight to direct participation in inventive work. Consistent with this pattern, a substantial share of managers remain actively engaged in innovation after transitioning into leadership roles: one in five files an invention disclosure in the year following promotion to manager, and managers contribute on average 0.27 disclosures per year while supervising a team, slightly more than the 0.21 disclosures produced by their subordinates on average. Managers overseeing inventive workers also tend to possess substantial technical expertise, as reflected in their educational backgrounds, prior inventive activity, and breadth of technological experience.

Together, these descriptive patterns motivate a central question: does a manager's own invention experience shape the inventive activity of the workers they supervise? Managers with hands-on experience in developing inventions may be better equipped to assess technical feasibility, provide informed feedback, and guide workers through the iterative process of refining ideas, but descriptive correlations alone cannot establish whether such experience has a causal impact on workers' innovation outcomes. To test the causal effect of managers on workers' inventive output, we exploit naturally occurring changes in manager–worker matches that arise from internal manager switches. As part of their normal career progression, managers frequently move across teams within the firm to acquire experience in different business units. A growing literature has used similar manager switches to identify managerial effects in other contexts (e.g., Cullen and Perez-Truglia 2023; Haegele 2022; Minni 2023). We document that these switches are common, not targeted to specific teams, and driven primarily by managers' career-development considerations rather than by workers' performance or innovation potential.

Building on our descriptive evidence, we focus on managers' own invention experience as our primary dimension of managerial heterogeneity.[5] We measure this experience using invention disclosures rather than patents, as disclosures capture upstream inventive activity that is less influenced by firm-level strategic or legal considerations.[6] Our event-study design thus compares workers' innovation outcomes before and after a manager switch, contrasting workers who experience large changes in manager invention experience with those whose incoming and outgoing managers have similar backgrounds. Our identification relies on the assumption that, absent the manager switch, innovation outcomes for these workers would have followed parallel trends. We provide direct evi-

[5] While prior studies have focused on characterizing the effect of different manager types based on worker outcomes or observable traits such as gender or promotion speed (Hoffman and Tadelis 2021; Haegele 2022; Cullen and Perez-Truglia 2023; Minni 2023), these measures are not directly tied to the domain-specific skills required for innovation.

[6] Consistent with this conceptual motivation, we show that managers' invention experience strongly predicts workers' subsequent inventive output, even after controlling for alternative manager characteristics such as tenure, gender, and performance evaluations.

dence in support of this assumption by examining pre-switch trajectories and conducting a series of robustness checks that address potential sorting on both past performance and anticipated future innovation.

Applying this event-study design, we find that managers' invention experience has large and economically meaningful effects on workers' innovation output. After a switch to a more invention-experienced manager, workers' production of high-quality inventions rises quickly and persistently. Four years after the switch, workers exposed to a manager whose prior invention experience is higher by one disclosure produce 0.014 additional patented inventions per year, relative to a baseline mean of 0.08. This effect is very large, given that the average manager with experience has around 8 inventions' worth of experience. That is, switching from a manager without experience to a manager with experience more than doubles workers' invention output. We also find positive effects on the quantity of inventive activity, measured by total invention disclosures (i.e., including inventions that are not patented). Consistent with these patterns, we find similar effects at intermediate and downstream stages of the innovation pipeline: workers exposed to more invention-experienced managers are more likely to produce patent applications and to generate inventions that are ultimately commercialized. Together, these results show that managers' invention experience matters not only for idea generation but also for the progression of ideas toward economically valuable outcomes along the entire innovation pipeline.

Beyond aggregate innovation outcomes, we uncover systematic changes in how innovation is produced and for whom manager effects are strongest. Following a switch to a more invention-experienced manager, workers initially reorient their inventive activity toward closer collaboration, particularly through co-invention with the manager, before subsequently increasing independent inventive output. This dynamic pattern is consistent with managers playing an active role in shaping early-stage idea development and transmitting innovation-relevant knowledge. We further show that these effects are not uniform across workers: manager invention experience has substantially larger impacts on employees who are already engaged in inventive activity.

Having established that managers' invention experience has large and persistent effects on workers' innovation output, we next examine the mechanisms underlying these effects. We find strong support for a knowledge-transmission channel: when workers switch to more invention-experienced managers, their inventive activity initially shifts toward close collaboration with the manager, followed by sustained increases in independent innovation. These effects persist even after the manager leaves the team and are strongest when managers' technical expertise overlaps with workers' inventive domains, consistent with the transfer of tacit, domain-specific knowledge. The concentration of effects among already inventive workers indicates that managerial experience amplifies the innovative capacity of employees with the prior knowledge required to leverage it, consistent with the view that knowledge spillovers in innovation require absorptive capacity Cohen and Levinthal (1990).

While we find little evidence that our results are driven primarily by monitoring or the selection of more talented workers, invention-experienced managers appear to influence the broader

innovation environment of their teams. In particular, managers with prior invention experience receive substantially higher ratings in the firm's 360-degree feedback system on innovation-specific leadership behaviors, such as encouraging experimentation and inspiring curiosity, without performing worse on other managerial dimensions. At the same time, we do not observe a systematic shift in realized patenting activity toward more exploratory or novel inventions (measured by IPC similarity to the firm's previous inventions), suggesting that changes in innovation culture alone cannot account for the patterns we document. In addition, invention-experienced managers are perceived as more effective at securing resources to develop ideas, consistent with the possibility that they are better able to mobilize organizational support for innovative projects. However, we do not observe corresponding increases in observable project inputs, such as larger inventor teams or greater collaboration, indicating that improved access to resources is unlikely to be the primary driver of the effects we document.

This paper contributes to a large theoretical literature in economics that studies how firms organize and incentivize innovative activity. Classic work on optimal contracts emphasizes the tension between exploration and exploitation and the challenge of rewarding long-run success under uncertainty (Holmstrom 1989; Baker et al. 1994; Manso 2011). Related research on multitasking highlights how incentive schemes shape effort allocation across measurable and hard-to-measure tasks, including innovation (Holmstrom and Milgrom 1991; Hellmann and Thiele 2011). A complementary strand focuses on organizational structure and information processing within firms, emphasizing the role of hierarchies and managerial expertise in allocating decision rights and solving complex problems (Aghion and Tirole 1994; Garicano 2000). While these frameworks highlight managers as central actors in the innovation process, empirical evidence on how managers shape workers' innovation outcomes inside firms remains scarce. We contribute by providing the first micro-level evidence on how managers' invention experience affects inventive activity within a large organization.

A large empirical literature studies how innovation can be stimulated, examining the effects of monetary incentives, prizes, and contests (Gneezy and Rustichini 2000; Moser 2005; Harhoff and Hoisl 2007; Erat and Gneezy 2016), R&D incentives and compensation schemes (Lerner and Wulf 2007; Sauermann and Cohen 2010; Ederer and Manso 2013; Gibbs et al. 2017), and broader institutional policies and individual determinants affecting innovative activity (Azoulay et al. 2011; Jaravel et al. 2018; Bell et al. 2019; Charness and Grieco 2019; Onishi et al. 2021; Akcigit et al. 2022; Cai et al. 2023; Hoisl et al. 2023). Because of limited data on how innovation unfolds within firms, most of this evidence is necessarily based on firm-level variation, independent inventors or scientists, or experimental settings. As a result, comparatively little is known about the internal organizational processes that shape innovative activity within firms. We contribute to this literature by providing novel empirical evidence from within a large firm and by documenting the role of managers as an important determinant of within-firm innovation output.

Finally, this paper also contributes to a growing body of research that emphasizes the importance of middle managers for worker performance and firm outcomes. Recent studies document

sizable manager effects on workers' career progression and productivity (Lazear et al. 2015; Hoffman and Tadelis 2021; Fenizia 2022; Haegele 2022; Adhvaryu et al. 2023; Cullen and Perez-Truglia 2023; Minni 2023; Weidmann et al. 2026). We contribute to this literature by studying manager effects in the context of within-firm innovation, a setting that is economically high-stakes yet empirically understudied and theoretically challenging, as workers' innovative actions are difficult to observe, slow to materialize, and inherently risky. Our first contribution is to provide the first evidence of large and robust manager effects on workers' innovation output along the entire innovation pipeline. Our second contribution is to go beyond documenting these effects and provide evidence in favor of a key mechanism: knowledge transmission from managers to workers. We provide evidence that invention-experienced managers build innovative capability among their teams, with implications for organizational design and innovation policy.

The rest of the paper proceeds as follows. Sections 2 and 3 introduce the setting and the new data we collect. Section 4 provides novel stylized facts on how innovation takes place within firms and motivates the particular role that managers play in the context of innovation. Section 5 presents our empirical strategy centered around manager switches. Section 6 reports our main findings on the impact of managers on workers' innovation output. Section 7 discusses potential underlying mechanisms. Section 8 concludes.

2 Setting

This paper draws on unique data from a global manufacturing firm headquartered in Germany. To preserve confidentiality, we omit identifying details about its specific characteristics. The firm produces technologically sophisticated intermediate goods used across a wide range of downstream industries. It employs over 200,000 workers, generates annual revenues in the billions of euros, and is widely regarded as a leading innovator in its sector. Its strong innovation capacity relative to its peers is reflected in both its substantial R&D investments and its consistently high inventive output (Appendix Table B3).

Our main analysis sample focuses on the firm's white-collar and managerial employees based in Germany. We impose these sample restrictions for two key reasons. First, innovation at the firm is overwhelmingly driven by white-collar and managerial employees. Blue-collar workers are less than one-tenth as likely to generate an invention. Second, while we provide some descriptive facts about innovation patterns of the firm's global workforce (Section 4), our empirical strategy requires detailed panel data on worker-manager assignments available only for the German workforce.[7] This restriction is not overly limiting for the purposes of this paper, as more than two-thirds of all inventions at the firm originate in Germany.

Column 1 of Table 1 summarizes the universe of the firm's white-collar and managerial workforce in Germany.[8] Women represent 22% of the workforce, a share consistent with the typical

[7] While the firm operates in over 50 countries, roughly a third of employees are based in the headquarters country.

[8] To maintain confidentiality, we do not disclose information that could identify the firm, including the exact number of employees.

manufacturing firm. The workforce is highly educated: 68% hold at least a bachelor's degree, and 22% possess a graduate degree. Employees exhibit substantial work experience: the average age is 44 years and tenure at the firm is long, averaging 15 years. Reflecting the firm's technological focus, 54% of employees hold engineering positions. Managers, defined as employees supervising at least one subordinate, account for 15% of the sample.

The firm's workforce is broadly comparable to that of other large manufacturing firms. Appendix Table B5 contrasts our main analysis sample with workers in other manufacturing firms surveyed in the 2018 BIBB, a nationally representative dataset on the German labor force. Most observable characteristics align closely across the two samples, including the share of women, average age, weekly hours, and the proportion of employees with supervisory responsibilities. Employees in our sample are, however, more highly educated and exhibit longer tenures, a pattern consistent with the firm's position as a leading innovator in its industry.

At the firm, employees work in fixed teams under a manager. Managers assign and prioritize tasks, coordinate day-to-day activities, and monitor progress. In addition, they provide task-specific guidance and facilitate collaboration within the team. Supervisors also conduct annual performance evaluations, determine bonus payments, and identify opportunities for employee development, such as training or promotion opportunities. These middle managers are also expected to motivate employees, mediate conflicts, and translate strategic objectives from senior leadership into actionable goals for their teams (Benson and Shaw 2024; Haegele 2024). Although fostering innovation is an explicit component of managers' own performance evaluation—and 69% of managers at the firm report that their impact on innovation is important for their career advancement (Haegele 2022)—these innovation-related goals are often long-term in nature and not always tightly linked to short-term pay outcomes. By contrast, meeting immediate operational objectives, such as delivering client projects on time, plays a more prominent role in both managerial evaluations and bonus payments.

Innovation at the firm involves the interaction of multiple different actors, as is typical for large firms. Corporate management sets broad technological priorities, but innovation activities are carried out across a wide range of business units rather than through a single centralized R&D department. Employees beyond those in formal R&D roles, often those closest to customers, regularly contribute ideas. Importantly, innovation is not only about idea generation but also about securing support for implementation: ideas typically must be promoted and championed, requiring approval, access to resources, time to develop, and sustained effort to build organizational support (Pajuoja et al. 2025). Middle managers play a central role in this process by supervising teams, screening idea quality, and coordinating the transition from ideas to implementation. Evidence from a survey of 1,659 German manufacturing firms that we conducted indicates that these features of innovative activity are widespread among large firms (see Appendix B for details on the survey findings).

As a manufacturing firm, the firm's innovation efforts focus primarily on technical advances, particularly the development of new or substantially improved products. Under the German Em-

ployee Inventions Act (*Arbeitnehmererfindungsgesetz*), employees are legally required to promptly inform their employer when they generate an invention, defined as a novel and non-obvious technical solution created through an inventive activity and capable of industrial application (i.e., patentable or protectable by a utility model). To inform their employer, employees submit invention disclosures through an internal online system to which every employee has access. Each disclosure lists all individuals who actively contributed to the invention. The firm's policy explicitly excludes supervisors from being listed unless they directly participated in the inventive activity.[9] While the disclosure requirement is established under German law, it applies to all employees employed by the firm, including those located outside Germany.

Once an invention disclosure is submitted through the online system, it enters the firm's internal review process. A patent attorney, supported by a team of technical specialists, reviews the disclosure, gathers additional technical information as needed, and determines whether the firm will claim the invention and pursue patent protection or release it back to the employee. When the firm claims an invention, the inventors are entitled to statutory financial compensation, making disclosure a direct and tangible incentive for employees. The firm administers the disclosure requirement strictly, as accurate and timely information is essential for establishing intellectual property rights and for resolving potential disputes over inventorship and compensation. Qualitative interviews with inventors and patent lawyers at the firm indicate that compliance with the disclosure requirement is very high. This interpretation is supported by the timing of disclosures: among disclosures that are eventually followed by a patent application, the average lag between disclosure submission and patent filing is eight months. If employees systematically delayed disclosure, many disclosures would be entered shortly before patent filing; instead, the observed lag indicates that disclosures are typically submitted well before patenting decisions are made.

3 Data

We integrate novel measures of employees' innovation activities along the full innovation pipeline—from invention disclosure to patenting and eventual commercialization—with comprehensive personnel records, compensation data, information on organizational structure, and multiple dimensions of performance evaluations.

3.1 Measures of Innovation

A central contribution of our study is that we observe employees' involvement in innovation activities along the entire innovation pipeline, from the initial invention stage to patenting and, ultimately, commercialization. This comprehensive coverage is possible because, under the German Employee Inventions Act (see Section 2), employees are legally required to promptly report any potentially

[9] Note that the disclosure requirement is independent of how the inventive idea originated, whether bottom-up from employees or top-down from managerial direction. Managers may provide feedback on inventions and allocate resources for further development, but they are not credited as inventors unless they made a substantive inventive contribution.

patentable invention to their employer, which they do through an internal online system. The system automatically time-stamps each submission and records the identity of all co-filing inventors, providing precise information on when an idea enters the firm's innovation pipeline. As a result, our data contain the full universe of invention disclosures submitted at the firm between 2008 and 2023 (N≈43,000). For each disclosure, we observe the internal file number, receipt date, names of all listed inventors, and the title of the invention.

For all invention disclosures that lead to a patent application, we observe detailed information on the resulting patent applications and their subsequent outcomes. These data include the filing date, title, descriptive abstract, filing country, and the legal entity within the firm to which the patent is assigned. We also observe whether and when the patent is published and granted, the associated patent identifiers, and any follow-on filings of the same invention in other jurisdictions. Using the patent identifiers, we merge in additional information from PATSTAT, including citation counts, patent family structures, and IPC technology classes. For patented applications, we also observe whether they are implemented in a commercialized product. This information is derived from royalty payments that the firm is legally required to make to employee-inventors under the German Employee Inventions Act.[10] Appendix C provides detailed descriptions of these innovation-related variables.

Our data offer two key advantages relative to existing datasets used to study innovation. First, we observe not only patented inventions but the entire universe of invention disclosures, allowing us to analyze innovative activity upstream of the patenting decision. Second, we observe which patented inventions are ultimately implemented in products, enabling us to measure downstream commercial impact. Both of these features allow us to construct rich and previously unavailable measures of both the quantity and quality of innovation. Such innovation data have typically not been accessible to researchers.[11]

3.2 Personnel Records and Organizational Structure

We complement the information on employees' innovation activities with comprehensive information from the firm's personnel records. These records include core demographic characteristics, such as gender, age, nationality, and educational qualifications, as well as detailed information on employees' positions within the organization, including tenure, job titles, functional area, division, location, and proxies for employees' hierarchical level. This detailed information allows us to relate innovation activities to workers' background and position information. The data further contain employees' working hours, absenteeism, earnings, and bonus payments. Crucially, the personnel records also track workers' assignments to teams and managers over time, allowing us to study how changes in supervisory relationships relate to innovation outcomes.

[10] Because commercialization data are available for one division of the firm, which is responsible for two-thirds of the firm's inventions, all analyses of commercialization focus on this division.

[11] A rare example of similar disclosure-level data in management research are Yang et al. (2021) who provide descriptive evidence on the correlation between firms' R&D structure and innovation output and Chien et al. (2025) who evaluate the effectiveness of a mentoring program on inventors' output.

3.3 Performance Evaluations

We also draw on rich information from the firm's talent management system, which provides several complementary measures of performance. First, annual performance evaluations are conducted by an employee's direct supervisor and are rated on a four-point scale. Second, for two years, the firm implemented a more granular behavioral evaluation system in which supervisors assessed employees on multiple dimensions beyond overall performance. The behavioral competencies differ by employee's position in the leadership ladder. For middle managers, evaluations cover several aspects of leadership, including stakeholder management, problem-solving, communication, and the ability to foster innovation in their teams. Behaviors are rated on a five-point scale. Third, for three years of the sample, we also observe detailed 360-degree feedback reports. These assessments aggregate evaluations from an employee's supervisor, peers, subordinates, and selected external stakeholders. The reports capture multiple facets of managerial behavior, such as stakeholder management, communication effectiveness, leadership style, problem solving, and innovation. These leadership dimensions are rated on a five-point scale. For data protection reasons, we cannot link individual ratings to the identity of the rater (e.g., supervisor vs. peer), but instead average all ratings into one average score. In addition to the ratings by others, the 360-degree evaluation also asks managers to rate themselves with respect to these leadership dimensions. See Appendix C for more details on the individual ratings.

4 New Stylized Facts on Within-Firm Innovation

Leveraging the unique combination of detailed innovation measures linked to internal personnel records, this section documents new stylized facts on how innovation unfolds inside a large manufacturing firm. We present evidence at three levels—individual inventors, co-inventorship structures, and managers—reflecting the different margins through which innovation is shaped within firms.

4.1 Inventors and the Innovation Pipeline

We begin by documenting how inventive ideas progress through the firm's innovation pipeline, from initial disclosure to patenting and eventual commercialization. As shown in Table 2, 58% of disclosures result in a patent application (Column 2) and 31% ultimately receive a granted patent (Column 3). Moreover, downstream success is rare even among patented inventions: only 2% of inventions are eventually commercialized (Column 4). Finally, the innovation process takes time. The average time from disclosure to patent filing is 8 months (Column 2) and to granting is 51 months (Column 3). These pipeline statistics underscore that innovation involves repeated screening decisions under uncertainty and long delays between effort and payoff.

The vast majority (89%) of inventions happen in engineering, motivating our empirical focus on workers in engineering roles, where the innovation margin is most salient. Among engineers, 28% file an invention disclosure during our sample period. Table 1 describes the characteristics of inventors, comparing all engineering employees (Column 2) to those who ever submit an invention

disclosure (Column 4), and those who repeatedly invent, defined by the top decile of quarterly inventions (Column 5). Inventors differ systematically from the broader population of engineers along several dimensions. They are more likely to hold advanced degrees, particularly PhD degrees (16%). These differences are even more pronounced among inventors who repeatedly invent and among whom 31% hold a PhD. Inventors are also more likely to be male. However, inventors do not substantially differ from non-inventors in terms of other demographics, such as age, German citizenship, and firm tenure. These inventor demographics closely mirror those documented for patenting inventors more broadly (e.g., Giuri et al. 2007): they are predominantly male, typically in their mid-forties, and substantially more likely to hold advanced degrees. Beyond selection into inventive activity at the extensive margin, Table 1 also documents patterns at the intensive margin. Employees who invent at least once file, on average, 0.72 invention disclosures per year. The top decile inventors produce on average 3.69 inventions per year.

4.2 Co-Inventorship Patterns

Innovation within the firm is predominantly collaborative. Panel A of Table 3 shows that the majority of invention disclosures in our sample (66%) list multiple inventors, with an average of 2.45 inventors per disclosure. While most collaborations occur within relatively close organizational and geographic boundaries—typically within the same function, division, city, and country—inventive activity nevertheless frequently spans formal team structures. Among disclosures with at least two inventors, contributors come from an average of 1.9 distinct teams, indicating that collaboration often extends across team boundaries even when remaining within broader organizational units. This pattern holds for both all invention disclosures and those that ultimately result in patents. At the same time, collaboration also exhibits substantial persistence. In 68% of invention disclosures, at least two inventors have collaborated previously. Panel B of Table 3 finds similar patterns when focusing on inventions made by inventors outside Germany. While the number of co-inventors and the number of distinct teams is slightly lower, the overall collaboration patterns are similar to our main sample of inventors based in Germany.

4.3 Manager Experience and Involvement

Managers play an active role in the firm's innovation process, not only by overseeing inventive work but also by contributing directly to it. Almost half of all invention disclosures list at least one manager as a co-inventor (Panel A of Table 3), indicating that managers frequently contribute directly to inventive activity (Table 3).[12]

Column 3 of Table 1 shows that managers of engineers (who represent the key group of inventors at the firm) possess substantial domain-specific knowledge and remain closely engaged with the

[12]This pattern is not mechanically driven by firm policies that require employees to list their direct supervisors on invention disclosures. To the contrary, the firm's policy explicitly excludes supervisors from being listed unless they directly participated in the inventive activity (see Section 2). Managerial presence on a disclosure therefore reflects substantive inventive contributions rather than supervisory responsibility.

technical content of their teams' work. 83% of managers hold at least a bachelor's degree and 13% have a PhD. They produce on average 0.27 invention disclosures per year, exceeding the average of 0.21 disclosures produced by their subordinates.

These stylized facts point to a central role for task-specific managerial human capital in shaping within-firm innovation. This also aligns with evidence from other knowledge-intensive and technical settings, where managerial roles require deep subject-matter expertise rather than solely general management skills (e.g., Amabile et al. 1988; Podolny and Hansen 2020). Consistent with this interpretation, Appendix Table B1 shows that engineering managers differ from managers outside engineering in terms of their skills and qualifications (Column 2 versus Column 4), suggesting that advancement into managerial roles in engineering reflects accumulated technical expertise rather than a transition away from it. They motivate our empirical focus in Section 5 on managers' prior invention experience and our use of manager switches to identify how changes in exposure to managerial expertise affect workers' inventive activity.

5 Empirical Strategy: Evidence from Manager Switches

The goal of our empirical strategy is to estimate how managers influence their workers' innovation output. We focus on managers' own invention experience as a particular driver of manager effects on workers, motivated by descriptive evidence showing that a substantial share of managers have extensive hands-on involvement in inventive activity prior to and during their transition into leadership roles. The ideal research design would randomly assign workers to managers. In the absence of random assignment in the real world, we exploit the fact that, as part of their normal career progression, managers frequently switch teams, creating naturally occurring changes in manager–worker matches that are plausibly unrelated to workers' underlying innovative potential. In the following subsections, we first describe the institutional features of manager switches within the firm and how we construct measures of managers' invention experience. We then outline the event-study framework used to estimate the causal effects of managers' invention experience on worker outcomes, including a detailed discussion of the identifying assumptions that underpin our design.

5.1 Manager Switches

A central feature of our identification strategy is that managers routinely switch teams within the firm. Manager switches are a standard component of the firm's career progression system. As in many large organizations, managers are expected to gain experience in multiple business units to be considered for senior leadership roles. These manager switches are thus common in large organizations, and several recent studies have exploited similar manager switches for identification (e.g., Haegele 2022; Cullen and Perez-Truglia 2023; Minni 2023). The underlying rationale behind using manager switches to study manager effects on workers is that manager switches are widespread, typically not targeted to particular teams, and driven by managers' career-advancement consider-

ations rather than by conditions within a specific team. Thus, they provide a source of plausibly exogenous variation in workers' exposure to different managers. One way to directly assess this assumption is to examine pre-trends in worker outcomes leading up to manager switches; we discuss this approach and its implications in more detail in Section 5.3, and present the corresponding empirical evidence including several complementary robustness tests in Section 6.3.

Manager switches in our panel are common, and the large variation in manager tenure with a team implies that workers cannot easily anticipate when a manager switch will occur. Manager switches also span the entire organization, including all division and firm locations, reflecting broad mobility patterns rather than targeted moves toward specific types of teams. Importantly, managers who switch teams look similar to those who do not across key observable characteristics, such as age, tenure, own performance rating, as shown in Columns 3 and 4 of Table 5. See Section 6.3 for additional robustness tests that corroborate that manager switches are not restricted to specific types of teams or workers.

5.2 Managers' Invention Experience

In estimating manager effects on workers' innovation output, we focus on managers' prior invention experience as the central managerial characteristic. We measure this experience using managers' inventive activity before they begin supervising a given worker. Our baseline measure captures a manager's invention experience in the years preceding a manager switch. For each transition event, we compute the total number of inventions disclosed by each outgoing and incoming manager prior to the quarter of the transition. Our preferred measure is based on invention disclosures rather than patent applications. Conceptually, invention disclosures capture the full set of ideas to which a manager contributed, upstream of the firm's patenting decision, which may reflect strategic, legal, or market considerations beyond the manager's control. Appendix Figure A16 shows that our results are robust to alternative operationalizations, including the annual rate of past disclosures, measures excluding co-invented disclosures, and measures based solely on patents.

Our emphasis on managers' own invention experience is motivated by economic theories of task-specific human capital and learning-by-doing (Arrow 1962; Gibbons and Waldman 2006). Innovation is a canonical setting in which these mechanisms are particularly salient: generating and developing new ideas requires tacit technical knowledge, the ability to navigate substantial uncertainty, and experience with the iterative process of refining early-stage concepts. Managers who have themselves engaged in inventive activity may therefore possess innovation-specific human capital that enhances their ability to evaluate ideas, identify promising research directions, and provide effective guidance to workers. In line with theory, we therefore expect prior invention experience to be a central dimension of managerial quality in innovative environments. Consistent with this expectation, recent empirical evidence shows that hands-on invention experience at the top of the organization is strongly associated with higher quantity and quality of firm-level innovation (Islam and Zein 2020).

While prior studies have focused on characterizing the effect of different manager types based on

worker outcomes or observable traits such as gender or promotion speed (Lazear et al. 2015; Frederiksen et al. 2020; Hoffman and Tadelis 2021; Haegele 2022; Cullen and Perez-Truglia 2023; Minni 2023), these measures are not directly tied to the domain-specific skills required for innovation. By contrast, inventive activity directly captures experience in the core task of interest: generating, evaluating, and developing new ideas under uncertainty. For this reason, we treat managers' invention experience as the theoretically relevant dimension of managerial quality in innovative settings. Consistent with this interpretation, Section 6.3.5 shows that managers' invention experience is a substantially stronger predictor of workers' inventive output than alternative manager characteristics such as gender, tenure, or executive status (Appendix Figure 6). Table 4 describes how managers' invention experience is related to other key manager characteristics, such as tenure, education, and technical background.

5.3 Event Study Design

Our empirical design draws on 880 manager switches in which a worker's direct manager leaves the team and is replaced by another manager. Motivated by the descriptive evidence in Section 4, our main analysis focuses on all workers in engineering, who are responsible for the vast majority (89%) of all invention disclosures. In Appendix E, we demonstrate that our results are robust to alternative sample definitions, including specifications that consider all workers who ever submitted an invention disclosure or those in teams where at least one member has ever submitted an invention disclosure.

To estimate the dynamic effects of managers' invention experience on workers' inventive output, we implement an event-study design around the event in which a manager switches teams. Our object of interest is the effect of a change in manager invention experience on outcome y_{it} for worker i in quarter t. We estimate the following event-study regression:

$$y_{it} = \sum_{j} \beta_j \mathbb{1}\{s(t) = j\} \Delta E_i + \alpha_i + \gamma_{s(t)} + \varepsilon_{it}, \tag{1}$$

where $s(t)$ indexes event time relative to the quarter of the manager switch (with $j = -1$ omitted as the reference period), and ΔE_i denotes the change in manager invention experience associated with the manager transition. Worker fixed effects α_i control for all time-invariant worker characteristics, while event-time fixed effects $\gamma_{s(t)}$ absorb common shocks at each relative time period. We cluster standard errors at the worker level.

We examine a range of outcome variables that capture both the quantity and quality of workers' inventive output along the innovation pipeline. Our primary outcome focuses on high-quality innovation and is defined as the number of invention disclosures by worker i in quarter t that ultimately result in a granted patent. This measure captures inventions that successfully pass both the firm's internal screening process and external patent examination. To separately assess changes in the quantity of inventive activity, we also consider the total number of invention disclosures, regardless

of whether they lead to patent protection. As intermediate outcomes, we study disclosures for which the firm decided to file a patent application irrespective of whether the patent was granted and, further downstream, disclosures that were ultimately commercialized into products, which represent particularly high-stakes innovation outcomes. All outcome variables are constructed as four-quarter rolling sums. The advantage of this aggregation is that it smooths short-run volatility in inventive activity. Appendix Figure A12 shows that our results are not sensitive to this choice: we obtain very similar patterns when estimating an annual event-study specification that uses non-overlapping yearly outcomes instead of rolling quarterly measures.

The identifying variation in our design comes from differences in the magnitude of the change in manager invention experience induced by a manager switch. We restrict attention to workers who experience a manager switch and compare how their outcomes evolve depending on whether the incoming manager has substantially more (or less) invention experience than the outgoing manager. In this sense, the event-study specification implements a difference-in-differences design in event time: we compare changes in outcomes before and after the switch for workers exposed to large changes in manager experience to changes for workers whose manager switches involve little or no change in experience. Workers who experience switches between managers with similar innovation backgrounds therefore serve as a natural control group for those exposed to large experience shocks.

A primary concern for identification is that manager mobility may be systematically related to team performance, either based on realized past outcomes or anticipated future potential. For example, bias could arise if the firm assigns technically strong managers to teams that have recently performed well, to teams expected to become more innovative in the near future, or reallocates managers in response to unobserved signals about forthcoming projects or technologies. Any of these patterns would violate the parallel trends assumption by inducing correlations between manager switches and unobserved team-level shocks.

We assess the plausibility of our identification assumption using an event-study framework that compares the pre-switch trajectories of workers exposed to large vs. small changes in manager invention experience. If manager switches are orthogonal to workers' underlying characteristics, innovation outcomes should follow parallel trends prior to the switch. Consistent with this prediction, we find no evidence of differential pre-trends in key innovation outcomes (Figure 1). Importantly, we also observe no pre-trends in non-innovation outcomes that should be unaffected by managerial invention experience, such as worker exit from the firm (Appendix Figure A7). In a set of robustness exercises, we further augment the baseline specification with rich fixed effects, such as division and calendar-time fixed effects, to account for potential firm-wide strategic shifts, including expansions in particular technological or business areas that could be correlated with the assignment of more invention-experienced managers. Section 6.3 presents additional tests supporting quasi-random assignment, including evidence that incoming managers have no effect on team outcomes before they take over the team (Appendix Table B8).

The tests discussed above address internal validity by examining whether innovation outcomes evolve similarly prior to manager switches. However, a related concern is whether the manager

switches we exploit for identification are themselves selected in ways that limit the generalizability of our results. If only a narrow subset of managers or workers were exposed to the switches used for identification, the generalizability of our estimates could be limited. To address this concern, Table 5 examines the balance of worker and manager characteristics by exposure to manager switches. We find that both groups closely resemble the broader population, suggesting that the manager switches we exploit are not highly selected. In additional robustness exercises, we further restrict the sample to manager switches arising from routine internal career transitions and to parts of the firm experiencing little contemporaneous restructuring, thereby reducing the scope for correlated organizational shocks. The results are qualitatively unchanged, supporting both the internal and external validity of our findings.

6 Manager Effects on Workers' Innovation Output

This section presents our main empirical evidence on how managers shape workers' innovation output within the firm. Exploiting quasi-exogenous changes in manager–worker matches arising from manager switches, we document large and persistent effects of managerial invention experience on both the quantity and quality of workers' innovation. We show that these effects arise at multiple stages of the innovation pipeline, from upstream idea generation to patenting and downstream commercialization; they are accompanied by systematic changes in collaboration patterns and differ across worker types. We conclude the section with a comprehensive set of robustness and validity checks that support a causal interpretation of our findings.

6.1 Worker Output Along the Innovation Pipeline

We begin by examining how managers' invention experience affects workers' inventive output at different stages of the innovation process, distinguishing effects on the quantity versus the quality of innovation and documenting how these effects evolve over time.

Patented Inventions. Panel A of Figure 1 presents our baseline event-study estimates of the effect of managers' invention experience on workers' high-quality inventive output, measured as invention disclosures that are eventually granted a patent. The figure plots the coefficients from Equation (1), tracing how workers' patentable inventions respond over time to a change in managers' invention experience induced by a manager switch. Reassuringly, the estimates in the pre-switch period are close to zero and statistically insignificant, indicating parallel pre-trends between workers who experience large vs. small changes in manager experience. This pattern supports the identifying assumption that, absent the switch, workers' innovation outcomes would have evolved similarly.

Following the manager switch, we observe a clear and sustained increase in high-quality inventive output. Because the outcome aggregates activity over the previous four quarters, the emergence of positive effects shortly after quarter 4 implies that workers begin producing additional patentable inventions relatively quickly after a more invention-experienced manager takes over the team. The

effect grows over the subsequent quarters and stabilizes after roughly two years. Four years after the switch, workers exposed to a manager whose prior invention experience is higher by one disclosure produce 0.014 additional patented inventions per year, relative to a baseline mean of 0.08. This effect is economically large and statistically significant (p-value = 0.000 for quarters 9–16).

Any Invention. Panel B of Figure 1 examines how manager invention experience affects the quantity of inventive activity, measured as the total number of invention disclosures. The estimates exhibit no systematic pre-trends prior to the manager switch, supporting the validity of the event-study design. After the switch, we observe a positive but somewhat more gradual increase in the number of disclosures. Because the outcome is again constructed as a four-quarter rolling sum, the modest rise beginning after the first year suggests that exposure to a more invention-experienced manager leads workers to generate more ideas over time, though the effect is smaller in percentage terms. By four years after the switch, workers exposed to a manager whose prior invention experience is greater by one disclosure produce 0.03 additional disclosures per year. The magnitude of this effect relative to the outcome mean of 0.23 is moderately smaller than for patented inventions.

Additional Outcomes along the Pipeline. We also examine two additional outcomes that further illuminate where along the innovation pipeline manager invention experience matters. First, as an intermediate outcome, we study invention disclosures for which the firm decided to file a patent application. Patent applications require substantial legal and administrative resources and therefore already reflect a meaningful quality threshold, while remaining distinct from our main outcome that conditions on eventual patent grant. As Table 6, Column 2 shows, we find patterns that closely mirror those for granted patents: exposure to a more invention-experienced manager leads to a statistically significant increase in patent applications, indicating that experienced managers not only foster idea generation but also help workers develop ideas that the firm deems worth protecting. Second, we examine disclosures that are ultimately implemented in commercialized products.[13] Table 6, Column 5, shows economically meaningful and statistically significant increases in commercialization following switches to more invention-experienced managers. Together, our results document the important impact managers have on workers' innovative output along the entire innovation pipeline.

6.2 Co-Inventorship Patterns

While our main results establish that managers' invention experience increases both the quantity and quality of workers' inventive output, they do not by themselves reveal how these effects arise. A key advantage of our data is that we can go beyond aggregate innovation outcomes and examine how the composition of inventive activity changes following a manager switch. In particular, we analyze whether inventions are produced solo or jointly, whether they are co-invented with the manager, and how co-inventorship patterns evolve. We return to these patterns in Section 7, where

[13] Commercialization information is available for one division of the firm for data availability reasons; this division accounts for approximately two-thirds of all disclosures in our sample.

we discuss how they inform the underlying mechanisms through which managers affect workers' innovative activities.

Solo Invention Activity. We first examine how exposure to a more invention-experienced manager affects the likelihood that workers collaborate with others on their inventions by distinguishing between solo inventions and inventions developed jointly with any co-inventors. Appendix Figure A1 studies the effect of invention-experienced managers on workers' solo invention disclosures that eventually yield a granted patent (Panel A) and on all inventions (Panel B). These exhibits allow us to assess whether experienced managers primarily stimulate individual inventive effort or instead encourage collaborative innovation, and whether any such shifts differ for higher-quality inventions. Both panels show no evidence that experienced managers affect solo inventions.

Co-Invented Activity with or without the Manager. Next, we analyze how gaining a more invention-experienced manager alters workers' propensity to engage in co-invention with or without that manager. Panels A and C of Figure 2 report estimates for inventions that are co-invented with the manager, while Panels B and D focus on inventions that are not co-invented with the manager. The top panels consider only disclosures that eventually result in a granted patent, whereas the bottom panels consider all invention disclosures. For inventions that are not co-invented with the manager (Panels B and D), inventive output initially declines in the quarters immediately following the manager switch. In contrast, co-invented output (Panels A and C) increases sharply and almost immediately after the switch. These dynamics suggest that when a more invention-experienced manager takes over a team, workers initially shift their inventive activity toward closer collaboration with the manager. Over time, however, the positive effects extend beyond joint work: inventive output that does not involve the manager also rises, indicating that exposure to an experienced manager ultimately enhances workers' independent innovative capacity as well.

Broader Collaboration Patterns. Finally, we examine how exposure to a more invention–experienced manager affects workers' broader co-invention behavior, both within and outside the immediate team. Specifically, we study whether workers' inventions involve larger or smaller inventor teams, whether they are more likely to include first-time collaborators versus prior co-inventors, and whether collaboration increasingly extends to inventors outside the worker's own team. These dimensions shed light on whether experienced managers primarily deepen existing collaboration within teams or instead act as catalysts for broader knowledge recombination by connecting workers to new collaborators across organizational boundaries. We again analyze these patterns separately for all invention disclosures and for those that ultimately receive patent protection, allowing us to assess whether changes in collaboration structure are especially pronounced for higher-quality inventions.

6.3 Robustness and Validity Checks

This subsection assesses the robustness of our main findings and the validity of the identifying assumptions underlying our empirical design. We conduct a comprehensive set of robustness tests that probe potential concerns related to endogenous manager mobility, sample selection, outcome

measurement, and alternative definitions of managers' invention experience. Across these exercises, the estimated effects of managers' invention experience on workers' inventive output remain stable in magnitude and statistically significant, reinforcing the interpretation that our results reflect a causal impact of managerial invention experience rather than confounding organizational or worker-level shocks.

6.3.1 Selection of Manager Switches

A primary concern for identification is that manager mobility may be systematically related to team performance, either based on realized past outcomes or anticipated future potential. Figures 1 to 2 find no evidence of differential pre-trends across various key innovation outcomes, suggesting that workers experiencing large differences in managers' invention experience face similar dynamics leading up to the switch to those who experience small differences in managers' invention experience. We expand this test by assessing pre-trends also in key non-innovation outcomes, such as workers' exit from the firm. Appendix Figure A7 shows that also for these additional outcomes, we do not find any evidence that would suggest that high-experience managers join teams that face different trajectories.

We present an alternative version of this test by examining whether the invention experience of incoming managers predicts team outcomes prior to their arrival. Appendix Table B8 shows that incoming managers have no effect on team innovation outcomes before they take over the team, further alleviating concerns about anticipatory sorting.

6.3.2 Attrition from Event Study Panel

Workers may exit our baseline analysis panel for two reasons. First, a worker is excluded from the panel if they are supervised by a manager other than the two managers that are present at the switch that occurs at event time 0. For example, if the new manager departs after six quarters, the worker is only included in the sample for six quarters following the switch. Second, a worker is excluded from the panel if they exit the firm and are no longer observed in the internal data.

To test whether these sources of attrition bias our results, we re-estimate our results using two alternative analysis panels. We allow workers to remain in the panel even if they are supervised by a manager other than the two that are present at the switch. Sixteen quarters after the switch, about half of workers have a different manager. Reassuringly, we find that our effects are qualitatively similar, and attenuated by around half, consistent with effects that are stronger under the experienced manager (Appendix Figure A10). We estimate similar effects when we allow workers to also remain in the panel when they exit the firm. In this fully balanced panel, we impute invention outcomes as 0 if workers have left the firm. We again estimate effects that are attenuated but qualitatively similar to our baseline results (Appendix Figure A11). Together, these exercises provide reassurance that sample selection occurring through worker attrition does not meaningfully bias our results.

6.3.3 Alternative Event-Study Specifications

We next examine the sensitivity of our results to alternative event-study specifications. First, instead of using four-quarter rolling sums of our outcome variables, we conduct our event-study analysis at the annual level. Appendix Figure A12 shows that both the magnitudes and dynamics of our main results remain unchanged. Second, we restrict the sample to workers experiencing their first manager switch during the sample period, ensuring that results are not driven by repeated exposure to managerial changes. Appendix Figure A13 reveals similar patterns. Third, we distinguish between different types of manager switches. We begin by restricting attention to purely internal manager transitions, in which both the outgoing and incoming managers remain employed at the firm, thereby focusing on switches that are most plausibly part of managers' regular career progression rather than driven by entry or exit from the firm. We then focus on manager switches that do not represent a promotion for the manager. Appendix Figure A14 shows that our results remain mostly unchanged. Finally, we estimate specifications that replace the continuous change in manager invention experience with a binary indicator for switching to a more invention-experienced manager using the bottom vs. top quartile of manager experience.

6.3.4 Alternative Measures of Managers' Invention Experience

Our baseline measure of managers' invention experience captures a manager's total history of invention disclosures in the years preceding a manager switch. Appendix Figure A16 shows that our results are robust to alternative operationalizations of invention experience, including measures based on the prior rate of disclosures, measures that exclude co-invented disclosures, and measures constructed using patent applications or granted patents only.

6.3.5 Other Manager Types

Finally, we assess whether our results reflect broader managerial characteristics rather than innovation-specific experience. We re-estimate the event study using alternative measures of managerial heterogeneity, including gender, tenure, German nationality, executive status, educational attainment, and performance ratings. Figure 6 shows that the effect of managers' invention experience clearly stands out in both magnitude and statistical significance relative to other manager characteristics.[14] These findings reinforce the interpretation that it is managers' domain-specific invention experience, rather than general managerial traits, that drives the observed effects on workers' innovation output.

[14] While firm tenure exhibits some predictive power for workers' innovation outcomes when considered in isolation, its effect becomes statistically insignificant and economically small once managers' invention experience is also included in the event-study specification. In contrast, managers' invention experience remains statistically significant and economically meaningful when both measures are included jointly.

7 Mechanisms

Having established that managers' invention experience substantially affects both the quantity and quality of workers' innovative output, a first-order question is *how* these managerial effects arise. In this section, we show that a key underlying mechanism is knowledge transmission: invention-experienced managers transmit innovation-relevant know-how to their teams. We contrast the empirical implications of this mechanism with alternative explanations emphasized in the economics literature—such as monitoring, selection of talent, motivation, and access to resources—and examine the extent to which these predictions are supported in the data.

7.1 Evidence in Support of Knowledge Transmission

Innovation often requires tacit technical knowledge—how to frame problems, navigate trade-offs, and refine early-stage ideas—that is difficult to codify and learn from written instructions alone. Theories of learning-by-doing and task-specific human capital (Arrow 1962; Gibbons and Waldman 2006) emphasize that such knowledge is accumulated through experience and embedded in individuals rather than fully captured by formal rules. Economic models of hierarchies and knowledge-based production (Garicano 2000; Dessein 2002; Garicano and Rossi-Hansberg 2006) emphasize that supervisors with greater expertise can improve subordinate performance by providing guidance when tasks are complex and information is imperfect. In the context of innovation, such guidance may be particularly valuable given high uncertainty and the iterative nature of inventive work. We therefore test four central predictions that follow from a knowledge-transmission mechanism.

First, a knowledge-transmission mechanism implies that expertise is conveyed through interaction between managers and workers, with direct collaboration in the inventive process providing a natural setting for such transfer. We therefore first examine co-invention between managers and workers. If invention-experienced managers place more value on hands-on guidance and mentoring, we should expect co-inventions between managers and workers to increase once an invention-experienced manager takes over. At the same time, if workers are acquiring knowledge rather than simply working harder under closer oversight, the effects should extend beyond joint projects. In particular, exposure to an experienced manager should also increase workers' independent inventive output—innovations produced without the manager's direct involvement. The data exhibit precisely this pattern. As shown in Figure 2, co-invented output rises immediately after the manager switch, while non-co-invented output initially falls. Over time, however, independent inventive activity increases and eventually exceeds pre-switch levels. This dynamic—an initial period of joint production followed by sustained growth in independent invention—indicates that workers' innovative capability improves after working with an experienced manager and is difficult to reconcile with explanations based solely on monitoring or motivation.

A second implication of knowledge transmission is that its effects should be strongest when a manager's technical expertise is directly relevant to the worker's inventive activity. If managers transmit know-how rather than simply motivate effort, exposure to an experienced manager should

disproportionately affect inventions in technological areas in which the manager has prior experience. To test this prediction, we use detailed patent classification data and construct a measure of technological proximity based on IPC codes. To measure the similarity of a given invention to the manager's (or worker's) prior inventions, we first compute pairwise proximity of each pair of four-digit IPC codes using the approach in Bloom et al. (2013). We then compute the average proximity of the invention's IPC codes to the IPC codes associated with the manager's (or worker's) prior inventions. We then classify close or distant inventions as being above or below the median average proximity in our sample (see Appendix C for details). Consistent with knowledge transmission, Figure 4 shows that the impact of a manager switch is substantially larger for patents that are closer to the manager's technological field of expertise. In Figure 4, red (blue) coefficients denote the effect of a manager's prior experience that is dissimilar (similar) to the worker's prior experience measured using patent IPC codes. The left pair of coefficients depicts effects on worker inventions that are dissimilar from their prior inventions, whereas the right pair depicts effects on worker inventions that are similar to their prior inventions. The estimated effects indicate that workers exposed to invention-experienced managers increase their innovative output primarily in domains in which the manager has previously invented, consistent with managers transmitting domain-specific knowledge rather than affecting innovation uniformly across technologies.

A third implication of a knowledge-transmission mechanism is that its effects should persist after the manager–worker relationship ends. Mechanisms such as monitoring or creating a supportive team environment operate primarily while the manager is present; once the manager leaves, workers' inventive output should revert toward prior levels. By contrast, if managers transmit skills and know-how, workers should continue to perform better even after the manager departs. To test this prediction, we examine how workers' inventive output changes when the new incoming manager herself leaves the team. We focus on workers who remained with the manager long enough for learning to plausibly occur. Appendix Figure A18 shows that we find that the positive effects of invention-experienced managers persist, even after they leave the team.

A fourth and last prediction of a knowledge-transmission mechanism concerns which workers benefit most. Because innovation is highly skill-intensive, the ability to learn from a manager likely depends on a worker's existing knowledge base. In the spirit of the absorptive capacity framework of Cohen and Levinthal (1990), for instance, workers with prior inventive experience should be better able to internalize and apply the know-how transmitted by invention-experienced managers. Consistent with this prediction, we find that the effects of managers' invention experience are substantially larger for workers with prior inventive activity than for workers with little or no invention experience (Figure 3). This finding points to complementarities between managerial expertise and workers' existing knowledge, consistent with learning rather than changes in effort or supervision.

7.2 Alternative Mechanisms

This section evaluates four types of alternative mechanisms through which invention-experienced managers may affect workers' innovation: (i) monitoring, incentive provision, and task allocation, (ii) selection of more talented workers, (iii) fostering of a more supportive innovation climate, and (iv) improved access to resources.

7.2.1 Monitoring, Incentives, and Task Allocation

A first alternative explanation for our findings is that invention-experienced managers affect workers' innovative output through monitoring, incentive provision, or the reallocation of workers' effort across tasks rather than through knowledge transmission. This explanation connects to a large literature in economics that models managers as supervisors who increase productivity by observing worker effort, shaping incentives, and directing attention across competing activities (e.g., Holmstrom and Milgrom 1991; Aghion and Tirole 1997). Under this explanation, more experienced managers raise innovative output by inducing greater worker effort and by prioritizing innovative activities, reallocating time away from routine responsibilities and toward invention.

This alternative explanation yields a set of empirical predictions that differ from those implied by knowledge transmission. First, monitoring operates through effort provision and therefore should affect output broadly rather than in a technologically specific manner, which is inconsistent with our findings. Second, if increased output reflects monitoring or stronger incentives, productivity gains should be concentrated in projects in which the manager is directly involved and should dissipate upon the manager's departure. Instead, while co-invention with the manager rises first, we subsequently observe sustained growth in workers' independent inventive activity, a pattern that is difficult to reconcile with these mechanisms. If task reallocation drove this pattern, independent innovation should increase immediately. Instead, it rises only after an initial period of increased co-invention with the manager, consistent with gradual knowledge transmission rather than a contemporaneous shift in effort allocation.

Third, the productivity gains persist after the manager leaves the team, which is also inconsistent with task allocation, as tasks should revert after the manager's departure. Instead, the persistence of these effects after the manager's departure suggests a lasting improvement in workers' productivity. Fourth and finally, monitoring, incentive provision, and task allocation should primarily affect measurable effort margins, such as the quantity of output, rather than its technical content or success. For instance, increased monitoring would be expected to generate more invention disclosures but not necessarily higher-quality innovations, which is at odds with our finding that manager impacts are much larger for high-quality outcomes, such as granted patents.

7.2.2 Selection of More Talented Workers

A second alternative explanation is that invention-experienced managers raise innovative output not by transmitting knowledge, but by attracting and retaining more talented workers. In this

selection-based view, differences in team innovation output across managers reflect differences in team composition rather than changes in workers' capabilities. A large literature in economics emphasizes the importance of sorting in shaping productivity (e.g., Lazear et al. 2015; Hoffman and Tadelis 2021). Managers with strong invention backgrounds may have better reputations, stronger internal networks, or greater influence over staffing decisions, enabling them to assemble teams of higher-ability inventors.

This mechanism implies a distinct set of empirical predictions. First, improvements in innovative output should largely reflect who works for the manager rather than how workers change after exposure. Under pure selection, higher-performing workers would already exhibit stronger inventive trajectories prior to assignment. Once matched to an invention-experienced manager, output should rise immediately due to composition effects rather than gradually through learning. In our setting, however, we observe no differential pre-trends prior to manager switches and instead find dynamic adjustment patterns—initial increases in joint invention followed by sustained growth in independent inventive activity—that are more consistent with learning than with sorting.

Second, selection does not naturally predict that workers' inventive activity reallocates toward the technological domains in which the manager has expertise. For a selection story to generate such domain-specific effects, managers would need to systematically attract workers whose latent talent is concentrated precisely in their own technological fields. By contrast, we observe shifts in workers' inventive direction following exposure to experienced managers, indicating that workers' technological focus changes over time rather than simply reflecting pre-existing specialization.

A selection-based explanation also generates distinct implications for team composition. If invention-experienced managers improve performance by attracting more talented workers, manager switches should be accompanied by observable changes in team membership or in the composition of co-inventors. We find no evidence of such adjustments: the arrival of an invention-experienced manager does not lead to systematic turnover or to changes in the set of collaborators with whom workers patent. Finally, our empirical design relies on worker fixed effects and therefore compares each worker's performance before and after exposure to an invention-experienced manager. The resulting estimates capture within-worker changes rather than differences across workers, making it unlikely that compositional sorting alone can account for the observed increases in innovation.

7.2.3 Motivation and Culture

A third potential mechanism is that invention-experienced managers increase inventive output by motivating workers and fostering a more supportive innovation climate. Innovative work is inherently uncertain, often requires repeated failed attempts, and depends on discretionary effort and initiative (Holmstrom 1989). Managers may therefore influence employees' willingness to engage in innovation by encouraging experimentation, legitimizing failure, and protecting time and resources for idea development (Edmondson 1999; Manso 2011; Aghion et al. 2013). Beyond immediate effort provision, experienced managers may also shape workers' beliefs and career aspirations, for example, by acting as role models, increasing confidence in pursuing inventive projects, or signaling that

innovative activity is valued within the organization. Managers with prior invention experience may be particularly well positioned to create such an environment because they better understand the uncertainty and iterative nature of innovative activity.

To examine this mechanism, we relate managers' invention experience to measures of leadership behavior drawn from the firm's 360-degree feedback system. These assessments capture multiple dimensions of leadership, including three ratings directly tied to fostering innovation: supporting experimentation, encouraging curiosity and challenging existing thinking, and securing resources for developing new ideas (see Section 3.3 for details). Figure 5 shows that managers with greater prior invention experience receive substantially higher ratings along these innovation-specific leadership dimensions. Moving from the 10th to the 90th percentile of the invention-experience distribution is associated with increases of roughly 0.2 to 0.4 standard deviations in innovation-related leadership ratings. The relationship appears both in evaluations by supervisors, peers, and subordinates and—albeit somewhat more modestly—in managers' self-assessments. Importantly, higher innovation leadership ratings are not accompanied by weaker performance in other managerial dimensions such as communication, stakeholder management, or coordination.

While these findings indicate that invention-experienced managers are perceived as more supportive of innovation, our broader set of empirical patterns is less consistent with a purely motivational or culture-based explanation. An innovation-climate mechanism would predict broad increases in inventive activity, potentially including greater experimentation or risk-taking, and effects that operate contemporaneously with the manager's presence. Instead, we observe several patterns that are difficult to attribute solely to changes in morale or willingness to experiment. First, the increase in innovation is concentrated in technological areas in which the manager has prior expertise. Importantly, we do not find that gains are concentrated in areas with increased novelty or risk-taking, whereas a climate-based mechanism would naturally predict more exploratory behavior (Table 7). The documented dynamic path in which collaboration with the manager rises initially but is followed by sustained increases in independent invention is much more consistent with skill acquisition rather than a contemporaneous encouragement effect. Finally, improvements persist after the manager leaves the team, suggesting that workers' capabilities change rather than only their immediate motivation.

7.2.4 Access to Resources

A further alternative mechanism is that invention-experienced managers may increase inventive output by securing greater internal resources for their teams. In this view, managers do not primarily improve workers' capabilities but instead improve the success of projects by obtaining funding, personnel, or organizational support. This mechanism is consistent with theories of internal capital markets and authority within firms which emphasize that managers influence how scarce organizational resources are allocated across competing projects (e.g., Stein 1997; Aghion and Tirole 1997).

While the 360-degree feedback data suggests that invention-experienced managers are more

likely to be perceived as effective at securing resources to develop new ideas (Figure 5), the remaining empirical patterns are difficult to reconcile with a purely resource-based explanation. First, it is difficult to reconcile the dynamic pattern that independent inventions only rise with a time lag with a resource-based explanation. Second, such a mechanism implies that effects should dissipate when the manager leaves the team, as access to internal networks and influence over project prioritization disappears. Third, resource access would also be expected to operate through increased project inputs, such as more personnel or coordination. Such increased inputs could likely manifest for instance in terms of larger inventor teams, more co-inventors per patent, or greater cross-functional collaboration. However, we do not find any evidence that invention-experienced managers yield changes along these margins (Appendix Figure A19).

7.2.5 Discussion

Taken together, our findings provide strong evidence that knowledge transmission from invention-experienced managers to workers is a central mechanism through which managers influence innovative output. The observed domain-specific effects, dynamic pattern from joint to independent invention, persistence after managerial departure, and complementarities with workers' prior experience are difficult to reconcile with monitoring or selection-based explanations. At the same time, we find some evidence consistent with complementary channels: invention-experienced managers are rated more highly on fostering innovation and securing resources, suggesting that motivation and access to organizational support—even though they alone cannot explain the empirical patterns we document—may reinforce the learning process.

8 Conclusion

This paper provides new evidence on the role of managers in shaping innovation within firms. Using uniquely detailed personnel and innovation data from a large manufacturing firm, we study how managers' own invention experience affects the quantity, quality, and trajectory of workers' inventive output. Exploiting plausibly exogenous variation arising from internal manager switches, we show that exposure to managers with greater hands-on invention experience leads to large and persistent increases in workers' production of high-quality inventions. These effects emerge quickly, extend across the entire innovation pipeline from idea generation to patenting and commercialization, and are economically meaningful relative to baseline innovation rates.

Our evidence points to a central mechanism: knowledge transmission from managers to workers. Workers initially collaborate more closely with invention-experienced managers and subsequently exhibit sustained increases in independent inventive activity, including continued performance gains after the manager departs. In addition, workers' inventive effort shifts toward the technological domains in which their managers have expertise. Taken together, these patterns indicate that managers do not merely improve the supervision or evaluation of innovative work; rather, they build technical capabilities among their subordinates by transmitting practical, innovation-relevant

know-how.

These findings have important implications for how firms organize and develop innovative capacity. They suggest that technically experienced managers function as carriers of productive knowledge within the firm, diffusing expertise across workers and teams. Promotion and assignment policies that move inventors into leadership roles may therefore generate returns not only through improved coordination but also through the accumulation of human capital among workers. Because the acquired skills persist beyond the manager–worker match, managerial expertise can create lasting improvements in a firm's innovative capability. Organizational policies that facilitate interaction and collaboration between technically experienced managers and workers may thus complement traditional innovation investments such as R&D spending or inventor compensation.

Finally, this study illustrates the value of rich internal firm data for understanding the microfoundations of innovation. While our analysis focuses on a single large manufacturing firm, the organizational features we study—decentralized innovation, managerial switches, and the coexistence of technical and leadership roles—are common in many knowledge-intensive organizations. Future research could examine how these mechanisms operate in other settings, how firms optimally select and train innovation-oriented managers, and how managerial expertise interacts with formal incentive schemes and organizational design.

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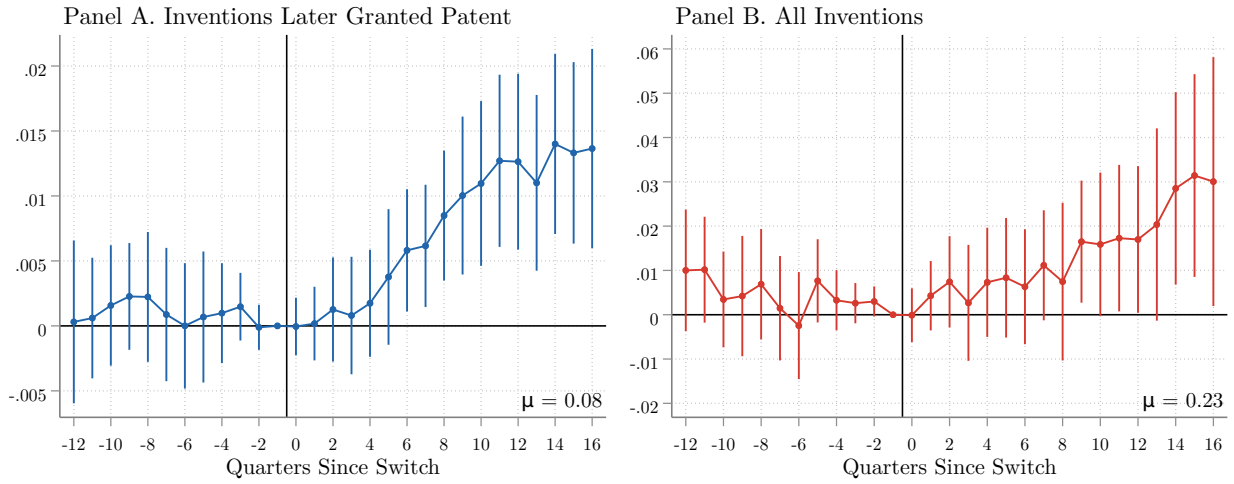
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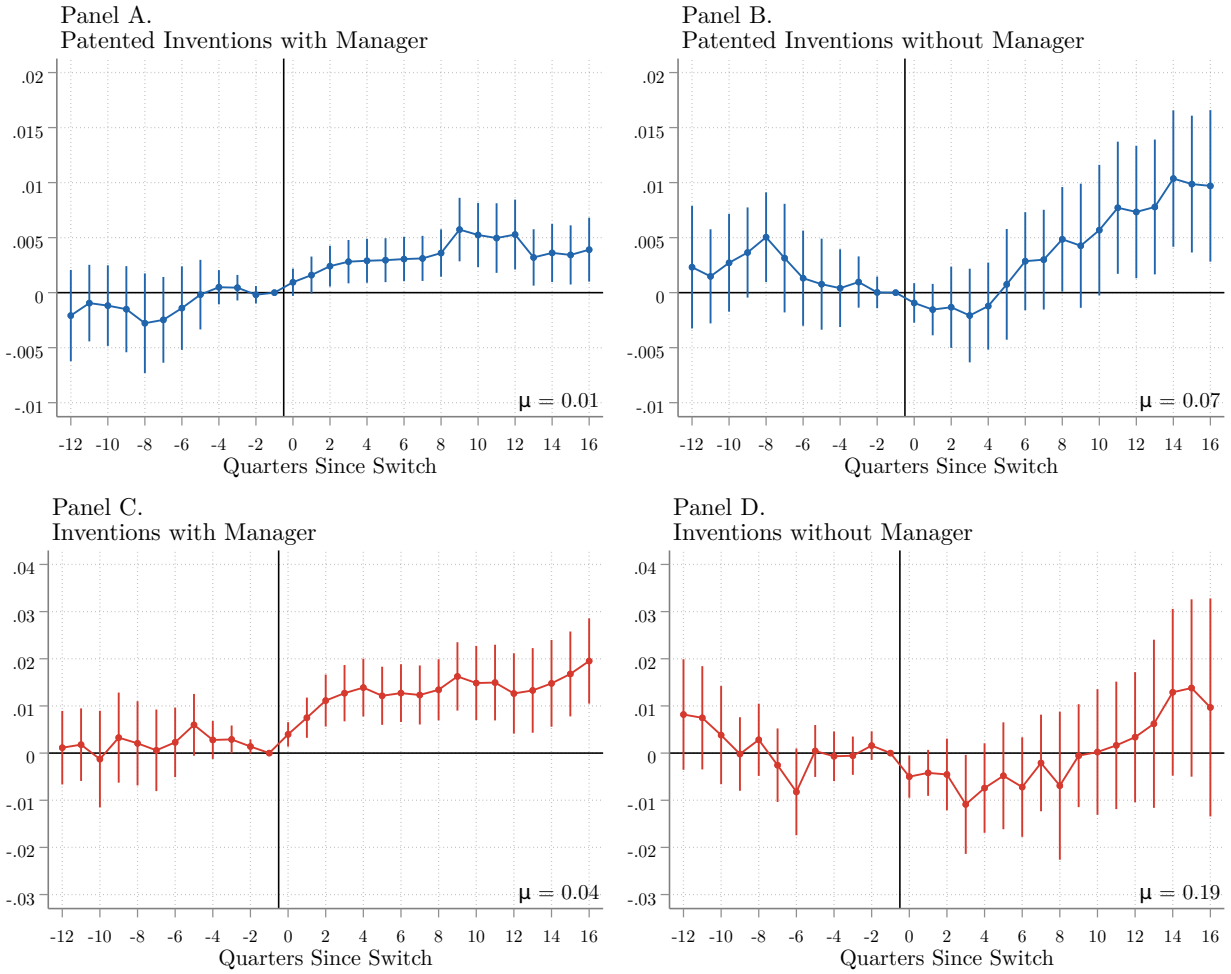
9 Figures

Figure 1: Manager Effect on Worker Innovation



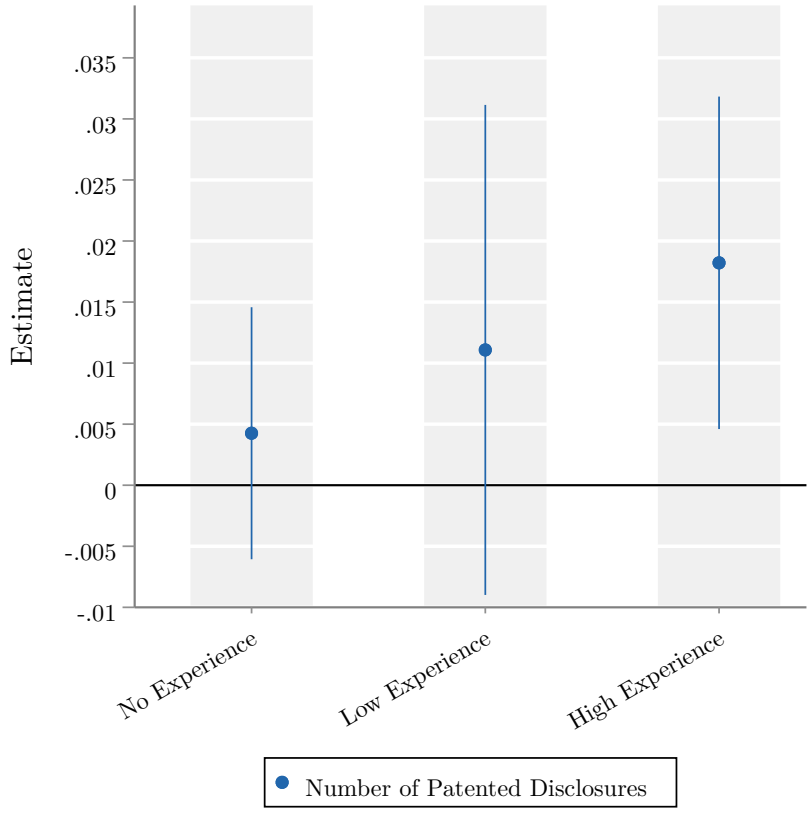
Notes: This figure depicts the time path of outcomes around a manager switch that occurs at event time $t = 0$. The outcomes are the 4-quarter rolling sums of the number of invention disclosures filed in a given quarter that are later granted a patent (Panel A) and the number of any invention disclosures filed in a given quarter (Panel B). The coefficients correspond to estimates of Equation (1), and denote the effect of having a manager with one more invention disclosure prior to rotation (i.e., more innovation experience). The coefficients indicate that having a manager with an additional invention increases workers' patented inventions by 0.014 after 16 quarters, and all inventions by around 0.03. Whiskers denote 95% confidence intervals. Standard errors clustered at the worker level.

Figure 2: Manager Effect by Invention With or Without the Manager



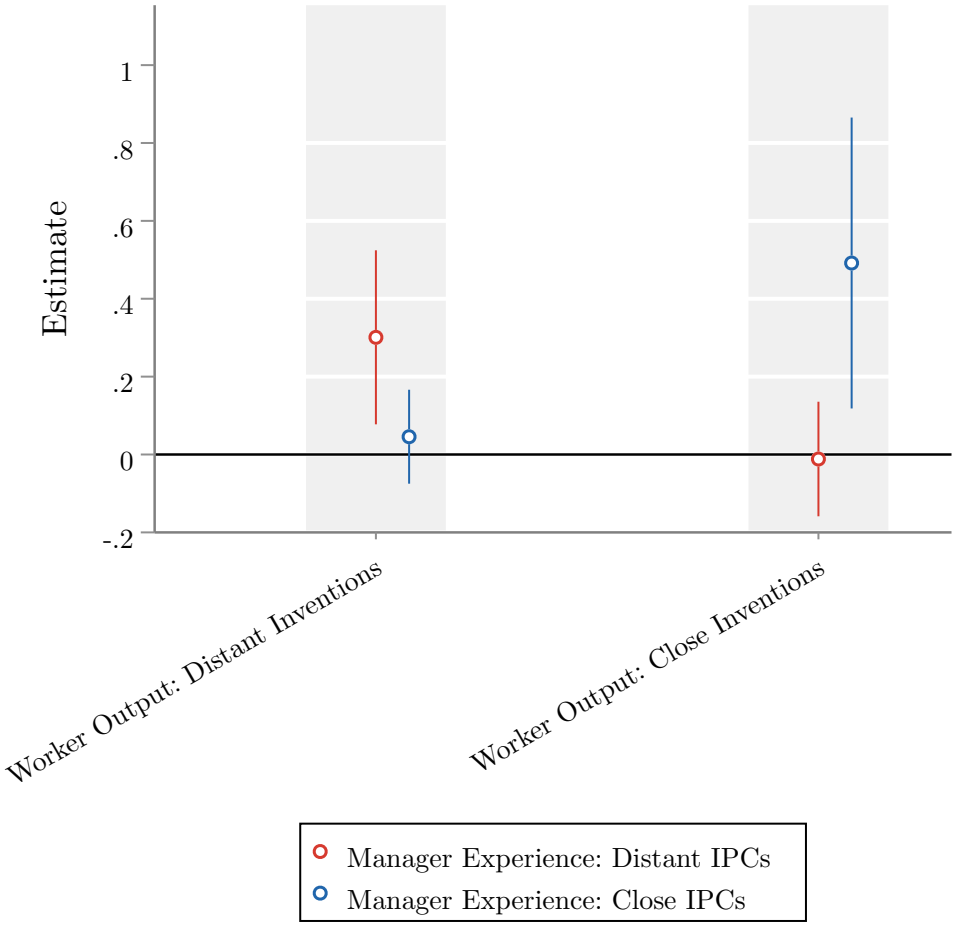
Notes: This figure depicts the time path of outcomes around a manager switch that occurs at event time $t = 0$. The outcomes are the 4-quarter rolling sums of the number of invention disclosures filed in a given quarter that are later granted a patent and are co-invented with a manager (Panel A), the number of invention disclosures filed in a given quarter that are later granted a patent and are not co-invented with a manager (Panel B), the number of any invention disclosures filed in a given quarter that are co-invented with a manager (Panel C), and the number of any invention disclosures filed in a given quarter that are not co-invented with a manager (Panel D). The coefficients correspond to estimates of Equation (1), and denote the effect of having a manager with one more invention disclosure prior to rotation (i.e., more innovation experience). Whiskers denote 95% confidence intervals. Standard errors clustered at the worker level.

Figure 3: Manager Effect By Worker Types



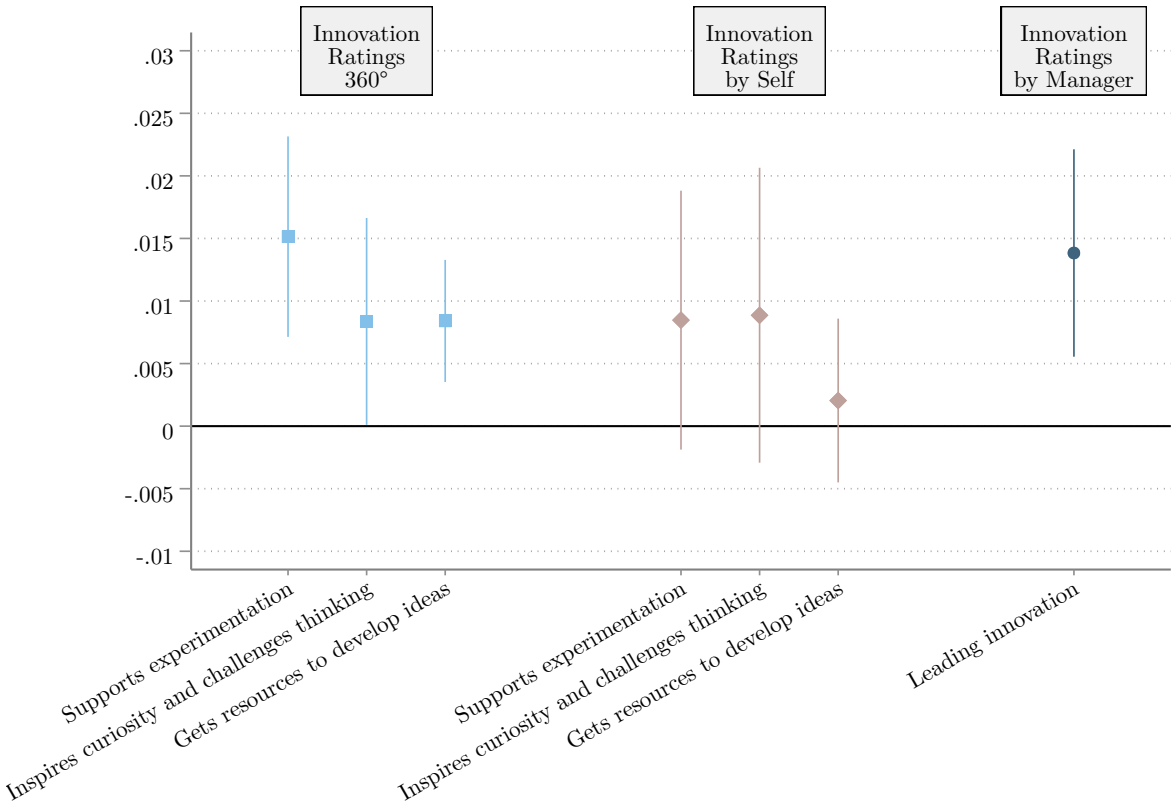
Notes: This figure documents heterogeneous impacts of manager experience. Impacts are estimated separately by worker experience, defined as the worker's annual rate of invention disclosures (measured using years prior to the event study window, i.e., $t <= -12$.). The outcome is the 4-quarter rolling sum of the number of invention disclosures filed in the fourth year after a manager switch and that are later granted a patent. Coefficients correspond to estimates from manager switches design (i.e., Equation (1)) for event time $t = 16$. Whiskers denote 95% confidence intervals. Standard errors clustered at the worker level.

Figure 4: Effects Split by Invention Content Similarity



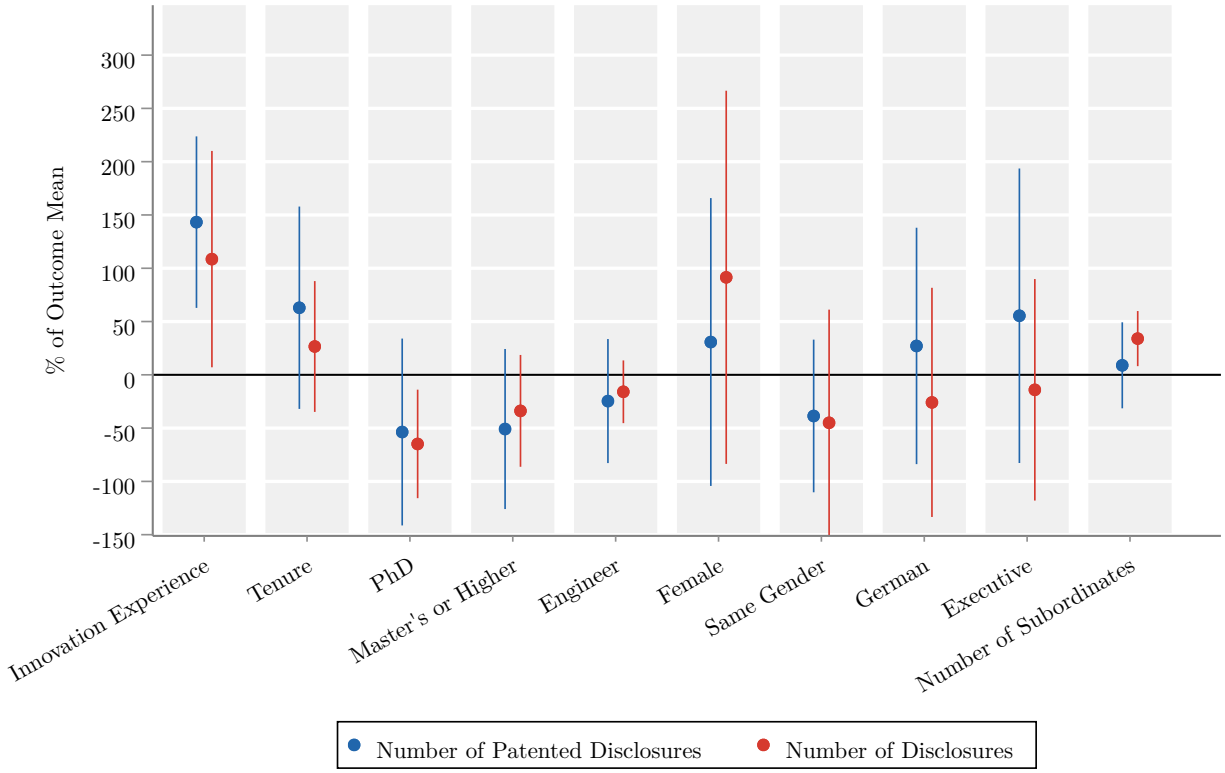
Notes: This figure presents estimates from two regressions that analyze heterogeneous impacts of manager experience by similarity of manager experience and worker output. The outcome is the annual number of patented inventions from the worker. Similarity of manager experience denotes IPC distance to the worker's previous inventions at the time of the manager switch. Worker distance denotes IPC distance to worker's own prior inventions. IPC distance is computed using the similarity of IPC codes as in Bloom et al. (2013). The regression specifications are a version of Equation (1) that pools multiple quarters. The base period consists of quarters -8 through -1 relative to a manager switch; the post-period consists of quarters 9 through 16; and the pre-period consists of quarters -15 through -9. Whiskers denote 95% confidence intervals. Standard errors clustered at the worker level. Data come from panel of workers with manager switches described in Section 5.

Figure 5: Managers' Invention Experience and Ratings



Notes: This figure presents correlations between manager experience (measured as prior invention disclosures) with ratings from the firm's feedback platform.

Figure 6: Effects of Alternative Manager Types



Notes: This figure presents effects of manager characteristics by estimating a variant of the manager switches design (i.e., Equation (1)). Each pair of coefficients pertains to a separate pair of regressions which replace the baseline measure of innovation experience with a different manager characteristic (e.g., manager education). The outcomes are the 4-quarter rolling sums of the number invention disclosures filed in a given quarter that are later granted a patent and the number of any invention disclosures filed in a given quarter. Coefficients correspond to estimates for event time $t = 16$. Whiskers denote 95% confidence intervals. Standard errors clustered at the worker level.

10 Tables

Table 1: Summary Statistics of Employees

	All Workers	Engineer	Manager	Ever Disclosed Invention	Top Decile Inventor
	(1)	(2)	(3)	(4)	(5)
Female (%)	22.3	12.7	7.1	7.1	5.6
German Nationality (%)	91.0	90.5	93.1	91.5	92.1
Age (Years)	43.7	43.4	47.9	43.6	43.3
Bachelor's (%)	67.9	75.2	83.2	84.7	89.7
Master's or Higher (%)	21.5	24.5	22.9	30.9	43.9
PhD (%)	5.9	8.4	13.3	15.5	31.3
Tenure (Years)	15.0	14.5	18.4	14.1	13.2
Manager (%)	15.4	14.3	100.0	21.0	23.2
Engineer (%)	54.0	100.0	76.9	93.5	97.9
Ever Disclosed (%)	16.0	27.6	33.1	100.0	100.0
Disclosures (Annual)	0.11	0.21	0.27	0.72	3.69
# Unique Workers	5X,XXX	2X,XXX	7,XXX	6,XXX	7XX
# Worker-Quarters	1,XXX,XXX	8XX,XXX	1XX,XXX	2XX,XXX	2X,XXX

Notes: This table reports average values of various characteristics of workers (rows) by subsample (columns). Sample consists of quarterly panel of German employees 2011-2023 (i.e., means are weighted by tenure). *Engineer* is defined as worker ever having engineering as their functional area. *Manager* is defined as worker currently managing an Engineer. *Top Decile Inventor* is defined as workers in the top decile of disclosures per quarter, conditional on any disclosures.

Table 2: Innovation Pipeline

	Inventions	Applied for Patent	Patent Granted	Commercialized
Months Since Disclosure				
Mean		7.7	51.3	
SD		(7.4)	(28.3)	
N or Percent	43,682	58.2%	30.5%	2.0%

Notes: This table describes the innovation pipeline. *Months Since Disclosure* denotes months between the date of the original invention disclosure and the date of the first patent application or patent granted. Data cover inventions firmwide starting in 2008. Statistics for patent granted and commercialized are computed for inventions filed in years prior to 2020 to reduce temporal censoring.

Table 3: Collaboration Patterns of Inventors

	Mean	%2+	p10	p25	p50	p75	p90	p95	p99	N
Panel A. Inventions with German Inventor										
Inventors (#)	2.45	66.1	1	1	2	3	5	5	8	2X,XXX
Inventors | Patent Granted (#)	2.55	70.4	1	1	2	3	5	6	8	6,XXX
Inventors Who Are Managers (#)	0.52	9.6	0	0	0	1	1	2	3	1X,XXX
Share of Inventions with Manager	0.40									1X,XXX
Teams | 2+ Inventors (#)	1.91	59.8	1	1	2	2	3	4	5	1X,XXX
Functional Areas (#)	1.11	10.3	1	1	1	1	2	2	2	1X,XXX
Share of Inventions with Engineer	0.98									2X,XXX
Divisions (#)	1.03	3.1	1	1	1	1	1	1	2	1X,XXX
Cities (#)	1.09	8.5	1	1	1	1	1	2	2	2X,XXX
Establishments (#)	1.25	20.9	1	1	1	1	2	2	3	1X,XXX
Countries (#)	1.09	9.0	1	1	1	1	1	2	2	1X,XXX
Any Prior Collaboration | 2+ Inventors	0.68									1X,XXX
Panel B. Inventions without German Inventor										
Inventors (#)	1.81	46.1	1	1	1	2	3	4	6	1X,XXX
Inventors | Patent Granted (#)	1.92	51.5	1	1	2	3	3	4	6	4,XXX
Teams | 2+ Inventors (#)	1.49	40.9	1	1	1	2	2	3	4	4,XXX
Establishments (#)	1.08	6.9	1	1	1	1	1	2	2	1X,XXX
Countries (#)	1.02	2.3	1	1	1	1	1	1	2	1X,XXX
Any Prior Collaboration | 2+ Inventors	0.56									8,XXX

Notes: This table presents summary statistics for the sample of inventions at the firm. Panel A presents statistics for inventions with at least one inventor based in Germany. Panel B presents statistics for inventions without an inventor based in Germany. %2+ denotes the percent of inventions with a value of 2 or more for a given characteristic. Engineers are defined as those whose functional area is ever listed as engineering.

Table 4: Manager Characteristics

	All Rotating Managers	No Experience	Low Experience	High Experience
	(1)	(2)	(3)	(4)
Female (%)	10.0	11.7	5.4	6.6
Age	46.9	46.4	47.1	48.3
Master's or Higher (%)	27.7	24.2	28.5	38.2
PhD (%)	15.2	10.4	20.3	30.3
Tenure (Decades)	1.7	1.7	1.7	1.8
Engineer (%)	64.4	55.8	78.1	91.8
Executive (%)	30.9	30.1	31.0	33.0
Number of Subordinates	11.6	11.9	11.2	9.9
Past Disclosures (Experience)	2.2	0.0	1.4	12.7
N	1,XXX	9XX	2XX	2XX

Notes: This table presents characteristics of managers used in the manager switches sample. Specifically, sample consists of managers who are located in Germany, supervise engineers, and have an observed rotation. *No Experience* is defined as a manager who has never disclosed an invention prior to rotation. *Low Experience* and *High Experience* are defined as being below and above the median invention rate (conditional on any prior inventions), respectively.

Table 5: Balance of Manager Switches

	Engineers w/Manager Switch	Engineers w/o Manager Switch	Manager w/Switch	Manager w/o Switch
	(1)	(2)	(3)	(4)
Female (%)	12.5	13.3	7.0	8.8
German Nationality (%)	91.3	88.9	93.0	93.2
Age (Years)	43.8	42.0	47.7	47.5
Bachelor's (%)	75.7	71.3	84.4	74.5
Master's or Higher (%)	23.3	28.5	23.3	20.9
PhD (%)	8.3	9.3	13.7	10.2
Tenure (Years)	14.8	13.3	18.1	18.4
Engineer (%)	100.0	100.0	78.6	61.9
Ever Disclosed (%)	30.8	23.6	36.5	27.2
Disclosures (Annual)	0.22	0.18	0.28	0.20
High Performance Rating (%)	11.0	10.9	15.8	15.7
Years with Current Manager	1.7	2.3	1.8	2.2
Number of Workers on Team	10.3	10.3	8.7	8.0
Number of Supervisees	1.1	0.5	7.1	5.0
Any Supervisee (%)	16.0	8.7	96.8	96.6
# Unique Workers	1X,XXX	8,XXX	5,XXX	1,XXX
Share of Firmwide Employment	32.4%	14.0%	10.4%	2.5%
# Worker-Quarters	6XX,XXX	1XX,XXX	1XX,XXX	1X,XXX
Share of Firmwide Employment	42.0%	9.6%	8.4%	1.2%

Notes: This table reports average values of various characteristics of workers (rows) by subsample (columns). Sample consists of quarterly panel of German employees 2011-2023 (i.e., means are weighted by tenure). Managers in Columns 3 and 4 are defined as managers of workers in Columns 1 and 2, respectively (i.e., restricting to managers of engineers). *Number of* and *Any Supervisee* defined as supervising a regular employee.

Table 6: Pooled Manager Effects

	(1) All Inventions	(2) Filed Inventions	(3) Patented Inventions	(4) Patent Citations	(5) Commercialized Inventions
Panel A. Post-Period Effect					
Δ Manager Experience	0.0229**	0.0153**	0.0118***	0.0519***	0.0061*
	(0.0091)	(0.0063)	(0.0028)	(0.0193)	(0.0031)
Panel B. Pre-Period Effect					
Δ Manager Experience	–0.0024	0.0101	–0.0002	0.0540*	0.0028
	(0.0048)	(0.0072)	(0.0020)	(0.0283)	(0.0021)
Outcome Mean	0.24	0.18	0.09	0.43	0.01
N (Worker-Quarters)	26,857	26,857	26,857	26,646	12,519
# Unique Workers	2,591	2,591	2,591	2,591	1,402

Notes: This table presents regression coefficients from 10 separate regressions that estimate the effect of a change in manager experience on worker invention output. The regression specifications are a version of Equation 1 that pools multiple quarters. The base period consists of quarters -8 through -1 relative to a manager switch; the post-period consists of quarters 9 through 16; and the pre-period consists of quarters -15 through -9. *All Inventions* denotes the number of invention disclosures filed in a given quarter. *Filed Inventions* denotes inventions that later have a patent application filed. *Patented Inventions* denots inventions that are later granted a patent. *Patent Citations* denotes the number of later patent citations, and is restricted to inventions filed before 2021. *Commercialized Inventions* denotes the number of inventions that are later commercialized, and is restricted to inventions filed before 2019 and to workers in the division where this outcome is observed. Δ *Manager Experience* denotes the change in manager invention experience around a manager switch, where manager invention experience is defined as the number of invention disclosures filed prior to the switch. Standard errors are clustered at the worker level. Data come from panel of workers with manager switches described in Section 5. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

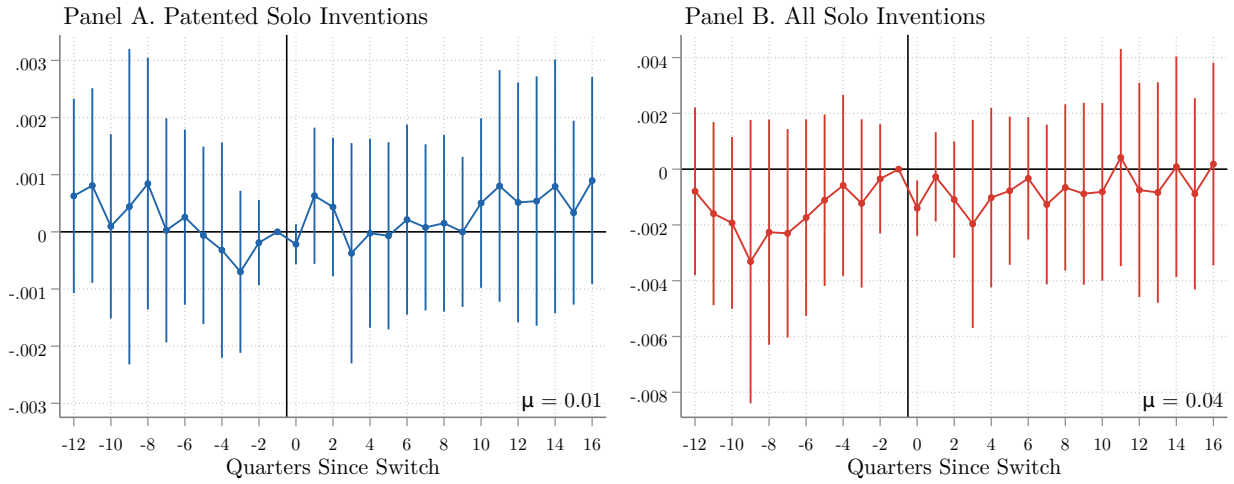
Table 7: Heterogeneity by Invention Novelty

	(1) Low Novelty	(2) High Novelty	(3) Low Recomb. Novelty	(4) High Recomb. Novelty	(5) Low Cosine Distance	(6) High Cosine Distance	(7) Low Exploration	(8) High Exploration
Panel A. Post-Period Effect								
Δ Manager Experience	0.0078***	0.0044***	0.0078***	0.0044***	0.0104***	0.0018*	0.0085***	0.0037***
	(0.0022)	(0.0013)	(0.0022)	(0.0011)	(0.0025)	(0.0011)	(0.0023)	(0.0010)
Panel B. Pre-Period Effect								
Δ Manager Experience	–0.0021	0.0006	–0.0015	0.0000	–0.0024*	0.0010	–0.0012	–0.0003
	(0.0015)	(0.0015)	(0.0014)	(0.0016)	(0.0014)	(0.0011)	(0.0017)	(0.0011)
Outcome Mean	0.05	0.04	0.05	0.04	0.06	0.03	0.07	0.02
N (Worker-Quarters)	26,857	26,857	26,857	26,857	26,857	26,857	26,857	26,857
# Unique Workers	2,591	2,591	2,591	2,591	2,591	2,591	2,591	2,591

Notes: This table presents regression coefficients from 16 separate regressions that estimate the effect of a change in manager experience on worker invention output. The regression specifications are a version of Equation 1 that pools multiple quarters. The base period consists of quarters -8 through -1 relative to a manager switch; the post-period consists of quarters 9 through 16; and the pre-period consists of quarters -15 through -9. Each column denotes a separate outcome, each of which reflects a subset of patented inventions classified by novelty. *Novelty* denotes weighted novelty score. *Recomb. Novelty* denotes frequency-weighted recombination novelty. *Cosine Distance* denotes cosine distance of a given invention to the firm's previous inventions. *Exploration* denotes exploitation vs. exploration index from March (1991). Standard errors are clustered at the worker level. Data come from panel of workers with manager switches described in Section 5. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A Appendix Figures

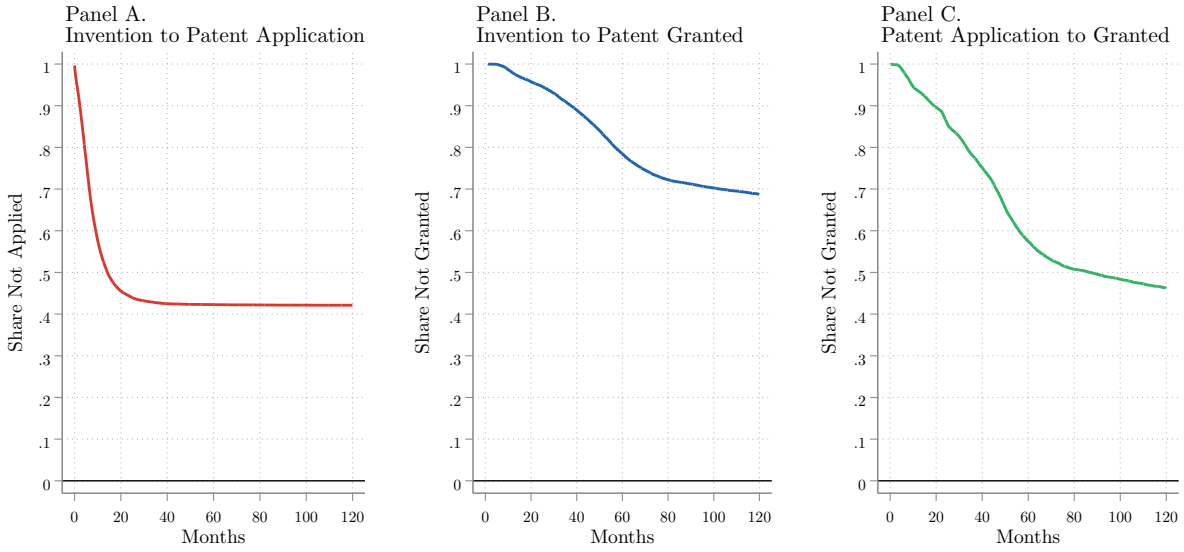
Figure A1: Manager Effect for Solo Inventions



Notes: This figure depicts the time path of outcomes around a manager switch that occurs at event time $t = 0$. The outcomes are the 4-quarter rolling sums of the number of invention disclosures filed in a given quarter that are later granted a patent and that have no co-inventors (Panel A) and the number of any invention disclosures filed in a given quarter that have no co-inventors (Panel B). The coefficients correspond to estimates of Equation (1), and denote the effect of having a manager with one more invention disclosure prior to rotation (i.e., more innovation experience). Whiskers denote 95% confidence intervals. Standard errors clustered at the worker level.

Figure A2: Flow Through the Innovation Pipeline

Figure A3: Innovation Pipeline Survival Functions



Notes: This figure plots Kaplan-Meier survival functions. Panel A plots time between the date of an invention disclosure and the filing date of its first patent application. Panel B plots time between the date of an invention disclosure and its first granted patent. Panel C plots the time between the first patent application and the first granted patent. Data covers firmwide inventions and patents, 2008 to 2023.

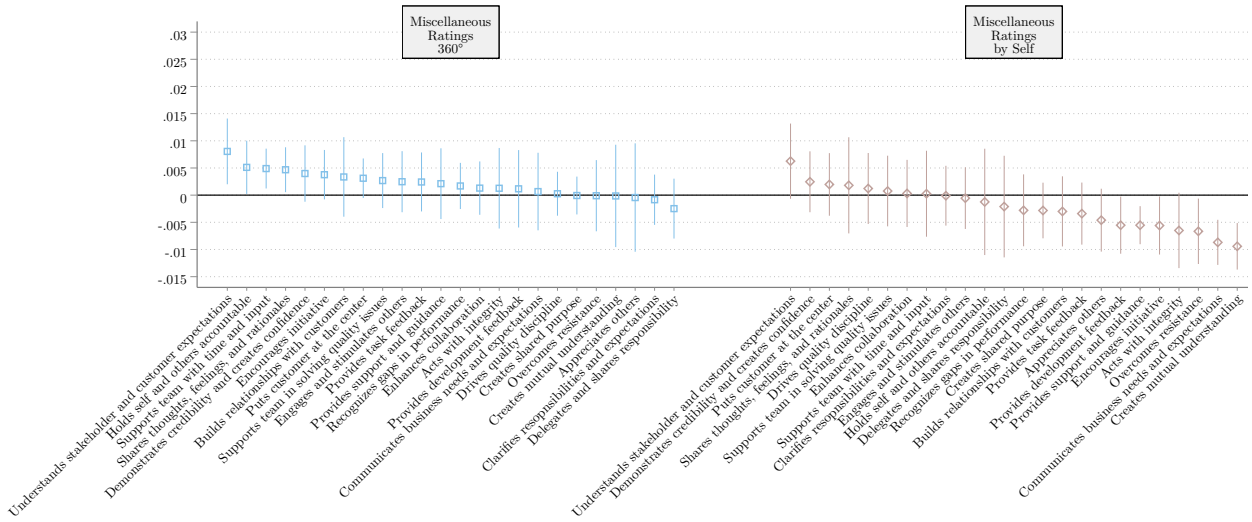
Figure A4: Manager Switches over Time

Figure A5: Manager Switches by Length in Position

Figure A6: Manager Effect By Additional Worker Types

Figure A7: Manager Effects on Non-Innovation Outcomes

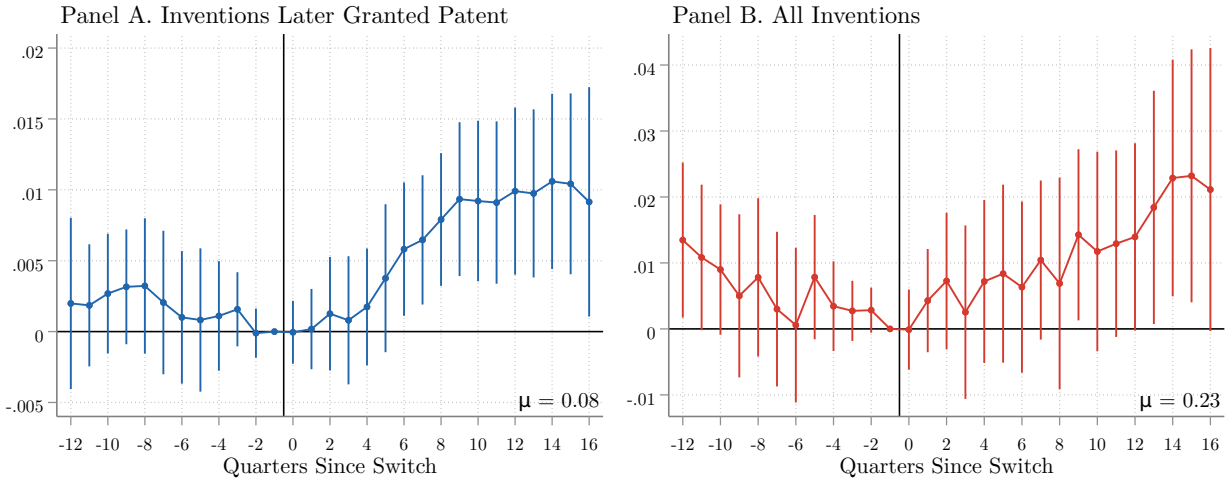
Figure A8: Managers' 360 Degree Ratings: Other Outcomes



Notes:

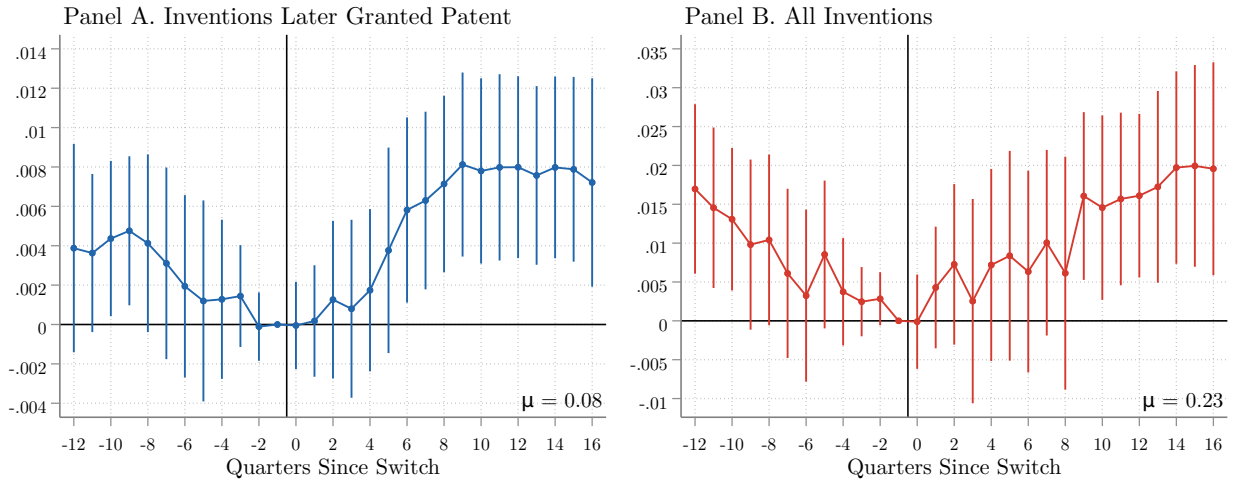
Figure A9: Managers' 360 Degree Ratings: Other vs Self-Ratings

Figure A10: Alternative Sample: Including Other Managers



Notes:

Figure A11: Alternative Sample: Balanced Panel



Notes:

Figure A12: Event Study at the Annual Level

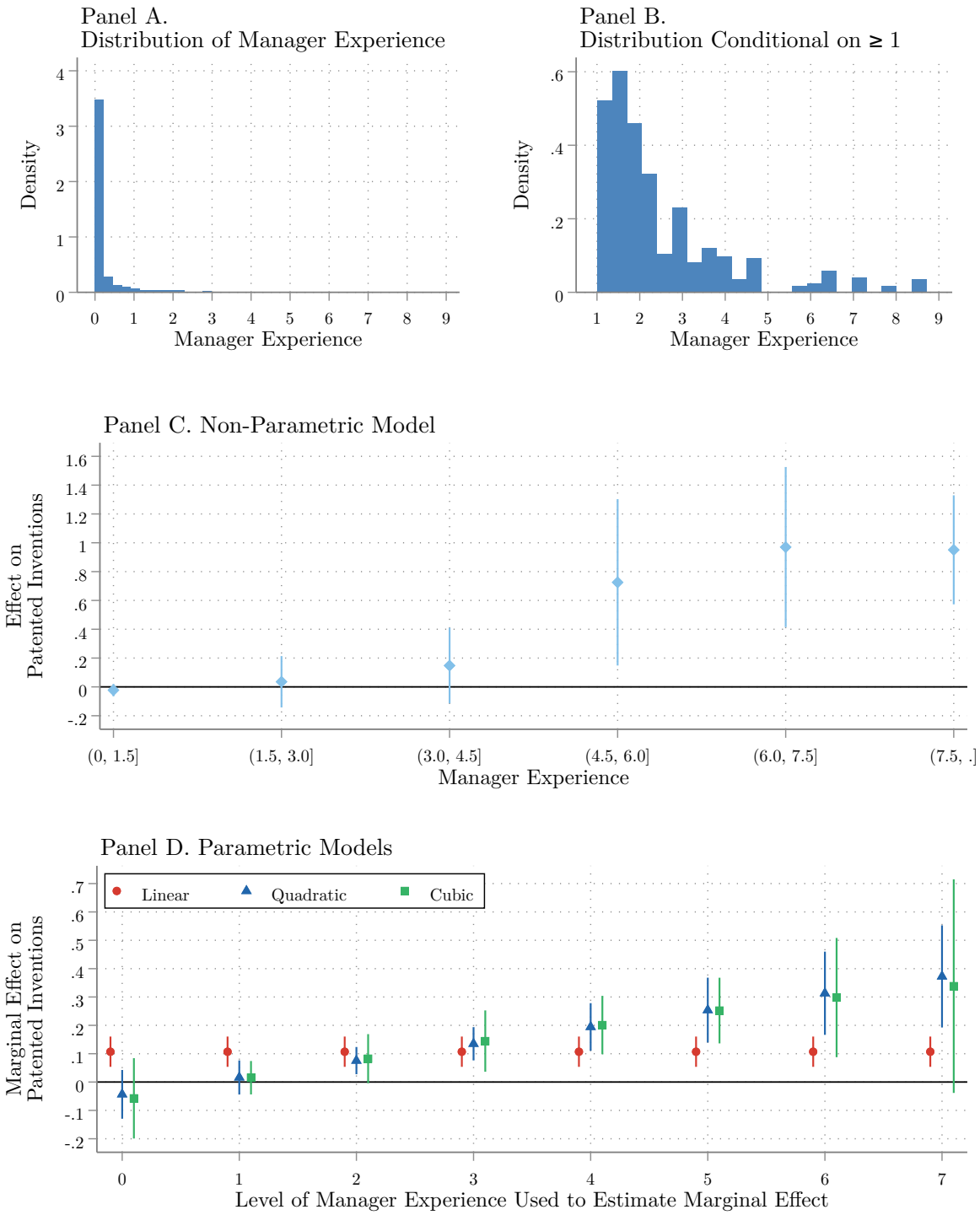
Figure A13: Event Study Restricted to First Events

Figure A14: Event Study Restricted to Internal Job Switches

Figure A15: Event Study Using Binary Manager Types

Figure A16: Alternative Measures of Managers' Invention Experience

Figure A17: Non-Linear Effects of Manager Invention Experience



Notes: This figure illustrates non-linearities in the effects of manager experience. Panels A and B present the histogram of manager experience. Panel C presents coefficients from the pooled manager switches specification. Rather than including a linear term for manager experience, the specification in Panel C applies equally-spaced bins of manager experience. Effects are relative to managers with no invention experience. Panel D estimates parametric models which include linear, quadratic, and cubic terms for manager experience. Standard errors clustered at the worker level.

Figure A18: Persistence of Manager Effects

Figure A19: Team-Level Outcomes

B Appendix Tables

Table B1: Additional Summary Statistics by Employee Type

	Non-Manager Engineer (1)	Manager of Non-Manager Engineer (2)	Non-Manager Non-Engineer (3)	Manager of Non-Manager Non-Engineer (4)
Female (%)	13.8	7.1	36.9	16.0
German Nationality (%)	89.9	93.3	91.2	93.4
Age (Years)	42.7	47.7	43.2	47.5
Bachelor's (%)	73.3	82.8	54.9	72.6
Master's or Higher (%)	24.7	22.8	17.3	18.7
PhD (%)	7.2	13.3	1.8	6.7
Tenure (Years)	13.9	18.2	15.1	18.5
Manager (%)	0.0	100.0	0.0	100.0
Engineer (%)	100.0	78.9	0.0	19.7
Ever Disclosed (%)	25.6	33.8	1.9	8.0
Disclosures (Annual)	0.19	0.28	0.01	0.03
# Unique Workers	2X,XXX	7,XXX	2X,XXX	7,XXX
# Worker-Quarters	7XX,XXX	1XX,XXX	5XX,XXX	1XX,XXX

Notes: This table reports average values of various characteristics of workers (rows) by subsample (columns). Sample consists of quarterly panel of German employees 2011-2023 (i.e., means are weighted by tenure). Engineers are defined as workers ever having engineering as their functional area.

Table B2: Balance of Manager Switches in Event Study Sample

	Engineers in Event Study Sample (1)	Engineers not in Event Study Sample (2)	Managers in Event Study Sample (3)	Managers not in Event Study Sample (4)
Female (%)	11.7	12.9	7.8	7.1
German Nationality (%)	92.5	90.5	92.0	93.4
Age (Years)	45.5	43.1	47.7	47.6
Bachelor's (%)	72.8	75.4	85.2	82.4
Master's or Higher (%)	19.0	25.1	25.9	22.0
PhD (%)	8.0	8.5	16.4	12.1
Tenure (Years)	17.0	14.0	18.2	18.2
Engineer (%)	100.0	100.0	81.6	74.6
Ever Disclosed (%)	30.4	29.2	39.9	33.7
Disclosures (Annual)	0.22	0.21	0.26	0.27
High Performance Rating (%)	10.5	11.1	16.5	15.5
Years with Current Manager	1.7	1.8	1.7	1.9
Number of Workers on Team	11.1	10.2	9.0	8.5
Number of Supervisees	1.1	1.0	8.0	6.4
Any Supervisee (%)	15.5	14.5	97.4	96.6
# Unique Workers	3,XXX	2X,XXX	1,XXX	5,XXX
Share of Firmwide Employment	5.2%	41.1%	2.5%	10.4%
# Worker-Quarters	1XX,XXX	6XX,XXX	3X,XXX	1XX,XXX
Share of Firmwide Employment	8.2%	43.5%	2.5%	7.1%

Notes: This table reports average values of various characteristics of workers (rows) by subsample (columns). Sample consists of quarterly panel of German employees 2011-2023 (i.e., means are weighted by tenure). Managers in Columns 3 and 4 are defined as managers of workers in Columns 1 and 2, respectively (i.e., restricting to managers of engineers). Employees not in event study sample are restricted to Engineers (Column 2) and their managers (Column 4), as in Table 5.

Table B3: Comparison to Other Multinationals

Table B4: Comparison of Firm's German to Global Workforce

Table B5: Comparison to German Firms

Table B6: Comparison of Firm's Patentors to All German Patentors

Table B7: Descriptives of Manager Switchess

Table B8: Endogenous Mobility Checks

C Data Appendix

This appendix provides additional details on the data sources used in the analysis.

C.1 Manager Evaluations

To characterize managers' leadership behavior, we draw on two types of manager evaluations.

C.1.1 360-Degree Evaluations

First, we use 360-degree evaluations, which are available for a subset of the sample covering three years. The evaluations are designed to capture multiple dimensions of managers' leadership behavior and are collected as part of a standardized internal assessment process. The 360-degree evaluations consist of several thematic modules, each intended to measure a distinct aspect of leadership behavior. The main modules include the following, with each module consisting of three individual questions.

- **Stakeholder Orientation**: Items capturing the extent to which the manager builds trust, manages expectations, and maintains productive relationships with internal and external stakeholders.
- **Effective Communication**: Items assessing clarity, transparency, and responsiveness.
- **Innovation Leadership**: Items capture openness to new ideas, encouragement of experimentation, and support for securing resources to develop ideas.
- **Quality Accountability**: Items capturing the extent to which the manager supports the team in identifying and resolving quality issues, holds themselves and others accountable for quality standards, and ensures follow-through on quality-related performance.
- **Trust Building**: Items capturing the extent to which the manager fosters mutual respect and demonstrates integrity.
- **Change Leadership**: Items capturing the extent to which the manager clearly communicates change initiatives, provides guidance on next steps, and addresses employee concerns during periods of transition.

All items are rated on a five-point Likert scale ranging from X TO Y. The wording of the scale anchors is consistent across modules.

For each evaluated manager, feedback is solicited from multiple sources, including supervisors, peers, subordinates, and selected external stakeholders. For data protection and confidentiality reasons, the data do not allow us to identify the role of individual raters. As a result, we average all non-self raters for each item and manager. In addition to evaluations by others, managers also complete a self-assessment using the same set of questions and the same five-point scale. We normalize each rating.

C.1.2 Leadership Ratings by Direct Supervisor

For two years of the sample, we also observe detailed leadership evaluations completed by managers' direct supervisors as part of the firm's regular performance review process. These supervisor ratings assess managerial leadership behaviors across multiple dimensions that are closely aligned with those captured in the 360-degree feedback reports, including innovation leadership, stakeholder orientation, trust building, quality accountability, and communication effectiveness.

Unlike the 360-degree evaluations, which aggregate feedback from multiple sources, these assessments are provided exclusively by the manager's direct supervisor. The supervisor ratings therefore reflect a single, hierarchical perspective on managerial behavior rather than an average across peers, subordinates, and other stakeholders. All items are rated on a common, five-point Likert scale. We normalize each rating.

C.2 Measures of Innovation Activity

D External Validity

E Additional Robustness

E.1 Manager Switches

E.1.1 Alternative Sample Definitions

In this section, we examine the robustness of our main results to alternative definitions of the analysis sample. Our baseline analysis focuses on workers in engineering, who are responsible for the vast majority (X%) of inventions. To probe robustness, we consider two alternative sample definitions. First, we expand the sample to include all workers who ever submitted an invention disclosure at any point during their tenure at the firm, regardless of whether they are actively innovating around the time of a manager switch. Second, we construct a broader team-level sample that includes all workers in teams where at least one team member has ever submitted an invention disclosure. This definition captures environments in which innovative activity is present at the team level, even if not all individual members directly generate disclosures.

Across both alternative samples, we re-estimate our baseline specifications and find results that are qualitatively similar to those reported in the main text. The magnitude and statistical significance of the manager effects remain stable, indicating that our findings are not driven by a particular definition of innovative workers or by selective sample inclusion. XXXXX

E.1.2 XX

a set of robustness exercises, we further augment the baseline specification with rich fixed effects, such as division and calendar-time fixed effects, to account for potential firm-wide strategic shifts,

including expansions in particular technological or business areas that could be correlated with the assignment of more invention-experienced managers

E.1.3 Measures of Managers' Invention Experience