Unpacking the Innovator-Inventor Gap: Evidence from Engineers*

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ABSTRACT

Using detailed administrative and survey data from engineers, we provide insights into the processes that lead to patent filing. We document these processes' opt-in, competitive nature, and how firm dynamics and demographics shape them. Only one-third of engineers submit ideas for patenting, and just half of these lead to patent applications. Women are significantly less involved at each stage of the journey from innovator to named inventor, contributing to a larger "innovator-inventor gap," which engineers perceive to be associated with ineffective management and culture. Analysis of citation patterns suggests that high-quality patents are lost in firms with larger gender gaps.

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While women comprise 35% of the STEM workforce, they make up only 13% of inventors; Black professionals represent 9% of STEM workers but only 1.2% of inventors (NCSES, 2023; Akcigit and Goldschlag, 2022). These discrepancies highlight a substantial "innovator-inventor gap," or the reduced rate at which innovators from underrepresented groups (URGs) become inventors on patents despite their presence in the STEM workforce (Chien, 2024). Understanding the gap and the more general underrepresentation of women and minorities in innovation is crucial due to its implications for technological competitiveness, economic growth (Bell et al., 2019b; Cook, 2018; Cook et al., 2021), and the direction and reach of innovation (Koning et al., 2020; Koffi and Marx, 2023). Further, if women, minorities, and children from low-income families received patents at the same rate as white men from high-income families, it is estimated that there would be four times as many inventors in the United States (Bell et al., 2019b).

Our study offers in-depth insights into the internal firm dynamics leading to patent filings by empirically examining the processes' transparency and management (Bloom and Van Reenen, 2010; Bloom et al., 2013; Tate and Yang, 2015; Bennedsen et al., 2022; Bradley et al., 2022) and the corporate culture (Guiso et al., 2015; Li et al., 2021; Graham et al., 2022) to ascertain how a blend of formal and informal incentives, socialization and employee traits (Azoulay et al., 2011; Bena and Li, 2014; Heath et al., 2023; Ewens, 2023; Malmendier and Tate, 2005; Sterling et al., 2020) contribute to the observed gap. While most patented inventions originate in firms, because decisions about who does or does not get to participate in inventing at firms happen before the point of patent filing, the gap and its causes remain largely unexplored. By analyzing new administrative data and survey responses from thousands of engineers, our study aims to unpack, for the first time, the conversion of innovators to inventors and how firm dynamics, culture, and demographic differences shape it. Such analyses help to inform debates about whether this innovator-inventor gap reflects an efficient filtering process at firms or is a cause for concern.

To conduct our analysis, we leverage confidential administrative datasets on ideas submitted for patenting obtained from four collaborating high-tech firms, covering 69,513 unique ideas from 31,585 engineers. The average idea submission involves 2.3 inventors, with 32% including a first-time inventor, 16% a female inventor, and 9% an underrepresented minority (URM) inventor.[1] However, only 59% of these ideas are submitted as patent applications, and just 41% are granted conditional on an application being made. While most unsubmitted ideas are closed, 3.2% receive intellectual property (IP) protection through other means like trade secrets and defensive publications. This raises questions about the reasons behind the rejection of so many innovative ideas and the extent to which they represent failed ideas or frictions in the

[1] In the context of inventors, we use the term "URM" to refer to individuals with an ethnicity that is not white or Asian, while we use the term "URM" to refer to URMS and individuals that are not male.

invention process.

Next, we offer insights into the "black-box" process of inventing and the many frictions engineers face in converting innovative ideas to inventions based on our literature review and interviews with thirteen patent professionals across various high-tech firms. These interviews uncovered meaningful variations in how an idea is collected from engineers and how an idea is reviewed and selected for IP protection, a costly endeavor. During our interviews, patent professionals also expressed that they believed some ideas worthy of IP protection were not even being submitted as invention disclosures due to factors like inadequate communication or innovator perfectionism. The interviewees also discussed strategies to improve inventor diversity and help convert early ideas into fully developed invention disclosures. As illustrated in Figure 1, their collective responses paint a picture of invention as a highly competitive, opt-in process in which only a subset of patentable ideas are submitted for consideration, and only a subset of them advance to patent application and eventual grant.

Another insight from our interviews is that converting R&D investments into valuable IP rights is far more nuanced and contingent than corporate innovation models acknowledge. This warrants a more detailed consideration of the process's various external and internal frictions. To support such a consideration, we develop a model of how engineers allocate time and effort toward inventive tasks and advance the hypothesis that early-stage exclusionary practices such as inadequate feedback increase the uncertainty surrounding the patent-worthiness of an inventive idea. Our model predicts this has a compounding influence, leading diverse inventors to rationally reduce the amount of effort they allocate toward inventive tasks due to the reduced ability to gauge their patenting success accurately. Conceptually, going from idea to invention does not solely depend on the quality of the idea but also signals to the innovator of an idea's patent-worthiness.

To assess the model's merits and determine where along the inventive path diverse engineers may withdraw, we turn to our survey of 3,989 engineers and firm-level invention data. We surveyed the engineers sequentially, with 75% of the responses from a survey sent to all engineers at the first firm and the remaining sent to small but representative samples of engineers at four other firms.[2]

The survey and administrative data yield several findings. First, both data sources independently reveal that participation rates decline at each stage of the inventive process. While more than half of innovators report having had a patentable idea, less than one-third of innovators have submitted an idea for patenting,

[2]Considering that the sampled firms share significant technological similarities, it's important to note that technological differences are not the underlying cause of the variation in the invention process. The sampled firms are similar and diverge from the average public patenting firm on other observable dimensions. For instance, our sampled firms generate six times more revenue, have two times more employees, 16 times more R&D expenditures, and 17 times more patents, but they are similar to the average public patenting firms in terms of profitability, Tobin's Q, patent value, and patent citation patterns.

consistent with the idea that some potential inventors remain "on the bench." Further, only half of the ideas submitted as invention disclosures get filed as patent applications, and only a subset of filed applications become granted patents. Later, we evaluate whether the marginal idea lost to friction in the process is consistent with high quality.

Second, our data allows us to unpack the origins of the innovator-inventor gap.[3] We find from the survey that females and URMs face distinct experiences within their companies, leading to a disparate innovator-inventor gap for each group. We find women (but not URMs) are disadvantaged across all stages of invention, from being assigned to patentable projects to submitting new ideas to having that idea turned into a patent application and ultimately to the application being granted.

Next, using a question multiplicity approach and triangulating across responses, we determine a relative pecking order of factors contributing to the innovator-inventor gap. In developing the questions testing potentially influential formal, informal, and personal factors, we rely on the precedent and exact form of question used in prior studies.[4] The factors contributing to the innovator-inventor gap, as surveyed engineers revealed, are management, motivation, culture, the invention submission and review process, mentoring, peer influence, and lastly, personal characteristics.

Better management is the top factor that would increase idea submission. The disparity in engineers' perception of management is notable, with women and URGs less likely to view management as supportive in the inventing process. Additionally, extrinsic and intrinsic or pro-social motivational factors significantly influence idea submission, with URGs significantly more likely to cite a desire to create social value as a motivation. Third, corporate culture, especially regarding aspirational values like collaboration and integrity, appears to contribute to the innovator-inventor gap. Female engineers are significantly less likely to report (i) experiencing managers explaining important details, (ii) having people with whom to collaborate, and (iii) experiencing managers being ethical and making fair decisions. Overall, our creation of a pecking order underscores the gap linked to changeable aspects of companies, like management practices and corporate culture, rather than unique individual determinants.

Next, we build upon the insights from the interviews and survey by testing the remaining predictions

[3]Our sample includes many engineers who self-identify as members of URGs: 77% self-identify as male, 22% as female, and 0.5% as non-binary, closely mirroring broader industry demographics, while ethnic composition varies geographically – dominantly Asian (77%) globally but balanced between white and Asian (45% each) within the U.S., which accounts for 33% of respondents. Professionally, the modal respondent is on an engineering team, has been at their current firm 7 years, is 41 years old and partnered (splitting work equally with their partner), and follows a hybrid work schedule.

[4]For instance, we draw from Graham et al. (2022) for questions on effective corporate culture and cultural norms. We replicate the generalized trust questions from Guiso et al. (2006), and we use the framework for high-performance leadership competencies developed by Schroder (1989).

of our theoretical model. Specifically, due to the constraints diverse engineers face in refining the signal of the patent-worthiness of their idea, our model predicts that firms with meaningful friction in the invention process, like unsupportive managers and an ineffective culture, will have fewer but higher-quality patents from those engineers facing the most frictions (e.g., women). Using a variety of datasets and approaches, we find evidence consistent with the predictions.

First, using the administrative data from the collaborating high-tech firms, our estimates suggest being female correlates with a 5 percentage point (p.p.) reduction in the probability of an idea being initially submitted and another 5 p.p. reduction in a submitted idea being converted into a patent application. Next, conditional upon making it through the patenting process, female patent holders at the firms in our study receive significantly more forward citations than their male counterparts, suggesting the quality of the marginal idea lost to frictions in the process is higher. This disparity remains evident even when we include a variety of patent, examiner, and firm controls as well as fixed effects for added robustness. The impact of this higher quality is very pronounced, as patents with female inventors at firms in our study are significantly more likely to reach the top decile of citations.

Second, because the firms willing to collaborate with us may have appreciable bias, we externally validate our initial findings using data on all U.S.-gendered patents issued to public firms for which Glassdoor data is available. Glassdoor is a career intelligence website that attempts to provide transparency about jobs, salaries, and companies by supplying crowd-sourced ratings for culture and management. Again, we find evidence consistent with female inventors producing higher-quality patents at firms with meaningful frictions in the inventive process.

We proxy for friction in the inventive process using a below-median culture or below-median management rating. In both cases, the interaction term between being female and having friction is associated with more citations. This indicates that the factors that rank highly in the pecking order we observed at our collaborating firms appear to generalize. It also helps emphasize the importance of our findings. Our point estimates suggest that moving from a below-median to an above-culture culture firm is associated with more patents with female inventors per year and increased forward citations, all else equal.

One key advantage of using a survey to unpack the forces driving the innovator-inventor gap is we hear directly from the engineers who are driving technological progress about their views of the inventive process at their firms. Our survey thus allows for a more direct view into the pre-patenting process than is afforded by external sources. Of course, as with any survey, there are concerns. As such, we carry out a series of robustness checks to determine the extent to which the engineers' survey responses are reliable and consistent with external data, finding them to be largely so. First, we cross-validate the survey responses with administrative idea submission data, where we have it, and find both sources to substantiate the attrition of females through the patenting process. Second, we repeat a question at one of our sampled firms via their routine employee engagement survey, avoiding IP or diversity framing, and find statistically indistinguishable results. Third, we replicate the survey among college students to ascertain whether the results are explicitly influenced by experiences within firms instead of broader societal factors, finding the former to hold. Finally, we also re-run our analysis on just the U.S.-based engineers to ensure historical and societal constructions of race and gender are not biasing our findings.

The remainder of the paper is organized as follows. Section 1 describes the related literature. Section 2 provides background information from interviews with patent professionals about the invention process. Section 3 presents a theoretical model. Section 4 presents the results of our survey of engineers, including a pecking order of factors contributing to the innovator-inventor gap. Section 5 analyzes the idea-level data and discusses the economic implications of our findings. Section 6 describes robustness checks, and Section 7 concludes.

1 Literature Review

This study uses administrative data on idea submission and a survey of engineers to uncover the forces leading innovators to become inventors. We then evaluate the social welfare implications from the forces driving the gap. In constructing our novel survey instrument, we rely on a vast, interdisciplinary literature exploring factors contributing to race and gender inequality such as management practices, corporate culture, assessment and feedback processes, training and mentoring, access to social networks, pecuniary and non-pecuniary incentives, early life exposure, and behavioral explanations such as overconfidence, stereotype threat and associated confirmation bias.

Prior surveys have explored strategic and operational dimensions of firm-level patenting (Cohen et al., 2000; Graham et al., 2009), but no study of which we are aware of has explicitly focused on the experiences of engineers, particularly diverse engineers, with the invention process. This omission is understandable given that the decision to patent often reflects firm rather than individual-level priorities and that inventions over ideas devised on the job belong to employers, not employees, under the hired-to-invent doctrine. But participation in inventing, even conditional upon presence in the workplace, matters for a few reasons: at the inventor level, the invention is associated with compensation, retention, and psychic and social benefits (Kline et al., 2019; Bell et al., 2019b; Chien, 2024); who invents also influences what inventions get commercialized, and for whose benefit (Koning et al., 2020; Koffi and Marx, 2023). By concentrating on the perspectives of engineers rather than management or executives, our study offers a unique contribution to the field and sheds light on how the invention process might be modified to become more inclusive.

Our study builds on a handful of previous surveys of inventors and potential inventors. The relevant inventor surveys from the EU are the PatVal-EU survey and the European Commission's Community Innovation Survey, carried out bi-annually. PatVal-EU was a one-time retrospective survey of inventors who had been granted a patent by the European Patent Office (EPO) with a priority date between 1993 and 1997. The survey was carried out nearly a decade after the inventor filed for the patent (2003-2004) and focused on rewards to the inventor from patenting (e.g., monetary rewards), research collaborations in the innovation process (e.g., developing the patent with an external co-inventor), and the subsequent patent use by the inventors' employers (e.g., licensing). While the administrators received a large number of responses at 8,963 responses, only 2.8% of the survey respondents identified as female, and no questions about ethnicity were asked on the survey (Giuri et al., 2007). Similarly, the Community Innovation Survey is a periodic survey that provides information on statistics about enterprises with product and business process innovations, their strategies, knowledge management, and innovation activities, as well as about factors that facilitate or hamper innovation (Commission', 2019).

One relevant inventor survey in the United States is Jaffe et al. (2000), which focused on inventors' contributions to knowledge spillovers rather than innovation processes. Like our study, Graham et al. (2009) concentrated on the high-tech sector but polled executives rather than innovators. The survey closest to ours is Ross et al. (2022), which seeks to explain the well-documented gap between the observed number of scientific publications produced by women and men in science. Basic scientific research is often a precursor to patent applications and commercialization but is usually conducted in university settings. Ross et al. (2022) survey 2,660 scientists regarding how credit is allocated for research done, and they find exclusion from authorship is common and differs significantly by gender, with 43% of women and 38% of men experiencing exclusion. We view our study that surveys high-tech engineers working in the private sector as a complement to their survey of scientists working in the public sector. Finally, Bennett and Chatterji (2023) study the entry decision of would-be entrepreneurs using a nationally representative survey documenting the importance of opportunity costs, prior experience, and confidence levels. Similarly to patenting, fewer than half of those who considered starting a business take even the lowest cost steps, like searching the Internet for potential competitors or speaking with a friend.

Our study contributes to several other important strands of literature. One strand focuses on innovation, inventorship, and incentives - both pecuniary and social - in the context of innovation, publishing, and protecting inventions. Given the challenges of obtaining pre-patenting private-sector data, most studies focus on the public sector to study determinants of inventorship. Our insights into the private sector complement these studies, which highlight the importance of incentives (Azoulay et al., 2007, 2010, 2011; Howell, 2017; Bell et al., 2019a; Ganguli et al., 2021; Myers and Lanahan, 2022). We also complement studies that explore the role of individual determinants of inventorship such as socioeconomic status (Bell et al., 2019b; Akcigit et al., 2017; Kerr et al., 2017; Aghion et al., 2022; Ganguli et al., 2020; Chien, 2022; Celik, 2023), specifically through our ability to create a relative ranking to enable comparisons across determinants. Finally, we add to a large body of research that explores how gender and ethnicity affect the production of new ideas (Ding et al., 2006; Galasso and Schankerman, 2010; Cook, 2014; Martinez et al., 2016; Cook, 2018; Hofstra et al., 2020; Ross et al., 2022; Waldfogel, 2023), and career achievements from them (Kamas and Preston, 2018; Ganguli et al., 2022; Linos et al., 2023).

Our finding that corporate culture and management practices have highly consequential and real effects on innovative outcomes is consistent with a rich literature showcasing their role in value creation (Bloom and Reenen, 2007; Guiso et al., 2015; Gorton et al., 2022; Li et al., 2021; Graham et al., 2022; **?**; Grennan and Li, 2023; Grennan, 2023). Specifically, we find that women are less likely to report that managers provide important details, and more likely to report they don't have someone with whom to collaborate. We find little evidence that women are too busy (Boudreau et al., 2017), a supply-side explanation some have suggested. (Norris et al., 2021) These possibilities are intriguing and consistent with research suggesting minorities lack the "cultural capital" and networks to access information (Cullen and Perez-Truglia, 2023; Chetty et al., 2022; Chien, 2022; Munn, 2017; Petersen et al., 2000). At present, the empirical findings in that literature are mixed, pointing to the need to take an interdisciplinary empirical lens as we did. This is important because the question of who, within a work setting, is recognized as an inventor for their work and whether their innovations are protected and promoted has substantial welfare consequences (Celik, 2023). Recognizing that culture is an important driver of innovative outcomes also complements research examining how to optimally incentivize invention (Lerner, 2005; Arora et al., 2018; Bloom et al., 2019) and motivate STEM professionals (Manso, 2011; Toivanen and Väänänen, 2012; Ederer and Manso, 2013; Bianchi and Giorcelli, 2020).

Finally, we contribute to the literature on sound practices in developing and protecting IP (Chien, 2019; Mezzanotti, 2021; Abrams et al., 2023). Our results are consistent with the view that leaders, patent professionals, and examiners all play a role in making innovation more inclusive, but so does public policy (Moser et al., 2014; Farre-Mensa et al., 2019; Pairolero et al., 2022; Kalyani, 2022). By describing the challenges in moving from being an innovator to a patented inventor, we help to characterize the forces that may need to be addressed to achieve parity benchmarks for patenting, commercialization, and entrepreneurial aspects of the invention. Our research, therefore, complements a growing literature examining differences in business outcomes for founders from URGs commercializing inventive ideas (Fairlie et al., 2022; Calder-Wang and Gompers, 2021; Ewens and Townsend, 2020; Howell and Nanda, 2023; Cook et al., 2023; Koffi and Marx, 2023; Miller, 2023; Gornall and Strebulaev, 2024).

2 Background Information from Interviews

We interviewed thirteen patent professionals, predominantly patent counsels, to gain insights into the pre-patent filing invention process. The firms included private firms, those recently undergoing an initial public offering (IPO), and well-established public firms. In doing so, we sought to broadly understand the patenting process at firms across their lifecycle stages; the firms also varied in terms of their culture and reputation for diversity and inclusion, with two firms chosen for their broader reputation as good and bad places to work, respectively. The patent professionals we spoke to primarily work at technology or manufacturing firms. Thus, while the interviewees are a selected sample, the firms that they work at comprise a set of firms that contribute meaningfully to the U.S. economy and its competitive positioning worldwide.[5]

Figure 1 presents a stylized representation of the many strategies firms use to collect inventive ideas that may warrant IP protection. For an idea to be submitted as an official invention disclosure, some firms have patent professionals reach out to inventors to see what they are working on and gather any ideas worthy of applying for IP protection. At other firms, there are inventor portals into which inventors submit their invention disclosure and then wait a few days, weeks, or months for feedback. Senior engineers and patent professionals also commonly collect ideas through group events such as roundtables, hack-a-thons, brainstorming, or jam sessions.

Further, as Figure 1 demonstrates, more firm differences arise once invention disclosures are tendered. Several firms use a two-stage assessment, where inventors receive preliminary feedback at the first stage. This intermediary step provides a conducive environment for refining disclosures before they are escalated to a patent review board. Conversely, some firms adhere to a singular, streamlined process wherein the patent review board immediately assesses the disclosure. The varying expertise of these committees and the possibility of blind reviews add layers of complexity to this evaluative stage. Moreover, we also heard IP legal review may further complicate the decision by considering factors beyond novelty and non-obviousness, such as IP budgetary constraints, alignment with R&D priorities, subjective assessments of the patent prosecution success, and estimated ease of detecting infringement.

[5]For a comparison of characteristics of the collaborating firms to a broader population of patenting and public firms, please see Appendix A.

Worthy ideas may be the subject of defensive publications or trade secrets, although we heard anecdotally among our firms that such designations based on patent idea submissions were relatively rare, with interviewees indicating that no more than 10% of submitted ideas are earmarked for alternative designations. For example, at one firm, the patent review board decides whether or not an idea is worthy of formal IP protection, including patents, trade secrets, defensive publications, and open-source licenses. Some ideas are formally designated as trade secrets, and employees are informed in accordance with the requirements for trade secrecy. A more formal process involved a patent-worthy idea dedicated to the public as a defensive publication. Such a strategy makes sense when the goal is defensive, to create prior art and prevent others from obtaining blocking patents, rather than to proactively and offensively sue others. Although defensive publications are never examined or subject to legal evaluation, they must be "published" to the world in order to fulfill their purpose of being available as prior art to block the idea from being patented. In contrast, ideas only qualify for trade secrets if they meet certain criteria – that the content be secret and the subject of efforts to maintain secrecy, and that the value of the trade secret derives from its secrecy. It is also the case that many of the ideas not selected for patenting may neither qualify for trade secret protection nor be worth the trouble of defensive patenting.

Once the patent legal team reviews an idea, it can reject it for patenting (or potentially alternatively designate it for defensive publication or trade secret protection), put the idea on hold, or advance it to patent application. When a patent is applied for, the process can also vary in terms of the degree to which outside or inside counsel are involved and the extent of back-and-forth between the inventors, patent attorney, and patent examiner during the patent prosecution process. Given our focus on the internal dynamics of the invention process within firms, we did not extensively investigate the roles of patent examiners, external intellectual property counsel, and the impact of patent publication but noted the rich literature that has developed in this area (Alcácer et al., 2009; Aneja et al., 2022; Hegde et al., 2023).

Next, we asked interviewees for insights into the process leading up to idea submission, and what steps their firms were taking, if any, to ensure inclusivity. While all interviewees kept track of submitted ideas, until recently, few firms systematically tracked diversity-related data for potential inventors or set specific performance goals related to diversity or the innovator-inventor gap. When we asked interviewees for specific ideas about improving inclusivity, we received many suggestions and broadly group them into improving mentorship, communication, and culture.

For instance, we heard that submitting the first idea is often the most difficult because it can feel complicated and unfamiliar. Mentorship programs were seen as an ideal way to connect could-be inventors with experienced inventors. Employee resource groups ("ERGs") associated with a particular affinity received praise as a potentially ideal platform for creating informal connections to help novices navigate the IP process. We also heard that communication and feedback could be improved, especially with regards to the "black box" nature of the internal rejection decisions. One professional noted that first-time inventors often do not know what they are being judged on, and may not receive an explanation as to why their idea was rejected, especially if they submitted through the portal. As such, the patent professionals perceived that the lack of communication could foster frustration, confusion, and resentment toward the patenting process.

Communication also meant making the IP process more central to the everyday activities of the engineers. One interviewee noted that some innovative engineers do not perceive themselves as inventive because they think they are just helping on a project, and it's important for patent teams to positively and publicly celebrate the inventors who received patents. Finally, interviewees suggested that when the IP process seems fun and collaborative, getting a broader audience involved is easier. This person suggested giving away prizes, gamifying inventions, and throwing patent parties as ways to celebrate an innovation culture. Finally, some interviewees said that improving work-life balance could make the invention more inclusive, as they believed that women might be too busy with work outside the workplace to be able to participate fully in the invention process.

Figure 2 is our depiction of the interviewees' insights into the innovation-to-invention process before submission. Drawing on precedents from institutional economics (North, 1991), Figure 2 classifies the many factors at the firm (external) and innovator (internal) levels that shape the decision to submit invention ideas. The boxes along the top of Figure 2 show that firm-level factors are grouped into informal and formal institutions such as culture and management practices. Individual-level traits include individual traits, early-life experiences, and career-life balance. The blue, yellow, and red dots indicate which facts are likely to influence individual ideas (blue), group ideas (red), and idea submission (yellow).

3 Theoretical Model

In this section, we present a static model of how engineers decide to allocate their time and effort between two types of tasks: (i) working on invention disclosures, which can potentially lead to payouts and (ii) other tasks, both technical and non-technical, which yield a fixed wage. In making these decisions, engineers face uncertainty regarding the quality of the ideas they could submit as potential invention disclosures. The model allows the engineer to put effort into gathering feedback to reduce this uncertainty. By examining how different factors, such as the potential payout from an invention, the wage earned from other tasks, and the effort required to reduce uncertainty, alter an engineer's decision concerning time and effort, we seek to learn more about the factors influencing the inventive process. While we do not know of specific models detailing how engineers optimally allocate their time toward inventive tasks, we draw upon insights from the entrepreneurship literature (Evans and Jovanovic, 1989; Levine and Rubinstein, 2017), and studies of how academics and creators choose projects (Azoulay et al., 2011; Waldfogel, 2023). Next, we summarize the various factors in our model.

- Total time (T) available for the engineer to work on tasks. The engineer chooses to spend their time on technical or engineering tasks likely to lead to inventions (T_i) or on other tasks, both technical and non-technical, that are unlikely to lead to inventions (T_o)
- Probability of successful invention disclosure (p) represents the likelihood that the invention disclosure will be successfully filed as a patent application.
- Cost of invention (C_i): This cost of invention abstracts away from the cost of equipment and resources and instead focuses on the mental cost. Mental costs associated with the inventive process include mental expenditures to gain tacit knowledge about the inventive process and invention-specific costs. The full cost of the invention is expressed as $C_{tk} + \alpha * S$. Where C_{tk} is the cost required to obtain tacit knowledge about the inventive process, $\alpha * S$ is an invention-specific cost and α represents the overall importance for the noisy signal in the cost of invention.
- The noisy signal S is a linear function of effort (E) and represents the engineer's perception of the quality of the idea or the potential payoff from an invention disclosure as $S = \mu - \beta E$. Where $\beta > 0$ represents the reduction in noise per unit of effort. In this case, the more effort the engineer puts in, the less noise in the signal. The cost of effort is linear and represented by kE where $k > 0$. The engineer's noisy signal encompasses their internal and external perceptions. Internal perceptions include believing one's idea is worthy. External perceptions are shaped by management, patent professionals, and the culture.
- Within the noisy signal, S, μ is a parameter that indicates the baseline quality of the idea before the engineer puts in any effort to reduce the noise. A high μ would represent a strong initial perception of the idea's quality or a high potential payout.

Next, we express the engineer's objective function. Implicit in our setup are the constraints that $T_i \geq 0$, $T_o \geq 0$, and $E \geq 0$.

$$\max_{\substack{T \geq T_i + T_o \\ 0 \leq p \leq 1 \\ 0 \leq \alpha \leq 1}} U(T_i, E) = (p_0 + \gamma E)(w_b T_i) + (1 - p_0 - \gamma E)(w_f (T - T_i)) - (C_{tk} + kE + \alpha(\mu - \beta E))T_i$$

To find the optimal allocation of time and effort, we take the partial derivatives of the objective function for T_i and E and set them to zero. Then, we solve for T_i. There are two potential solutions. Since one of the solutions, $T_i = 0$ means that the engineer spends no time on the inventive tasks, we focus on the second solution. We then also use that solution to solve for E. We see that:

$$T_i = \frac{(p_0 + \gamma E)(w_b - w_f)}{C_{tk} + kE + \alpha(\mu - \beta E)}$$

$$E = \frac{\gamma(w_b - w_f) - k + \alpha\beta}{\gamma^2}$$

3.1 Key Trade-offs Engineers Face

The equation for E shows that engineers face a few key trade-offs that drive optimal effort. First, wage differences matter. Effort is proportional to the wage difference between inventive and other tasks. Larger, faster wage differences incentivize engineers to invest effort in reducing the noise signal. By putting in more effort, the engineer can reduce the uncertainty surrounding the idea's potential payoff. However, this comes at the cost of time and resources that could be spent on other tasks. Second, the rate at which submitted ideas are approved for filing ("success rate") matters. Effort is positively related to the rate at which the probability of success increases with effort (i.e., γ). A higher success rate incentivizes the engineer to allocate more effort to a given task. The final trade-off is cost. The costs associated with the effort play a role in determining the optimal level of effort. As costs increase, especially those associated with gaining tacit knowledge, which can be more challenging for diverse engineers when there are meaningful frictions in the invention process, effort will decrease. Overall, engineers must weigh the benefits of better understanding the idea's quality against the costs of the effort required to reduce the uncertainty.

Similarly, consider the fundamental trade-off that is the payout vs. wage trade-off. The trade-off is between working on an invention disclosure with a potentially bigger payout and working on other technical tasks that offer a fixed wage. When the potential payout of an invention disclosure is high, engineers might be more inclined to allocate their time and effort to that invention disclosure, anticipating a greater reward. On the other hand, when the fixed wage for other technical tasks is high, engineers might prioritize those tasks over working on invention disclosures, especially if the potential payout from the invention disclosure is uncertain or not high enough to justify the effort.

3.2 Model Implications for Social Welfare

A natural corollary of the proposed model is that in firms where diverse engineers incur elevated effort costs, their rational response entails submitting fewer ideas, albeit when they do submit, their submissions will be of superior quality compared to their more representative counterparts with lower effort costs. Specifically, we postulate that diverse engineers will predominantly engage in idea submission when the prospective benefits exceed the effort costs they confront. That is, diverse engineers grappling with higher costs of refining their ideas' quality signal (S), opt to submit only when the signal's robustness regarding the patent's potential is evident, denoting a superior quality. This condition is mathematically represented by establishing a higher quality signal cut-off point ((P_{urg}) for URGs. In contrast, engineers from representative groups with lower associated costs tend to pursue a broader array of patents, encompassing those with moderate payouts, which results in a lower average quality cut-off point (P_{rg}). Thus, a second corollary of the proposed model is that due to diverse engineers' constraints in thoroughly refining their signals, we conjecture that the variance in the distribution of both their submitted ideas and awarded patents will be shifted higher and comparatively narrower.

3.3 Extending the Model

Two potential extensions of the model include incorporating non-pecuniary rewards and team-based invention. We acknowledge by focusing on pecuniary rewards solely, we may miss meaningful interactions between pecuniary and non-pecuniary factors. However, we believe one could reinterpret the above derivation by broadening the framework to incorporate considerations of both social and private value. Engineers from diverse backgrounds might be inclined to dedicate time to innovative activities, particularly if the invention disclosure holds significant social value pertinent to their respective communities. The payoff could include intrinsic or social benefits, which only come from a high-quality disclosure.

In our model, if teams blend diverse ideas, then this could raise the initial quality of the idea (μ), offsetting some of the higher costs faced by diverse engineers. As our interviewees suggest, the culture will likely impact these team dynamics. Thus, a natural conjecture is that in a workplace with an effective culture, collaboration can enhance the quality of ideas, but in an ineffective culture, biases or unequal recognition of efforts can undermine any cost reductions or improvements in the quality of the idea. One could tests for such nuances, however, Hong and Page (2004) model the production of scientific ideas in teams and predict that contributions from diverse engineers need not be of higher quality to be beneficial. Instead, diversity is greater than the quality of the idea because the diverse engineer's idea is more likely to be uncorrelated with the “groupthink” idea put forth by the representative group. This model is more general and does not rely on a collaborative culture or team dynamics to be ineffective; rather, any friction or bias that makes it more costly for diverse engineers to contribute is considered suboptimal. For these reasons, we abstract away from team-based invention.

4 Survey Data and Results

We use an original survey of engineers to assess how the invention process is perceived and what factors they experience as working for and against more significant involvement in the process. We incorporate questions regarding various factors underscored by interviewees, thereby enhancing the survey’s comprehensive scope and depth. Moreover, we ensured respondent anonymity to foster candidness, especially on sensitive subjects like workplace discrimination. We acknowledge that, as with any survey, the administration of the survey is relevant to how the survey is administered. In Appendix A, we include a copy of the survey instrument and detail the precautions we took to mitigate bias and enhance reliability, like randomizing answer choices to prevent order-of-presentation biases.

To deploy the survey, we worked with human resources (HR) or internal teams responsible for surveying employees to match company-specific terminology. For four firms, an employee sent the solicitation email, and for one firm, we sent the solicitation email. We include examples of the emails in Appendix A. Our response rate varied across settings, ranging from a low of 7% to a high of 16%, which is comparable to previous academic surveys (Graham and Harvey, 2001; Gompers et al., 2020; Graham et al., 2022; Eldar and Grennan, 2023). In total, we collected 3,989 responses from engineers, and we did not remove any responses.

Following the recommendation of List (2007), we compare the characteristics of collaborating firms with the broader population of patenting firms and Compustat firms. In general, the firms in our sample are larger in terms of assets and employees, have more revenue, and more R&D expenditures. In terms of their patents, they are, on average, indistinguishable in terms of citations and value Kogan et al. (2017). However, our sample of firms are granted more patents per year. The collaborating firms’ most common patent technology subcategories are digital communication, audio-visual technology, computer technology, telecommunications, and optics. Despite that tilt toward high technology, the sampled firms cover over 30 technology subcategories.

4.1 Demographics of respondents

Table 1 summarizes the demographic information reported by our sample of 3,989 engineers. Confidentiality was ensured to promote honest answers, and a "Prefer not to answer" option was available for sensitive questions. For instance, among the 3,758 (95% of the total) respondents who responded to the gender question, 77% self-identify as male, 22% as female, and 0.5% as non-binary. Another 231 respondents (5.8% of respondents) indicate that they "Prefer not to answer." The female representation rate (22%) was confirmed by HR departments as being slightly below the actual percentage, indicating that females may have felt more comfortable selecting "prefer not to answer." This percentage, however, is within range of those reported by policymakers for high-tech engineers.[6]

Among respondents, 3,714 (93% of the total) indicated their ethnicity. A dominant 77% identified as Asian, followed by 20% white, 2% Latinx, 1% multi-racial, 0.5% black, and 0.2% as American Indian, Alaska Native, or Native Hawaiian. This ethnic breakdown coincides with the geographic distribution of the respondents, with 38% hailing from North America, 28% from East Asia, 23% from Southeast Asia, 7% from South Asia, 3% from the Middle East, and 1% from Europe. Additionally, less than 1% reported from Australia, Africa, and South America. Among U.S. respondents, which account for 33% of the total, the ethnic breakdown is different. The U.S. survey population was 45% each white and Asian, followed by 5% Latinx, 3% multi-racial, 1% black, and 0.4% American Indian, Alaska Native, or Native Hawaiian.

Half of the respondents work in engineering business units, and a quarter work in data science, while the remaining are split between manufacturing (13%), products (10%), and business (5%). Regarding the ongoing work-from-home debates (Bloom et al., 2014; Barrero et al., 2023), 70% work in a hybrid setting, 20% are fully remote, and 10% work in-office, a pattern observed domestically and internationally. The average engineer has been at his firm for seven years and is 41. Educational attainment shows that most international engineers have an undergraduate degree (47%), whereas, in the U.S., 39% possess a graduate degree. Lastly, regarding non-work life, 80% of the respondents are partnered, with 73% of those having working partners. A significant 71% share household responsibilities equally with their partners.

We observed significant gender differences by demographic group on several of these dimensions. Of particular note, female engineers were much less likely to have a partner that did not work (9% v. 33%), much less likely to have a partner that took primary responsibility for household and family (4% v. 25%), and much more likely to play the primary household and family role for their families. (17% v. 10%) They were also much more likely to have a "fully remote" work environment. (28% v. 19%), which could allow

[6] A 2021 report found that 28% of engineering graduates are women (Bello et al., 2021), but women are even less represented in digital information technology, computing, and physics.

more flexibility in fulfilling home household and family responsibilities and lead to greater isolation.

4.2 Awareness of and Participation in the IP Process

Table 2 provides descriptive statistics for engineers' general awareness and participation in the IP process. Columns 1 to 2 present the number of observations and mean for the full sample of engineers. Columns 3 to 8 report the number of observations and means for those that self-identify gender and ethnicity broken into subgroups. First, we compare those that represent the majority demographic of engineers (Asian or White males), which we label the Representative Group ("RG") with URGs. Second, we compare those who self-report their gender as male and female. Finally, in the last column, we report on URMs. In columns (5), (7), and (8), the stars are used to denote the significance level from a t-test, indicating the likelihood that the observed differences in group means for URGs, females, and URMs are not due to chance.

Panel A shows that 40% of all respondents are "aware of the process and tools where you can submit an idea for patenting," with slightly more engineers at 45% indicating that they have attended IP training. These percentages are statistically indistinguishable across demographics. This suggests information alone is unlikely to encourage broader participation in the invention process.

Panel B summarizes engineers' perceptions of their participation in the early steps of the invention process, and Panel C summarizes participation in the later steps. Unsurprisingly, participation rates are highest early on: 55% of engineers believe they have had an idea that might be patentable, 65% are assigned tasks with IP work, 61% are interested in working more on tasks that would lead to being a named inventor, and 47% have sought help with navigating their Company's patent process. Examining the later steps, however, reveals that the average engineer has not submitted an invention disclosure. Only 32% of engineers report submitting an inventive idea, and only 15% indicate having one filed as a patent application, suggesting about a 50% internal rejection rate.

Figure 3 depicts this stark drop-off from having an idea that might be patentable to submitting a patent application. The figure shows six steps in the inventor's path from ideation to patent application: (1) having inventive ideas or interest in working on tasks that would lead to being a named inventor, (2) assigned early-stage IP work, (3) sought advice, (4) sought training, (5) submitted an idea, (6) patent application filed. Step 3 through 6 are all conditional on being part of one of the first two steps.[7] While the process

[7]Given differences in sample sizes across firms, we took the maximum of "Have you ever had an idea that you thought might be patentable?" with "Are you interested in working more on tasks that would lead to being a named inventor?" and labeled it Step 1 "Inventive ideas." This provides us with the largest possible baseline as subsequent steps in the process are conditional. As such, inventive idea rates are different than if you were to look at the individual questions reported in Table 2. For additional definitions and details, please see Appendix A.

starts with over three-fifths of engineers participating, by first submission, 45% of those with ideas have dropped out, and by the end, three-quarters are gone.

Next, we explore demographic differences given prior country-level data on a more pronounced innovator-inventor gap for women and URMs (Carpentier and Raffo, 2023). Notably, we observe statistically significant differences early on in the inventive process: 63% of RG engineers report participating in the early steps (e.g., being assigned IP work) while only 55% of women do. This 8-percentage point (p.p.) gap is potentially consistent with a managerial bias regarding the projects and tasks engineers are assigned to, something we explore later. This gap continues in later stages, with 33% of RG engineers submitting ideas and only 30% of females doing so. Similarly, 15% of male engineers have had an idea filed as a patent application, whereas only 11% of female engineers have.

Interestingly, the gap does not hold for URM engineers. In both the early and late stages of the invention process, URM engineers indicate greater levels of participation. This could indicate bias in the hiring process, such that URM engineers must be at a higher-performance level even to be considered for the job or other differences such as motivation. Finally, women are much more likely to submit through the anonymous inventor portal than through more social means, like with the help of a patent professional or at brainstorming sessions, suggesting a potential for social isolation or friction in the idea-collection process.

Figure 4 plots the relative differences in the innovator-inventor gap for females (magenta) and URMs (teal) by plotting the cumulative positioning across each of the six steps. The upper figure focuses on gender, and the lower figure on URM engineers. Each bar is relative to the path of RG engineers. Of note for females is that they are behind both in inventive ideas and are further behind in terms of being assigned IP work. They do make up for these disparities somewhat by seeking out advice and training. So much so that females close about half the gap to 3.3. p.p. difference by the time they submit ideas despite a 7.7 p.p. difference early on. In contrast, URM engineers are actually at an advantage because they appear to be more likely to be pulled into early-stage IP tasks such as brainstorming sessions or being assigned patent KPIs. This advantage persists in that they are also more likely to submit an idea and for that idea to be filed into a patent application. This again suggests that the path and lived experience of diverse engineers may not be the same for women and those from underrepresented ethnicities. In fact, in our sample of survey responses, those from URM engineers indicate that they are more likely to have their ideas filed as patent applications (22%) as opposed to Asian and white male engineers (15%). Alternatively, Appendix Figure B.1 repeats the illustration of the stark-drop off but plots lines for females, URMs, and Asian and white males separately.

4.3 Engineers' Self-identity, Confidence, and Aspirations

Next, we explore individual determinants of participation in the IP process such as behavioral tendencies. The survey data presented in Table 3 draws from three different panels: self-identity (Panel A), confidence in inventive ideas (Panel B), and time and aspirations for inventing (Panel C). While 96% of engineers identify as problem-solvers, only 46% see themselves as inventors, despite the similarities between these roles in identifying and solving issues innovatively. This discrepancy is even more pronounced for female engineers, highlighting that alternative framings may be a simple way to help STEM professionals transition further along the invention path. Despite these differences in identity, all engineers perceive that becoming a named inventor positively or significantly impacted their life and rate it similarly on a 3-point scale.

In Panel B, engineers report low confidence in deciding the worthiness of submitting their idea as an invention disclosure, with a mean score of just 0.10. However, RGs engineers are more confident (0.17) compared to URGs and females, who show negative confidence scores. Importantly, when uncertain, four-in-five engineers would seek advice, but URG engineers seek advice do not seek advice from patent professionals. One potential explanation is that there may be a perception among URG engineers that the cost of consulting with a patent professional is high due to systemic biases and stereotyping relative to less formal advice channels.

Finally, in Panel C, we can better understand time use and aspiration for invention. About half (48%) of engineers believe that engaging in the patent process is a "good use of time," and there are no demographic differences. Similarly, in terms of time allocation, engineers on average spend 15% of their workweek on tasks likely to lead to invention disclosures, and a striking 61% on tasks unlikely to do so. Interestingly, URMs spend a statistically significant lower amount of time (51%) on tasks unlikely to lead to inventions. One explanation for different time allocations across demographics could stem from the projects assigned (e.g., not being regularly assigned projects with patent KPIs). Therefore, we ask engineers their perception of the gender equality in projects assigned. Consistent with prior self-reported participation, there were significant variations by demographic groups. RG engineers perceive more equality (1.08) compared to URGs and females (0.86). These differences are significant at the 1% level. Overall, these statistics foreshadow how internal management practices may serve as a barrier to fostering a more inclusive invention process.

4.4 Perceptions of the Inventive Process

Table 4 describes the objectives engineers prioritize when working on inventions, as well as the feedback they receive and experiences they perceive others to have. The set of questions in Panel A elicit responses from engineers related to the self-reported amount of risk they take with their inventive tasks. It derives from work by Kerr et al. (2014); Chien (2014); Acemoglu et al. (2022); Abrams et al. (2023) recognizing the various types of patents inventors may pursue. If engineers from URGs take lower risks, overcoming the challenging, non-obviousness requirement for obtaining a patent may be harder to achieve. Here we observe that the majority of engineers (58%) report working on incremental changes as solutions to problems, 23% work on experimenting with risky changes, 12% work on defensive patents, and 6% focus on other activities such as translating academic research into a patent for commercialization. While the mix is slightly different from engineers from URGs, the results are not statistically distinguishable. Importantly, the self-reported risk-taking across demographic groups is indistinguishable. This suggests that the riskiness of the inventive idea is unlikely to differ by demographics.

One aspect of the inventive process beyond risk that my vary by demographics is the importance an inventor places on private versus social value. [8] From an economic perspective, striking the right balance between private economic gains from patenting activity and social welfare is vital. Interestingly, engineers from URGs are more likely to believe that inventions they work on should focus on social value (18% versus just 10% of RG engineers). This is consistent with prior research suggesting a lack of representativeness by inventors translates into a lack of breadth in the direction of inventive activities (Koning et al., 2021). It could also help explain why these same engineers do not report higher rates of "pro-social" motivation as most influential in encouraging actual idea submission (see Table 6, Panel A).

Panel B examines the nature and effectiveness of the feedback received during the invention process. One startling revelation is that 25% of engineers were unaware they could receive advice or feedback, a statistic that can be improved with more transparent review processes. Engineers in our survey indicate a preference for peer and mentor feedback (18%) over other forms, with females showing a significantly higher reliance (27%). This could be consistent with anecdotes suggesting that non-dominant demographics receive lower-quality feedback that is often unrelated to issues of substance. In fact, there is a statistically significant 12 p.p. lower level of satisfaction (44%) with feedback reported by engineers from URGs. In contrast, the majority (56%) of RG engineers were satisfied, and satisfaction even drops to 37% among underrepresented minorities (URM), potentially consistent with stereotype bias from patent professionals.

Panel C delves into perceptions related to gender equality and management support in the invention process. The data shows that the majority of the 3,115 engineers believe that men and women are equally likely to be named as inventors. This belief is significantly higher among RG engineers than among URG

[8]For instance, Bloom et al. (2013) and Lucking et al. (2020) find that the social returns to R&D are about three times higher than private returns in the United States from 1980 to 2015, but less is known about which inventors focus on which values.

engineers. When it comes to managerial encouragement and support for submissions, the mean score stands at 0.65 for all engineers, but it drops by half for URM engineers. This significant and considerable drop highlights the potential for a managerial gap in fostering a more inclusive innovation environment. Given that the overall perception of the equality and supportiveness of the workplace vary across demographics, this suggests leaders hoping to foster inclusive innovation may want to focus on improving corporate culture and management practices.

4.5 Additional Factors Influencing Invention

As our interviews exemplify, a broad range of factors influence who becomes an inventor. Additional questions offer insights into other individual and informal determinants of inventorship. Specifically, through a series of questions on mentoring, early life exposure to inventorship, professional networks, and prior STEM job experiences, we seek to understand the magnitude of the role these forces play. The results are included in Appendix B in Table B.1, Table B.2, and Table B.3.

Consistent with prior studies, we find that mentoring plays an important role in shaping the aspirations of STEM professionals. We find that 24% of engineers have participated in formal patent mentorship programs and 38% report receiving informal mentorship. Asian and white males report significantly higher rates of informal mentorship. Surprisingly, among those without a mentor, 79% indicate they simply had not thought about seeking mentorship. Common explanations for lack of mentorship, such as time constraints or avoidance due to a fear of exposing weaknesses, did not resonate with the engineers.

The table on mentoring underscores its value in an engineer's career attainment and satisfaction. When asked about the perceived benefits, mentored engineers reported benefits across the board. Mentees indicate a desire to work on more inventions, greater confidence in their ability to incorporate their mentor's tips into their work process, have the social connections necessary to get their invention ideas accepted by patent professionals and have more social connections from introductions to new inventors that they anticipate working with. Interestingly, females' perceptions of mentorship are significantly more positive than their male counterparts.

Next, we examine early life exposure, such as through family connections, education, and community initiatives. The significance of this exposure is grounded in the theory of social learning, where individuals are influenced by the observations of role models within their social circles. While these social learning aspects play a role in an individual's propensity to pursue a technical career, they rank lower than other factors. The most important social learning factor was role models, yet respondents say financial considerations are 2x more important than role models and a "desire to solve problems for people in my community" is 1.5x more important. These findings suggest additional research into the optimal balance between pecuniary and non-pecuniary incentives to innovate is merited. Another intriguing finding is that exposure to engineers and scientists from books ranked as more influential than through social learning, suggesting potential outsized benefits of the public library system and diverse representation in books.

Finally, when asked about professional networks and prior STEM job experiences, we learn about the social dynamics that influence career trajectories in the STEM fields. Factors such as feeling excluded or being bullied can deter talented individuals from pursuing or continuing careers in invention. We learn that 22% of females report being bullied while only 4% of males do, and this difference is statistically significant. Similarly, 7% of females report experiencing sexual harassment while only 1% of males do. The table not only highlights the prevalence of such negative experiences but also points to the need for creating more inclusive and supportive environments, as the top reason for leaving a prior STEM job was the work environment rather than the job duties. In conclusion, while this subsection provides an overview of additional factors, it invites a deeper exploration of the nuanced ways in which mentoring, early life exposure, and professional networks contribute to shaping the next generation of inventors.

5 A Pecking Order of Factors Influencing Invention

5.1 Methodology

To derive a "pecking order" among various factors influencing idea submission and greater participation in the invention process, we rely on our survey of high-tech engineers. Central to our approach is to incorporate question multiplicity – asking the same question in multiple ways (Fowler, 2014) – which is a common solution for reducing bias and capturing relative nuance in a respondent's perspective. We frame the same underlying question regarding determinants of participation in the invention process in positive, negative, hypothetical, and open-ended formats. For instance, we asked, "What prevents invention submission?" "What would facilitate greater involvement in invention?" "What has been most influential in encouraging idea submission?" and used open-ended text questions to ask, "How can participation in invention submission be increased?" This repetitive question structure is instrumental in capturing a full range of perspectives.

The rationale behind this approach draws from behavioral economics and survey methodology literature, suggesting that individuals' responses can vary significantly based on the context and framing (Kahneman and Tversky, 1981; Stantcheva, 2023). Positive framings tend to elicit responses that reflect respondents' aspirations and affirmative experiences, while negative framings can reveal underlying concerns and challenges that might not be apparent through positive questions alone. The inclusion of a hypothetical question allows respondents to consider potential actions, thus uncovering latent factors that direct questioning might not surface, especially if the engineer is prone to engaging in "cheap talk." Importantly, neuroscience research indicates these different types of questions activate different parts of the brain, serving to mitigate bias (Kang et al., 2011). Thus, our approach of question multiplicity allows us to examine the relative ranking of determinants with minimal bias.

5.2 Results

We present the survey responses to each of the four different question framings in Table 5 and Table 6. Table 5 focuses on the factors working for and against participation in the submission of invention disclosures. While we randomized the order of answers for respondents, we present the answers grouped into three broad categories: (i) individual inventor characteristics, (ii) formal characteristics such as management practices and the invention process, and (iii) informal characteristics such as corporate culture. We relied on the interviews and literature review to develop the list of factors, and we relied on precedents from earlier studies to generate the wording of potentially influential formal, informal, and personal factors to avoid ambiguity. Table 6 summarizes engineers' perceptions of the most influential factors in encouraging idea submission and elicits hypothetical advice for increasing participation in an open-ended format.

It is evident from Table 5 and Table 6 that management practices and culture are among the most important factors. As such, Table 7 provides additional details about day-to-day practices at the firms, including cultural norms, what engineers experience leadership to do, and overall trust levels. Importantly, we replicate exact wording from prior studies for topics like culture, leadership, and trust. For instance, we draw from Graham et al. (2022) for questions on effective culture and cultural norms. We replicate generalized trust question on the World Values Survey and used in academic research by Guiso et al. (2006), and we utilize the framework for high-performance leadership competencies developed by Schroder (1989).

Broadly speaking, when framed in a positive context, we see that individual determinants are the most commonly cited, such as too little time. However, triangulating across questions allows us to observe that too little time is significantly linked to managers not assigning engineers to tasks likely to yield patentable inventions rather than being too busy with work at home. Thus, triangulating across questions allows us to determine which factors contribute the most to the innovator-inventor gap. As revealed by engineers, the hierarchy of factors contributing to the innovator-inventor gap is management, motivation, culture, the invention review process, and lastly, individual determinants. Even within this revealed pecking order, though, we observe that females and URMs' perceptions are distinctive.

Leadership and management practices influence the innovation-invention gap. Better management is the top factor that would increase idea submission. The manager's contribution to the innovator-inventor gap is readily apparent across various questions and framing techniques. Women are significantly less likely to perceive managers as "supportive of women's representation in the inventing process" and less likely to perceive that "men and women are equally assigned to projects that lead to inventive disclosures." The finding that project assignment is where the disparity starts is critical because a notable survey finding is that once assigned to projects, engineers' allocation of time toward tasks likely to lead to inventions is consistent across all demographics, as is the riskiness of the inventive ideas. Project mismanagement also serves as a unifying explanation for the factors engineers cited as preventing them from submitting more inventive ideas: 45% indicate "I don't feel the work I do is likely to yield patentable inventions," and 31% indicate "I'm too busy with other work." Finally, when asked how participation in idea submission could be increased, especially for engineers from URGs, "better management" was the most common answer.

Second, we find the origin of the engineers' motivations contribute to the innovation-invention gap. Extrinsic motivation (i.e., motivation that is driven by external rewards like prize money for receiving a patent) is the top factor influencing idea submission out of 12 potential factors. Specifically, 41% of engineers perceive pecuniary awards as influential, and significantly more URMs do (54%). But the second most common factor influencing idea submission is linked to intrinsic or pro-social motivation; specifically, 38% of engineers indicate that "knowing that I'm solving a problem for the greater good" influences them. Interestingly, though, only 23% of URMs cite intrinsic motivation, suggesting a motivation gap, which is consistent with a model by Bénabou and Tirole (2003) that predicts that motivation increases when employees feel empowered, especially for complex tasks (e.g., new idea generation), but battles for dominance can foster negative feelings and detract from empowerment (e.g., no collaboration). Thus, gaps in motivation by gender and ethnicity and the type of inventions that engineers are likely to pursue as a result of such motivations appear to be an important part of the more pronounced innovator-invention gap for these groups.

Rounding out the top three factors influencing idea submission is corporate culture. Isolating the specific elements of culture (Gorton et al., 2022), collaboration and integrity are two cultural values that come to the forefront that leaders could invest time and resources to make more effective. Specifically, we see that URMs indicate that information sharing is the top cultural norm helping innovators to invent, and it is statistically significantly higher based on relative ranking. Yet females are considerably less likely to experience managers explaining important details (76% male, 63% female). Without information sharing as a norm, this suggests women are left out of the loop when it comes to going from innovative ideas to inventions. Supporting this argument, women are significantly more likely to indicate that they do not have people with whom to collaborate (11% male, 22% female) and who could help them determine the patent-worthiness of their ideas. This suggests that female engineers perceive a lack of team mentality as a significant barrier in transitioning from an innovator to a named inventor.

Second, we find that the cultural value of integrity helps explain the innovator-inventor gap. All URGs say holding employees accountable for unjust actions is a cultural weakness working against invention. Notably, females report significantly lower levels of trust (i.e., women think that most of the time, people at [Company] are just looking out for themselves rather than trying to be helpful). Yet females also rank trust as the second most important day-to-day interaction helping the firm achieve its inventive goals, whereas males rank trust in the middle. One potential reason is that females are significantly less likely to experience leadership in making ethical, fair decisions (82% male, 64% female). In contrast, males rank day-to-day activities like information sharing and comfort in suggesting ideas, concerns, and critiques as more important for achieving inventive goals.

More broadly, drawing upon insights about how culture works, it is evident that recognition, a tool leaders can use to help their employees learn the culture, seems to be relatively influential in encouraging participation in the invention process. Specifically, corporate culture is an informal institution typified by patterns of behavior and reinforced by people, systems, and events. Culture is manifest in many elements, but it brings unity to employees' perspectives through their expectations for how they need to behave to fit in and succeed in their firm (Grennan and Li, 2023). Recognition is a tool leaders can use to bring unity to employees' perspectives, serving as both a reflection and a driver of the firm's cultural values. When employees feel recognized, they are more likely to exert motivated effort as recognition fulfills a fundamental human need for appreciation and validation, boosting self-esteem and promoting a positive work identity (Akerlof and Kranton, 2005). Importantly, URM engineers indicate that lack of recognition works against invention and rank recognition as less influential in encouraging idea submission than RG engineers. Consistently across two different framings, we find that recognition inside the company is more important than external recognition and that internal recognition is linked to the innovator-inventor gap.

Ranking fourth in the relative pecking order is the patent submission process itself. Two of the top five suggestions from the open-ended question for improving participation in the invention process involved the submission process. Engineers from all demographics uniformly recommend including more brainstorming and collaborative invention sessions. This is consistent with recent anecdotes from Meta, highlighting the success of their guided invention sessions with female engineers (Ahlstrom, 2023). Another common recommendation was simplifying and anonymizing the patent submission and review process. However, triangulating between questions again shows nuance in this recommendation. One-on-one meetings with patent professionals, which could be an easy way to simplify the submission process, were perceived to be significantly better by RG engineers than URM engineers (29% vs. 18%). The same holds true for additional training sessions (62% of RG favor them whereas only 54% of URM do). Instead, what stands out among URG engineers is a strong desire for mentorship, with 59% saying it would facilitate greater involvement in the IP process and it being the fourth most influential in encouraging idea submission.

Other less prominent factors in the relative pecking order that we observe include social or contextual determinants such as peers, the need to link invention more explicitly to incentive compensation and promotion requirements, and individual determinants such as overcoming the discomfort of rejection. An important implication of our relative pecking order is that the gap from innovator to inventor is linked to changeable aspects of companies, like management practices and corporate culture, rather than unique individual determinants. Another implication is that what may help females differs from what may help URMs. For instance, these demographics indicate different desires: females want more encouragement from management and collaborators, and URMs want brainstorming sessions and a culture more supportive of innovation.

6 Economic Implications

So far, our study underscores the complexity of the path from idea generation to patent application filing for engineers in high-tech firms. Detailing this process and deriving a hierarchy of factors influencing idea submission helps establish why failures can occur throughout the process. Notably, engineers perceive management practices and corporate culture to have a prominent position in the hierarchy of factors influencing idea submission and these factors meaningfully increase the costs of refining the signal of the quality of one's inventive idea. Specifically, management behaviors such as uneven information sharing or biased project assignments make it much more costly for certain engineers to reduce the uncertainty surrounding the patent-worthiness of their innovative idea. These insights are important as they reveal weaknesses in the invention process that offer opportunities for improvement. To better understand the potential efficiency gains from reducing frictions inherent in the invention process, we test the predictions from our model about engineers' participation in the invention process and its relation to the quality of the ideas they submit.

Our empirical tests leverage the data from our collaborating firms on ideas submitted for internal patent review before patent applications are officially filed. Table 8 summarizes the patterns in idea generation across 31,585 engineers at four high-tech firms, showing variations in the progression of ideas to patent applications. The average idea submission involves 2.3 inventors but varies across firms from 1.8 to 2.8. Around one-third of ideas include a first-time inventor, 16% a female inventor, and 9% a URM inventor.

However, submission rates for patent applications vary tremendously from a high of 96% to a low of 31%. On average, only 59% of these ideas are submitted as patent applications, and just 41% are granted patents conditional on being submitted. The success rates vary across firms, with some submitting many more ideas for patenting and being granted more patents, suggesting potential culling even before submission. These firm-specific differences underscore the heterogeneity in the invention process. Using this data, we test whether an innovator-inventor gap is more pronounced for women and URMs. Our primary regression specification is:

$$Step_{ift} = \alpha + \beta Fem_{ift} + \mu X_{ift} + \gamma_f + \rho_t + \varepsilon_{ift} \tag{1}$$

where $Step_{ift}$ is an ordinal variable representing the maximum step in the IP process achieved (i.e., 1 = idea submission, 2 = patent application, and 3 = patent granted). The observation unit is idea i submitted to firm f in year t. Fem_{ift} is an indicator variable for having a female be named on the idea submitted. This is one example of a measure of submitter characteristics; other characteristics we explore are first-time inventors and URM inventors. X_{ift} is a vector of idea controls, such as the total number of inventors. γ_f represents a firm fixed effect and ρ_t is a year fixed effect.

Table 9 summarizes our estimates for the progress of female inventors along the inventive path. Across each firm individually, and in consolidated examinations of all three firms, ideas with a female inventor move forward less frequently than other submitted ideas. This holds regardless of whether we consider the presence of a female inventor (Panel A) or the percentage of female inventors (Panel B). Columns (5) and (6) present the results from when we combine the data across firms, with column (6) including firm fixed effects. In each case, the gap for women is more pronounced, and these results are significant at the 99th percentile. The economic magnitude of the estimates suggests, on average, holding all else constant, that submitting an idea with a female inventor reduces the probability of advancing to the next step by 5.1 percentage points.

In Appendix Table B.4, we repeat this exercise for URM engineers. In two of the three firms that provided ethnicity data, we fail to reject the hypothesis that ideas submitted with a URM inventor progress at the same rate as representative inventors. For one firm, we see a slight URM advantage. Across all three firms, the point estimate suggests that ideas with a URM inventor are 2.6 percent more likely to advance to the next stage. While the evidence for the URM advantage is consistent with our survey findings, evidence from more firms is needed.

Our examination of the administrative idea-level datasets corroborates the survey findings. While the inherent limitations of survey-based regression analysis preclude definitive causal inferences, we have also thoroughly assessed our survey data. The survey data has self-reported progress on the invention path, but it also has an extensive array of interesting self-reported covariates on factors like self-identity, risk-taking in the inventive process, culture, and management. We report these results in Appendix Table B.5 for gender and Appendix Table B.6 for ethnicity. The supplementary analyses underscore the potential robustness of our initial conclusions, notably, the inclusion of controls does not change the fact that females appear to be significantly disadvantaged at every stage in the inventive process. Interestingly, again, we find that the results for URMs are more mixed and inconclusive.

Next, we test whether patents produced by women at firms that are more costly for them to refine the signal on the patent-worthiness of their idea are of higher quality. To test this prediction, we turn to the gendered data from the U.S. PTO and analyze subsamples of data based on firm characteristics. Our primary specification is:

$$Quality_{pfsct} = \alpha + \beta Fem_{pfsct} + \mu X_{pfsct} + \gamma_f + \rho_s + \lambda_c + \theta_t + \varepsilon_{pfsct} \tag{2}$$

where $Quality_{pfsct}$ is the number of forward citations (Trajtenberg, 1990). The observation unit is granted patent p submitted by firm f headquartered in state s in technology class c in application year t. Fem_{pfsct} is an indicator variable for having a female as a named inventor on the patent. We also consider the percentage of female inventors and an indicator for having a female inventor as the lead inventor. X_{pfsct} is a vector of patent controls including backward citations (Hall et al., 2005; Moser et al., 2018), examiner citations (Alcácer and Gittelman, 2006; Alcácer et al., 2009), and claims (Lanjouw and Schankerman, 2004). The firm-specific controls in the vector include firm size, the market-to-book ratio, the R&D-to-sales ratio, the ratio of cash to capital, leverage, and return on assets in the year of application as recommended by Lerner and Seru (2022). γ_f represents a firm fixed effect, ρ_s is a headquarter state fixed effect that accounts for the concentration of businesses and research institutions in states like California and Massachusetts have on the number of citations received, λ_c is a technology class fixed effect, and θ_t is a year fixed effect.

Table 10 reveals the patents by females at our firms are of higher quality, on average. In Panel A, we focus on the sample of firms we interviewed and surveyed. Given that the culture may be changing at these high-tech firms, we focus our analysis on the most recent 10-year period. Column (1) presents the result without controls, and Column (2) presents the result with controls for having a female indicator. The point estimates of 0.15 and 0.13 are statistically significant and suggest that patents with a female inventor at these firms with meaningful frictions in the IP process receive more citations, all else equal.

Patent forward citations are highly skewed in their distribution, with only a few patents receiving a disproportionately high number of citations. As an alternative to simple counts of forward citations, we also consider whether a patent receives citations in the top decile of all patents in Table 10 Panel B. Again, consistent with a model in which women only submit when they have a very strong signal of the patent-worthiness of their idea, we see that patents with a higher percent of female inventors at our firms with meaningful frictions in the IP process are more likely to be in the upper decile of forward patent citations, all else equal. In the last panel of Table 10, we replicate the same analysis but for the full sample of public firms over the same period. Here, we find evidence consistent with the prior literature that patents with female inventors receive fewer citations (Jensen et al., 2018; Hochberg et al., 2023; Subramani and Saksena, 2023).

One potential limitation of the analysis we conducted is that our sample is only based on a few high-tech firms and there may be some unobservable confounded. To help mitigate this concern, we return to our pecking order of factors influencing invention, which revealed that poor management and an ineffective culture are among the top three most important factors. To generalize our test of whether the marginal patent produced by women at firms where it is more costly for them to refine the signal on the patent-worthiness of their idea is of higher quality, we incorporate external data on culture and management practices into our test. Specifically, we expanded our analysis to include all public patenting firms that matched Glassdoor's culture and management ratings. We then condition on being in a firm with an ineffective culture, defined as having a below-median rating.[9] Our exact specification is:

$$Quality_{pfsct} = \alpha + \beta_1 Fem_{pfsct} + \beta_2 Fem \times Culture_{pfsct} + \beta_3 Culture + \mu X_{pfsct} + \gamma_f + \rho_s + \lambda_c + \theta_t + \varepsilon_{pfsct} \quad (3)$$

where $Quality_{pfsct}$ is the number of forward citations. The observation unit is granted patent p submitted by firm f headquartered in state s in technology class c in application year t. Fem_{pfsct} is an indicator variable for having a female as a named inventor on the patent. $Culture_{pfsct}$ is an indicator variable for a firm having a below-median culture rating on Glassdoor. We also examine $Mgmt_{pfsct}$, which is an indicator variable for a firm having a below-median leadership rating on Glassdoor. X_{pfsct} is the same vector of patent, examiner, and firm controls from the prior specification. γ_f represents a firm fixed effect, ρ_s is a headquarter state fixed effect, λ_c is a technology class fixed effect, and θ_t is a year fixed effect.

In Table 11, we present the estimates from these regressions for a large sample of U.S. patenting firms

[9]The engineer survey had a question about culture that exactly matched a question about effective culture on a survey of 1348 North American executives. In that study, Graham et al. (2022) show that executives' perceptions of the effectiveness of their culture are closely linked to Glassdoor ratings, which justifies our assumption that Glassdoor can reasonably measure culture. Other recent studies using Glassdoor data include Liu et al. (2022), Sockin and Sojourner (2023), and Cai et al. (2023).

matched to culture and management data. The estimate of 0.132 (std. err. = 0.065) on the interaction term implies that being a female inventor in a firm with meaningful frictions in the inventive process as proxied by an ineffective culture is associated with 0.132 more citations. As Panel B documents, a similar pattern holds when we look at bad management. The point estimate of 0.162 on the interaction term is again significant at the 95th percentile and again suggests being a female inventor in a firm with meaningful frictions is associated with more citations.

As a robustness check, we repeat this exercise in Appendix Table B.7 using the percent of female inventors and an indicator for a female lead inventor. In each case, the interaction term is significant and positive. These associations could reflect either the causal effect of friction in the invention process brought about by an ineffective culture and poor management or a correlation with unobservables. While we do not have an identification strategy to isolate quasi-experimental variation in culture or management practices, our results include a rich set of control variables and do not meaningfully change as various control variables are included or as we move across data sets and proxies. Moreover, these results are consistent with the predictions of our model of how innovators allocate time and effort toward inventive tasks.

Lastly, we quantify the number of patents with female investors potentially lost to bad culture or weak management per year. To generate this estimate, we aggregate the number of patents issued with a female inventor in a given firm-year and run both within-firm and cross-sectional tests. As reported in Appendix Table B.8, our estimates suggest that a U.S. public patenting firm with a below-median culture rating on Glassdoor is granted 12.4 fewer patents per year, all else equal, than a firm with an above-median culture.

Finally, we explore the last prediction from our model, that the variance in citations to female patents will be shifted and compressed. If it is more costly for women to refine their signal on the patent worthiness of their idea such that they only pursue very high-quality patents, we would expect to see both higher citations and a smaller variance in the distribution of citations. We analyze the variance of the forward citations by creating the simple difference-in-differences analysis (i.e., 2 x 2 box) where one dimension is male vs. female and the other dimension is effective vs. ineffective culture. Instead of calculating the mean, we calculate the standard deviation of citations. Appendix Table B.8 presents the simple difference-in-differences estimate for the standard deviations, which suggests the female distribution in the bad culture firm is more compressed. We test the null hypothesis of equivalence of the standard deviations using bootstrapped standard errors with 1000 repetitions and reject it. In the row below the simple difference-in-differences estimate for the standard deviations, we report the 95% confidence interval from the bootstrapped repetitions of the standard error and observe that it is less than 0. This analysis suggests that being female in a firm with an ineffective culture is associated with an alternate distribution of citations.

In conclusion, these analyses suggest meaningful gains in terms of high-quality inventions becoming public knowledge could be achieved by reducing friction in the invention process. Importantly, the friction brought about by an ineffective culture and poor leadership can be changed and improved over time. Finally, while our results suggest that diverse inventors submit higher-quality ideas, it is possible, as Hong and Page (2004) predict, that even if diverse inventors do not contribute higher-quality ideas, the diversity of their ideas relative to the "groupthink" norm, could produce higher-quality inventions. Thus, our evidence that meaningful frictions in the invention process exist and are associated with inventive outcomes provides an important insight. They help us determine the extent to which established inventors are or are not representative of potential innovators—given that we find that potential inventors appear to be meaningfully different and more diverse than actual inventors, this has important policy implications. For example, to support inclusive innovation, firms, and policymakers must look beyond the existing population of inventors and their traits and instead focus on making the culture and processes more inclusive.

7 Robustness

Using a survey to quantify early steps in the invention process, we gain direct insights from the engineers creating new technologies about their perceptions of the patenting process. Yet this unique benefit of surveys could be offset by three primary concerns: (i) that the respondents may be a selected sample of engineers very interested in patents or inclusive innovation, (ii) that survey answers could be self-serving, and (iii) that observed correlations may be driven by some unobserved common characteristic (e.g., the success or lack thereof at the firm). We consider each of these concerns below.

To help rule out a selected sample and self-serving answers, we asked one firm that regularly surveys its employees to include an invention question in its routine workforce feedback survey. The results from this separate engagement survey are consistent with the findings from the invention survey. In Appendix Table A.2, we present the responses to the one-off innovation questions in the routine survey regularly sent to a sample of employees. Specifically, we asked on the routine workforce survey, "Have you ever had an idea that you thought might be patentable?" The workforce innovation survey and the innovation survey responses are statistically indistinguishable. To further validate the drop-off we observed along the inventive path, we also asked "Have you ever submitted an innovative idea as an invention disclosure?" Again, the results are statistically indistinguishable.

Furthermore, the differences across the stages are nearly identical, with a decline of 27.5 p.p. and 29.8 p.p., respectively, across questions. Lastly, we compared the one-off question and survey responses for just females and found similar responses. To ascertain the internal reliability of the survey data, we divided the survey responses into quartiles based on the duration to completion. In Appendix Figure A.4, we plot the responses across the quartile. We find no difference in responses, suggesting that the respondent's answers are reliable.

In Appendix C, we analyze the results for U.S.-based engineers only. Given the U.S.'s history with respect to gender and race may differ from global trends, it's important to understand the extent to which this perspective may be confounding our results. Moreover, as a global innovation leader, the U.S. influences engineering cultures worldwide. Surprisingly, we find relatively few differences across locations, suggesting that these multinational high-tech firms cultivate a uniform corporate culture to streamline operations, ensure consistency in brand and service standards across various geographical locations, and facilitate smoother communication and collaboration among a globally dispersed workforce.

In Appendix D, we use a student survey to distinguish the influence of workplace environments from broader societal factors on engineers' patenting activities. The student responses, especially from URGs, are consistent with the findings from the main survey that there needs to be internal changes within firms to boost engineers' patenting engagement. Our analysis compares student expectations with professional engineers' experiences, highlighting disparities in anticipated versus actual time spent on inventive tasks. Notably, students, particularly URGs, show a shift towards valuing the social impact of patents, suggesting evolving priorities in the upcoming workforce.

8 Conclusion

This study presents new evidence on the competitive, opt-in nature of the invention process inside high-tech firms and determinants of the innovator-inventor gap, where few STEM professionals transition to being named inventors. Most previous work on inventors focuses on factors influencing the extensive margin, like access to STEM education, or factors influencing the intensive margin, like financial incentives. Our results point to a new channel – friction in the invention process within firms – as a critical factor in determining who becomes an inventor and the quantity and quality of inventions they pursue. These frictions in the invention process help explain why there is a more pronounced innovator-inventor gap for females. Importantly, we provide evidence that these frictions are so costly to females that they prevent high-quality and potentially impactful ideas from being disclosed to society.

By analyzing new idea-level data and surveying engineers, we unpack the many forces underlying the innovator-inventor gap. Our analysis guides the magnitude of the challenge and a relative pecking order of factors that could be targeted to make innovation more inclusive. Consistent with prior research in the public sector, we find that the innovator-inventor gap is more pronounced for females (Ding et al., 2006; Martinez et al., 2016). But our detailed data allows us to break down the steps from the early stage (i.e., being assigned to tasks with IP work) to the later stage (i.e., moving from idea submission to patent application). Despite no difference in the propensity to have a patentable idea, females are disadvantaged by a meaningful economic magnitude across every subsequent stage. For instance, our estimates suggest being female correlates with a 10 percentage point lower chance of having an inventive idea submitted internally to a patent professional and advancing to the patent application phase.

Furthermore, the pecking order of factors contributing to the innovator-inventor gap indicates that changeable aspects of companies, like management practices and corporate culture, are more important than unique individual determinants. For instance, females are 13 p.p. less likely to experience managers explaining important details, but all engineers view information sharing as a top 3 factor in achieving innovative goals. Adding to the informational challenges women face in the journey from having an innovative idea to being a named inventor is a lack of collaborators and advisors to assess the patent-worthiness of their ideas, with 22% of females, compared to 11% of males, indicating such troubles. Finally, another implication of our study is that what may help females is distinct from what may help URMs. For instance, these demographics indicate different desires: females want more encouragement from management and collaborators, and URMs want brainstorming sessions and a culture more supportive of innovation.

Our results suggest that policies designed to increase inclusive innovation may also be beneficial for increasing economic growth. Examining the patents granted to U.S. public firms, we find that patents with female inventors working at firms with meaningful frictions in the innovation process, as proxied by ineffective culture and poor management, are of higher quality and more likely to be in the top 10 percent of citations. This outcome is consistent with our model, which predicts that the costs females face in refining the signal of the patent-worthiness of their inventive idea are higher because of the disproportionate frictions they face. Therefore, developing and testing pilots to increase inclusive innovation is a particularly promising direction for research and policy.

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Figure 1.
Variations in invention submission process across firms
This figure illustrates the diverse approaches and methodologies employed by firms in the invention submission process, showcasing the differences in idea collecting methods, phases of review, and chances to iterate on an invention disclosure filings (IDF) based on feedback. The figure encapsulates the heterogeneous practices across firms shedding light on the varying interactive dynamics between engineers, patent professionals, and patent review boards. Comparing these varied approaches underscores the importance of understanding intra-firm dynamics in analyzing innovation outputs and the inclusiveness of methods used to collect new ideas and transform those inventive ideas into patented technologies.

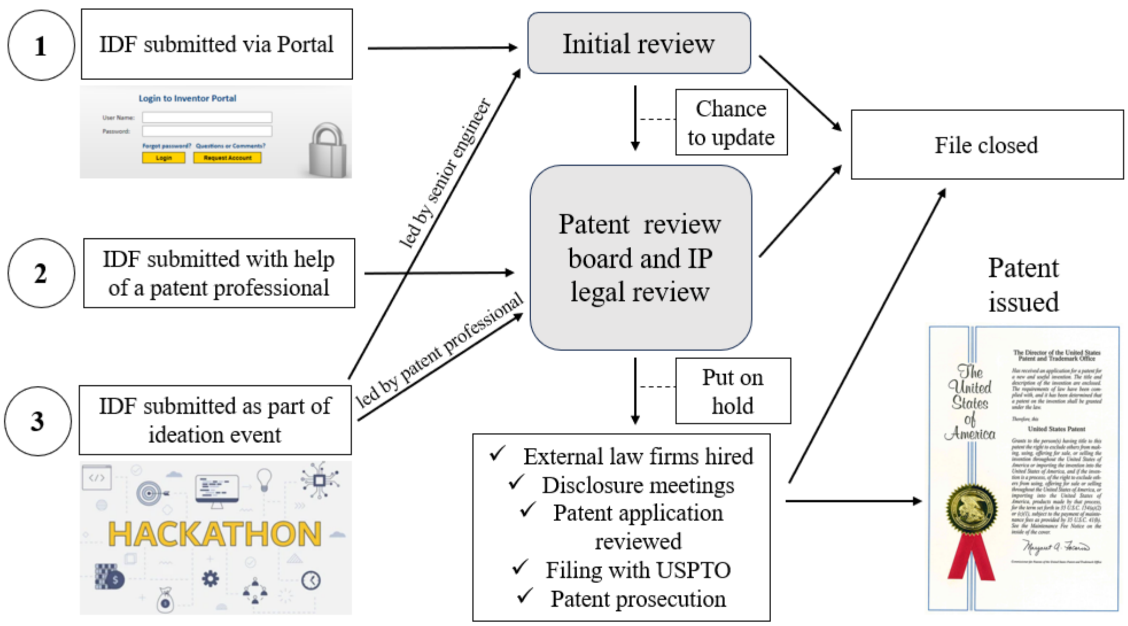


Figure 2.

Factors influencing the invention submission process

This figure illustrates the distinct factors at the firm (external) and innovator (internal) levels that shape the decision to submit invention ideas. The boxes along the top of the figure show that firm-level factors are grouped into informal and formal institutions such as culture and management practices. Individual-level traits are grouped into individual traits, early-life experiences, and career-life balance. The blue, yellow, and red dot indicate which facts are likely to influence individual ideas (blue), group ideas (red), and idea submission (yellow).

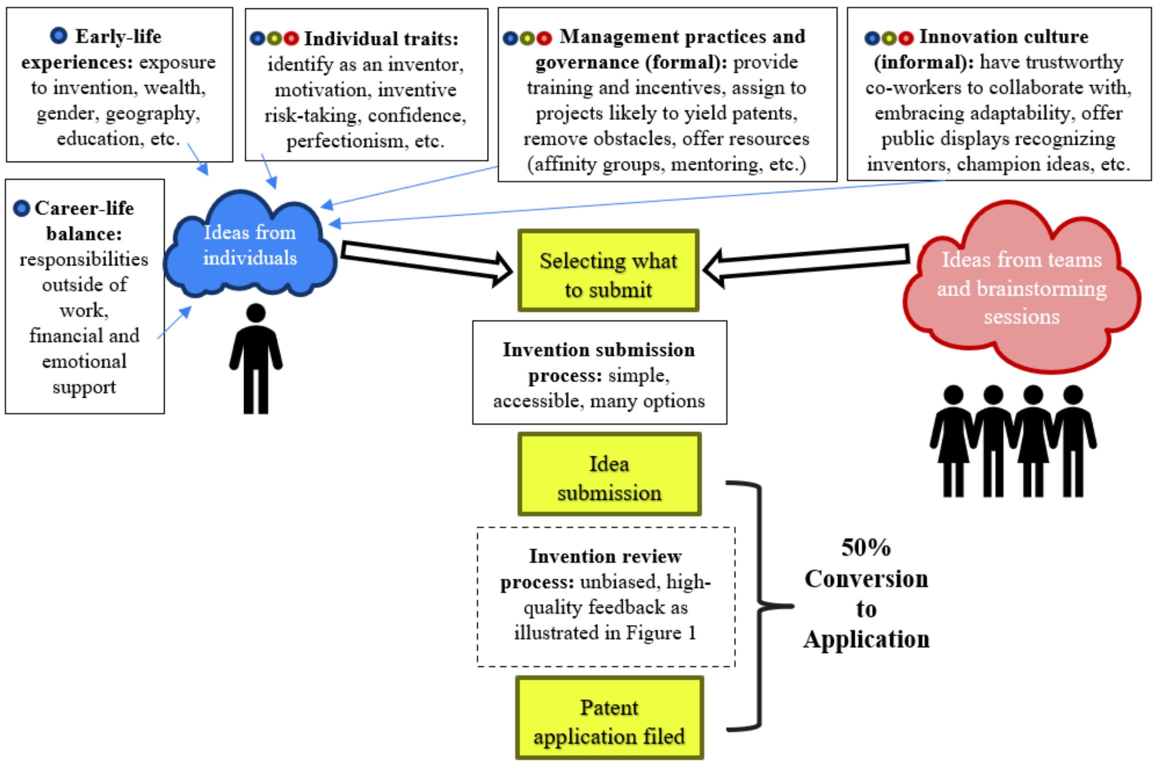


Figure 3.

Steps in the inventor's path from ideation to patent

This figure illustrates the attrition of engineers through various stages of the invention process, from ideation to patent application filing. The numbers mark the percent of engineers partaking in a specific step. It offers a detailed view into the journey from inventive idea to granted patent, pinpointing where engineers with potentially worthy ideas may fall off track.

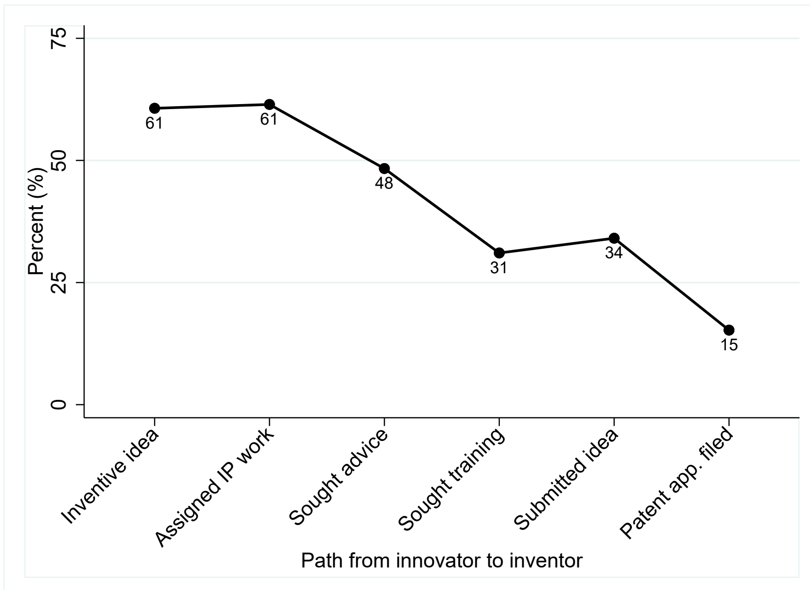


Figure 4.

Relative progress in the inventor's path by gender and ethnicity

This figure illustrates the cumulative positioning of underrepresented engineers through various stages of the invention process relative to well-represented engineers (i.e., Asian and white males). The figure on top focuses on gender. The magenta bars represent the cumulative position of female engineers and the numbers represent the percentage point difference relative to Asian or white males. The figure on the bottom focuses on ethnicity. The cyan bars represent the cumulative position of engineers from under-represented ethnicities and the numbers represent the percentage point difference relative to Asian or white males.

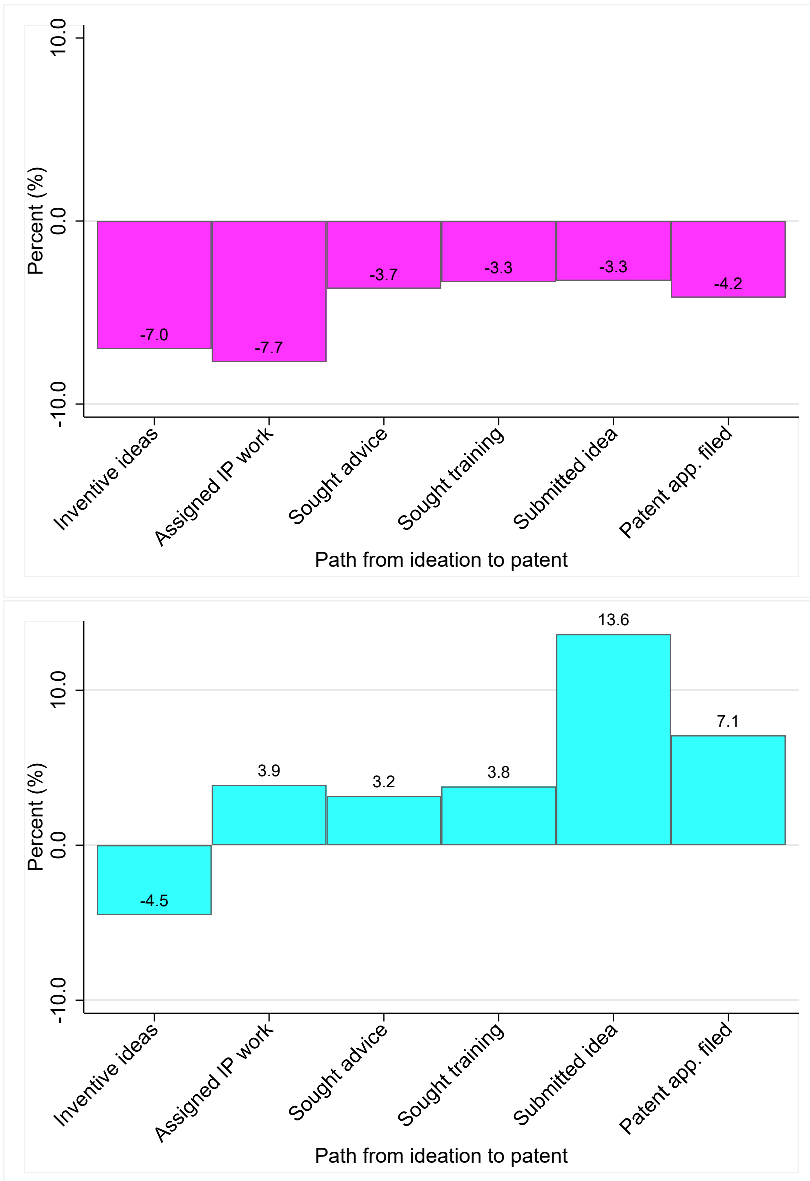


Table 1.

Demographic summary statistics from survey of engineers

This table provides descriptive statistics from the survey demographic variables questions for all survey respondents from engineers and technical staff. For a detailed description of each variable, see Appendix B. The survey questions are presented in Appendix A.

Panel A. Demographic characteristics	Obs. (1)	Mean (2)	USA Mean (3)	Male Mean (4)	Female Mean (5)
Gender					
Female	3758	22%	20%	0%	100%***
Male	3758	77%	80%	100%	0%***
Other (e.g., non-binary, transgender)	3758	0.5%	0.8%	0%	0%**
Ethnicity					
American Indian, Alaska Native, or Native Hawaiian	3714	0.2%	0.4%	0.2%	0.0%
Asian	3714	77%	45%	75%	83%***
Black	3714	0.5%	1%	0%	1%
Latinx	3714	2%	5%	2%	3%
Multi-racial	3714	1%	3%	1%	1%
White	3714	20%	45%	22%	14%***
Geographic Location					
East Asia	3989	28%	0%	31%	21%***
Europe	3989	1%	0%	1%	1%
Middle East	3989	3%	0%	3%	2%**
North America	3989	38%	100%	35%	35%
United States of America	3989	33%	100%	33%	28%**
South Asia	3989	7%	0%	7%	7%
Southeast Asia	3989	23%	0%	21%	33%***
Other (e.g., Australia, Africa)	3989	1%	0%	1%	0%
Business unit					
Business (e.g., sales, strategy, leadership)	3746	5%	7%	4%	6%**
Data science	3746	24%	31%	25%	18%***
Engineering	3746	49%	37%	47%	58%***
Manufacturing	3746	13%	8%	14%	10%***
Products	3746	10%	18%	10%	8%
Work environment					
In office	596	10%	9%	11%	7%
Hybrid	596	70%	72%	70%	66%
Fully remote	596	20%	18%	19%	28%**
Experience					
Time at [Company] (years)	3742	7.1	7.0	7.4	6.3***
Age (years)	3532	41.0	44.0	42.2	36.8***
Education [highest level completed]					
High school degree	3549	7%	7%	7%	9%*
College degree	3549	47%	35%	47%	46%
Graduate degree	3549	36%	39%	36%	38%
Doctorate degree	3549	9%	19%	10%	7%***
Non-work life					
I am single	309	20%	17%	18%	23%
I am partnered	309	80%	83%	82%	77%
My partner does not work	247	27%	25%	38%	9%***
My partner works	247	73%	75%	62%	91%***
My partner and I share equally in household and family duties	245	71%	75%	66%	79%**
My partner takes primary responsibility for household and family	245	17%	12%	25%	4%***
I take primary responsibility for household and family duties	245	12%	13%	10%	17%*

Table 2.

Engineers' awareness and participation in the IP process

This table provides descriptive statistics of the engineers' awareness and participation in the invention process segregated by demographic groups. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
			RG	RG	URG	Male	Female	URM
	Obs.	Mean	Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Awareness of invention process	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I am aware of the process and tools where you can submit an idea for patenting. (1 = Yes, 0 = No)	3912	40%	2724	40%	39%	40%	39%	45%
Have you ever attended an IP training? (1 = Yes, 0 = No)	559	45%	259	46%	45%	45%	47%	40%
Yes, within the last 12 months	559	16%	259	21%	12%***	20%	12%**	19%
Yes, through an affinity group	339	21%	150	13%	28%***	12%	31%***	23%
Panel B. Participation in early steps of the invention process								
Have you ever had an idea that you thought might be patentable? (1 = Yes, 0 = No)	556	55%	259	58%	50%*	59%	47%**	62%
Are you regularly tasked with IP work? (e.g., participating in invention-creation meetings, authoring engineering documents, working on projects with patent KPIs) (1 = Yes, 0 = No)	747	65%	346	66%	62%	68%	55%***	73%*
Are you interested in working more on tasks that would lead to being a named inventor? (1 = Yes, 0 = No)	3128	61%	2345	62%	55%***	62%	55%***	58%
Have you ever sought help with navigating [Company's] patent process (e.g., by attending a training, talking to a patent professional, or patent mentor)? (1 = Yes, 0 = No)	750	47%	346	50%	45%	47%	50%	39%*
Panel C. Participation in later steps of the invention process								
How much have you participated in [Company's] patent process? (2 = Filed patent, 1 = Submitted but not filed, 0 = Did not submit)	3630	0.49	2611	0.49	0.42**	0.50	0.41***	0.69***
I have submitted Invention Disclosure(s) (1 = Yes, 0 = No)	3834	32%	2697	32%	28%**	33%	29%**	35%
An invention disclosure of mine has been filed as a patent application (1 = Yes, 0 = No)	3630	15%	2611	15%	12%**	16%	11%***	22%**
How many patent applications have been filed?	465	2.5	362	2.5	1.9	2.6	1.7	2.6
How was the Invention Disclosure submitted? Check all that apply.								
Via the inventor portal	586	38%	281	37%	40%	35%	52%***	28%*
Through a brainstorming or harvesting session	395	20%	194	20%	16%	21%	15%	22%
With the help of a patent professional	634	9%	301	10%	7%	9%	7%	5%
Patent professional reached out to me	354	5%	168	5%	5%	6%	5%	6%
I reached out to the patent professional	354	7%	168	6%	5%	7%	4%	9%

Table 3.

Engineers' self-identity and perceived impact of their inventive ideas

This table provides descriptive statistics of the engineers' self-identity and the perceived impact of their inventive ideas. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a *t*-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate *p*-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
	Obs.	Mean	RG Obs.	RG Mean	URG Mean	Male Mean	Female Mean	URM Mean
Panel A. Self-identity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Do you self-identify as an inventor?	3874	46%	2700	49%	35%***	49%	35%***	36%**
Do you self-identify as a problem-solver?	561	96%	260	97%	95%	97%	96%	94%
Life impact of becoming an inventor	107	1.23	55	1.23	1.27	1.21	1.36	1.13
Panel B. Confidence in inventive ideas								
Are you comfortable deciding if your idea is worthy of submitting as an invention disclosure? (-2 = uncomfortable, 2 = comfortable)	3104	0.10	2332	0.17	-0.12***	0.17	-0.13***	-0.02
If you were unsure whether to submit an Invention Disclosure, what would you do next?								
Submit the Invention Disclosure anyway (and not seek advice)	3703	12%	2622	13%	9%***	13%	7%***	18%**
I will seek advice:	3512	80%	2535	79%	85%***	79%	85%***	82%
From someone else	413	50%	205	48%	59%*	49%	59%*	51%
From a patent professional	413	24%	205	24%	18%	24%	20%	19%
Not submit the Invention Disclosure (and not seek advice)	3512	10%	2535	10%	9%	10%	9%	5%
Panel C. Time for inventing								
Do you believe engaging in the patent process is a good use of your time? (1 = Yes, 0 = No)	191	48%	87	47%	51%	48%	50%	35%
In a typical work week, what percent (%) of your work time do you spend on the following tasks?								
Technical or engineering tasks that are likely to lead to inventions	238	15%	106	16%	12%	15%	13%	16%
Technical or engineering tasks that are <u>unlikely</u> to lead to inventions	238	61%	106	61%	60%	62%	60%	51%*
Other non-technical tasks	238	25%	106	23%	27%	23%	27%	34%
Men and women are equally assigned to projects that lead to inventive disclosures. (- 2 = Strongly disagree, 2 = Strongly agree)	3112	1.02	2341	1.08	0.86***	1.07	0.86***	0.50***

Table 4.

Engineers' perceived objectives, feedback, and subjectivity of the IP process

This table summarizes engineers' perceptions of the objectives of invention and their lived experiences of submitting ideas. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
	Obs.	Mean	RG Obs.	RG Mean	URG Mean	Male Mean	Female Mean	URM Mean
Panel A. Perceived objectives of the invention process	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
When working on projects that may result in Invention Disclosure, I focus on:								
Defending products and inventions from competitive threats	371	12%	187	14%	9%	14%	9%	10%
Experimenting with big, risky ideas that may prove to be foundational	371	23%	187	25%	23%	25%	23%	23%
Incremental changes as solutions to the problems	371	58%	187	57%	60%	55%	61%	58%
Other	371	6%	187	3%	8%*	6%	8%	10%
The invention I worked on is primarily of value to individuals or businesses that use it directly (-2 = Strongly disagree, 2 = Strongly agree)	152	1.24	70	1.23	1.18	1.22	1.25	1.02
The invention that I worked on is of significant value to society at large, beyond its direct users (-2 = Strongly disagree, 2 = Strongly agree)	141	0.46	59	0.44	0.47	0.48	0.46	1.06**
In your view, what should be prioritized when developing an invention?								
Private value	223	5%	101	6%	0%**	5%	5%	0%
Social value	223	12%	101	8%	18%**	9%	17%*	24%
Both equally	223	18%	101	21%	17%	19%	17%	12%
It depends on context	223	65%	101	65%	64%	67%	61%	65%
Panel B. Feedback received from invention process								
I did not realize I could receive advice or feedback	326	25%	157	24%	28%	28%	21%	40%*
I receive better advice on submissions from peers and mentors	326	18%	157	18%	25%	17%	27%**	20%
I was satisfied with the feedback being offered	326	52%	157	56%	46%	52%	51%	37%*
I would rather focus on the future than feedback on what I cannot change	236	12%	111	14%	9%	13%	9%	10%
The feedback being offered is too negative	236	6%	111	4%	6%	6%	5%	5%
The feedback being offered is too vague	326	12%	157	10%	17%	11%	16%	13%
Panel C. Perception of the invention process								
For each of statement, indicate your level of agreement (-2 = Strongly disagree, 2 = Strongly agree)								
Men and women are equally likely to be named as inventors.	3115	1.04	2339	1.09	0.92***	1.08	0.93***	0.61***
Men and women are equally likely to submit an invention disclosure.	3116	0.95	2342	1.01	0.82***	1.00	0.83***	0.40***
My manager encourages the submission of invention disclosures.	3183	0.65	2381	0.68	0.62	0.66	0.63	0.28***
Mgmt. supports increasing women's representation in the inventing process.	3310	0.78	2431	0.82	0.68***	0.82	0.68***	0.60*
Invention process participants are positively and publicly recognized.	3123	0.81	2347	0.82	0.81	0.81	0.82	0.64

Table 5.

Factors working for and against participation in the IP process

This table provides descriptive statistics of the engineers' perceptions of the factors that are working against participation and that would encourage participation in the patenting process. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
	Obs.	Mean	RG Obs.	RG Mean	URG Mean	Male Mean	Female Mean	URM Mean
Panel A. Factors preventing the submission of Invention Disclosures	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Individual inventor characteristics								
Discomfort with deciding if my idea is worthy of submitting	615	28%	292	30%	30%	27%	31%	26%
I don't feel the work I do is likely to yield patentable inventions	615	45%	292	50%	44%	48%	43%	33%**
I have not perfected my inventions to my satisfaction	615	13%	292	14%	15%	13%	13%	20%
Too busy	615	51%	292	55%	49%	55%	50%	51%
Too busy at home	566	29%	260	30%	32%	31%	37%	32%
Too busy with other work	566	31%	260	33%	26%	34%	21%***	32%
Management practices and the invention process								
Inventors are not positively and publicly celebrated	615	4%	292	5%	4%	4%	4%	4%
Not encouraged by management	615	14%	292	15%	14%	15%	12%	12%
The Invention Disclosure process needs improvement	264	9%	129	9%	7%	10%	8%	5%
Informal characteristics (e.g., cultural values and norms)								
Discomfort with disclosing my ideas to the patent review board	615	3%	292	3%	3%	4%	3%	6%
I do not have people with whom to collaborate on inventions	615	14%	292	11%	20%**	11%	22%***	13%
Inefficient workplace interactions	615	6%	292	6%	7%	5%	6%	3%
Our culture does not support inventing	566	6%	260	4%	7%	6%	5%	11%**
Panel B. Factors that would facilitate greater involvement in IP process								
Change management practices								
Being assigned to projects more likely to yield patentable inventions	3119	5%	2345	5%	6%	5%	5%	8%
Being given more time to work on patentable inventions	3069	5%	2313	5%	4%	5%	4%*	11%**
Inventor recognition, like a celebration, plaque, or limited-edition t-shirt	3614	5%	2556	4%	7%***	4%	6%**	12%***
Offer more training (in-person or virtual)	3661	61%	2596	62%	63%	61%	63%	54%*
Change the cultural norms								
Strengthen the innovation culture	3119	3%	2345	3%	3%	3%	2%	10%***
Encourage mentoring by senior engineers/scientists	3614	50%	2556	48%	59%***	47%	63%***	39%***
Change invention process								
Offer more brainstorming sessions to get early ideas	3614	9%	2556	7%	12%***	7%	11%***	25%***
One-on-one meeting with patent professionals	3614	28%	2556	29%	26%*	29%	27%	18%***
Simplifying and anonymizing the patent process	3661	20%	2596	21%	18%**	21%	18%*	19%

Table 6.

Factors influential in encouraging engineers to submit ideas

This table provides descriptive statistics of the engineers' perceptions of the factors most influential in encouraging engineers to submit invention disclosures. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a *t*-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate *p*-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
				RG	URG	Male	Female	URM
	Obs.	Mean	RG Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Most influential in encouraging idea submission	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Patent awards	410	41%	200	41%	43%	41%	43%	54%*
Knowing that I'm solving a problem for the greater good	410	38%	200	44%	34%*	43%	34%	23%**
Culture of innovation at [Company]	410	33%	200	37%	32%	37%	32%	37%
Peers	410	23%	200	25%	20%	25%	22%	17%
Recognition inside of the [Company]	410	23%	200	24%	24%	25%	24%	17%
Mentors at [Company]	410	20%	200	19%	25%	19%	24%	31%
Recognition outside of the [Company]	410	18%	200	17%	21%	17%	21%	17%
Performance reviews and firing and promotion decisions	410	11%	200	10%	12%	9%	14%	9%
Patent professionals	410	10%	200	11%	7%	11%	6%	11%
Management	410	9%	200	9%	13%	9%	11%	23%***
Internal trainings and policies	410	6%	200	7%	6%	6%	5%	9%
Famous inventors	410	5%	200	6%	3%	5%	5%	0%
Panel B. How can participation in idea submission be increased, especially for employees from under-represented groups?								
Better management	1568	20%	1173	19%	24%**	19%	25%***	13%
Offer more brainstorming sessions	1568	17%	1173	18%	15%	17%	16%	10%
Improve the culture	1568	14%	1173	13%	18%**	14%	18%*	23%
Simplify and anonymize the patent process	1568	13%	1173	13%	9%*	14%	8%***	29%***
Offer more training	1568	12%	1173	11%	14%	11%	14%	19%
Assign to projects more likely to yield inventions	1568	10%	1173	8%	15%***	8%	16%***	6%
Greater pecuniary incentives	1568	9%	1173	10%	7%*	10%	7%	3%
Provide more time for invention	1568	4%	1173	4%	5%	4%	6%	3%
More recognition, publicity, and appreciation	1568	4%	1173	4%	5%	4%	5%	3%
Create a mentoring program	1568	1%	1173	1%	1%	1%	1%	0%
One-on-one meetings with patent professionals	1568	0.2%	1173	0.1%	0.6%*	0.1%	0.6%**	0.0%
Require idea submission for career advancement	1568	0.1%	1173	0.0%	0.3%*	0.1%	0.0%	3.2%***

Table 7.

The current state of management, culture, and trust

This table provides descriptive statistics of the engineers' perceptions of management, culture, and trust for their co-workers. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
	Obs.	Mean	RG Obs.	RG Mean	URG Mean	Male Mean	Female Mean	URM Mean
Panel A. Cultural norms	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Please evaluate the day-to-day interactions at [Company] and indicate which of these factors help us achieve our inventive goals (-2 = Weakness, which works against invention, 2 = Strength, key factor helping us to invent)								
Employees feel empowered, confident, and healthy	373	1.33	193	1.38	1.31	1.34	1.28	1.42
Information sharing among employees	376	1.32	195	1.34	1.29	1.33	1.22	1.66**
Employees' comfort in suggesting ideas, concerns, critiques	375	1.28	194	1.34	1.20	1.31	1.16	1.26
Trust among employees	371	1.25	193	1.28	1.25	1.24	1.27	1.34
New ideas develop organically	372	1.17	192	1.23	1.09	1.21	1.03	1.30
Broad agreement about goals	366	0.76	191	0.74	0.76	0.72	0.83	0.61
Willingness to hold employees accountable for unjust actions	358	0.21	189	0.31	0.09*	0.25	0.09	0.03
Urgency with which employees work	348	0.08	180	0.17	-0.08*	0.10	-0.03	-0.14
Average strength of cultural norms	381	0.94	195	0.98	0.87	0.95	0.87	0.94
Panel B. Management Practices								
I experience [Company] leadership to do the following: (0 = No, 1 = Yes)								
Give clear expectations	318	78%	172	80%	73%	80%	70%	85%
Provide coaching	307	61%	167	63%	36%	64%	48%	81%
Support my career development	332	80%	176	81%	79%	81%	76%	91%*
Gather multiple perspectives for decisions	325	65%	176	66%	61%	67%	57%	66%
Explain important details	321	73%	174	78%	67%*	76%	63%**	76%
Be pro-active about improving or removing barriers to inventiveness	282	59%	153	58%	57%	58%	54%	76%*
Inspire confidence, enthusiasm, and the courage to be inventive	289	70%	159	72%	63%	73%	62%*	78%
Be ethical and make fair decisions	322	77%	177	82%	69%**	82%	64%***	73%
Panel C. Effective culture and trust								
I believe [Company]'s corporate culture: (1 = Needs a substantial overhaul, 4 = is exactly where it should be)	377	3.16	197	3.25	3.14	3.21	3.09	3.20
Would you say that most of the time, people at [Company] are trying to be helpful, or that they are mostly just looking out for themselves? (-2 = Always looking out for themselves, 2 = Trying to be helpful)	375	1.52	194	1.65	1.34***	1.59	1.38**	1.48

Table 8.
Summary statistics from idea submission databases
This table provides descriptive statistics from the collaborating firms invention disclosure databases that contain all ideas submitted, even those for which a patent application is not pursued. For a detailed description of each variable, see Appendix A.

	Firm 1	Firm 2	Firm 3	Firm 4	All firms	
					Simple Mean	Weighted Mean
Invention disclosure data	(1)	(2)	(3)	(4)	(5)	(6)
Unique ideas submitted	1295	1584	237	66397	17378	69513
Unique inventors	957	1216	166	29246	7896	31585
Total inventors per idea	1.9	2.7	1.8	2.8	2.3	2.7
Any first-time inventor	35%	29%	33%	30%	32%	30%
Any female inventor	21%	14%	22%	7%	16%	7%
Percent female inventor	10%	6%	14%	5%	9%	?%
Any underrepresented minority (URM) inventor	N.A.	20%	3%	4%	9%	5%
Submitted as a patent application	50%	59%	96%	31%	59%	32%
Patent granted given application	32%	32%	59%	N.A.	41%	32%

Table 9.
Analysis of idea submission databases
This table reports estimates from Equation 1 that studies whether engineers fall off the inventive path with novel idea submission databases sourced from four collaborating firms. The main variable of interest is step in the IP process, where 1 = idea submission, 2 = patent application, and 3 = patent granted. In Panel A and Panel B, the analysis concentrates on gender. Panel C examines first-time inventors, and Panel D combines the analysis. Additional control variables include the number of inventors. Details of controls, fixed effects, and observations pertinent to all panels are listed beneath Panel D. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Dep. var. = Step in IP process					
	Firm 1	Firm 2	Firm 3	Firm 4	All firms	
Panel A.	(1)	(2)	(3)	(4)	(5)	(6)
Has a female inventor	-0.054	-0.120**	-0.145	-0.061***	-0.033***	-0.051***
	(0.037)	(0.052)	(0.093)	(0.007)	(0.007)	(0.007)
Adjusted R^2	0.230	0.108	0.231	0.079	0.066	0.106
Panel B.						
Pct. female inventors	-0.082	-0.302***	-0.138	-0.106***	-0.055***	-0.102***
	(0.053)	(0.102)	(0.116)	(0.013)	(0.013)	(0.013)
Adjusted R^2	0.230	0.111	0.225	0.079	0.066	0.106
Panel C.						
Has a first-time inventor	-0.101***	-0.122***	-0.059	-0.033***	-0.024***	-0.032***
	(0.036)	(0.047)	(0.076)	(0.004)	(0.004)	(0.004)
Adjusted R^2	0.177	0.109	0.220	0.079	0.066	0.105
Panel D.						
Pct. female inventors	-0.082	-0.270***	-0.135	-0.098***	-0.048***	-0.094***
	(0.053)	(0.102)	(0.118)	(0.013)	(0.013)	(0.013)
Pct. first-time inventors	0.058	-0.210***	-0.043	-0.095***	-0.076***	-0.090***
	(0.044)	(0.058)	(0.096)	(0.005)	(0.006)	(0.005)
Observations	1149	1549	141	65765	68604	68604
Adjusted R^2	0.231	0.117	0.211	0.083	0.068	0.110
Control variables	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y
Firm fixed effects	N	N	N	N	N	Y

Table 10.

Female patent citations at sampled firms

This table reports estimates from Equation 2 that tests the model's prediction that female inventor's patents will be of superior quality if invented at a firm with meaningful frictions in the IP process. The measure of patent quality in Panel A is the number of forward citations a patent accumulates, while Panel B it is an indicator variable that identifies patents falling within the top decile of citations for their application year. We proxy for frictions in the IP process using an dincator variable for firms we surveyed and interviewed. Panel C extends the analysis of Panel A to encompass the entire population of public firms for comparative purposes. Control variables include backward citations, examiner citations, total claims, firm size, market-to-book ratio, R&D-to-sales ratio, cashflow-to-capital ratio, leverage, and profitability. All panels include firm, headquarter state, technology class, and application year fixed effects. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Dep. var. = Forward citations			
Panel A. Sampled firms, most recent 10 years	(1)	(2)	(3)	(4)
Has a female inventor	0.148**	0.130*		
	(0.068)	(0.068)		
Pct. female inventors			0.254	
			(0.166)	
Lead female inventor				0.216**
				(0.103)
Observations	29512	29512	29512	29512
Adjusted R^2	0.038	0.043	0.043	0.043
Panel B. Sampled firms, most recent 10 years	Dep. var. = Top decile of citations			
Has a female inventor	0.008**	0.008**		
	(0.004)	(0.004)		
Pct. female inventors			0.019**	
			(0.009)	
Lead female inventor				0.006
				(0.006)
Observations	29512	29512	29512	29512
Adjusted R^2	0.451	0.454	0.454	0.453
Panel C. Public patenting firms, most recent 10 years	Dep. var. = Forward citations			
Has a female inventor	-0.560***	-0.452***		
	(0.075)	(0.075)		
Pct. female inventors			-1.381***	
			(0.174)	
Lead female inventor				-0.437***
				(0.113)
Observations	419827	416087	416087	416087
Adjusted R^2	0.186	0.208	0.208	0.207
Controls	N	Y	Y	Y
Fixed effects	Y	Y	Y	Y

Table 11.

Female patent citations at firms with an ineffective culture and poor management

This table reports estimates from Equation 3 that tests whether a female-invented patent from firms with ineffective culture and/or managers receive more citations. Panel A focuses on ineffective culture, and Panel B on poor management. Control variables include backward citations, examiner citations, total claims, firm size, market-to-book ratio, R&D-to-sales ratio, cashflow-to-capital ratio, leverage, and profitability. All panels include industry, headquarter state, technology class, and application year fixed effects. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Dep. var. = Forward citations	
Panel A. Ineffective culture	(1)	(2)
Has a female inventor	-0.267***	-0.245***
	(0.046)	(0.046)
Has a female inventor × Ineffective culture	0.117*	0.132**
	(0.065)	(0.065)
Ineffective culture	-0.188***	-0.262***
	(0.044)	(0.047)
Observations	119575	118840
Adjusted R^2	0.046	0.065
Panel B. Poor management		
Has a female inventor	-0.277***	-0.255***
	(0.046)	(0.046)
Has a female inventor × Poor management	0.148**	0.162**
	(0.065)	(0.065)
Poor management	-0.387***	-0.375***
	(0.043)	(0.045)
Observations	119575	118840
Adjusted R^2	0.046	0.065
Controls	N	Y
Fixed effects	Y	Y

Internet Appendix

A Interviews, Survey Questions, and Logistics

For our interviews, we promised the patent professionals anonymity to encourage frank discussion. We used interviews to learn about the invention process and identify any under-researched ideas relevant to the innovator-inventor gap. We also used the interviews as a guide to develop our survey instrument. The interviews occurred via Zoom and varied in length, lasting from 25 to 60 minutes. The interviewees seemed thoughtful and forthcoming in their responses.

Using careful design and sample planning, we created a beta version of our survey. To minimize measurement error, we talked to survey design experts to vet its design, including internal human resources (HR) teams responsible for designing and assessing employee survey measures throughout the calendar year. After receiving feedback from these specialists, the final survey contained six different modules (e.g., familiarity with the IP process, mentoring, etc.). We include the various modules at the end of this Appendix, but it is important to recognize that the surveys were bespoke in the sense that each firm modified the language to reflect their internal terminology and process. For instance, not all firms like to use the word "brainstorming." We also randomized the modules received by survey respondents and made some questions conditional on prior affirmative or negative responses about participation in inventive activities to reduce the time required to complete the survey. The median time to complete the survey is 8 minutes and 15 seconds. The average time to complete the survey is 29 minutes and 29 seconds. The surveys were all administered over the Internet, leaving the survey window and returning to complete it was possible. The survey is anonymous, does not require subjects to disclose their names, and is approved by the Institutional Review Board (IRB) at the authors' home institutions.

One advantage of online administration is the ability to randomly scramble the order of choices within a question to mitigate potential order-of-presentation effects. Specifically, the survey scrambled the order of answers when the respondent needed to assess various factors, or there were multiple choices. We did not reverse order the Likert scale, but we did repeat some aspects of the questions. From a survey design perspective, incorporating questions with both positive and negative biases is crucial as it mitigates acquiescence bias, ensuring that respondents are not merely agreeing with statements but are actively engaging with and considering each item. Further, the repetition of essentially equivalent questions framed differently enables the cross-verification of responses, enhancing the reliability and validity of the collected data by identifying inconsistencies and capturing a more nuanced understanding of respondents' perspectives.Participants were allowed to skip questions if they did not want to answer them, so the number of observations varies across questions. Most multiple-choice questions included a free-text response option, so that survey takers could provide answers not explicitly specified in the question. In addition, we use survey techniques that help attenuate the effect of noise attributable to potential respondent behavioral biases. To avoid engineers engaging in "cheap talk" about invention, we use a mix of questions that elicit hypothetical and real decisions, which neuroscientists have shown activate different parts of the brain and reduce bias.

Finally, invitations to take the survey followed different formats. A combination of HR professionals, patent professionals, and/or academics emailed the invitation. We know that framing a survey directly about invention or IP may deter some would-be inventors from taking the survey. For this reason, we iterated back and forth with HR departments on language but they typically had the final say. Figure A.3 provides an example of a solicitation email used at one firm. Figure A.4 provides a second example. Similar language was used at the two other firms that internally sent the email as well. In each case the solicitation was sent to a diverse yet representative sample of engineers, and invitations were sent staggered. After the survey ended, we worked directly with HR departments to ensure the sample demographics matched their targeted representativeness. At one firm, female engineers were purposefully oversampled. At each firm, we sent the survey on a different initial date, and reminder emails were sent approximately two weeks after the initial invitation. In each case, the survey closed within six weeks of opening the survey.

Corporate accounting data are from the Compustat-CRSP fundamental annual database and are used to benchmark the surveyed and interviewed firms to a broader population of firms. Definitions are as follow.

Sales revenue $= REVT$

Revenue growth $= REVT/REVT_{t-1}$

Number of employees $= EMP$

Assets $= AT$

Firm size $= log(AT)$, in which AT is in real 2010 dollars.

R&D expenditures $= \log(1 + XRD)$ where missing values are set equal to 0

Is R&D active = indicator for $XRD > 0$

Intangible assets-to-total assets $= INTAN/AT$

Asset growth $= AT/AT_{t-1}$

Investment-to-Capital $= ((CAPX - SPPE) - (CAPX_{t-1} - SPPE_{t-1}))/PPENT_{t-1}$

Market Capitalization (MEQ) $= PRCC\_F \times CSHO$

Market Value of Assets $(MVA) = MEQ + DLC + DLTT + PSTKL - TXDITC$

Market-to-book ratio $= MVA/AT$

Profitability $= OIBDP/AT$

Debt-to-Assets $= (DLC + DLTT)/AT$

Some survey questions are combined to help illustrate a pattern. For instance, the stages of fallout in the inventor's path from ideation to granted patent combine similar but bespoke questions. Specifically, inventive ideas is "Yes, I have had an idea that I thought might be patentable" or "I am interested or very interested in inventing more." Assigned IP work includes those with an inventive idea or who had been assigned to an early-stage patent project. Sought advice is someone who indicated that yes they would seek advice if unsure conditional on being "Assigned IP work." Sought training is someone who attended training, has a mentor, or indicates an awareness of IP condition on being "Assigned IP work." Submitted idea is conditional on "Assigned IP work," as is patent application filed.

Table A.1.
Benchmarking responses to Compustat
This table provides descriptive statistics from the survey and interview firms relative to Compustat firms. Column 1 summarizes public firms from the survey and interview process, column 2 summarizes public firms from Compustat that have been granted a patent in the last 5 years, and column 3 summarizes all public firms from Compustat for the most recent fiscal year-end that occurred before the date of the survey and interviews. Panel A summarizes firm characteristics. Panel B summarizes patent characteristics. All samples are limited to North American firms. For a detailed description of each variable, see the definitions in Appendix A.

Panel A. Firm characteristcs	Survey and interview firms (1)	Patenting firms (2)	Compustat firms (3)
Sales revenue	66,813	11,878***	4,300
Revenue growth	14%	24%	70%
Number of employees	3.6	1.8***	1.1
Firm size	10.3	7.6***	6.8
Is R&D active	100%	81%*	42%
R&D expenditures	10,617	665***	243
Intangible assets-to-toal assets ratio	21%	23%	17%
Asset growth	5%	5%	6%
Net investment-to-capital raito	28%	20%	34%
Market-to-book ratio	2.8	2.1	3.7
Profitability	-8.4%	-1.1%	-10.7%
Debt-to-asset ratio	29.7%	29.4%	30.5%
Panel B. Patent characteristics			
Patents granted (2018-2022)	2670	162***	
KPSS value per patent	24.1	25.1	
KPSS citations per patent	0.4	0.5	

Table A.2.

External validation: question on routine workforce feedback survey

Column 1 of this table presents the responses to one-off innovation questions included as part of a routine survey that is regularly sent to a sample of employees to gather workforce feedback. Panel A includes all respondents and Panel B includes female respondents. Column 1 of Panel A indicates that 59.8% of employees on the workforce survey have had an idea that they thought might be patentable. This is consistent with the 55.4% in Column 2 that reflects the percentage of respondents to our innovation process survey. This 55% is also reported in Table 2 of this paper. Column 3 displays the t-statistic from the hypothesis test that the means are equivalent.

	Workforce Survey	Innovation Survey	t
Panel A. All responses	(1)	(2)	(3)
Have you ever had an idea that you thought might be patentable?	59.8%	55.4%	-0.741
Observations	82	556	638
Have you ever submitted an innovative idea as an invention disclosure?	32.3%	25.6%	1.276
Observations	82	3,834	3,916
Panel B. Female responses			
Have you ever had an idea that you thought might be patentable?	55.2%	47.0%	-0.808
Observations	29	168	197
Have you ever submitted an innovative idea as an invention disclosure?	17.2%	28.7%	1.347
Observations	29	787	816

Figure A.1.
Benchmarking frequency of patents by technology subcategry
This histogram delineates the distribution of technology subcategories, as per the classification framework proposed by Schmoch (2008), for patents filed in 2018 or later and issued to public firms in North America. Frequencies of patents granted to the firms in our sample are superimposed on the histogram in mustard color for comparative analysis.

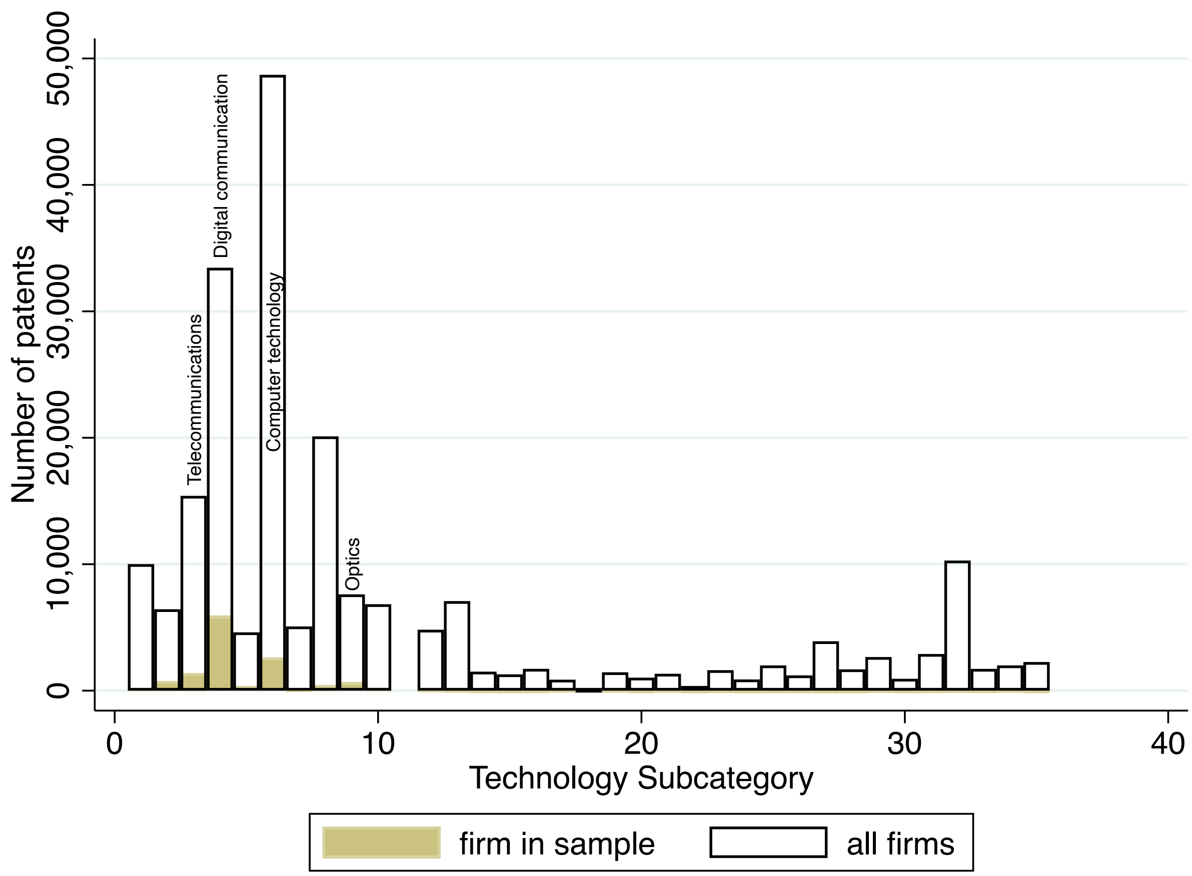


Figure A.2.

Distribution of technology subcategories for sampled firms

This figure illustrates the percentage composition of patents across various technology subcategories, as classified according to Schmoch (2008), and issued to the public firms in North America that our sample of engineers work at. The data pertains to patents filed in the year 2018 or subsequent years. For example, the "Digital Communication" subcategory constitutes the largest segment, accounting for 17% of the patents in the sample. Yet the data from the sampled firms exhibits a diverse technological landscape, featuring representation from over 30 distinct technology subcategories.

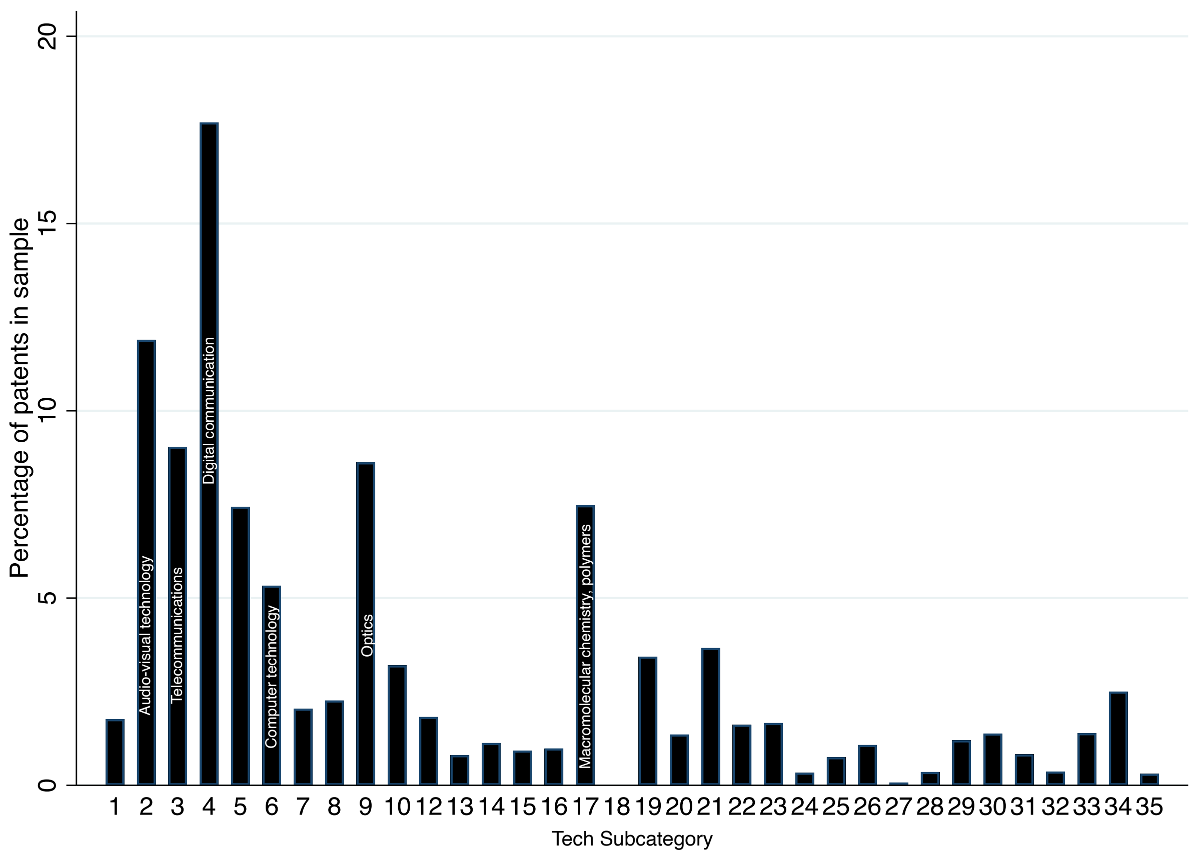


Figure A.3.

Example of survey solicitation email

This figure displays a representative survey solicitation email designed to avoid any respondent framing and ensure unbiased, genuine responses regarding innovation perspectives and experiences. The language within this email was crafted with the help of firms' HR departments to maintain neutrality, refraining from leading the potential respondent towards any predetermined conclusions or inducing any response bias. The objective of presenting this figure is to provide transparency in our data collection process and the integrity of the survey instrument.

Subject: Please Complete this Survey – We Need Your Help!

Dear X,

ABC strives to be an innovative company, and as a member of our community, your unique perspectives on the innovation process are invaluable to us. In partnership with researchers at the Diversity Pilots Initiative (diversitypilots.org), we are conducting a short, voluntary survey to understand the diverse range of experiences encountered by our employees. We would greatly appreciate your input.

The survey aims to drive meaningful change and foster a more inclusive environment for all workers at ABC. Your contribution to this initiative would help us gauge the current innovation process and shape future strategies and practices.

Please don't worry; your responses will be kept confidential and used only for research and improvement at ABC. Here are the details of the survey:

- It should take approximately 10 minutes to complete.
- We have ensured that the survey is as simple as possible to navigate and can be completed at your own pace.
- **Follow this link to the Survey**: ${l://SurveyLink?d=Take the Survey}
- Or copy and paste the URL below into your internet browser: ${l://SurveyURL}
- Follow the link to opt out of future emails: ${l://OptOutLink?d=Click here to unsubscribe}

Your experiences are what we need to make this data collection genuinely representative. Even if you don't consider yourself to be an inventor, we want to hear from you and understand your insights. We look forward to your participation and greatly value your input. **Please take some time out of your busy days to complete the survey.**

Figure A.4.

Example of survey solicitation email

This figure displays a representative survey solicitation email designed to avoid any respondent framing and ensure unbiased, genuine responses regarding innovation perspectives and experiences. The language within this email was crafted with the help of firms' HR departments to maintain neutrality, refraining from leading the potential respondent towards any predetermined conclusions or inducing any response bias. The objective of presenting this figure is to provide transparency in our data collection process and the integrity of the survey instrument.

SUBJECT: PATENT SURVEY: INVENTING AT COMPANY

Dear NAME,

My name is NAME, and I am X here at COMPANY. As you may know, COMPANY has more than X patents worldwide and owns one of the strongest patent portfolios in the tech industry. Patents give us the ability to protect and leverage our innovations so that we can continue to serve our customers and realize business success.

For the first time ever, COMPANY's Patent Team is conducting a survey of worldwide technical workers to determine views on Inventing at COMPANY. The survey responses will help the Patent Team better serve our inventor community, which will further strengthen our patent portfolio. We want to hear from everyone, from those who have never participated in COMPANY's patent process, to those who have dozens of patents.

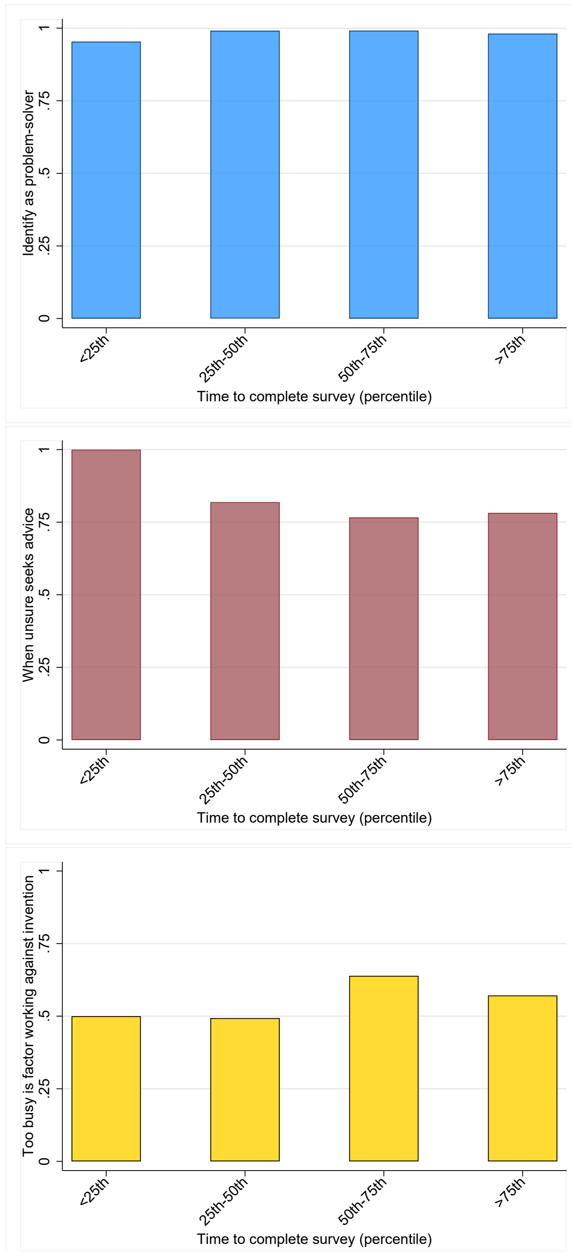
The survey requires about 5 minutes to complete. Thank you in advance for your participation, and we would appreciate receiving your input by DATE.

Access the survey HERE.

Sincerely,

NAME

Figure A.5.
Reliability of survey measures
The plot shows bar graphs for three survey questions from various modules (aspiration to invent, identity as an inventor, factors working against invention, etc.). Each bar represents the mean response by quartile of duration taking the survey. The responses are statistically indistinguishable by survey duration.



Survey Introduction

Participation in this survey is voluntary. You do not have to answer every question and you can withdraw from participation at any time by closing your internet browser. The information that is collected will be shared on an anonymous basis with researchers and may be publicized within [Company] in the aggregate. You may withdraw from the survey at any time. At the end of the survey, you can indicate whether you would like to be contacted to provide additional information.

The survey concerns inventing at [Company] and requires about 10 minutes to complete. It includes multiple parts, as follows:

Part 1: Familiarity with Invention
Part 2: Intellectual Property Development
Part 3: Patent Mentoring (Not all firms included this module)
Part 4: Exposure to Invention (Not all firms included module)
Part 5: Prior Work Experiences (Not all firms included module)
Part 6: Demographics
Part 7: Contact Information and Open-ended Response

Part 1: Familiarity with Invention

1. Are you aware that [Company] has an invention submission process and tools where you can submit ideas to be reviewed for potential patenting?

- Yes
- No

2. Have you attended a company training on inventing? (choose all that apply)

- Yes within the last 12 months
- Yes but it's been more than 1 year
- Yes through an employee resource group training
- No I have not

3. Do you self-identify as a problem-solver?

- Yes
- No

4. Do you self-identify as an inventor?

- Yes
- No

5. Have you ever had an idea that you thought might be patentable?

- Yes
- No

6. Are you regularly assigned projects that you think could yield patentable inventions?

- Yes
- No

7. Are you interested in working more on tasks that would lead to being a named inventor?

- Yes
- No

Part 2: Intellectual Property Development

Ideas are submitted to the [Company] Legal Department using [fill in]. A submitted idea is referred to as an "invention disclosure." The term "inventing" refers to designing or creating technology (not merely implementing technology at the direction of someone else) to solve a problem in the field including through an invention disclosure.

1. Have you ever sought help with navigating the patent process (e.g., by talking to a patent professional or mentor)?

- Yes
- No

2. How comfortable are you in deciding whether an idea is worthy of submitting as an invention disclosure?

Slider with range -2 = Very uncomfortable, 0 = Neither comfortable nor uncomfortable, 2 = Very comfortable

3. If your idea has previously been submitted as an invention disclosure, how was it submitted? (check all that apply)

- Via the inventor portal
- Through a mining session led by a patent professional
- Through a brainstorming session led by an engineer
- With the help of a patent professional that reached out to me
- With the help of a patent professional that I reached out to
- I don't know

4. Within the past 12 months, have any of your [Company] invention disclosures been drafted as patent applications or designated as trade secrets?

- I have not submitted any disclosures
- Yes, as a patent
- Yes, as a trade secret
- No
- I don't know

5. When did you first become an inventor? (Approximate years ago)

- 0-2 years ago
- 3-5 years ago
- 6-10 years ago
- Over 10 years ago (you can call me Ben Franklin/Hedy Lamarr)

6. What was the impact on your life of becoming an inventor?

Slider with range 0 = No impact, 1 = Positive impact, 2 = Significant impact

7. Please expand on the impact on your life of becoming an inventor if you would like.

8. In the context of your invention disclosure(s), please check all factors that were relevant to the feedback you received on the submission.

- I did not realize I could receive advice or feedback

- My collaborator solicited feedback for the group
- The feedback being offered is too vague
- I receive better advice on submissions from peers and mentors
- The feedback being offered is too negative
- I would rather focus on future opportunities than feedback on what I cannot change
- I was satisfied with the feedback being offered

9. If you were unsure whether to submit an invention disclosure, what would you do next? (choose one)

- Seek advice from patent professionals
- Seek advice from a master inventor
- Not submit the invention disclosure (and not seek advice from someone else)
- Submit the invention disclosure anyway (and not seek advice from someone else)

10. When working on projects or products that may result in inventive disclosure(s), do you focus on:

- Incremental changes as solutions to the problems
- Experimenting with big risky ideas that may prove to be foundational
- Defending products and [Company]'s inventions from competitive threats
- Other (please specify)

11. The invention I worked on is primarily of value to individuals or businesses that use it directly

Slider with range-2 = Strongly disagree, 0 = Neutral, 2 = Strongly agree

12. The invention that I worked on is of significant value to society at large beyond its direct users

Slider with range-2 = Strongly disagree, 0 = Neutral, 2 = Strongly agree

13. In your view, what should be prioritized when developing an invention?

- Private value
- Social value
- Both equally
- It depends on context

14. Do you believe engaging in the patent process is a good use of your time?

- Yes
- No

15. In a typical work week, what percent (%) of your work time do you spend on the following tasks? *Note: this question forces the response to add to 100 before moving on.*

Technical or engineering tasks that are likely to lead to inventions ______
Technical or engineering tasks that are **unlikely** to lead to inventions ______
Other non-technical tasks ______

16. For each statement, indicate your level of agreement (-2 = Strongly disagree, 0 = Neutral, 2 = Strongly agree):

- Men and women are equally assigned to projects that lead to inventive disclosures.
- Men and women are equally likely to be named inventors.
- Men and women are equally likely to submit an invention disclosure.
- In instances where projects or innovations do not succeed, men and women are proportionately blamed or held responsible.
- Management supports women's representation in the inventing process.
- Men and women are equally publicly and positively recognized for their invention successes.

17. Which of the following have been most influential in encouraging you to submit invention disclosures at [Company]? (check up to 3)

- Current manager

- Peers
- Patent professionals
- Famous inventors
- Mentors at [Company]
- Culture of innovation at [Company]
- Incentive compensation/patent awards
- Internal trainings and policies
- Performance reviews and promotion decisions
- Recognition outside of [Company]
- Recognition inside of [Company]
- Knowing that I'm solving a problem for the greater good

18. Please indicate which factors are preventing you from submitting more invention disclosures. (check up to 3)

- Discomfort with deciding if my idea is worthy of submitting
- I have not perfected my inventions to my satisfaction
- I don't feel the work I am assigned is likely to yield patentable inventions
- I do not have people with whom to collaborate on inventions
- Not encouraged by management
- Inefficient workplace interactions
- Too busy at home
- Too busy with other work
- The invention disclosure process needs improvement
- Discomfort with disclosing my ideas to the patent review board or a patent professional
- Our corporate culture does not support inventing
- Public recognition works against more invention (e.g., inventors are not positively and publicly celebrated)
- Other (please specify)

19. What do you believe would encourage your involvement with the invention process? (check up to 3)

- One-on-one meeting with patent professional
- Mentoring from a senior engineer/scientist
- Roundtables, hackathons, or brainstorming sessions to get early ideas
- Patent training
- Simplifying and anonymizing the disclosure process so that one does not need to go through a manager or patent professional
- Strengthening the innovation culture
- Being given more time to work on patentable inventions
- Being assigned to projects more likely to yield patentable inventions
- Inventor recognition, like a celebration or celebratory plaque
- Other (please specify)

20. How can participation in the invention process be increased, especially for employees from under-represented groups?

Part 3: Patent Mentoring

21. Have you in your time at [Company] ever acted as a patent mentor to a less experienced employee?

- Yes
- No

22. Have you in your time at [Company] ever received patent mentorship from a more experienced employee?

- Yes
- No

If the answer to mentorship is no, ask the following two questions.

23. If the answer to mentorship is no, what are the reasons you have not sought patent mentorship? (check all that apply)

- I could not identify a potential mentor with overlapping interest
- I did not believe patent mentorship would benefit me
- I did not have time for patent mentorship or it was offered at inconvenient times
- I want to avoid activities that highlight my weakness to leaders
- I felt that the program would benefit my employer more than it would benefit me
- I did not think about it
- My co-workers already help me with IP so I don't need a mentor
- I want to participate in patent mentorship but was unable to

24. If you were to be paired with a mentor, what type of affinity would you like to share? (Check all that apply)

- Same gender
- Same age
- Same ethnicity
- Same university
- Overlapping affinity does not matter

If the answer to mentorship is yes, ask the following questions.

25. For the next set of questions, think of your most recent patent mentorship relationship where you were the protégé (i.e., the person receiving mentorship).

Slider with range-2 = Strongly disagree, 0 = Neutral, 2 = Strongly agree

- I have learned about patenting and become a better inventor as a result of being part of the program
- Patent mentorship increased my satisfaction at work
- I am planning to work on more invention disclosures at work
- I feel confident that I can incorporate my mentor's tips into my work process and develop new inventions
- I feel confident that I have the social connections necessary to get my invention ideas accepted by IP professionals

How often would your patent mentor provide you with advice, suggestions, or support?

- Daily
- Several times a week
- Weekly
- Several times a month
- Monthly

26. Who first initiated mentor-protégé like contact?

- Your mentor by offering unsolicited advice, suggestions, or support.

- You by asking the person for advice, suggestions, or support.
- Other (please specify)

27. Did you and your mentor have an affinity? (Check all that apply)

- Yes, we are the same gender
- Yes, we are the same age
- Yes, we are the same ethnicity
- Yes, we went to the same university
- No, we do not have an overlapping affinity

If [Company] has a formal mentorship program, ask the following question.

28. Since your formal mentorship relationship ended, on average how many times per month have you met with your mentor/mentee outside of your regularly scheduled work meetings, even if just briefly?

- 0 times
- 1-2 times
- 3-4 times
- 5 or more times

Part 4: Exposure to Invention

1. How important have the following factors been in influencing you to pursue a technical career? *Slider with range 0 = Not applicable, 1 = Not at all important, 5 = Very important*

- Desire to solve global societal problems
- Desire to solve problems for people like me and in my community
- Financial considerations
- I attended a specialized STEM school
- I realized I had talent in math/science
- I received special recognition by being placed in 'advanced' or 'special' programs
- Intrinsic love of science & technology
- Parent's encouragement
- Role model
- Teacher's encouragement

2. How important was exposure to engineers and scientists in your pursuit of a technical career? *Slider with range 0 = Not applicable, 1 = Not at all important, 5 = Very important*

- One or both of my parents was a scientist or engineer
- I had one or more extended family members who were scientists or engineers
- I had a role model within my community that was a scientist or engineer
- I knew someone that was a scientist or engineer to whom I looked up to
- I was inspired by one or more books I had read either fiction or nonfiction

3. Which of the sources of support have been important in your pursuit of a technical career? (check all that apply)

- Financial support (e.g., scholarships or from family)
- Emotional support
- Network support (e.g., helped me get a job or find mentors)
- Childcare support

Part 5: Prior Work Experiences

1. Please assess the importance of your post high-school network to your pursuit of a STEM career. (0 = Not applicable, 1 = Not at all important, 5 = Very important)

- Anyone in my network
- Same-sex network
- Same-ethnicity network
- Same-university network
- Other-affinity network

2. If you've left a previous STEM job, please indicate the importance of the following possible reasons for doing so. (0 = Not applicable, 1 = Not at all important, 5 = Very important)

- I left due to unfairness I experienced or witnessed at my workplace
- I was not satisfied with my work environment
- I was recruited away to a different job
- I was not satisfied with my job duties
- I did not feel that I belonged or that there were other people like me in my workplace

3. Please indicate which, if any, of the following is true about your previous workplaces (Check all that apply).

- Experienced unfair management
- Experienced stereotyping
- Experienced bullying
- Experienced sexual harassment

Part 6: Demographics

Thank you for your help! The demographic information will be used to identify trends by correlating answers to inventing questions with residence, department, tenure, etc. The information that you provide **will not** in any way be used to identify you.

1. In which country or state do you reside?

2. How long have you worked at [Company] or one of its legacy companies?

- Less than 12 months
- 12 months to 2 years
- 2 to 5 years
- 5 to 10 years
- Over 10 years

3. Which business unit are you in?

- Business (e.g., sales, strategy)
- Data science
- Engineering
- Manufacturing
- Products

4. What is your gender identity?

- Female
- Male
- Non-binary
- Other
- Prefer not to say

5. How old are you?

- Under 30
- 30-39

- 40-49
- 50-59
- 60+
- Prefer not to say

6. How do you self-identify ethnically?

- Hispanic or Latin American
- White
- Black or African American
- American Indian, Alaska Native, Native Hawaiian, or Other Pacific Islander
- Asian
- Two or more ethnicities
- Prefer not to say

7. Which of the following is true of you regarding your spouse or partner? (Check all that apply)

- I am not partnered
- My partner works full-time
- My partner works part-time
- My partner does not currently work
- Prefer not to answer

8. If you have a partner, please indicate which of the following is true:

- I take primary responsibility for household and family duties
- My partner and I share equally in household and family duties
- Prefer not to answer

9. Where do you typically work during the week?

- In office
- Hybrid
- Fully remote

10. What is your highest level of education?

- High school degree
- Technical or associate degree
- Undergraduate degree
- Master's degree
- Doctoral degree

11. Would you say that most of the time people at your [Company] are trying to be helpful or that they are mostly just looking out for themselves?

- Trying to be helpful
- Sometimes trying to be helpful
- Neither helpful nor harmful
- Mostly looking out for themselves
- Always looking out for themselves

12. I believe [Company]'s corporate culture:

- Is exactly where it should be
- Needs some work but is close to where it should be
- Needs considerable work to get to where it should be
- Needs a substantial overhaul

13. I experience [Company] leadership to do the following (Check all that apply)

- Give clear expectations

- Provide coaching
- Support my career development
- Gather multiple perspectives for decisions
- Explain important decisions
- Be proactive about improving and removing barriers to inventiveness
- Inspire confidence, enthusiasm, and courage to be inventive
- Be ethical and make fair decisions

14. Please evaluate the day-to-day interactions at [Company] and indicate which of these factors help us achieve our inventive goals (-2 = Weakness, works against invention; 2 = Strength, key factor helping us to invent):

- Employees feel empowered, confident, and healthy
- Information sharing among employees
- Employees' comfort in suggesting ideas, concerns, critiques
- Trust among employees
- New ideas develop organically
- Broad agreement about goals
- Willingness to hold employees accountable for unjust actions
- Urgency with which employees work

Part 7: Contact Information and Open-ended Response (Optional)

Please provide your contact information and any additional comments or feedback about invention at [Comapny].

1. How can [Company]'s invention submission process be improved?

2. Would you like to be contacted to further discuss these topics?

- No, I would not like to be contacted.
- Yes, I would like to be contacted.

3. Please enter your name and email address:

B Additional Figures and Tables

Figure B.1.

Steps in the inventor's path from ideation to patent by gender and ethnicity

This figure illustrates the attrition of female engineers and engineers from underrepresented ethnicities ("URM") through various stages of the invention process, from ideation to patent application filing. The figure on the top focuses on gender and the figure on the bottom ethnicity. The dashed magenta line and circles represent the average for female engineers. The dashed cyan line and squares represent the average for engineers from URM. The navy line and triangles represent the average for Asian or white male engineers. The numbers mark the percent of engineers partaking in a specific step. It offers a detailed view into the journey from inventive idea to granted patent, pinpointing where engineers with potentially worthy ideas may fall off track.

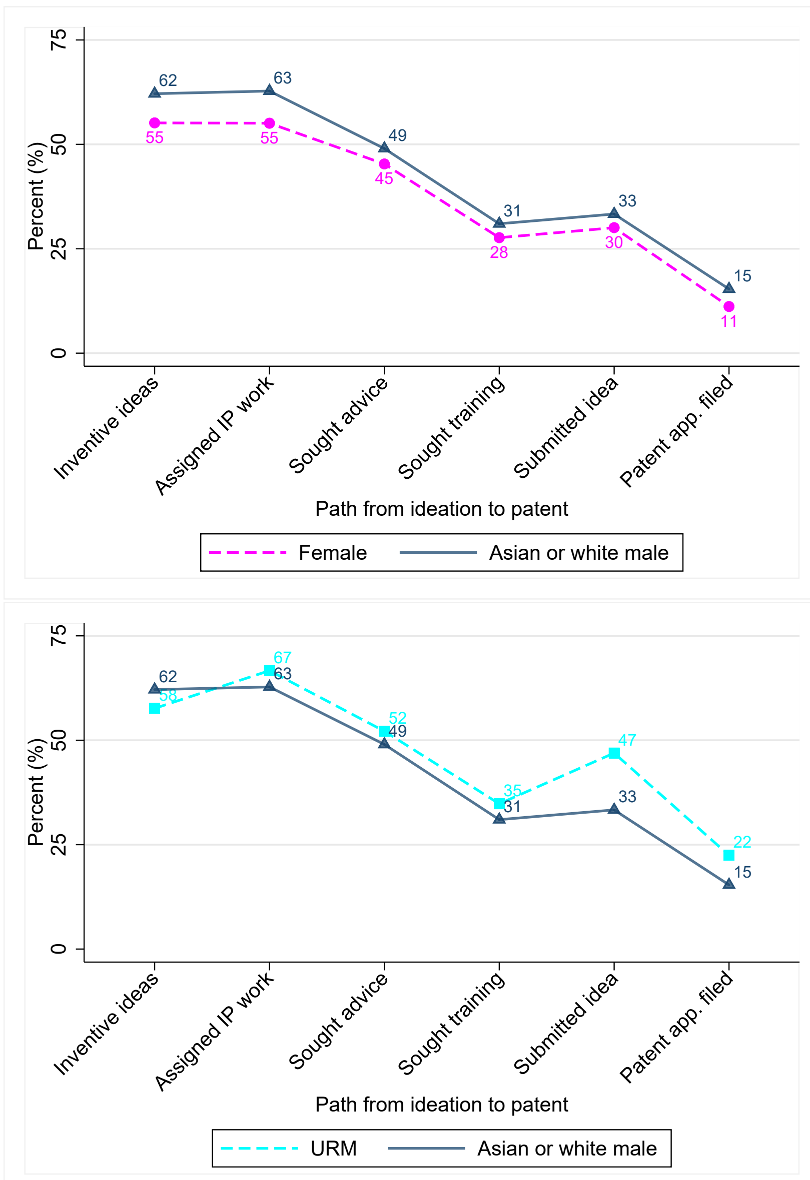


Table B.1.

Mentorship and perceived impact

This table provides descriptive statistics of mentorship and the perceived impact of such relationships. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
			RG	RG	URG	Male	Female	URM
	Obs.	Mean	Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Mentorship in your time at [Company]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Have you ever participated in a formal patent mentorship program?	251	24%	131	12%	44%***	12%	54%***	22%
Have you ever received informal patent mentorship?	354	38%	184	42%	38%	39%	46%	34%
Have you ever acted as a patent mentor?	140	39%	67	54%	18%***	53%	17%***	21%
Panel B. Perspective of those without a mentor								
What are the reasons you have no sought patent mentorship?								
I could not identify a potential mentor with overlapping interest	148	3%	77	3%	4%	3%	2%	8%
I did not believe patent mentorship would benefit me	148	7%	77	6%	8%	6%	10%	0%
I did not have time for patent mentorship	148	11%	77	12%	12%	12%	8%	17%
I did not think about it	148	79%	77	81%	78%	82%	78%	83%
I want to avoid activities that highlight my weakness to leaders	148	1%	77	1%	0%	1%	0%	0%
My co-workers already help me with IP so I don't need a mentor	148	3%	77	4%	2%	3%	4%	0%
Panel C. Perspective of those with a mentor and perceived impact								
How often would your patent mentor provide you with advice, suggestions, or support? (1 = Monthly, 6 = Several times a day)	115	1.7	54	1.7	1.7	1.7	1.7	1.6
Who first initiated the mentor-protégé like contact?								
Your mentor, by offering unsolicited advice, suggestions, or support	83	14%	35	29%	5%***	26%	5%***	13%
You, by asking the person for advice, suggestions, or support	83	7%	35	14%	2%*	15%	0%***	13%
You, by joining a formal mentorship program or an affinity group	83	78%	35	57%	93%***	59%	95%***	75%
To what extent do you disagree or agree with the statements about mentorship? (-2 = Strongly disagree, 2 = Strongly agree)								
I am planning to work on more invention disclosures at work	223	0.8	117	0.7	0.9	0.7	1.1**	0.7
I feel confident that I can incorporate my mentor's tips into my work process	221	0.7	116	0.7	0.6	0.6	0.8	0.4
I feel confident that I have the social connections necessary to get my invention ideas accepted by IP professionals	218	0.7	115	0.7	0.7	0.7	0.8	0.7
I learned a lot about patenting and become a better inventor	222	0.7	113	0.6	0.9*	0.5	1.1***	0.7
Being mentored increased my satisfaction at work	223	1.0	117	0.9	1.1	0.9	1.3***	0.8
Mentorship has helped me develop professionally and think broadly	89	1.2	34	1.2	1.2	1.1	1.3	1.0
I have benefited from my mentoring relationship	86	1.2	32	1.3	1.1	1.1	1.2	0.7*
My mentor introduced me to new inventors that I anticipate working with	86	1.1	31	1.0	1.1	1.0	1.2	1.1

Table B.2.

Early life exposure to invention

This table provides descriptive statistics of early life exposure to invention and the perceived impact in pursuing invention. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
			RG	RG	URG	Male	Female	URM
	Obs.	Mean	Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Factors influencing the pursuit of a technical career	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
How important have the following factors been in influencing you to pursue a technical career?								
Parent's encouragement	176	0.3	82	0.1	0.6*	0.1	0.6*	-0.2
Teacher's encouragement	154	0.1	69	0.0	0.3	-0.1	0.3	0.1
Role model	172	0.8	81	0.7	1.0	0.6	1.2***	0.6
Financial considerations	191	1.5	91	1.5	1.4	1.5	1.4	1.4
Intrinsic love of science and technology	172	0.3	78	0.1	0.6**	0.1	0.6**	0.1
Desire to solve global societal problems	168	0.4	76	0.3	0.6	0.3	0.6	0.4
Desire to solve problems for people in my community	182	1.1	84	1.1	1.0	1.1	1.0	0.5**
I realized I had talent in math/science	157	-0.6	73	-0.5	-0.5	-0.7	-0.4	-1.3*
Special recognition from being placed in advanced programs	148	-1.6	68	-1.8	-1.5	-1.9	-1.2**	-2.1
I attended a specialized STEM school	162	0.0	74	0.0	0.1	-0.1	0.1	-0.4
Panel B. Exposure to engineers and scientists								
How important was exposure to engineers or scientists in your pursuit of a technical career?								
One or both of my parents was a scientist	173	-1.4	80	-1.5	-1.3	-1.5	-1.2	-1.8
I had extended family members who were scientists	179	-1.1	82	-1.0	-1.0	-1.3	-0.8	-1.6
I had a role model within my community that was a scientist	166	-1.2	74	-1.4	-1.1	-1.3	-1.2	-1.0
I knew someone that was a scientist to whom I looked up to	162	-0.8	71	-0.8	-0.7	-0.9	-0.6	-1.2
I was inspired by one or more books I had read	168	-0.2	77	0.1	-0.5*	0.0	-0.5*	-0.9
Panel C. Sources of support in pursuit of a technical career								
Which of the sources of support have been important in your pursuit of a technical career?								
Financial support (e.g., scholarships or from family)	177	0.4	79	0.1	1.0***	0.0	0.9***	0.5
Emotional support	169	0.3	74	-0.1	0.8***	-0.2	0.8***	0.5
Network support (e.g., helped me get a job or find mentors)	166	0.4	76	0.2	0.5	0.1	0.7**	0.5
Childcare support	148	-1.5	65	-2.2	-0.8***	-2.0	-0.9***	-1.8

Table B.3.

Prior work experience

This table provides descriptive statistics of prior work experiences of STEM professionals and highlights the prevalence of issues commonly reported anecdotally. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a *t*-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate *p*-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
			RG	RG	URG	Male	Female	URM
	Obs.	Mean	Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Professional network	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Please assess the importance of your post-high-school network to your pursuit of a STEM career.								
Anyone in my network	149	0.9	72	0.8	1.2	0.8	1.0	0.8
Same-sex network	132	-0.6	64	-1.0	-0.1***	-1.0	0.0***	-0.7
Same-ethnicity network	132	-0.6	64	-1.1	0.1***	-1.1	0.1***	0.1
Same-university network	137	0.1	66	-0.2	0.6**	-0.3	0.7***	-0.3
Other-affinity network	71	-1.1	38	-1.1	-1.0	-1.2	-1.0	-1.4
Panel B. Previous work experiences								
If you've left a previous STEM job, please indicate the importance of the following possible reasons for doing so.								
I left due to the unfairness I experienced or witnessed	66	0.0	25	-0.2	0.1	-0.1	0.1	0.6
I was not satisfied with my work environment	83	0.9	35	0.9	0.8	0.9	0.9	0.4
I was recruited away to a different job	74	0.1	30	-0.1	-0.1	0.0	0.3	-0.2
I was not satisfied with my job duties	80	0.5	32	0.3	0.6	0.3	0.6	0.3
I did not feel that I belonged or that there were other people like me	54	-0.3	22	-0.6	0.0	-0.1	-0.6	0.6
Please indicate which, if any, of the following for you is true about your previous workplaces.								
Experienced at least one of the following	199	32%	92	20%	41%***	25%	41%**	42%
Experienced unfair management	199	26%	92	20%	28%	24%	28%	37%
Experienced stereotyping	199	7%	92	4%	8%	5%	9%	5%
Experienced bullying	199	12%	92	2%	22%***	4%	22%***	11%
Experienced sexual harassment	199	4%	92	1%	5%	1%	7%**	0%

Table B.4.

Analysis of idea submission databases by ethnicity

This table examines whether engineers fall off the inventive path with actual idea submission databases sourced from three collaborating firms. The main variable of interest is step in the IP process, where 1 = idea submission, 2 = patent application, and 3 = patent granted. In Panel A and Panel B, the analysis concentrates on ethnicity. Panel C combines the analysis with prior analysis of gender and first-time inventor status. Additional control variables include the number of inventors. Details of controls, fixed effects, and observations pertinent to all panels are listed beneath Panel C. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Dep. var. = Step in IP process				
	Firm 2	Firm 3	Firm 4	Firms 2, 3 & 4	
Panel A.	(1)	(2)	(3)	(4)	(5)
Has a URM inventor	0.049	-0.245	0.022**	0.052***	0.026***
	(0.047)	(0.200)	(0.009)	(0.009)	(0.009)
Adjusted R^2	0.106	0.218	0.078	0.069	0.103
Panel B.					
Pct. URM inventors	0.090	-0.321	-0.028	0.049**	-0.020
	(0.084)	(0.283)	(0.021)	(0.020)	(0.020)
Adjusted R^2	0.106	0.213	0.078	0.069	0.103
Panel C.					
Has a female inventor	-0.111**	-0.162*	-0.058***	-0.046***	-0.054***
	(0.053)	(0.096)	(0.007)	(0.007)	(0.007)
Has a first-time inventor	-0.112**	-0.035	-0.030**	-0.027***	-0.033***
	(0.047)	(0.080)	(0.004)	(0.004)	(0.004)
Has a URM inventor	0.058	-0.275	0.022**	0.053***	0.027***
	(0.047)	(0.202)	(0.009)	(0.009)	(0.009)
Observations	1549	133	65765	67447	67447
Adjusted R^2	0.111	0.225	0.080	0.070	0.105
Control variables	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y
Firm fixed effects	N	N	N	N	Y

Table B.5.

Gender and the inventive path conditional on demographics, identity, and risk-taking

This table summarizes the extent to which female engineers' perceptions and experiences along the inventive path are distinct. The table uses survey data and ordinary least squares (OLS) regressions for the analyses. Details of controls and fixed effects pertinent to all panels are listed beneath Panel E. Each panel represents step(s) in the inventive path. Demographic controls include age, work experience, education, region, and business unit. Inventive risk controls for the focus of the invention process (defensive, experimental, incremental, or other). Self-identity controls for identifying as an inventor and the action taken if unsure whether to submit an Invention Disclosure. Culture controls include aggregate cultural norms, cultural effectiveness, and generalized trust. Management controls account for managerial encouragement. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

Panel A. Dep. var = Yes, I have had an idea that might be patentable.						
	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.092*	-0.107**	-0.029	-0.035	-0.114**	-0.045
	(0.047)	(0.054)	(0.055)	(0.048)	(0.056)	(0.054)
Observations	483	371	330	371	330	372
Adjusted R^2	0.062	0.104	0.083	0.259	0.096	0.065
Panel B. Dep. var = Yes, I am aware of the IP process and tools.						
Female	-0.056***	-0.052***	0.022	-0.019	-0.013	-0.055***
	(0.018)	(0.019)	(0.030)	(0.019)	(0.035)	(0.019)
Observations	3744	3464	331	3387	332	3585
Adjusted R^2	0.138	0.172	0.005	0.211	0.013	0.129
Panel C. Dep. var = Yes, I have submitted Invention Disclosure(s).						
Female	-0.083***	-0.073***	0.080*	-0.053***	0.011	-0.086***
	(0.017)	(0.018)	(0.045)	(0.018)	(0.051)	(0.018)
Observations	3678	3442	314	3364	313	3563
Adjusted R^2	0.142	0.184	0.027	0.195	-0.004	0.125
Panel D. Dep. var = Yes, an Invention Disclosure of mine has been filed as a patent.						
Female	-0.057***	-0.045***	-0.009	-0.029**	-0.067	-0.062***
	(0.014)	(0.014)	(0.060)	(0.014)	(0.061)	(0.015)
Observations	3515	3415	295	3335	288	3400
Adjusted R^2	0.049	0.128	0.117	0.138	0.097	0.052
Panel E. Dep. var = Step in IP process.						
Female	-0.143***	-0.119***	0.056	-0.083***	-0.062	-0.151***
	(0.029)	(0.029)	(0.081)	(0.029)	(0.087)	(0.029)
Observations	3515	3415	295	3335	288	3400
Adjusted R^2	0.127	0.193	0.064	0.210	0.045	0.122
Firm fixed effects	Y	Y	Y	Y	Y	Y
Demographics	N	Y	N	N	N	N
Inventive risk	N	N	Y	N	N	N
Self-identity	N	N	N	Y	N	N
Culture	N	N	N	N	Y	N
Management	N	N	N	N	N	Y

Table B.6.

Ethnicity and the inventive path conditional on demographics, identity, and risk-taking

This table summarizes the extent to which URM engineers' perceptions and experiences along the inventive path are distinct. The table uses survey data and ordinary least squares (OLS) regressions for the analyses. Details of controls and fixed effects pertinent to all panels are listed beneath Panel E. Each panel represents step(s) in the inventive path. Demographic controls include age, work experience, education, region, and business unit. Inventive risk controls for the focus of the invention process (defensive, experimental, incremental, or other). Self-identity controls for identifying as an inventor and the action taken if unsure whether to submit an Invention Disclosure. Culture controls include aggregate cultural norms, cultural effectiveness, and generalized trust. Management controls account for managerial encouragement. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

Panel A. Dep. var = Yes, I have had an idea that might be patentable.						
	(1)	(2)	(3)	(4)	(5)	(6)
Underrepresented minority (URM)	0.066	0.126	0.163*	0.147**	0.075	0.087
	(0.071)	(0.083)	(0.084)	(0.073)	(0.080)	(0.081)
Observations	458	342	311	345	312	347
Adjusted R^2	0.058	0.097	0.097	0.250	0.089	0.066
Panel B. Dep. var = Yes, I am aware of the IP process and tools.						
URM	-0.089**	-0.086*	-0.067	-0.036	-0.049	-0.097**
	(0.041)	(0.048)	(0.048)	(0.047)	(0.050)	(0.043)
Observations	3683	3398	312	3322	314	3525
Adjusted R^2	0.138	0.170	0.009	0.210	0.010	0.126
Panel C. Dep. var = Yes, I have submitted Invention Disclosure(s).						
URM	-0.089**	-0.064	-0.072	-0.040	-0.093	-0.085**
	(0.039)	(0.046)	(0.072)	(0.045)	(0.072)	(0.041)
Observations	3616	3378	296	3301	297	3505
Adjusted R^2	0.132	0.175	0.023	0.189	-0.002	0.114
Panel D. Dep. var = Yes, an Invention Disclosure of mine has been filed as a patent.						
URM	0.016	0.013	0.083	0.052	0.047	0.024
	(0.036)	(0.037)	(0.095)	(0.037)	(0.088)	(0.038)
Observations	3452	3353	277	3274	272	3341
Adjusted R^2	0.043	0.120	0.102	0.132	0.073	0.044
Panel E. Dep. var = Step in IP process						
URM	-0.042	-0.034	0.030	0.027	-0.004	-0.025
	(0.072)	(0.075)	(0.130)	(0.074)	(0.126)	(0.076)
Observations	3452	3353	277	3274	272	3341
Adjusted R^2	0.118	0.182	0.047	0.202	0.025	0.111
Firm fixed effects	Y	Y	Y	Y	Y	Y
Demographics	N	Y	N	N	N	N
Inventive risk	N	N	Y	N	N	N
Self-identity	N	N	N	Y	N	N
Culture	N	N	N	N	Y	N
Management	N	N	N	N	N	Y

Table B.7.

Robustness check: Female patent citations at firms with an ineffective culture and poor management

This table is a robustness check to our main table testing the hypothesis that a female-invented patent from firms with ineffective culture and/or managers receive more citations. This table considers alternative proxies for female inventors, including the percent female inventors and lead female inventors. Panel A focuses on ineffective culture, and Panel B on poor management. Control variables include backward citations, examiner citations, total claims, firm size, market-to-book ratio, R&D-to-sales ratio, cashflow-to-capital ratio, leverage, and profitability. All panels include industry, headquarter state, technology class, and application year fixed effects. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Dep. var. = Forward citations	
Panel A. Ineffective culture	(1)	(2)
Pct. female inventors	-0.673***	
	(0.111)	
Pct. female inventors × Ineffective culture	0.393**	
	(0.154)	
Ineffective culture	-0.263***	-0.244***
	(0.046)	(0.044)
Lead female inventor		-0.290***
		(0.070)
Lead female inventor × Ineffective culture		0.207**
		(0.099)
Observations	118840	118840
Adjusted R^2	0.065	0.065
Panel B. Poor management		
Pct. female inventors	-0.730***	
	(0.111)	
Pct. female inventors × Poor management	0.515***	
	(0.154)	
Poor management	-0.381***	-0.358**
	(0.044)	(0.042)
Lead female inventor		-0.326***
		(0.071)
Lead female inventor × Poor management		0.275***
		(0.099)
Observations	118840	118840
Adjusted R^2	0.065	0.065
Controls	N	Y
Fixed effects	Y	Y

Table B.8.

Simple Difference-in-differences: Gender and Culture

This table presents the standard deviations for forward citations when granted patents are grouped into the simplified categories of gender and culture. Entries in the differences column and row represent simple differences except for the lower right column entry which represents the difference-in-differences estimate. No controls and fixed effects are used in these calculations.We test the null hypothesis that the difference-in-difference estimate is zero using bootstrapped standard errors, and present the 95% confidence interval below.

Panel A: Forward Citations (Standard Deviation)			
Gender/Culture	Effective	Ineffective	Difference
Female	3.762	2.252	1.509
Male	6.744	3.573	3.171
Difference	-2.982	-1.321	-1.662
95% Confidence Interval		[-3.012, -0.313]	

C Engineers in the United States

The United States, with its diverse mix of cultures, ethnicities, and histories, presents a particularly intriguing setting against which to analyze the barriers to patenting for high-tech engineers. Given the nation's rich diversity, with its long-standing challenges and progress in matters of race and gender, the experiences of U.S. engineers can offer distinct insights that might be less discernible in a global sample.

While our broader investigation, which encompassed survey responses from high-tech engineers and interviews with patent professionals, emphasized the experiences of URGs in multinational firms, it is essential to investigate the uniquely American context for two reasons. First, one cannot discount the possible nuances and complexities that arise due to the U.S.'s distinct historical trajectory, especially in matters of gender and racial dynamics. Thus, we are particularly interested in whether the opt-in, competitive ethos of innovation we observed within these firms is more or less evident in the United States.

A second reason to study the U.S. is its role in shaping innovation culture worldwide, given that its academic institutions and corporate behemoths serve as a foundational learning experience for young engineers. Thus, with their specific cultural and historical idiosyncrasies, American institutions could influence the emergence of certain behaviors and tendencies that subsequently manifest as factors working for or against the patenting process worldwide.

For these reasons, in this Appendix, we present tables and analyses that replicate our main findings but focus exclusively on engineers working in the United States. Through this narrowed lens, we look for any distinct patterns or insights that may further our understanding of the dynamics of the invention process within firms and any barriers to inclusive innovation in the high-tech engineering domain.

Table C.1.

Engineers' awareness and participation of the IP process

This table provides descriptive statistics of the engineers' awareness and participation in the invention process segregated by demographic groups. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
	Obs.	Mean	RG Obs.	RG Mean	URG Mean	Male Mean	Female Mean	URM Mean
Panel A. Awareness of invention process	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I am aware of the process and tools where you can submit an idea for patenting. (1 = Yes, 0 = No)	1297	50%	806	50%	45%	49%	50%	39%**
Have you ever attended an IP training? (1 = Yes, 0 = No)	308	46%	144	49%	41%	46%	47%	25%***
Yes, within the last 12 months	308	16%	144	22%	7%***	21%	9%**	13%
Yes, through an affinity group	132	13%	60	7%	17%*	6%	22%***	0%
Panel B. Participation in early steps of the invention process								
Have you ever had an idea that you thought might be patentable? (1 = Yes, 0 = No)	304	59%	143	60%	55%	62%	51%	63%
Are you regularly tasked with IP work? (e.g., participating in invention-creation meetings, authoring engineering documents, working on projects with patent KPIs) (1 = Yes, 0 = No)	473	71%	220	72%	71%	73%	64%*	76%
Are you interested in working more on tasks that would lead to being a named inventor? (1 = Yes, 0 = No)	833	63%	592	63%	61%	63%	60%	63%
Have you ever sought help with navigating [Company's] patent process (e.g., by attending a training, talking to a patent professional, or patent mentor)? (1 = Yes, 0 = No)	477	49%	221	53%	44%*	49%	51%	32%***
Panel C. Participation in later steps of the invention process								
How much have you participated in [Company's] patent process? (2 = Filed patent, 1 = Submitted but not filed, 0 = Did not submit)	1104	0.65	728	0.64	0.55	0.65	0.55	0.69
I have submitted Invention Disclosure(s) (1 = Yes, 0 = No)	1278	37%	800	38%	31%**	38%	34%	31%
An invention disclosure of mine has been filed as a patent application (1 = Yes, 0 = No)	1104	22%	728	22%	16%*	23%	16%**	24%
How many patent applications have been filed?	204	3.4	143	3.6	2.4	3.4	2.0	2.6
How was the Invention Disclosure submitted? Check all that apply.								
Via the inventor portal	382	36%	184	40%	28%**	36%	42%	18%***
Through a brainstorming or harvesting session	213	30%	107	32%	24%	32%	18%*	32%
With the help of a patent professional	420	11%	199	13%	7%*	12%	7%	7%
Patent professional reached out to me	172	8%	81	10%	6%	11%	4%	11%
I reached out to the patent professional	172	12%	81	11%	8%	13%	4%	17%

Table C.2.

Engineers' self-identity and perceived impact of their inventive ideas

This table provides descriptive statistics of the engineers' self-identity and the perceived impact of their inventive ideas. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively..

	Full sample		Specific subgroups					
			RG	RG	URG	Male	Female	URM
	Obs.	Mean	Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Self-identity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Do you self-identify as an inventor?	1292	48%	804	52%	35%***	51%	35%***	33%***
Do you self-identify as a problem-solver?	309	96%	144	98%	96%	98%	96%	94%
Life impact of becoming an inventor	72	1.22	41	1.25	1.25	1.23	1.41	0.89
Panel B. Confidence in inventive ideas								
Are you comfortable deciding if your idea is worthy of submitting as an invention disclosure? (-2 = uncomfortable, 2 = comfortable)	815	0.26	582	0.39	-0.09***	0.36	-0.16***	-0.02*
If you were unsure whether to submit an Invention Disclosure, what would you do next?								
Submit the Invention Disclosure anyway (and not seek advice)	1254	17%	794	18%	14%*	19%	10%***	21%
I will seek advice:	1085	79%	717	76%	83%**	76%	86%***	80%
From someone else	276	50%	138	49%	60%	50%	60%	46%
From a patent professional	276	24%	138	23%	18%	23%	20%	21%
Not submit the Invention Disclosure (and not seek advice)	1085	8%	717	8%	8%	8%	9%	5%
Panel C. Time for inventing								
Do you believe engaging in the patent process is a good use of your time? (1 = Yes, 0 = No)	169	47%	77	43%	49%	43%	53%	26%
In a typical work week, what percent (%) of your work time do you spend on the following tasks?								
Technical or engineering tasks that are likely to lead to inventions	132	11%	60	14%	7%**	13%	9%	6%
Technical or engineering tasks that are <u>unlikely</u> to lead to inventions	132	62%	60	65%	58%	65%	58%	61%
Other non-technical tasks	132	26%	60	21%	35%***	22%	32%**	33%
Men and women are equally assigned to projects that lead to inventive disclosures. (- 2 = Strongly disagree, 2 = Strongly agree)	808	0.76	579	0.87	0.32***	0.85	0.24***	0.41**

Table C.3.

Engineers' perceived objectives, feedback, and subjectivity of the IP process

This table summarizes engineers' perceptions of the objectives of invention and their lived experiences of submitting ideas. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
			RG	RG	URG	Male	Female	URM
	Obs.	Mean	Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Perceived objectives of the invention process	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
When working on projects that may result in Invention Disclosure, I focus on:								
Defending products and inventions from competitive threats	245	13%	126	15%	10%	15%	10%	13%
Experimenting with big, risky ideas that may prove to be foundational	245	24%	126	25%	22%	24%	24%	17%
Incremental changes as solutions to the problems	245	55%	126	55%	57%	54%	54%	57%
Other	245	8%	126	5%	12%*	7%	12%	13%
The invention I worked on is primarily of value to individuals or businesses that use it directly (-2 = Strongly disagree, 2 = Strongly agree)	85	1.23	41	1.23	1.04	1.24	1.19	0.90
The invention that I worked on is of significant value to society at large, beyond its direct users (-2 = Strongly disagree, 2 = Strongly agree)	78	0.48	35	0.31	0.56	0.45	0.53	0.94
In your view, what should be prioritized when developing an invention?								
Private value	126	5%	58	3%	0%	3%	8%	0%
Social value	126	11%	58	9%	18%	9%	14%	20%
Both equally	126	13%	58	10%	16%	11%	16%	10%
It depends on context	126	71%	58	78%	66%	77%	63%*	70%
Panel B. Feedback received from invention process								
I did not realize I could receive advice or feedback	185	24%	92	21%	40%	26%	26%	56%***
I receive better advice on submissions from peers and mentors	185	19%	92	18%	28%	18%	30%	17%
I was satisfied with the feedback being offered	185	56%	92	62%	40%***	54%	51%	33%*
I would rather focus on the future than feedback on what I cannot change	119	13%	61	15%	13%	14%	11%	10%
The feedback being offered is too negative	119	8%	61	7%	5%	10%	3%	10%
The feedback being offered is too vague	185	15%	92	14%	21%	15%	19%	11%
Panel C. Perception of the invention process								
For each of statement, indicate your level of agreement (-2 = Strongly disagree, 2 = Strongly agree)								
Men and women are equally likely to be named as inventors.	809	0.79	577	0.88	0.48***	0.87	0.41***	0.54
Men and women are equally likely to submit an invention disclosure.	809	0.66	577	0.77	0.28***	0.75	0.22***	0.28**
My manager encourages the submission of invention disclosures.	871	0.58	613	0.65	0.50	0.60	0.53	0.28**
Mgmt. supports increasing women's representation in the inventing process.	979	0.74	655	0.83	0.51***	0.81	0.44***	0.56*
Invention process participants are positively and publicly recognized.	813	0.75	580	0.80	0.69	0.77	0.68	0.66

Table C.4.

Factors working for and against participation in the IP process

This table provides descriptive statistics of the engineers' perceptions of the factors that are working against participation and that would encourage participation in the patenting process. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
			RG	RG	URG	Male	Female	URM
	Obs.	Mean	Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Factors preventing the submission of Invention Disclosures	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Individual inventor characteristics								
Discomfort with deciding if my idea is worthy of submitting	456	27%	217	29%	32%	26%	35%*	27%
I don't feel the work I do is likely to yield patentable inventions	456	46%	217	51%	46%	47%	49%	34%**
I have not perfected my inventions to my satisfaction	456	12%	217	11%	14%	11%	15%	18%
Too busy	456	51%	217	56%	45%**	56%	47%	48%
Too busy at home	407	26%	185	28%	28%	29%	31%	29%
Too busy with other work	407	33%	185	35%	27%	35%	24%*	37%
Management practices and the invention process								
Inventors are not positively and publicly celebrated	456	4%	217	5%	4%	4%	5%	4%
Not encouraged by management	456	15%	217	15%	15%	15%	13%	11%
The Invention Disclosure process needs improvement	171	8%	89	9%	5%	9%	5%	7%
Informal characteristics (e.g., cultural values and norms)								
Discomfort with disclosing my ideas to the patent review board	456	3%	217	3%	4%	4%	3%	7%
I do not have people with whom to collaborate on inventions	456	13%	217	10%	17%**	9%	22%***	9%
Inefficient workplace interactions	456	5%	217	5%	6%	5%	4%	2%
Our culture does not support inventing	407	6%	185	4%	7%	6%	6%	10%
Panel B. Factors that would facilitate greater involvement in IP process								
Change management practices								
Being assigned to projects more likely to yield patentable inventions	824	10%	584	9%	11%	10%	11%	10%
Being given more time to work on patentable inventions	774	8%	552	8%	8%	8%	8%	13%
Inventor recognition, like a celebration, plaque, or limited-edition t-shirt	1199	10%	746	9%	14%***	9%	15%**	12%
Offer more training (in-person or virtual)	1219	55%	763	57%	54%	57%	53%	55%
Change the cultural norms								
Strengthen the innovation culture	824	5%	584	4%	6%	5%	3%	12%**
Encourage mentoring by senior engineers/scientists	1199	39%	746	37%	50%***	36%	57%***	37%
Change invention process								
Offer more brainstorming sessions to get early ideas	1199	17%	746	15%	21%**	16%	22%**	24%**
One-on-one meeting with patent professionals	1199	18%	746	18%	17%	18%	16%	16%
Simplifying and anonymizing the patent process	1219	21%	763	22%	22%	22%	23%	21%

Table C.5.

Factors influential in encouraging engineers to invent and ideas for underrepresented inventors

This table provides descriptive statistics of the engineers' perceptions of the factors that have been most influential in encouraging engineers to submit Invention Disclosures. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
				RG	URG	Male	Female	URM
	Obs.	Mean	RG Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Most influential in encouraging idea submission	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Patent awards	276	47%	134	47%	55%	47%	55%	56%
Knowing that I'm solving a problem for the greater good	276	36%	134	43%	35%	42%	33%	26%
Culture of innovation at [Company]	276	30%	134	34%	29%	33%	30%	33%
Peers	276	26%	134	27%	22%	27%	25%	22%
Recognition inside of the [Company]	276	23%	134	25%	21%	25%	24%	11%
Mentors at [Company]	276	17%	134	15%	25%*	17%	24%	30%*
Recognition outside of the [Company]	276	18%	134	18%	22%	18%	22%	15%
Performance reviews and firing and promotion decisions	276	12%	134	13%	13%	12%	13%	11%
Patent professionals	276	11%	134	10%	4%*	10%	4%	11%
Management	276	8%	134	7%	13%	8%	9%	26%***
Internal trainings and policies	276	6%	134	7%	5%	7%	3%	7%
Famous inventors	276	6%	134	5%	4%	5%	7%	0%
Panel B. How can participation in idea submission be increased, especially for employees from under-represented groups?								
Better management	425	23%	299	23%	23%	22%	27%	14%
Offer more brainstorming sessions	425	17%	299	18%	17%	17%	19%	10%
Improve the culture	425	14%	299	12%	21%**	14%	19%	24%*
Simplify and anonymize the patent process	425	20%	299	19%	22%	20%	19%	31%*
Offer more training	425	15%	299	14%	17%	15%	16%	21%
Assign to projects more likely to yield inventions	425	15%	299	14%	16%	13%	19%	7%
Greater pecuniary incentives	425	8%	299	10%	6%	9%	8%	3%
Provide more time for invention	425	6%	299	6%	4%	5%	5%	3%
More recognition, publicity, and appreciation	425	2%	299	3%	1%	3%	0%	3%
Create a mentoring program	425	2%	299	2%	2%	1%	3%	0%
One-on-one meetings with patent professionals	425	0.2%	299	0.3%	0.0%	0.3%	0.0%	0.0%
Require idea submission for career advancement	425	0.2%	299	0.0%	1.2%*	0.3%	0.0%	3.4%***

Table C.6.

Mentorship and perceived impact

This table provides descriptive statistics of mentorship and the perceived impact of such relationships. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
				RG	URG	Male	Female	URM
	Obs.	Mean	RG Obs.	Mean	Mean	Mean	Mean	Mean
Panel A. Mentorship in your time at [Company]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Have you ever participated in a formal patent mentorship program?	171	13%	91	4%	29%***	5%	39%***	5%
Have you ever received informal patent mentorship?	299	41%	152	45%	41%	42%	49%	36%
Have you ever acted as a patent mentor?	93	45%	49	61%	13%***	57%	18%***	13%*
Panel B. Perspective of those without a mentor								
What are the reasons you have no sought patent mentorship?								
I could not identify a potential mentor with overlapping interest	108	4%	56	4%	6%	4%	3%	9%
I did not believe patent mentorship would benefit me	108	10%	56	9%	11%	8%	15%	0%
I did not have time for patent mentorship	108	13%	56	16%	11%	15%	9%	9%
I did not think about it	108	76%	56	77%	78%	79%	74%	91%
I want to avoid activities that highlight my weakness to leaders	108	0%	56	0%	0%***	0%	0%***	0%***
My co-workers already help me with IP so I don't need a mentor	108	5%	56	5%	3%	4%	6%	0%
Panel C. Perspective of those with a mentor and perceived impact								
How often would your patent mentor provide you with advice, suggestions, or support? (1 = Monthly, 6 = Several times a day)	65	1.7	34	1.6	1.6	1.6	1.7	1.5
Who first initiated the mentor-protégé like contact?								
Your mentor, by offering unsolicited advice, suggestions, or support	46	26%	23	43%	11%**	37%	11%**	33%
You, by asking the person for advice, suggestions, or support	46	13%	23	22%	6%	22%	0%**	33%
You, by joining a formal mentorship program or an affinity group	46	61%	23	35%	83%***	41%	89%***	33%
To what extent do you disagree or agree with the statements about mentorship? (-2 = Strongly disagree, 2 = Strongly agree)								
I am planning to work on more invention disclosures at work	143	0.8	75	0.7	0.7	0.7	1.0	0.4
I feel confident that I can incorporate my mentor's tips into my work process	142	0.5	74	0.6	0.4	0.5	0.6	0.1*
I feel confident that I have the social connections necessary to get my invention ideas accepted by IP professionals	139	0.7	74	0.8	0.4	0.7	0.6	0.3
I learned a lot about patenting and become a better inventor	140	0.6	73	0.4	0.7	0.5	0.9*	0.5
Being mentored increased my satisfaction at work	144	0.9	77	0.9	0.9	0.8	1.2**	0.7
Mentorship has helped me develop professionally and think broadly	41	1.0	16	0.8	1.2	0.8	1.3**	0.5
I have benefited from my mentoring relationship	40	1.1	15	1.0	1.0	1.0	1.2	0.0
My mentor introduced me to new inventors that I anticipate working with	40	0.8	15	0.7	0.6	0.8	0.8	0.5

Table C.7.

The current state of management, culture, and trust

This table provides descriptive statistics of the engineers' perceptions of management, culture, and trust for their co-workers. Columns 1 to 2 summarize the frequency and mean for the full sample, while columns 3 to 8 report statistics for specific subgroups based on gender and ethnicity. Asian and white male engineers define the represented group (RG), while females and underrepresented minorities (URMs) define the underrepresented group (URG). The stars in columns 5, 7, and 8 denote the significance level from a t-test, indicating the likelihood that the observed differences in subgroup means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Full sample		Specific subgroups					
	Obs.	Mean	RG Obs.	RG Mean	URG Mean	Male Mean	Female Mean	URM Mean
Panel A. Cultural norms	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Please evaluate the day-to-day interactions at [Company] and indicate which of these factors help us achieve our inventive goals (-2 = Weakness, which works against invention, 2 = Strength, key factor helping us to invent)								
Employees feel empowered, confident, and healthy	253	1.36	133	1.46	1.28	1.39	1.27	1.37
Information sharing among employees	255	1.38	134	1.40	1.37	1.37	1.31	1.70*
Employees' comfort in suggesting ideas, concerns, critiques	255	1.27	134	1.34	1.14	1.31	1.13	1.27
Trust among employees	252	1.24	133	1.26	1.23	1.23	1.26	1.37
New ideas develop organically	253	1.22	133	1.26	1.17	1.23	1.15	1.41
Broad agreement about goals	249	0.73	132	0.71	0.70	0.69	0.84	0.54
Willingness to hold employees accountable for unjust actions	242	0.24	129	0.32	0.11	0.26	0.15	-0.10**
Urgency with which employees work	237	0.03	124	0.10	-0.17	0.03	-0.08	-0.07
Average strength of cultural norms	259	0.95	134	0.99	0.86	0.95	0.89	0.95
Panel B. Management Practices								
I experience [Company] leadership to do the following: (0 = No, 1 = Yes)								
Give clear expectations	215	81%	113	82%	78%	83%	75%	88%
Provide coaching	207	65%	109	67%	36%	69%	52%	87%
Support my career development	228	83%	118	81%	84%	82%	80%	96%*
Gather multiple perspectives for decisions	224	71%	119	71%	68%	72%	63%	79%
Explain important details	219	78%	116	83%	73%	81%	69%*	85%
Be pro-active about improving or removing barriers to inventiveness	192	63%	103	62%	60%	63%	57%	82%*
Inspire confidence, enthusiasm, and the courage to be inventive	193	73%	105	74%	67%	75%	64%	89%*
Be ethical and make fair decisions	221	83%	119	89%	78%**	87%	72%***	80%
Panel C. Effective culture and trust								
I believe [Company]'s corporate culture: (1 = Needs a substantial overhaul, 4 = is exactly where it should be)	263	3.10	135	3.18	3.10	3.15	3.00	3.26
Would you say that most of the time, people at [Company] are trying to be helpful, or that they are mostly just looking out for themselves? (-2 = Always looking out for themselves, 2 = Trying to be helpful)	260	1.56	132	1.70	1.39***	1.62	1.44	1.48

D Student Survey

While our exploration into the factors that help facilitate involvement in the innovation process across firms reveals suggestive evidence, consistent with the existence of meaningful hurdles for engineers from URGs, it is also important to consider alternative explanations. For this reason, we explore the academic environment where foundational learning transpires for engineers. It is conceivable that the observed tendencies and behaviors manifesting as barriers to inclusive innovation within corporate environments may have their genesis in the educational experiences and institutional cultures of the universities.

Surveying STEM students thus becomes a critical parallel inquiry, as it permits an examination of whether these disincentives and biases are ingrained during the formative academic phase and subsequently carried into the professional realm. If this is the case, the locus of responsibility could potentially shift from the corporate entities to the academic institutions, necessitating a recalibration of policy interventions and institutional reforms aimed at fostering a more inclusive innovation ecosystem at the foundational level of post-secondary education.

Next, we describe the results from a survey of students enrolled in a set of core courses in the Physics department, Engineering department, Mathematics department, Computer Science department, and Leavey School of Business at Santa Clara University (SCU) in June of 2023. The response comes from a sample of students enrolled in core (i.e., required) courses for majors. Unlike the engineers, the students were incentivized to participate with the chance at a prize. Each student who completed the survey and provided their email address was entered in a drawing for $500. The student response rate was 21%, which is higher than for the sample of engineers.

D.1 Summary statistics

In Table D.1, we summarize the details of the demographic information collected from the student sample of 132 survey respondents. Confidentiality was ensured to promote honest answers, and a "Prefer not to answer" option was available for sensitive questions. For instance, among the student respondents, 52% self-identify as male, 44% as female, and 2% as other and 3% prefer not to provide their self-identified gender. Consistent with other studies suggesting women fall out at a later stage, the percentage of survey respondents self-identifying as female is double what it is among surveyed engineers in high-tech firms.

In terms of ethnicity, the percentage of Asian respondents is 48% which is similar to the 45% observed in the survey for engineers from the United States. SCU is a historically Hispanic-serving university and we do see that the percentage of student respondents indicating Latinx or multiple ethnicities is much higher than for the engineering sample. The gains to diversity appear to be primarily result in a lower sample of white respondents with only 29% of respondents indicating they are white as compared to 45% in engineers in high-tech firms. In terms of breakdown, all years are represented but the majority of students are sophomores (a common time to take required rather than elective courses). Twenty-two percent immigrated to the US to go to school or for a parent to take a job.

Most aspire to be engineers upon graduation (46%), some entrepreneurs (15%), some in science or technical roles (13%), and 26% are unsure. These numbers largely reflect the indicated majors with 35% declaring an engineering major, 33% a business major, 18% a math or science major, 5% a data science major, and 9% still undeclared.

Turning to Table D.2, we see that students indicate that they are somewhat familiar with the process of inventing a new product or technology, but less familiar with the process of patenting an invention. We then ask students how familiar they perceive themselves to be relative to their peers. Here, we see that students from URGs are more likely to indicate that they are familiar with the invention and patenting process. One-in-five students indicate that they have attended a workshop, seminar, or course that discussion invention of the patenting process, with most indicating that they had learned about patenting through coursework.

Among students 44% indicate that they have had an idea that they thought might be novel or patentable and the percentage is the same among students from URGs. Despite students having ideas, only 8% indicated that they acted on this idea b pursuing a patent for it. Given the small sample, it is hard to discern a statistical difference, but we do observe that students from URGs are more likely to have pursued the idea on their own relative to peers who are more likely to indicate pursuing the idea through a job or internship. Interestingly, when we asked about the feedback received on the idea, students from URGs are more likely to have sought advice from engineers, scientists, or professors, whereas their peers are less likely to have even tried to solicit advice.

Table D.3 begins to explore students' self-identity and the perceived impact of their inventive ideas. Here, we see no difference in the reported rates at which students self-identify as inventors or problem-solvers. We do, however, see much higher percentage of students identify as problem solvers (94%) which is similar to the levels we see with engineers. Interestingly, we see no difference in confidence in coming up with a new technical idea or in successfully navigating the process to bring the idea to impact. Unlike when we focus on engineers, when we ask students what they would do if they were unsure whether to submit an idea or not, students are much more likely to see advice and do so from someone experienced (e.g., inventor, mentor, or professor). We see that students from URGs are more likely to aspire to be a named inventor, and interestingly, they perceive differences in terms of the percentage of time that they think they will spend on technical tasks likely and unlikely to lead to invention in their first post-college job. This marks a difference from the engineers who did not have differences in expectations. This need for members of URGs to update their prior beliefs to a larger extent than their peers is intriguing and potentially consistent with the subsequent time and effort allocations discussed in the main body of the paper.

Finally, we ask the students about the perceived objective of the invention process. Here, we do see that students from URGs are less likely to indicate that they focus on experimenting with big, risky ideas that may prove to be foundational. Next, as with the engineers, we see that students from URGs are more likely to want to work on inventions that have meaningful social value in addition to private value, and they are more likely to believe that social value should be prioritized when developing an invention.

Table D.4 examines the factors influencing students to pursue a technical career. Here we see that money is less influence to students from URGs than it is to their peers. Money is the #2 most influential for any student but #5 for students from URGs. Whereas knowing that they are solving a problem for the greater good or solving a problem that they have personally experienced or been exposed to is more influential to students from URGs. Finally, to a lesser extent positive feedback received from others is more influential to members of URGs. The top three factors for students from URGs are knowing that I'm solving a problem for the greater good (48%), knowing that I'm solving a problem that I have personally experienced (40%) or been exposed to and work or internship experience (31%).

Next, we ask students "What resources or initiatives do you believe would increase your desire to pursue invention as part of your career?" Here again we see differences. The top 3 answers are mentoring from an engineer or scientist (53%), coursework (47%), and training and events focused on invention (39%). Yet for students from URGs, a top 3 answer is "having role models that I have an affinity with (e.g., race, gender) talk to me about careers involving invention." This need for role models may help to explain why students from URGs also have less accurate perceptions of the time they will be able to spend on inventive activities.

Table D.5 explores mentorship and its perceived impact. We see no difference in rates of mentorship among students based on ethnicity or gender. Three-in-ten students indicate that they have a mentor whom they can speak to about ideas for an invention. Similar to engineers, the most common reason for not having a mentor is that they had not thought about it. Interestingly, about 29% of students from URGs say they could not find a mentor, but this rate is similar to all students. The only answer that is statistically different for diverse students is their belief that their peers help plenty so they do not need mentors. If the students could choose, they would like to receive mentorship from professionals in their field of study rather than from academic advisors, peers, or even someone knowledgeable with an affinity (e.g., same race or gender). Finally, this table examines the perspective of those with a mentor and the perceived impact. The results are nearly identical across race and gender. Most strongly agree that they have benefitted from the mentoring relationship, and feel confident that they can incorporate their mentor's tips to develop inventions. Two results of note are that students from URGs with a mentor are much more likely to have a professor as a mentor (74% vs. 51% for any student), yet they also are less likely to agree that they are planning to pursue a career in invention and work on more inventions as a result of mentorship.

Table D.6 examines students participation in STEM activities to prepare for college. This, like our survey of students, helps us understand better the paths that led to becoming an engineer and how that may have shaped actions and perceptions toward inclusive innovation. Here we learn that gendered-extracurricular activities along with robotics club rank as the most influential in their decision to pursue a STEM degree. When asked what motivated them to attend a STEM event in the first place, we see that students from URGs are more motivated by "Practice - implementing real-life solutions." Skills development and networking are the other motivators in the top 3. Finally, consistent with anecdotes, the sample of students from URGs are more likely to indicate that "yes" they are the first person in their family to complete high school and to study STEM in college.

Panel A of Table D.7 echoes previous results and may serve as an explanation for the learned behavior and desire for recognition and encouragement by engineers from URGs. We see that students from URGs are significantly more likely to indicate that parent and teacher's encouragement as well as special recognition from being placed in advanced programs at school were important factors influencing their pursuit of a technical career. Here, as in previous questions, we see that both financial considerations and the ability to do meaningful work play a big role too. Panel B examines exposure to engineers and scientists. Here we learn that students pursuing a technical career are more likely to have had a parent who was also a scientist, suggesting exposure is important. Finally, Panel C explores sources of support. While there is no statistical difference by demographics, it is worth noting the relative ranking of which sources of support are most important. Here we learn that most important sources of support are financial support (3.8), emotional support (3.3), community support (3.0), network support (2.5), and finally childcare support (2.1).

D.2 Comparison to engineers

Some of the questions posed to students are nearly identical to those of engineers. In the next set of questions, we directly test whether students' answers and their perceptions of the invention process differ from those of the engineers. These tests help substantiate arguments that some of the barriers to patenting are firm-specific rather than an artifact of bias from educational experiences or related exposures earlier in life.

Table D.8 compares and contrasts engineers' vs. students' perceptions of the inventive process. Panel A focuses on awareness and familiarity with invention. Surprisingly, students claim to be more aware of the inventive process but have attended fewer trainings on or off-campus. When asked about a patentable idea, fewer students indicate that they have had one (44% of students vs. 55% of engineers). Interestingly, inventive ideation is statistically indistinguishable when focusing on engineers from URGs vs. students from URGs. This suggests that improved language and framing, even early in the educational process, may help get those with inventive ideas to recognize that they are, in fact, patentable ideas.

The importance of self-identity is reinforced in Panel B, which summarizes perceptions of self-identity and confidence as inventors among engineers and students. Students are less likely to identify as inventors than engineers, which is unsurprising given their experience. Interestingly though, the results are statistically indistinguishable when we look at students vs. engineers from URGs. As noted before, when the question is framed as a problem-solver rather than an inventor, the rates of self-identifying with the term are much higher for students and engineers from URGs. Like the perception of a patentable idea, this suggests language and more accurate renderings of inventors may help mitigate the fallout from an inventive concept to submitting it as a patent application. The comfort level in navigating the process of bringing ideas to impact is also statistically indistinguishable for students vs. engineers from URGs but significantly different when comparing as a whole. This tells us that self-identity early on is a factor, but it is not the only factor taken together with the rest of the results. In fact, the next question starts to point to where additional confusion may arise. Students from URGs are significantly more likely to indicate that they would seek advice if they were unsure whether to submit an idea. The question of mentoring and feedback then becomes a crucial consideration.

Another critical factor appears to be time. Panel C of Table D.8 shows meaningful differences in what students think their typical work well will look like in terms of time allocated to tasks relative to what actual engineers say. Students are much more likely to believe they will spend time working on tasks likely to lead to inventive disclosures and much less time on tasks unlikely to lead to inventive disclosures. The gap is much starker and larger when looking at engineers vs. students from URGs. While we learned that engineers from URGs are being assigned tasks less likely to yield a patentable invention, this under-assignment is coupled with students from URGs believing that they will spend more time on tasks likely to lead to inventive disclosures than their peers. This could result from a lack of exposure to engineers or mentors, leading to a less accurate perception of reality.

Finally, in Panel D, we focus on the perceived objectives of the inventive process. Here a few comparisons stand out. First, there is no statistical difference to reject the hypothesis that students and engineers have the same tolerance for risk when approaching inventive tasks. This is important because if we see later on that they are failing to have patents granted, it should not be because their patents are riskier or of a different quality since everyone appears to have the same tolerance for risk. We see a divergence in the goals of the patenting process. Again, engineers and students from URGs strongly believe that the social value, or the significance to society at large, beyond the direct users of the product matters more. In different forms of the question (Likert scale and simple yes vs. no), students, especially those from URGs, prioritize social value over private value in invention. For example, 28% of students believe social value should be prioritized vs. 12% of engineers. On a Likert scale, students are 0.35 points less likely to think that the inventions they will work on should primarily be of value to individuals or businesses that use them directly.

Table D.1.
Students demographic statistics
This table provides descriptive statistics from the survey demographic variables questions for all student survey responses.

Panel A. Demographic characteristics	Obs. (1)	Mean (2)
Gender		
Female	132	44%
Male	132	52%
Non-binary	132	1%
Other	132	1%
Prefer not to say	132	3%
Ethnicity		
Asian	132	48%
African American/Black	132	2%
Hispanic/Latino	132	8%
Two or more ethnicities (not Hispanic/Latino)	132	6%
American Indian, Alaska Native, Native Hawaiian, or other Pacific Islander	132	2%
White/Caucasian	132	29%
Prefer not to say	132	5%
Immigrant status		
Immigrated to the US to go to school or for a parent to take a job	129	22%
Major		
Business	132	33%
Data science or analytics	132	5%
Engineering	132	35%
Math or science	132	18%
Undeclared	132	9%
Desired post-college job title		
Engineer	128	46%
Entrepreneur	128	15%
Scientist	128	6%
Technical staff	128	7%
Other	128	26%
Education (Current status)		
Freshman	131	14%
Sophomore	131	43%
Junior	131	17%
Senior	131	13%
Graduate student	131	14%

Table D.2.

Students' awareness and participation in the invention process

This table provides descriptive statistics of students' awareness and participation in the invention process. Observations are reported in column (1), and the percentages of students indicating "yes" are reported in column (2). Columns (3) and (4) repeat this exercise but only for students who self-identify as being a member of an underrepresented group ("URG"). To match the context of the survey of professional engineers, URG is defined as self-reporting a gender that is not male or an ethnicity that is not White and not Asian). The stars in the table denote the significance level from a t-test, indicating the likelihood that the observed differences in group means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Any student		Student from URGs	
	Obs.	Mean	Obs.	Mean
Panel A. Awareness of the invention process	(1)	(2)	(3)	(4)
How familiar are you with the process of inventing a new product or technology? (1 = Not at all, 5 = Very familiar)	144	2.63	68	2.72
How familiar are you with the process of patenting an invention? (1 = Not at all, 5 = Very familiar)	134	2.11	61	2.13
How familiar, compared to you, do you think your peers in your field of study are with the invention and patenting process? (-1 = less familiar, 0 = about the same, 1 = more familiar)	152	-0.04	71	0.06*
Have you attended a workshop, seminar, or course that discussed invention or the patenting process? (1 = Yes, 0 = No)	155	19%	72	18%
A course	155	10%	72	11%
An event organized on campus	155	5%	72	3%
An event organized off-campus	155	6%	72	4%
Panel B. Participation in the invention process				
Have you ever had an idea that you thought might be novel or patentable? (1 = Yes, 0 = No)	146	44%	72	44%
Did you act on this idea, for example, by pursuing a patent for this idea or invention? (1 = Yes, 0 = No)	146	8%	72	8%
On my own	146	4%	72	6%
Through the University	146	2%	72	3%
Through my job or internship	146	1%	72	0%
Panel C. Feedback received				
In the context of your inventive ideas, please check all factors that are relevant to any feedback you received.				
I did not realize I could receive advice or feedback	78	14%	39	18%
I did not try to solicit any feedback	78	29%	39	21%
I do not have inventive ideas	110	13%	44	16%
I received advice on my idea from my peers	78	45%	39	46%
I received advice on my idea from senior engineers, scientists, or professors	78	26%	39	31%
I was satisfied with the feedback being offered	78	21%	39	23%
The feedback being offered is too negative	78	1%	39	3%
The feedback being offered is too vague	78	13%	39	13%

Table D.3.

Students' self-identity and perceived impact of their inventive ideas

This table provides descriptive statistics of the engineers' self-identity, confidence, aspirations, and the perceived impact of their inventive ideas. Observations are reported in column (1), and the percentages of students indicating "yes" are reported in column (2). Columns (3) and (4) repeat this exercise but only for students who self-identify as being a member of an underrepresented group ("URG"). To match the context of the survey of professional engineers, URG is defined as self-reporting a gender that is not male or an ethnicity that is not White or Asian. The stars in the table denote the significance level from a t-test, indicating the likelihood that the observed differences in group means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Any student		Students from URGs	
	Obs.	Mean	Obs.	Mean
Panel A. Self-identity	(1)	(2)	(3)	(4)
Do you self-identify as an inventor?	154	37%	72	35%
Do you self-identify as a problem-solver?	154	94%	72	92%
Do you self-identify as a leader?	154	74%	72	78%
Panel B. Confidence in inventive ideas				
How confident are you in coming up with a new technical idea? (1 = Not at all confident and 5 = Very confident)	149	2.83	69	2.90
How confident are you in successfully navigating the process to bring this idea to impact?	141	2.64	65	2.69
What would you do next if you were unsure whether to submit an idea as an Invention Disclosure?				
Submit the idea anyway (and not seek advice)	145	1%	71	0%
I will seek advice:	145	92%	71	96%
From someone experienced (e.g., inventor, mentor, professor)	145	71%	71	76%*
From a patent professional	145	21%	71	20%
Not submit the idea (and not seek advice)	145	6%	71	4%
Panel C. Aspirations and time for inventing				
Do you aspire to be a named inventor? (1 = Yes, 0 = No)	178	54%	72	71%
In your first post-college job, what percent (%) of your time do you expect to spend on the following tasks:				
Technical tasks that are likely to lead to inventions	116	25%	59	28%
Technical tasks that are unlikely to lead to inventions	116	42%	59	37%*
Other non-technical tasks	116	32%	59	35%
Panel D. Perceived objectives of the invention process				
When working on projects or products that may result in an invention, I focus on:				
Expanding academic research into something patentable	133	17%	69	20%
Experimenting with big, risky ideas that may prove to be foundational	133	26%	69	19%**
Incremental changes as solutions to the problems	133	55%	69	58%
Other	133	2%	69	3%
The innovative or inventive tasks that I want to work on will be primarily of value to individuals or businesses that use it directly. (-2 = Strongly disagree, 2 = Strongly agree)	115	0.89	60	0.89
The innovative or inventive tasks that I want to work on will be of significant value to society at large, beyond its direct users.	111	0.87	59	0.95
The innovative or inventive tasks that I want to work on will be of significant value to people like me or in my community.	114	0.83	61	0.82
In your view, what should be prioritized when developing an invention?				
Private value	178	17%	72	19%
Social value	178	40%	72	51%
Value to people like me or in my community	178	31%	72	43%
It depends on the context	178	43%	72	64%

Table D.4.

Factors influencing students to pursue a technical career

This table provides descriptive statistics of students' awareness and participation in the invention process. Observations are reported in column (1), and the percentages of students indicating "yes" are reported in column (2). Columns (3) and (4) repeat this exercise but only for students who self-identify as being a member of an underrepresented group ("URG"). To match the context of the survey of professional engineers, URG is defined as self-reporting a gender that is not male or an ethnicity that is not White or Asian. The stars in the table denote the significance level from a t-test, indicating the likelihood that the observed differences in group means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Any student		Students from URGs	
	Obs.	Pct. indicating "Top 3" most influential	Obs.	Pct. indicating "Top 3" most influential
Panel A. Most influential in encouraging you to pursue technical	(1)	(2)	(3)	(4)
Chance to make money from an invention	128	34%	67	27%*
Courses, training, and events	128	12%	67	15%
Culture of innovation in the bay area	128	22%	67	22%
Famous inventors	128	3%	67	1%
Getting good grades in school	128	9%	67	7%
Knowing that I'm solving a problem for the greater good	128	44%	67	48%
Knowing that I'm solving a problem that I have personally experienced or been exposed to	128	34%	67	40%
Mentors	128	14%	67	13%
Peers	128	14%	67	15%
Positive feedback I've received from others	128	26%	67	30%
Public recognition	128	9%	67	9%
Work or internship experience	128	29%	67	31%
Panel B. What resources or initiatives do you believe would increase your desire to pursue invention as part of your career?				
Anonymize and simplify the invention process	128	13%	68	9%
Brainstorming sessions to get early ideas	128	34%	68	31%
Coursework focused on invention	128	47%	68	53%
Having role models that I have an affinity with (e.g., race, gender) talk to me about careers involving invention	128	37%	68	47%***
Having someone at the University reach out to me about my ideas	128	31%	68	32%
Inventor recognition, like a celebration or limited-edition t-shirt	128	9%	68	7%
Mentoring from an engineer or scientist	128	53%	68	49%
Training and events focused on invention	128	39%	68	40%

Table D.5.

Mentorship and perceived impact

This table provides descriptive statistics of mentorship received and the perceived impact of such relationships. Observations are reported in column (1), and the percentages of students indicating "yes" are reported in column (2). Columns (3) and (4) repeat this exercise but only for students who self-identify as being a member of an underrepresented group ("URG"). To match the context of the survey of professional engineers, URG is defined as self-reporting a gender that is not male or an ethnicity that is not White or Asian. The stars in the table denote the significance level from a t-test, indicating the likelihood that the observed differences in group means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Any student		Students from URGs	
	Obs.	Mean	Obs.	Mean
Panel A. Mentorship	(1)	(2)	(3)	(4)
Do you have a mentor whom you could speak to about ideas you might have for an invention? (1 = Yes, 0 = No)	130	32%	68	28%
Panel B. Perspective of those without a mentor	(1)	(2)	(3)	(4)
What are the reasons you have not sought mentorship?				
I was unable to find a mentor	88	33%	49	29%
I don't believe a mentor would benefit me	88	6%	49	4%
I don't have time or could only meet with a mentor at inconvenient times	88	16%	49	16%
I didn't know I should have one	88	59%	49	65%
My peers help me plenty, so I don't need a mentor	88	11%	49	18%**
Wanted to avoid activities that highlighted my weakness to others	88	9%	49	12%
If you could choose, who would you most like to receive mentorship from?				
Academic advisor	87	20%	49	20%
Professional in my field of study	87	51%	49	45%
Patent attorney	87	6%	49	6%
Fellow student or peer	87	7%	49	6%
Someone knowledgeable that I have an affinity with (e.g., race or gender)	87	17%	49	22%
Panel C. Perspective of those with a mentor and perceived impact	(1)	(2)	(3)	(4)
How many times per month have you met with your mentor?	39	2.3	18	2.4
Which of the following describes your mentor?				
Professor	41	51%	19	74%***
Professional in my field of study	41	54%	19	42%
Patent attorney	41	5%	19	5%
Fellow student or peer	41	27%	19	26%
Did you and your mentor have an affinity? (1 = Yes, 0 = No)	41	41%	19	53%
Same gender	41	27%	19	26%
Same age	41	27%	19	26%
Same ethnicity	41	22%	19	21%
Same major	41	22%	19	21%
To what extent do you disagree or agree with the statements about mentorship? (-2 = Strongly disagree, 2 = Strongly agree)				
I am planning to pursue a career in invention and work on more inventions	38	0.1	17	-0.1
I feel confident that I can incorporate my mentor's tips to develop inventions	38	0.8	18	0.8
I feel confident that I have the social connections to get my ideas accepted	34	0.3	15	0.3
I learned a lot about patenting, and I have become a better inventor	36	0.4	16	0.3
I have benefitted from my mentoring relationship	39	1.3	18	1.3
My mentor introduced me to new inventors that I anticipate connecting with	36	0.1	16	0.3

Table D.6.

Students participation in STEM activities to prepare for college

This table provides descriptive statistics of students' motivation and participation in STEM activities and events. Observations are reported in column (1), and the percentages of students indicating "yes" are reported in column (2). Columns (3) and (4) repeat this exercise but only for students who self-identify as being a member of an underrepresented group ("URG"). To match the context of the survey of professional engineers, URG is defined as self-reporting a gender that is not male or an ethnicity that is not White or Asian. The stars in the table denote the significance level from a t-test, indicating the likelihood that the observed differences in group means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Any student		1 =	2 =	3 =	4 =	5 =	Students from URG	
			Not at all		Somewhat important		Very		
	Obs.	Mean	important				important	Obs.	Mean
Panel A. STEM activities	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
If you participated in any of the following activities before enrolling in college, how influential were they on your decision to pursue STEM?									
Robotics club	62	2.1	58%	6%	15%	8%	13%	31	2.4
Math club	56	1.9	63%	7%	20%	4%	7%	31	2.1
Hackathon	63	2.0	59%	10%	10%	13%	10%	31	2.0
Gendered extracurricular STEM activity	59	1.9	64%	8%	5%	15%	7%	34	2.3**
STEM camp	58	2.1	57%	9%	9%	17%	9%	31	2.2
Programs/activities at the library	57	1.7	70%	11%	7%	5%	7%	34	1.7
Panel B. STEM activity motivation									
What is your motivation for attending STEM events? (Check all that apply)									
Fun - A creative outlet	52	54%						24	58%
Networking - Make industry connections	52	69%						24	75%
Practice - Implement real-life solutions	52	71%						24	88%**
Skills - Grow and learn advanced technical skills	52	77%						24	75%
Society - Help make progress on community-based goals	52	29%						24	29%
Teamwork - Collaborate with like-minded individuals	52	71%						24	63%
Winning - I love competitions	52	23%						24	21%
Panel C. Achieving a college education									
What kind of high school did you attend?									
Public school	130	48%						72	50%
Private school	130	54%						72	53%
School specializing in STEM	130	2%						72	4%
Please answer "yes" or "no" to the following questions. I was the first person in my family to:									
Complete high school	178	4%						72	8%
Complete college	178	5%						72	4%
To study STEM in college	178	15%						72	22%
Pursue a post-graduate STEM degree	178	13%						72	17%
Pursue a post-graduate STEM degree in another country	178	10%						72	11%

Table D.7.

Factors students perceive as influential in their pursuit of a technical career

This table provides descriptive statistics of the factors, role models, and sources of support that students perceive as influential in their pursuit of a technical career. Observations are reported in column (1), and the percentages of students indicating "yes" are reported in column (2). Columns (3) and (4) repeat this exercise but only for students who self-identify as being a member of an underrepresented group ("URG"). To match the context of the survey of professional engineers, URG is defined as self-reporting a gender that is not male or an ethnicity that is not White or Asian. The stars in the table denote the significance level from a t-test, indicating the likelihood that the observed differences in group means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	Any student		1 =	2 =	3 =	4 =	5 =	Students from URG	
			Not at all	Somewhat important			Very		
	Obs.	Mean	important				important	Obs.	Mean
Panel A. Factors influencing the pursuit of a technical career	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
How important have the following factors been in influencing you to pursue a technical career?									
Parent's encouragement	111	3.1	16%	17%	27%	16%	23%	61	3.4**
Teacher's encouragement	89	2.3	38%	18%	22%	15%	7%	49	2.7***
Role model	105	2.8	26%	14%	27%	20%	13%	56	2.8
Financial considerations	114	3.6	10%	11%	23%	25%	32%	62	3.6
Intrinsic love of science and technology	110	3.4	12%	16%	20%	19%	33%	60	3.4
Desire to solve global societal problems	109	3.1	19%	14%	26%	18%	23%	60	3.2
Desire to solve problems for people in my community	108	3.2	14%	13%	31%	21%	21%	58	3.3
I realized I had talent in math/science	106	3.1	18%	12%	29%	20%	21%	58	3.3*
Special recognition from being placed in advanced programs	78	1.7	56%	24%	10%	9%	14%	45	2.0**
I attended a specialized STEM school	108	3.2	21%	9%	23%	25%	21%	59	3.2
Ability to do meaningful work	111	3.5	8%	12%	30%	21%	30%	61	3.5
Ability to engage in citizen science	83	1.8	65%	8%	13%	11%	2%	46	1.7
Less discrimination than other fields	82	2.0	54%	13%	16%	10%	7%	45	1.9
Panel B. Exposure to engineers and scientists	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
How important was exposure to engineers or scientists in your pursuit of a technical career?									
One or both of my parents was a scientist	91	2.4	47%	10%	14%	14%	14%	52	2.7**
I had extended family members who were scientists	85	2.3	52%	5%	18%	11%	15%	48	2.5
I had a role model within my community that was a scientist	82	2.3	41%	16%	24%	11%	7%	46	2.2
I knew someone that was a scientist to whom I looked up to	84	2.6	31%	24%	18%	13%	14%	47	2.5
I was inspired by one or more books I had read	85	2.2	44%	24%	9%	13%	11%	49	2.1
I received encouragement from a role model	83	2.3	42%	14%	24%	13%	6%	46	2.3
Panel C. Sources of support in pursuit of a technical career	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Which of the sources of support have been important in your pursuit of a technical career?									
Financial support (e.g., scholarships or from family)	90	3.8	17%	6%	9%	23%	46%	48	3.8
Emotional support	84	3.3	23%	8%	20%	18%	31%	46	3.3
Network support (e.g., helped me get a job or find mentors)	65	2.2	45%	14%	25%	8%	9%	34	2.5
Childcare support	52	1.8	67%	6%	15%	2%	10%	24	2.1
Support from my community	76	2.8	26%	20%	24%	13%	17%	41	3.0

Table D.8.

Student vs. engineers: awareness, goals, and self-identity

This table compares and contrasts engineers vs. students perceptions of the inventive process. It summarizes familiarity with the invention process, the goals of the inventive process and careers, and self-identity in relation to invention. Observations are reported in column odd columns, the percent of students or engineers reporting "yes" are reported in even columns. Columns (1) to (4) explore the full sample, and Columns (5) to (8) focus on engineers and students that are members of underrepresented groups ("URG"). To match the context of the survey of professional engineers, URG is defined as self-reporting a gender that is not male or an ethnicity that is not White or Asian. The stars in the table denote the significance level from a t-test, indicating the likelihood that the observed differences in group means are not due to chance. ***, ** and * indicate p-values under the assumption of a single test of 1%, 5%, and 10%, respectively.

	All engineers		All students		Engineers from URG		Students from URG	
	Obs.	Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
Panel A. Awareness of invention process	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Awareness of invention and patenting process	3912	40%	134	69%***	904	39%	61	66%***
Have you ever attended a relevant training? (1 = Yes, 0 = No)	559	45%	155	19%***	183	44%	72	18%***
Have you ever had an idea that you thought might be patentable? (1 = Yes, 0 = No)	556	55%	146	44%**	182	49%	72	44%
Panel B. Self-identity and confidence								
Do you self-identify as an inventor?	3874	46%	154	37%**	891	35%	72	35%
Do you self-identify as a problem-solver?	561	96%	154	94%	183	95%	72	92%
How comfortable are you in navigating the process of bringing your idea to impact? (-2 = Not at all comfortable, 2 = Very comfortable)	3104	0.10	151	-0.29***	642	-0.12	70	-0.24
If you were unsure whether to submit an idea, what would you do next?								
Submit the invention anyway (and not seek advice)	3703	12%	145	1%***	838	9%	71	0%***
I will seek advice	3512	80%	145	92%***	770	85%	71	96%**
Not submit the invention (and not seek advice)	3512	10%	145	6%	770	9%	71	4%
Panel C. Time for invention								
In a typical work week, what percent (%) of your work time do you spend (expect to spend) on the following tasks?								
Technical or engineering tasks that are likely to lead to inventive disclosures	238	15%	116	25%***	97	12%	59	28%***
Technical or engineering tasks that are unlikely to lead to inventive disclosures	238	61%	116	42%***	97	60%	59	37%***
Other non-technical tasks	238	25%	116	32%***	97	27%	59	35%
Panel D. Perceived objectives of the invention process								
When working on projects or products that may result in an invention, I focus on:								
Experimenting with big, risky ideas that may prove to be foundational	371	23%	133	26%	113	22%	69	19%
Incremental changes as solutions to the problems	371	58%	133	55%	113	61%	69	58%
Other (e.g., defensive patenting or expanding academic research)	371	19%	133	19%	113	17%	69	23%
The invention I worked on is primarily of value to individuals or businesses that use it directly (-2 = Strongly disagree, 2 = Strongly agree)	152	1.24	115	0.89***	58	1.18	60	0.89**
The invention that I worked on is of significant value to society at large, beyond its direct users (-2 = Strongly disagree, 2 = Strongly agree)	252	0.64	111	0.87***	119	0.71	59	0.95**
In your view, what should be prioritized when developing an invention?								
Private value	223	5%	132	3%	92	0%	70	3%
Social value	223	12%	132	28%***	92	18%	70	27%
Both, it depends on context	223	83%	132	69%***	92	82%	70	70%*