Firm Heterogeneity in the Identification and Reward of Inventors*

Sabrina Di Addario[†] Alice H. Wu[‡]

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Abstract

This paper investigates firm heterogeneity in identifying inventor talent and rewarding inventors for patent applications. Using Social Security employment records in Italy linked to patent applications, we find substantial firm heterogeneity in the rate at which employees become inventors. Young workers are less likely to apply for their first patents at a lower-wage firm. The gap between firms disappears, however, for experienced inventors. Upon the initial patent application, young workers receive a 5-9 log-point wage increase. We build a model of employer learning and incentive contracts to explain our findings, especially why low-wage firms set a higher bonus for new inventors than high-wage firms despite similar retention rates.

Keywords: Labor Market for Inventors, Productivity, Wage Differentials

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[†]Bank of Italy Sabrina.Diaddario@bancaditalia.it

[‡]Department of Economics, University of Wisconsin - Madison. hwu526@wisc.edu

1 Introduction

Expanding the stock of inventor talent is crucial for increasing the rate of innovation, a central driver of economic growth (Romer 1990; Aghion and Howitt 1992). The increasing availability of matched employer-employee data linked to patent records allows researchers to study the supply and demand of inventors at a larger scale. A rising literature has used such data to analyze demographic, socioeconomic, and financial factors that affect who becomes an inventor (Bell, Chetty, Jaravel, Petkova, and Van Reenen 2019a; Bell, Chetty, Jaravel, Petkova, and Van Reenen 2019b), and characterize the employers (Akcigit and Goldschlag 2025) and earnings of inventors (Aghion, Akcigit, Hyytinen, and Toivanen 2018; Kline, Petkova, Williams, and Zidar 2019; Toivanen and Väänänen 2012).

Less attention has been paid to the role of firms in identifying inventors from the pool of their employees, and the firm heterogeneity in wage returns to patent. As pointed out by Akcigit and Goldschlag (2025), a better understanding of the firms that employ inventors could allow for the design of more targeted innovation policies that improve productivity. This paper provides novel evidence on firm heterogeneity in discovering and rewarding inventors from the employment-patent linked data in Italy, the sixth largest economy among OECD members.[1] Italy has experienced a prolonged productivity slowdown, and young workers have been challenged by a decline in economic opportunities relative to older cohorts (Bianchi, Bovini, Li, Paradisi, and Powell 2023; Goldin, Koutroumpis, Lafond, and Winkler 2024; Daruich, Di Addario, and Saggio 2023). This macroeconomic backdrop makes it more urgent to investigate inefficiencies in the discovery and promotion of talent in the labor market, especially workers who have the potential to become inventors and contribute to innovation.

We focus on the labor market for potential inventors, for whom we observe whether and when they file a patent application at each employer, annual wages, and other job characteristics from administrative data. We investigate the differences between lower-wage and higher-wage firms in (1) discovering new inventors (i.e., the employees applying for a patent for the first time), and (2) wage returns to patent applications. We interpret the

[1]Italy's nominal GDP was 2.37 trillion in 2024, the sixth largest among OECD countries, according to data on GDP from the World Bank.

findings with a model of employer learning and incentive contracts, taking into account the endogenous investment decisions by firms and the endogenous effort choice by workers. The model helps us explain why low-wage firms set a higher bonus for new inventors than high-wage firms despite similar retention rates.

In Italy young inventors are highly concentrated in a few firms: about 90% of the successful inventors younger than 35 are employed by less than 5% of the firms with at least one inventor (Figure 1). In contrast, the distribution of the younger workers who have not yet applied for a patent but will eventually do so (possibly at another employer) is relatively more balanced across firms. These patterns suggest that in Italy a large share of firms do not encourage or support younger employees to innovate, under-investing in discovering new inventors.

Using the employer-employee Italian Social Security Institute (INPS) data matched to European patent applications by Depalo and Di Addario (2014), we identify roughly 112,000 *potential* inventors who are either estimated to have a high probability of ever inventing based on observable characteristics or contribute to at least one patent application assigned to their employers during the sample period (1987-2009). Relative to an average worker in the INPS data, potential inventors earn, on average, 20 log-point higher wages, are more likely to work in white-collar jobs, and are less likely to have a temporary contract.

The firms in our sample have hired at least one inventor between 1987 and 2009.[2] We classify the firms based on the quartile of mean coworker wages, and estimate the differences between quartiles in the probability that a worker files her first patent application at her current employer. Potential inventors who are younger than 35 and have not applied for patents are 19% less likely to become inventors while employed in lower-wage firms (quartile 1) than similar workers in higher-wage firms (quartile 4). The differences between firms in filing first patent applications are smaller for older potential inventors. Thus, on average, higher-wage firms are more able to scout for new inventors, especially when they are young.

[2]The firms are connected by the job movements of the inventors, who are defined as the workers with at least one patent application between 1987 and 2009. Please note that we include firms that hire inventors but may not file a patent application during the sample period.

The gap in the patent application rate between lower- and higher-wage firms, however, regards only potential inventors without an invention yet: after workers apply for a patent ("experienced inventors"), the gap disappears for both younger and older workers. Experienced inventors appear more likely to apply for patents again at lower-wage quartiles relative to quartile 4. This contrast suggests that lower-wage firms on average also engage in patenting, but they are more likely to rely on experienced inventors rather than on potential inventors. These findings can be explained by employer learning (e.g., Altonji and Pierret 2001; Farber and Gibbons 1996; Lange 2007; Kahn 2013; Schönberg 2007). Firms may be reluctant to assign innovation tasks to employees whose ability is not yet known, especially if they are young; on the contrary, they may be more willing to offer the opportunity to patent to experienced inventors, who have already shown their ability with prior patent applications. Lower-wage firms appear to support experienced inventors as much as higher-wage counterparts, but overlook younger workers with a potential to invent, resulting in a substantial gap in the discovery of new inventors between firms.

Do firms reward workers for patent applications and how does inventors' wage growth vary across firms? We provide regression estimates of the differential wage returns to a person's patent application between quartiles of firms. Conditioning on person fixed effects and controlling for industry and geographic regions, younger potential inventors earn a 4.7 log-point significantly higher wage when they file their first patent application in quartile 4. This pattern is consistent with the findings that wages start to rise *before* patents are granted (Depalo and Di Addario 2014; Bell, Chetty, Jaravel, Petkova, and Van Reenen 2019a). Yet, existing studies on inventors' wage growth have rarely looked at the differences between firms. We find that the wage return to a younger person's first patent application is 3.9 log-point higher at lower-wage firms (quartile 1) than at higher-wage firms (quartile 4). Older workers who file their first patent application also receive a wage increase in the same year, but the relative gap in wage return between quartile 1 and quartile 4 is smaller.

In contrast with new inventors, we do not find a significant wage premium after patenting for experienced inventors who have already applied for patents before. These findings can also be explained by employer learning: a person's first-ever patent application provides a greater information shock to employers than the subsequent applications filed by experienced inventors. Wages, reflecting firms' perceptions of worker ability, rise faster for newly identified inventors than for those already recognized as high ability.[3]

Why is the wage return to a person's first patent application higher at lower-wage firms in quartile 1? One hypothesis is that low-wage firms face a higher turnover of new inventors and have to set a higher wage return to counter poaching from competitors. However, we find no evidence supporting this. Relative to similar coworkers, new inventors are in fact more likely to stay in the next year, and even in three years, there is no evidence that new inventors in quartile 1 are more likely to be poached by a higher-wage firm. The lack of poaching of inventors from lower-wage firms suggests employer learning alone cannot explain why lower-wage firms set a higher premium for first patent applications. In the model below we show that considering employer learning and incentive contracts simultaneously can better explain the firm heterogeneity in rewards for patenting.

We build a dynamic model for the labor market of potential inventors: firms post wage contracts and invest in employees' research, and workers choose employers and effort on innovation accordingly. Information on worker ability is imperfect but symmetric between firms and workers, and a patent application will fully reveal the worker as a high-ability inventor. In equilibrium, the more productive firms would set a higher base wage and invest more in a worker's research than their less productive counterparts.[4] This equilibrium result is consistent with the empirical finding that workers are less likely to become inventors at lower-wage firms. A worker's effort on innovation is not contractible; each person chooses an effort that maximizes her expected earnings net the cost of effort today, plus her option value on the labor market next period, which is higher if she is recognized as an inventor. When there are fewer opportunities for new inventors to move between firms, the increase in option value is lower, and firms would rely more on the

[3]The underlying assumption of employer learning models such as Altonji and Pierret (2001) is that employers adjust wages as they learn about the errors in the initial assessment of worker ability.

[4]We find supportive evidence that higher-wage firms invest more in research-related activities by matching about 7% of the firms in our data to the Survey of Industrial and Service Firms (INVIND), which is run by the Bank of Italy every year. The R&D investment variable is missing in 90% of the firm-year observations, but the mean investments in several categories indicate that lower-wage firms invest less in innovation-related activities (Appendix Table B.2).

bonus contingent on invention to incentivize workers, as in Harris and Raviv (1979) and Holmström (1979).

The model predicts that the more productive firms invest more in employees' research but set a lower bonus if (1) firm investment and worker effort are complementary in innovation production, and (2) the production function is sufficiently concave in worker effort. A higher investment by firms under the complementarity condition incentivizes workers to put more effort into innovation. With a diminishing return to worker effort, the more productive firms that have already invested more would set a lower bonus than less productive counterparts. Through the lens of incentive contracts, we therefore provide an explanation for the higher wage return to patenting at lower-wage firms, a pattern that cannot be explained by employer learning alone given the lack of poaching.

1.1 Contribution to the Literature

This paper contributes to several strands of literature. First, we contribute to the growing literature on the dynamics of inventors' careers. Recent studies in the labor market for inventors rely on linking data on patents to US tax records (e.g. Bell et al. 2019a, Bell et al. 2019b, Jaravel, Petkova, and Bell 2018 and Kline et al. 2019) or administrative employer-employee data that provides wages and employment information (e.g. Akcigit, Baslandze, and Lotti 2023 in Italy; Aghion, Akcigit, Hyytinen, and Toivanen 2018 in Finland). Building on the PATSTAT-INPS data in Depalo and Di Addario (2014), we find significant wage returns to first-time inventors that are consistent with estimates in other advanced economies (Aghion et al. 2018; Bell et al. 2019a). We contribute to the return-to-invention literature by documenting the gap in wage returns between low-wage and high-wage firms, for workers who are applying for patents for the first time. We provide a dynamic model to explain our findings through employer learning and incentive contracts, both of which help interpret the returns to inventors in Toivanen and Väänänen (2012).

Previous studies have emphasized the role of childhood exposure to innovation and socioeconomic background in the likelihood of becoming an inventor (Bell et al. 2019b; Aghion, Akcigit, Hyytinen, and Toivanen 2023). Our analysis of the heterogeneity in the discovery of new inventors between firms suggests that an earlier exposure to firms that engage younger workers in patenting activity is another important channel through which high-ability researchers and inventors can be recognized by the labor market.

Last but not least, our study of the career progression of younger potential inventors is related to the growing literature on the career challenges faced by younger workers in Italy. A series of reforms aimed at increasing the flexibility of the labor market led to a high share of temporary contracts and wage depression that hurt younger workers disproportionately (Daruich, Di Addario, and Saggio 2023). The aging population and delayed retirement further reduce the opportunities available to younger workers (Bianchi and Paradisi 2023; Bianchi et al. 2023). We contribute to this literature by showing that there is a substantial gap between lower-wage and higher-wage firms in discovering inventors from younger workers. A slow discovery of younger inventors can be particularly costly, given that workers often face human capital depreciation (Aghion et al. 2024) and that innovation productivity often peaks in a worker's early 40s (Bell et al. 2019a; Kaltenberg, Jaffe, and Lachman 2023).

The remainder of this paper is structured as follows. Section 2 describes the matched INPS-PATSTAT data and the selection of potential inventors. Section 3 presents our empirical findings on the heterogeneity in talent discovery and wage returns to patent applications between firms. Section 4 presents a two-period model of employer learning and incentive contracts that reconciles our main empirical findings. Section 5 discusses a policy implication and concludes.

2 Data

We build a panel data on the employment and innovation history of more than 100,000 potential inventors in Italy, using the database in Depalo and Di Addario (2014) that matched the employer-employee data from the Italian Social Security Institute (INPS) with the Worldwide Patent Statistical Database (PATSTAT). The original database in Depalo and Di Addario (2014) contains the employment and patent records for about sixteen thousand Italian inventors and the employment history of their coworkers across employers from 1987 to 2009.

In this section, we first summarize the matching between PATSTAT and INPS originally done by the team Depalo and Di Addario (2014), and then we discuss the methodology used to identify potential inventors, who are the workers who either file a patent application during the sample period or are predicted to do so based on observable characteristics. Throughout the empirical analysis, we focus on the panel of potential inventors to study the role of firms in discovering new inventors.

2.1 INPS-PATSTAT Matched Database

PATSTAT contains the universe of patent applications ever submitted to the European Patent Office (EPO). It provides detailed information both on the inventors listed in the applications, and on the assignees, or owners of the patent, which are typically the inventors' employers. Depalo and Di Addario (2014) selected all the patent applications submitted by any firm located in Italy, as recorded in PATSTAT 2009.[5] Between 1987 and 2009, EPO received more than 50,000 patent applications from the private sector, submitted, overall, by 36,000 inventors from $16,000$ firms.

After cleaning the names of inventors and firms applying for patents, Depalo and Di Addario (2014) asked INPS to match the firms with employers (by name and location) in their administrative data, and to match the inventors with individual employees (by name and municipality of residence). INPS returned a de-identified database of about $16,000$ matched inventors (as well as 4.5 million coworkers employed in the same company) and all the firms in which these inventors have transited in our observational period, even before or after submitting a patent. We refer to Depalo and Di Addario (2014) for further details on the matching process.

The matched INPS-PATSTAT database contains information on a worker's annual wage at her employer in the private sector, type of contract (permanent or temporary), occupation group (blue or white collar), and basic demographic information such as gender or year of birth. INPS also provided information at the establishment level, such as size, sector, location, and dates of business opening and closure. The matching between

[5]This restriction excludes patent applications by individuals, universities, or public entities that could not be matched with INPS data, which only covers the private sector in Italy.

patent applications and employment records also allows us to build a measure of worker's on-the-job innovation outputs, and identify the employer at which a worker files her first patent application ever, if it occurs during the sample period.

2.2 Selection of Workers with Inventor Potential

In this paper, a person is defined as a "matched inventor" if she is acknowledged on a patent application submitted by her employer at the time of initial filing. Among the 4.5 million coworkers of the matched inventors, the vast majority are unlikely to ever become an inventor. For example, an inventor with patents at the largest automobile company in Italy would have thousands of coworkers who work in factories rather than in R&D departments. Unfortunately, we do not have access to a person's educational background or detailed occupation codes in the INPS sample. Instead, we rely on observable information such as broad occupation groups (white collar/blue collar), type of contract (permanent/temporary/seasonal), and demographic characteristics to predict how likely a worker is to ever file a patent application.

To do so, we first restrict to workers who entered the INPS sample between age 14 and 55, were employed in the private sector for at least five years between 1987 and 2009, and spent more years in white-collar than in blue-collar occupations.[6] This initial selection restricts the sample to 1.5 million workers. We then fit a Poisson model of ever-inventing on observable demographic and employment characteristics, specified as follows:

$$E[Inv_i|x_i, z_{it}, j(i,t), t] = exp\left(x_i'\lambda + z_{it}'\gamma + \psi_{j(i,t)} + \theta_t\right) \tag{2.1}$$

where $Inv_i = 1$ if worker i is a "matched inventor", i.e. she has at least one patent application and she is matched to INPS employment records between 1987 and 2009. The individual-level controls, x_i, include a dummy for whether the person is female, the age at which she first enters the INPS data and its interaction with whether her employment

[6]The restriction on the minimum age a person enters the INPS sample removes the outliers who were employed by a private sector employer at a young age, and also workers older than 55 for whom we can only observe employment closer to retirement. The restriction that we observe a person for at least five years (not necessarily consecutively) ensures the panel is long enough and allows us to keep track of wage changes and job movements for at least some years. Finally, the third restriction is motivated by the finding that most inventors have a white-collar job status (Table 1's column 1); note, however, that our restriction does not exclude the possibility that potential inventors work in blue-collar jobs in some years.

records are left-truncated in 1987 (due to data constraint). The time-varying controls at person-year level, z_{it}, include a cubic polynomial of age, a cubic polynomial of tenure at the worker's current employer $j(i,t)$, characteristics of her current job (white versus blue collar, permanent versus temporary contracts) and their interactions with her age. Finally, to take into account the heterogeneity in patenting across firms and over time, we control for firm fixed effects $\{\psi_{j(i,t)}\}$ and calendar year fixed effects $\{\theta_t\}$.

The estimates in Table B1 indicate that younger workers have a higher chance of ever inventing, consistent with age profile of inventors (Figure 2). Women are about a third as likely to invent as similar male coworkers at the same firm. Employees with longer tenure are more likely to apply for a patent, and white-collar workers are more than six times as likely to become an inventor as blue-collar coworkers. Workers on permanent contracts are more likely to invent (column 1), but this relationship is driven by the heterogeneity between firms.[7]

To select the potential inventors, we rank the 1.5 million workers in the estimation sample by the predicted probability of ever-inventing from model (2.1). As shown in Figure 3, the distribution of the estimated probabilities among the matched inventors (i.e. those with at least one patent application matched to the INPS data) is skewed more to the right than the distribution among all workers. We classify a worker as a "potential inventor" if any one of the following conditions holds:

1. $max\{\hat{p}_{it} : age_{it} <= 35\} \geq 0.05$: the maximum estimate of an employee's propensity to invent when they are less than 35 years old exceeds the median estimate among the matched inventors younger than 35;[8]
2. $max\{\hat{p}_{it} : age_{it} > 35\} \geq 0.06$: the maximum estimate of an employee's propensity to invent when they are older than 35 exceeds the median estimate among the matched inventors older than 35;
3. any matched inventor.

This selection rule results in a total of about 112,000 potential inventors, including

[7]Column 1 of Table B1 shows the estimates of Poisson regression (2.1) without firm fixed effects. Conditional on firm fixed effects (column 2), permanent contract has a positive but much smaller predictive power of future invention.

[8]The age 35 threshold is selected based on Figure 2, which shows that the probability of a worker becoming an inventor increases faster in the early career, peaks at around age 32, and begins to flatten after age 35.

about 97,000 workers who do not have a matched patent during the 1987-2009 period but are estimated to ever invent with a relatively high probability. In comparison with the full estimation sample of 1.5 million workers, the vast majority of potential inventors are male (Table 1). They also are younger (-2 years on average), more mobile across firms, more likely to be white-collar than blue-collar workers, and more likely to have a permanent contract. On average there is a 22 log-point wage gap between potential inventors and workers in the estimation sample; this gap increases with age: it is about 14 log points at age 30, and raises to over 30 log points at age 45 and above. Table 1 also compares potential inventors with the matched inventors. While on average matched inventors earn 22 log points higher wages than potential inventors, the wage gap at age 30 is relatively small, which suggests that the selection based on model (2.1) allows us to compare workers who are similar early in their careers.

To examine the age profile for becoming an inventor (Figure 2), we fit a logistic regression of filing the first patent application on age dummies, gender, and calendar year fixed effects. The rate at which a potential inventor files her first patent is steeply increasing with age up to age 32, when it reaches the peak, and slowly declines afterward, stabilizing at a 4 log-points higher level than that at age 25. Throughout this paper, we estimate separate models for workers younger vs. older than 35, given the age profile shown above.

3 Empirical Findings

We analyze the firm heterogeneity in the identification of inventors, and in the reward for patent applications. First, we study the differential rates at which potential inventors apply for patents at lower-wage versus higher-wage firms. We find a significant gap between lower- and higher-wage firms in the probability of their workers filing the first-ever patent application. Second, we estimate the wage return to a new patent application at different tiers of firms, and we find that the return is on average higher at lower-wage firms.

3.1 Becoming an Inventor at Low-Wage versus High-Wage Firms

We estimate the probability that an individual will file her first patent application as an employee.[9] For a worker with no prior patenting experience, the first patent application submitted at her current employer will also be her first patent application ever. After the person's first-ever patent application, we refer to her as an "experienced inventor".

We analyze the differences in becoming an inventor in lower-wage versus higher-wage firms. Coworker wages are used as a proxy for firm productivity, which we cannot directly measure in the data.[10] This ranking choice is consistent with the micro-foundation for the AKM models, in which more productive firms set a higher wage premium in an imperfectly competitive labor market (Abowd, Kramarz, and Margolis 1999; Card, Cardoso, Heining, and Kline 2018; Kline 2024). Denote by $j(i,t)$ the primary employer of worker i in year t, and by $Q(i,t)$ the quartile of mean coworker wage to which her employer belongs.[11] On average potential inventors at the bottom quartile are less likely to submit patent applications than workers at higher-wage quartiles (Table 2). The gap between low- and high-wage firms is larger for younger than for older workers (Figure 4).

We estimate a Poisson regression of a person becoming an inventor at their current employer as follows:

$$E[y_{it}|j(i,t),x_{it}] = exp\left(\beta_0 + \sum_{q<4} \underbrace{\beta_q \times 1[Q(i,t)=q]}_{\text{if leave-out mean in quartile } q} + \underbrace{x'_{it}\Gamma}_{\text{controls}} + \underbrace{\phi_{G(j(i,t))} + \theta_t}_{\text{fixed effects}}\right) \tag{3.1}$$

where y_{it} is an indicator for worker i filing her first patent application at employer $j(i,t)$.

[9] This paper considers only the patent applications submitted by firms, not by individuals. Patent applications report the names of each inventor who contributed to the invention. Note that state-owned enterprises, which undertook a large amount of R&D between 1950 and 1994, are not included in our data (Antonelli, Barbiellini Amidei, and Fassio 2014).

[10] We find supportive evidence that the mean wage is positively correlated with a firm's revenue and investment. We matched about 7% of firms in our INPS sample to the INVIND Survey by fiscal code or firm name. INVIND reports firm-level investment in machinery, material and immaterial goods, housing, and R&D. The matched firms in quartile 1 have lower revenue and lower investment than those in the other quartiles of the wage distribution (see Appendix Table B.2).

[11] Following Card et al. (2018), for each person-year, we compute the mean coworker wage at her employer and rank the leave-out mean coworker wage into quartiles. Note that the same firm could belong to different quartiles for high- and low-wage employees. We also provide regression estimates after ranking firms by the mean wage each year; in this case, $Q(i,t)$ assumes the same value for all coworkers (see Appendix Table B.3, mirroring Table 3).

The coefficient of interest β_q represents a proportional increase in the mean outcome when a worker is employed by a firm in quartile q, relative to the mean in quartile 4 that pays the highest wages. The covariates x_{it} include sex, a cubic polynomial in age (normalized at age 35), indicators for white/blue collar and permanent/temporary contract, and their interactions with age. We also control for the calendar year to absorb any common trend, 2-digit industry fixed effects to account for time-invariant heterogeneity in patenting across industries, and geographic region fixed-effects to absorb unobserved heterogeneity across regions. For each person i, the estimation sample includes all years she is employed (i.e., she is present in the INPS data) until y_{it} changes from 0 to 1 at employer $j(i,t)$.[12]

We fit separate models for the workers younger than thirty-five and for those who are older; the age cutoff was selected based on the age profile of becoming inventors shown in Figure 2. For each age group, we further distinguish between the workers who had and those who had not a prior patent application elsewhere.

3.1.1 Potential Inventors without Patenting Experience

We first focus on the potential inventors who have not applied for any patent. The younger potential inventors are 19% less likely to file their first patent application when they are employed in a quartile 1 firm than similar workers in quartile 4, as shown in the first column of Table 3. The gap between quartiles 2 and 4 is insignificant, while the potential inventors in quartile 3 are 16% more likely to become inventors than those in quartile 4. We find a similar pattern among the younger matched inventors who have not patented by year t but will do so by 2009, the end of our sample period. Column 2 shows that the employees in quartile 1 are 15% less likely to become inventors than similar workers in quartile 4. Moreover, the estimated relationship between firm ranking (quartile) and the rate of becoming an inventor is also monotonic: younger matched inventors in quartile 2 are 12% less likely to become inventors than observably similar workers in quartile 4, and those in quartile 3 are 10% less likely to do so.

[12] That is, y_{it} changes from 0 to 1 in the year worker i files her first patent application at employer $j(i,t)$. For potential or matched inventors who have not applied for a patent before, this will indicate their first patent application ever. For experienced inventors who have applied for patents elsewhere, $y_{it} = 1$ indicates their first application at the current employer.

We then examine the potential inventors who are older than 35. On average, these workers are less likely to become inventors than employees aged 28-32 (Figure 2). However, we do not find any difference in the probability of filing the initial patent between the older potential inventors employed in quartile 1 firms and those in quartile 4. If anything, the employees of lower-wage firms are more likely to become inventors, although the effect is only significant at the 10 percent level (column 4 of Table 3). Restricting the sample to the matched inventors shows a pattern more similar to that of younger workers: the workers in lower quartiles are 7%-10% less likely to become inventors than comparable workers in quartile 4 (column 5). However, the estimated gap between firms is notably smaller than it occurs for younger matched inventors (column 2).

These findings suggest that lower-wage firms provide fewer opportunities to patent for employees without prior experience, especially if they are young.

3.1.2 Experienced Inventors

Do lower-wage firms assign fewer innovation tasks to everyone or just to potential inventors, whose innovation ability is not yet revealed? To answer this question, we estimate regression (3.1) on the experienced inventors who have already applied for a patent.[13] In this case, the gap between quartile 1 and quartile 4 in filing the first application at the current employer disappears, both for younger and older workers (respectively, column 3 and 6, Table 3): experienced inventors are as likely to apply for a patent again at lower-wage and higher-wage firms. In contrast, the experienced inventors in quartiles 2 and 3 are more likely to apply for a new patent at their current employers than those in quartile 4, especially if they are young.

The contrast between potential inventors and experienced inventors suggests that lower-wage firms discover new inventors at lower rates than higher-wage firms, but they do not necessarily provide fewer patenting opportunities to the employees who have already proved their ability.

[13]The first patent application at the current employer of an experienced inventor is not her first patent application ever.

3.2 Wage Returns to Patent Applications

Are workers rewarded for filing new patent applications? To answer this question, we use the annual wages of the potential inventors in the INPS data. To estimate the wage return to a new patent in each firm quartile, we specify an OLS regression as follows:

$$ln(w_{it}) = \underline{\mu} + \underbrace{\sum_{q<4} \mu_q \times 1[Q(i,t) = q]}_{\text{avg wage difference rel. to quartile 4}} + \underline{\gamma} \times y_{it} + \underbrace{\sum_{q<4} \gamma_q \times y_{it} \times 1[Q(i,t) = q]}_{\text{excess returns to new patent rel. to quartile 4}} \tag{3.2}$$

$$+ \underbrace{x'_{it}\Lambda}_{\text{controls}} + \underbrace{\alpha_i + \phi_{G(j(i,t))} + \theta_t}_{\text{fixed effects}} + e_{it}$$

in which $ln(w_{it})$ is the log annual wage of worker i in year t. The coefficient $\underline{\gamma}$ represents the average wage return to a new patent application among workers in the base group, quartile 4. And $\{\gamma_q : q < 4\}$ represent the excess returns to a patent application in other quartiles of employers, relative to the base. The regression includes the same set of time-varying controls, x_{it}, as in (3.1). In addition to year, industry, and region-fixed effects, we include person-fixed effects to absorb unobserved individual heterogeneity that matters for wages. Therefore, the excess returns $\{\gamma_q\}$ can be interpreted as within-person wage increases when a person produces a patent application in quartile q relative to the base quartile 4.

As expected, younger potential inventors on average earn 13 log-point higher wages when they are employed by quartile 4 rather than by quartile 1 firms (column 1 of Table 4). In the year of their first patent application, younger potential inventors in quartile 4 earn a further 4.7 log-point significant wage premium. However, the excess return to a new application, denoted by γ_1 in (3.2), is estimated to be 3.9 log points significantly higher in quartile 1 than in quartile 4.[14] The higher return to new inventors in lower-wage firms is robust to the estimation of (3.2) in the matched inventors sample (column 2 of Table 4).

Potential inventors in quartiles 2 and 3, on average, experience a similar wage return

[14]The differences in wage returns to a worker's first patent application between firm quartiles are about 3-5 times larger if we ignore individual heterogeneity (dropping person fixed-effects from 3.2), as shown in Appendix Table B.4.

to their first patent applications ever as those in quartile 4. The average returns for the matched inventors in quartiles 2 and 3 are positive but smaller than in quartile 4. We find a smaller wage gap between matched inventors across quartiles even before they become inventors (see $\hat{\mu}_q$'s in column 1 vs. column 2), which suggests that firms may have additional information about future inventors, so as to set a higher wage even before they start patenting.

Wage returns to initial patent applications are smaller for potential inventors who are older than 35, as shown in column 4 of Table 4. When an older potential inventor files her first patent application at a firm in quartile 4, she earns a 3.1 log-point significant increase in wage, which is about 1.6 log-points lower than the estimate for younger potential inventors. The excess return to the first patent application in quartile 1 is 2.1 log points, which is 55% of the excess return $\hat{\gamma}_1$ among younger potential inventors (column 1).

Experienced inventors who have applied for patents at former employers do not receive a wage increase when they file their first patent applications at their current firm. In quartile 4, we find a noisily estimated 1.6 log-point increase when an experienced inventor begins patenting again (columns 3 and 6). Yet there are no excess returns to patenting in lower-wage quartiles.

These findings confirm that firms reward workers for their first patent applications, in spite of the fact that it takes a few more years to know if the patent will be granted successfully. The wage returns among younger potential inventors are significantly higher in the bottom quartile, which pays the lowest wages on average. The estimated wage returns are similar when we rank firms by the one-year lagged mean coworker wage, which mitigates concerns about firm-wide shocks that affect both the quartile of coworker wage $Q(i,t)$ and a person's own wage in the same year.[15]

[15] We show in Appendix Table B.5 that younger potential inventors receive a 3.6 log-point wage increase upon their first patent applications in (lagged) quartile 4, or a 7.8 log-point increase if they are in quartile 1. Older potential inventors receive very similar wage returns as estimated in Table 4 when we rank firms by leave-out coworker wages in the same calendar year.

3.2.1 Interpreting the Wage Returns to Patenting via Employer Learning

Employer learning provides an explanation for why first-time inventors receive a higher wage increase than experienced inventors when they apply for patents, and why younger workers experience a stronger wage increase than older counterparts. A patent application sends a positive signal about a worker's research or innovation ability. As employers revise upward the belief about a potential inventor's ability, employer learning models suggest that wage bids would rise.[16]

In contrast with potential inventors, there is less room for upward belief updating about the ability of experienced inventors who have already showcased their ability in earlier patent applications. A similar argument can be made for older workers who have been observed in the labor market for a longer period of time. The marginal impact of a patent application on employers' belief about worker ability is smaller for experienced and older workers, and therefore makes sense of a smaller wage increase in columns 3-6 of Table 4.

3.2.2 Why is there a higher wage return to patenting at lower-wage firms?

Can employer learning explain the higher wage return to a patent application at lower-wage firms? The answer depends on the initial selection of workers into lower-wage versus higher-wage firms and the subsequent sorting of workers between firms.

First, the labor market may hold a lower prior on the workers who are initially employed by lower-wage firms. Employees whose coworker wages are placed in quartile 1 earn 48 log-point lower wages on average than the workers in quartile 4 (Table 2). Conditional on observable individual and firm characteristics, there remains a 23 log-point wage gap between the employees in quartile 1 and similar workers in quartile 4 (Appendix Table B.4). The average wage gaps reflect differences in the market perception of the ability of workers in lower-wage versus higher-wage firms. When the prior belief

[16] In a perfectly competitive labor market, wages would increase to fully match the marginal revenue product of labor expected from a worker (Altonji and Pierret 2001; Farber and Gibbons 1996; Lange 2007; Kahn 2013; Schönberg 2007). In an imperfectly competitive labor market, wages that are marked down from the marginal revenue product would also increase when there is public and positive information about talent (Wu 2025).

is lower for a potential inventor in quartile 1, a patent application, as a signal on research ability, generates a stronger increase of the posterior employer belief relative to the prior and therefore a higher wage return in quartile 1 (columns 1-2 of Table 4).

Second, lower-wage firms may have to set a higher wage return to patent applications when they face a higher turnover. We find some mixed evidence that supports this hypothesis. 16% of the younger potential inventors in quartile 1 move to a new firm the following year, versus 10%-14% in higher-wage quartiles (Appendix Figure B.1a). By setting a higher wage return to patent applications, firms in quartile 1 may counter the risk of turnover and increase the probability of retaining an inventor. To test this idea, we estimate a Poisson regression of job mobility between firms in 1-3 years on whether a worker files a patent application this year, interacted with firm quartiles:

$$
\begin{aligned}
ln\,(E[\text{Move}_{it}|j(i,t),x_{it}]) = m_0 + &\underbrace{\sum_{q<4} m_q \times 1[Q(i,t)=q]}_{\text{avg mobility rel. to quartile 4}} + \underbrace{\eta_0 \times y_{it}}_{\triangle\text{mobility in quartile 4}} \\
&+ \sum_{q<4} \underbrace{\eta_q \times y_{it} \times 1[Q(i,t)=q]}_{\text{excess mobility response rel. to quartile 4}} + \underbrace{x_{it}\,\Psi}_{\text{controls}} + \underbrace{\phi_{G(j(i,t))} + \theta_t}_{\text{fixed effects}}
\end{aligned}
\tag{3.3}
$$

Denote by $\text{Move}_{it} := 1[j(i,t+1) \neq j(i,t)]$ any job movement between firms in the next year. Column 1 of Table 5 shows that on average younger potential inventors who file their first patent application are 74% significantly less likely to move to a new firm than otherwise similar workers.[17] Importantly, we do not see a significant increase in turnover among new inventors in quartile 1 relative to quartile 4. It is possible that the higher wage return to a patent application in quartile 1 results in an equal retention of first-time inventors across firms temporarily.

Looking out three years, however, we still do not find evidence of poaching of new inventors from higher-wage firms that would have justified the excess return in quartile 1. With $\text{Move}_{it} := 1[j(i,t+3) \neq j(i,t)]$, we find no increase in job mobility in 3 years (Appendix Tables B.6-B.8). Experienced inventors are consistently less likely to move than the potential or matched inventors who have not applied for a patent in 3-7 years (Appendix Figure B.1 (c) versus (a)-(b)). Furthermore, there is no evidence that

[17] See the Poisson coefficient on y_{it} in column 1. $exp(-1.35) \approx 0.26$.

filing a patent application helps a worker move up the job ladder, except for the potential inventors in quartile 2, who are more than twice as likely to move to a higher-wage quartile of employers relative to workers who are already in the highest quartile (Table B.7).[18]

In summary, we find that younger potential inventors are 19% less likely to file their first patent application at a lower-wage employer in quartile 1 than similar workers in quartile 4. The gap between low-wage and high-wage firms in patent applications disappears, however, among experienced inventors who have already applied for patents before. Further, there is a significant 5-9 log-point increase in a person's annual wage when she files her first patent application, and the average wage return is highest at firms in quartile 1.

From the perspective of employer learning, at least part of the wage increase upon workers' first patent applications reflects an upward change in employers' belief about their ability. Due to the lack of poaching of new inventors, however, the positive belief update alone cannot explain why firms in quartile 1 set a higher return to first patent applications. We formally consider incentive contracts as an alternative explanation in the next section and specify the conditions under which employer learning plus incentive contracts can resolve this puzzle.

4 A Model of Talent Discovery

We develop a two-period dynamic model that incorporates employer learning, incentive contracts, and the sorting of forward-looking workers between firms. We describe the model in the conceptual framework, and then derive equilibrium results that help explain the empirical findings above.

4.1 Conceptual Framework

This model concerns the investment decisions by firms on the innovation endeavors of workers, and the design of wage contracts given uncertainty about workers' binary ability to invent.

[18] For the employees in quartile 4, we define a between-firm movement within quartile 4 as an upward move.

Firms collect revenue from routine activity and from the innovation outputs of workers. Low-ability workers are as productive as high-ability workers in routine activity, but they cannot invent. In contrast, a high-ability worker can produce a patent application with probability $h(\tau, e)$, which is increasing both in the investment τ made by her employer and in her own effort e. Within each firm, it is challenging to reach the efficient level of innovation because (1) the firm is uncertain about worker ability until a successful invention, and (2) worker effort is not contractible as commonly assumed in the principal-agent problem (e.g., Harris and Raviv 1979; Holmström 1979). Given information about a worker at the beginning of each period, firms simultaneously post contracts that comprise a base wage $\underline{w}$, investment τ on the worker's innovation activity, and a bonus γ conditional on the worker's success in inventing.

Information is symmetric between firms, and workers do not have private information about their own ability types. In the first period, there is a common prior about a person's ability. If the worker successfully invents during $t = 1$ (output $p_{i1} = 1$), at the beginning of the second period she will be publicly known as high-ability. Otherwise, market beliefs evolve according to the fact that she has not invented ($p_{i1} = 0$).

Workers who are on the job market observe the contracts posted by potential employers. They make a discrete choice between employers and decide their own effort conditional on the choice of firm. At $t = 1$, each worker chooses an employer based not only on the current contract and her idiosyncratic preferences over firms $\{\epsilon_{i1j}\}$, but also on her expected value on the labor market next period. Workers who hold a higher belief about their inventing ability will have a stronger preference for high-τ jobs that invest more in innovation. Due to this dynamic incentive of potential inventors, firms with higher investment in innovation do not need to offer a high bonus to elicit effort from workers. The more promising inventors are willing to forgo current compensation in return for a higher option value, as in Stern (2004).

We specify the firms' problem and the workers' problem below and solve the model via backward induction. In equilibrium, the more productive firms set higher base wages for workers and invest more in innovation, but they set a lower bonus upon successful inventions because the higher investment can already elicit sufficient effort from workers.

We map the model implications to our empirical findings, especially the puzzle that higher-wage firms set lower rewards for patenting.

4.2 Model Specification

We introduce the model environment that features workers who vary in innovation ability and firms that vary in productivity. We describe the labor market matching process across two periods. To keep it simple, the information about workers is symmetric between all players in each period.

4.2.1 Notation

Workers. A person's ability to invent, $\alpha_i \in \{H, L\}$, is not known initially to workers or firms. Let π_{i1} denote the common prior about worker i at the beginning of $t = 1$. If a worker produces a patent application during the first period $t = 1$, she will be known as an H-ability inventor at the beginning of $t = 2$. Otherwise, firms share the posterior belief $\pi_{i2} = Pr(\alpha_i = H|\pi_{i1}, p_{i1} = 0, j(i, 1))$, conditional on the fact that she does not have a patent application during $t = 1$ while being employed by firm $j(i, 1)$.

Firms. Firms (indexed by j) are endowed with publicly known productivity ϕ_j. They simultaneously post contracts for a worker based on public information about her at the beginning of each period. A contract contains a base wage $\underline{w}_{itj} \in \mathbb{R}^+$, a proportional increase in wage, γ_{itj}, if worker i produces a patent application ($p_{it} = 1$), and an investment in innovation $\tau_{itj} \geq 0$.

Firms operate at constant returns to scale at the match level. Hence, a firm's output is the sum of the match outputs across employees. The expected output from a worker of ability α, conditional on firm investment τ and worker effort e, can be written as:

$$Y_j(\alpha, \tau, e) := \underbrace{\phi_j \times}_{\text{Productivity}} \left(\underbrace{1}_{\text{Routine}} + \underbrace{\theta \times 1[\alpha = H] \times h(\tau, e)}_{\text{Expected Innovation}} \right) - \underbrace{\zeta/2 \times \tau^2}_{\text{Innovation Cost}} \tag{4.1}$$

where $\theta > 0$ represents the return to innovation in proportion to a firm's productivity ϕ_j. There is a convex cost of allocating workers to innovation tasks, determined by parameter

$\zeta > 0$.[19]

Labor Market Dynamics. All workers are on the labor market at $t = 1$. Each person observes contracts $\{\underline{w}_{i1j},\ \gamma_{i1j},\ \tau_{i1j}\}$ posted by firms and draws idiosyncratic preferences firms from a type-I extreme value distribution:

$$F(\{\epsilon_{itj}\}) = exp\left(\sum_j exp(-\epsilon_{itj})\right) \tag{4.2}$$

Worker i chooses effort e_{i1j} that maximizes her expected utility conditional on entering firm j. Denote by $j(i, 1)$ her employer at $t = 1$ that offers the highest utility conditional on her effort choice and idiosyncratic preference.

Following a dynamic extension of Card et al. (2018), a worker can get back on the market at $t = 2$ with probability $\lambda \in [0, 1]$, in which case she redraws her preferences across potential employers from (4.2), independent of her preferences at $t = 1$. Other workers who are not on the market at $t = 2$ stay put.

We state the problems of workers and firms in each period. The model is solved backward in Appendix A1, and we discuss the model results below.

4.2.2 Workers' Problem

At the beginning of $t = 2$, given contracts $\{(\underline{w}_{i2j},\ \gamma_{i2j},\ \tau_{i2j})\}$ from employers, a worker who re-enters the job market chooses her employer $j(i, 2)$ as follows:

$$j(i,2) = argmax_j\ u_{i2j} + \epsilon_{i2j} = E[b\ ln(w_{i2j})|\pi, \tau_{i2j}, e_{i2j}] - c(e_{i2j}) + \epsilon_{i2j} \tag{4.3}$$

$$\text{where } w_{i2j} = \underline{w}_{i2j} \times \left(1 + p_{i2} \times \gamma_{i2j}\right)$$

$$e_{i2j} = argmax_e\ \underbrace{\pi\, h(\tau_{i2j}, e)}_{\text{Pr. patent}} \times \underbrace{b\ ln(1 + \gamma_{i2j})}_{\text{bonus}} - \underbrace{\frac{c}{2}e^2}_{\text{effort cost}}$$

$$= \frac{\pi \times b\ ln(1 + \gamma_{i2j})}{c} \times h_2(\tau_{i2j}, e_{i2j})$$

[19]This cost may include investment in computing power that often grows in a convex way as employees spend more time on innovation. It may also absorb the management costs of moving workers away from routine activities at a firm. For example, a firm may have to establish an in-house research lab, hire new managers, and establish a new performance evaluation system for workers who are increasingly involved in innovation tasks.

The optimal effort she puts on innovation maximizes the expected wage bonus net the cost of effort, given the contract provided by a potential employer j. The effort is increasing in the wage incentive γ_{i2j} as long as the probability of producing a patent application is increasing in effort e. Furthermore, the effort is increasing in τ_{i2j} iff the worker's effort and the firm's investment are complementary in the production of patents.[20]

At $t = 1$, every worker is on the market, observes initial contracts $\{(\underline{w}_{ij}, \gamma_{ij}, \tau_{i1j})\}$, and draws preferences over firms from (4.2). Let $\beta_W \in [0, 1]$ denote the exponential discount factor shared by all workers. When $\beta_W > 0$, workers take into account their option value at $t = 2$ when choosing an employer at $t = 1$. The discrete choice faced by a worker with prior π_1 is summarized by:

$$\begin{aligned} j(i,1) = argmax_j\ \boldsymbol{u_{i1j}} + \epsilon_{i1j} = & \underbrace{E[b \times ln(w_{i1j})|\, \pi_1,\, \tau_{i1j},\, e_{i1j}]}_{\text{expected utility from wage at t=1}} - c(e_{i1j}) + \epsilon_{i\,1\,j} \\ & + \beta_W \times \underbrace{E_y[\Omega_j\,(\pi_2)\ |\, \pi_1,\, \tau_{i1j},\, e_{i1j}]}_{\text{option value at t=2}} \end{aligned} \tag{4.4}$$

in which her optimal effort conditional on the contract provided by a potential employer j solves:

$$\begin{aligned} e_{i1j} &= argmax_e\ \ \underbrace{\pi_1\, h(\tau_{i1j}, e)}_{\text{Pr. patent}} \times \underbrace{\big(b\, ln(1 + \gamma_{i1j}) + \beta_W \triangle_p \Omega_j\big)}_{\text{bonus + change in option value}} - \frac{c}{2} e^2 \\ &= \pi \times h_2(\tau_{i1j}, e) \times \frac{\big(b\, ln(1 + \gamma_{i1j})\ + \beta_W \triangle_p \Omega_j\big)}{c} \end{aligned} \tag{4.5}$$

And her option value depends on whether she will produce a patent application at $t = 1$, which determines her posterior belief π_2:

$$\Omega_j(\pi_2) = \underbrace{(1 - \lambda) \times u_{i2j}(\pi_2)}_{\text{not on market, stay at j}} + \underbrace{\lambda \times E[max\{u_{i2j'}(\pi_2) + \epsilon_{i2j'}\}]}_{\text{on market}}$$

Denote by $\triangle_p \Omega_j$ the change in option value when she has a patent application, that is, $\Omega_j(1) - \Omega_j(\pi_2(0))$.[21] The higher the $\triangle_p \Omega_j$, the more effort forward-looking workers are

[20] Given any belief $\pi > 0$, $\frac{\partial e}{\partial \tau} \propto h_{12}$. See details in equation (7.3) in Appendix A1.

[21] According to the information structure in Section 4.1.1., $\pi_{i2}(1) = 1$ and $\pi_{i2}(\pi_2(0)) = Pr(\alpha_i = H|\pi_{i1}, j(i, 1)\, p_{i1} = 0) < 1$.

willing to put into innovation even in the absence of a bonus at the $t = 1$ employer.[22]

4.2.3 Employers' Problem

Given public employer belief π_2 at the beginning of $t = 2$, firms post contracts that maximize their expected profit in the second period. Let $\delta_{ij} = 1[j(i,1) = j]$ indicate whether a worker is an incumbent employee or a potential candidate from other firms. Firm j's problem can be expressed as:

$$v_{2j}^{(\delta)}(\pi_2) = max_{(\underline{w},\gamma,\tau)}\, s_{2j}^{(\delta)}(\underline{w},\gamma,\tau) \times \left(E_\alpha[Y_j(\alpha,\tau,e)|\pi_2] - \underline{w}(1+\gamma\times\pi h(\tau,e))\right) \tag{4.6}$$
$$= \left(\phi_j \times (1+\theta\times\pi\times h(\tau,e)) - \frac{\zeta}{2}\tau^2 - \underline{w}(1+\gamma\times\pi h(\tau,e))\right)$$
$$\text{s.t. worker effort } e = e(\tau,\gamma) \text{ solves (4.3)}$$

Despite symmetric information between firms, the labor supply of incumbent employees is less elastic than that of new workers whenever $\lambda < 1$, resulting in lower wages for stayers.[23]

At $t = 1$, given prior π_{i1}, firms set contracts that maximize their profits at $t = 1$ and expected returns from an incumbent employee at $t = 2$. Letting $\beta_J \in (0,1]$ denote the

[22] The option value can also be interpreted as a preference for innovation tasks, where workers with a higher prior π_1 have a stronger preference for higher firm investment τ that would increase the chance of being experienced as H-ability the next period.

[23] The firm-specific labor supply is the expected probability that a worker is employed by firm j in period $t = 2$. Firms do not know if their employees at $t = 1$ re-enter the labor market at the beginning of $t = 2$ and therefore cannot price discriminate. The labor supply for an incumbent vs. outside worker can be expressed as:

$$s_{2j}^{(\delta)}(\underline{w},\gamma,\tau) = \begin{cases} 1-\lambda\times(1-s_{2j}) & \text{if } \delta = 1, \text{ (incumbent employees)} \\ \lambda\times s_{2j}(\underline{w},\gamma,\tau) & \text{if } \delta = 0, \text{ (outside workers)} \end{cases} \tag{4.7}$$
$$\text{elasticity } \xi_{2j}^{(\delta)} = \frac{\partial\, ln\, s_{2j}^{(\delta)}(\underline{w},\gamma,\tau)}{\partial ln(\underline{w})} = \frac{\underline{w}}{s_{2j}^{(\delta)}} \times \lambda s_{2j}(1-s_{2j})\frac{b}{\underline{w}} = \frac{\lambda\times s_{2j}}{s_{2j}^{(\delta)}} \times b(1-s_{2j})$$

in which s_{2j} is the logit choice probability that a worker on the market chooses firm j given the posted contracts and idiosyncratic preferences drawn from (4.2).

exponential discount factor shared by all employers, each firm solves:

$$max_{(\underline{w},\gamma,\tau)} \quad \underbrace{s_{1j}(\pi_1)}_{\text{labor supply}} \times \left(\underbrace{E_\alpha[Y_j(\alpha,\tau,e)] - \underline{w}(1+\gamma\times\pi_1 h(\tau,e))}_{\text{expected profit at t=1}} + \beta_J \underbrace{E[v_{2j}^{(1)}(\pi_2)|\pi_1,\tau,e]}_{\text{continuation value}} \right)$$

s.t. worker effort e solves (4.5)

The firm's investment in an employee's innovation at $t = 1$ matters not only for the production of a patent today but also for the public information about the worker in the next period. Firms that face a higher turnover of inventors will have a continuation value decreasing in τ, and set a lower investment than they would have if $\beta_J = 0$. The investment decision is equivalent to the provision of general skill training, which is inefficiently low when firms cannot retain the worker (Acemoglu and Pischke 1998; Manning 2012; Stevens 1994).

In equilibrium, workers take the contracts from firms as given, (if on market) pick an employer, and choose their effort in innovation optimally. Firms take into account the labor supply and the effort chosen by workers given the contracts they post. Each firm will also take as given the contracts that are posted simultaneously by other firms conditional on the public information about worker ability. We complete the backward induction in Appendix A1.

4.3 Equilibrium Results and Links to Empirical Findings

We derive three equilibrium results from the model and discuss the assumptions under which they can explain the empirical findings in Section 3.

Proposition 1 (Positive Relationship between Firm Productivity and Base Wages) *Assume that the labor supply is not perfectly elastic with respect to wages, $b < \infty$. We have the base wages set by firms to be strictly increasing in firm productivity ϕ_j in both periods.*

Proposition 1 suggests we can preserve the ranking of firm productivity by using the mean wage at a firm, which is an underlying assumption in our empirical analysis. We do not have a direct measure of firm productivity from the INPS data, but we match 7% of the firms in our sample to INVIND by fiscal code or firm name. Appendix Table B.2 shows that lower-wage firms have lower revenue and invest less on average than higher-wage ones, providing evidence for Proposition 1.

Proposition 2 (Heterogeneity in Firm Investment on Innovation) *Assume that the patent production function $h(\tau, e)$ satisfies $h_1 > 0, h_2 > 0$, $h_{12} > 0$ and $h_{22} < 0$. Given any positive belief about a worker's ability to invent, we have each firm's investment, τ_{tj}, to be increasing in firm productivity ϕ_j in both periods.*

The assumption on the production function for patent applications suggests that with any chance of a worker being H-ability, firms would be willing to invest in her research to maximize expected returns to innovation. At $t = 2$, the return to a successful invention is higher at a more productive firm, and we therefore have the second-period investment τ_{2j} to be increasing in firm productivity ϕ_j.[24] At $t = 1$, forward-looking firms consider how their investment today affects the revelation of inventor talent in the next period. Firms that anticipate higher turnover of publicly revealed H-ability workers would set fewer innovation tasks initially. In Italy, we do not find evidence that successful inventors at lower-ranked firms move elsewhere faster (Appendix Figure B.1 or Table 5). The dynamic concern about turnover that would have lowered the initial investment τ_{1j} at low-productivity firms is not as important as in the U.S. labor market, where workers move more frequently (Wu 2025).

We find supportive evidence of this proposition among a sample of firms that can be matched to the INVIND survey with information on investment.[25] The positive relationship between firm productivity and its investment in innovation can explain why potential inventors are significantly less likely to file their first patent application at firms that pay lower wages (Table 3).

Proposition 3 (Wage Bonus for Invention) *Assume that the patent production function $h(\tau, e)$ satisfies $h_1 > 0, h_2 > 0$, $h_{12} > 0$ and $h_{22} < 0$. The bonus for an invention in each period is de-*

[24] See the first-order-condition w.r.t. τ in Appendix equation (7.9).

[25] Appendix Table B.2 shows that among the subsample of firms that are matched to INVIND, lower-wage firms in quartile 1 invest less in R&D, material/immaterial, machinery, or housing than higher-wage firms.

creasing in firm productivity ϕ_j if the patent production function is sufficiently concave in worker effort: $h_{22} := \frac{\partial^2 h(\tau,e)}{\partial e^2} \ll 0$, and the belief about worker ability π is bounded such that $\pi\, h < 0.5$.

Under the assumption that $h_{12} > 0$, a firm's investment τ and a worker's own effort e are complementary. Forward-looking workers at $t = 1$ would maximize their chance of successfully inventing by putting more effort in response to higher investments by employers (see equation 4.5).[26] The more productive firms set a higher investment τ (Proposition 2) and therefore can elicit more effort from workers than lower-productivity firms, holding fixed the level of bonus. With diminishing returns to worker effort ($h_{22} \ll 0$), the positive relationship between firm productivity and investment in turn yields a negative relationship between productivity and bonus γ, among workers whose likelihood of patenting πh is less than 0.5.[27]

This model prediction is consistent with our empirical finding that the wage premium for a person's initial patent application is almost twice as high at lower-wage firms in the bottom quartile than in the top quartile (columns 1 and 4 of Table 4). Employer learning alone cannot explain this finding unless new inventors at lower-wage firms are being poached by higher-wage firms, which we do not find in the data. By considering incentive contracts and firms' investment decisions simultaneously, we derive reasonable conditions of the production function under which the bonus is decreasing in firm productivity.

The condition $\pi h < 0.5$ in Proposition 3 implies that the negative relationship between bonus and firm productivity may not apply to workers who are known to be H-ability inventors with an over 50% chance of patenting. This implication is supported by our finding that experienced inventors are rewarded similarly between lower-wage and higher-wage firms (columns 3 and 6 of Table 4).

In summary, this 2-period model with dynamic decisions by firms and workers helps reconcile the key empirical findings in Section 3:

1. Younger workers are less likely to become inventors at lower-wage firms.

[26]From (4.5) we have $\frac{\partial e_{i1j}}{\partial \tau_{i1j}} \propto h_{12} > 0$.

[27]The condition that h_{22} has to satisfy for γ to be decreasing in firm productivity is expressed in (7.18) and (7.19) in Appendix A2.

2. There is a positive wage increase upon first patent application.
3. Wage return to a person's first patent application is higher at lower-wage firms, although new inventors at such firms are not being poached at a higher rate.

5 Conclusion

This paper investigates the heterogeneity in the identification and rewarding of inventors across firms in Italy. We find that younger potential inventors are 42% less likely to file their first patent application at a lower-wage firm in the bottom quartile than similar workers in the top quartile, where wages are higher. The gap between low-wage and high-wage firms in patent applications disappears, however, among experienced inventors who have already applied for patents before. Further, there is a significant 5-9 log point increase in a person's annual wage when she files her first-ever patent application, and the wage returns are significantly higher at firms that pay lower wages.

We interpret the empirical findings through a model of employer learning and incentive contracts. Heterogeneous firms invest in workers' research and use a bonus to incentivize workers to invent. The more productive firms invest more but set a lower bonus when (1) firm investment and worker effort are complementary in innovation production, and (2) there is a sufficiently diminishing return to worker effort. This model contributes to the employer learning literature by taking into account the dynamic incentives of firms and workers simultaneously.

Our findings on firm heterogeneity have a potential policy recommendation on the design of R&D policy. A large number of younger workers who are capable of inventing are not given a chance to do so at lower-wage firms. A policy subsidizing the promotion of younger inventors, targeting the number of young employees allowed to participate in the innovation process, could encourage firms to invest more in the identification and nurturing of talent. Such a policy can be particularly beneficial for countries like Italy, where younger workers face worsening economic opportunities amid a prolonged productivity slowdown.

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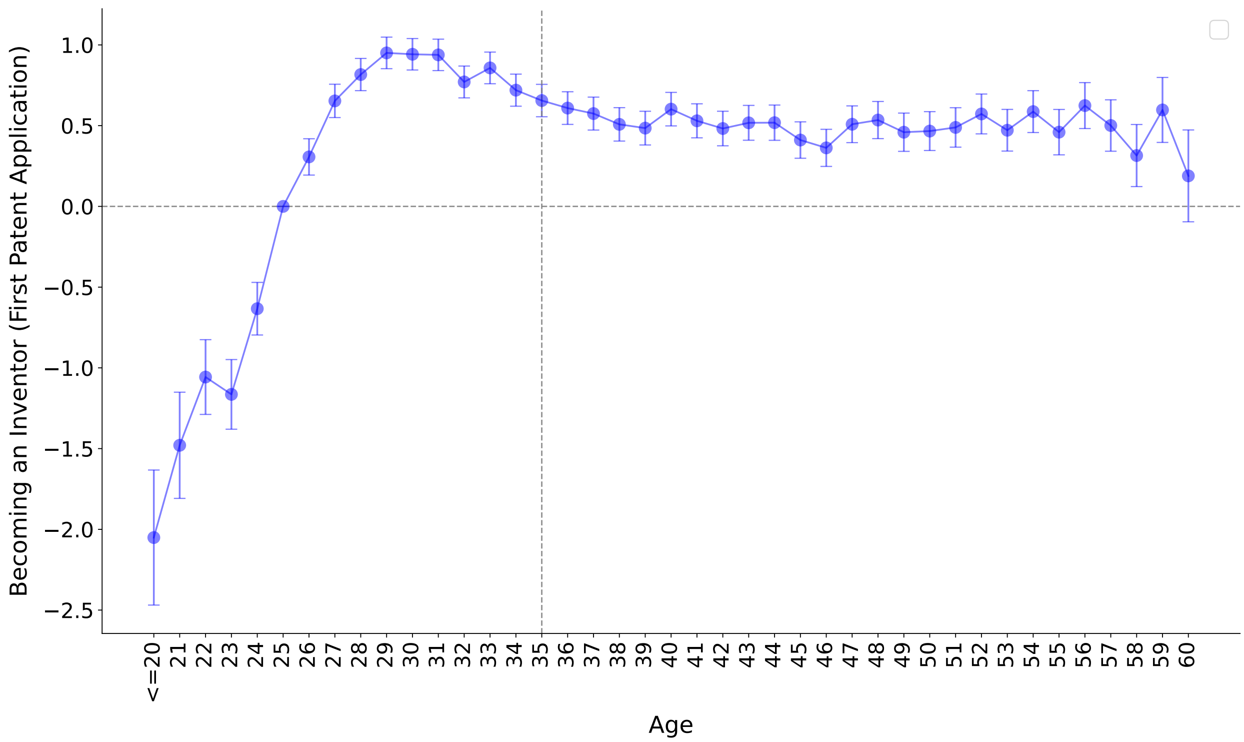
6 Figures

Figure 1: Lorenz Curves - Distribution of Younger Inventors Across Firms in Italy

Notes: This figure shows the distribution of younger inventors across firms. For each firm with at least one inventor matched in the INPS data, we compute the number of younger employees who apply for a patent at age ≤ 35, and the number of younger employees who have not applied for a patent but will do so at another firm in the future (the "not-yet inventors"). We require the patent applications to be assigned to inventors' primary employers in the year of initial filing. Younger inventors are more concentrated than younger workers who will become inventors elsewhere: about 90% of the younger inventors are employed by the 5% of firms (about 550 firms).

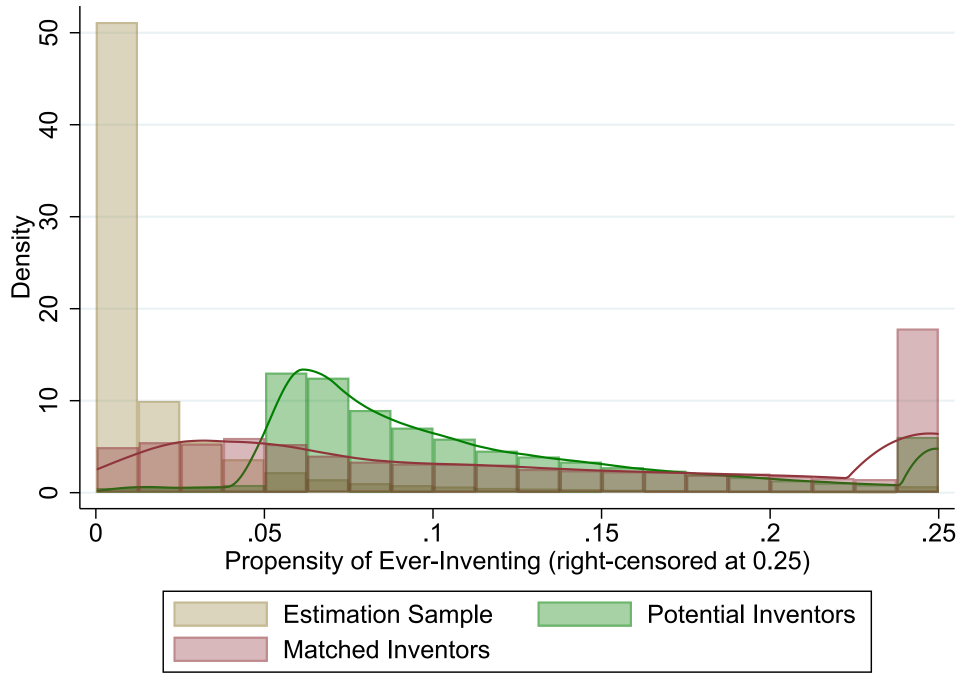
Figure 2: Becoming an Inventor by Age



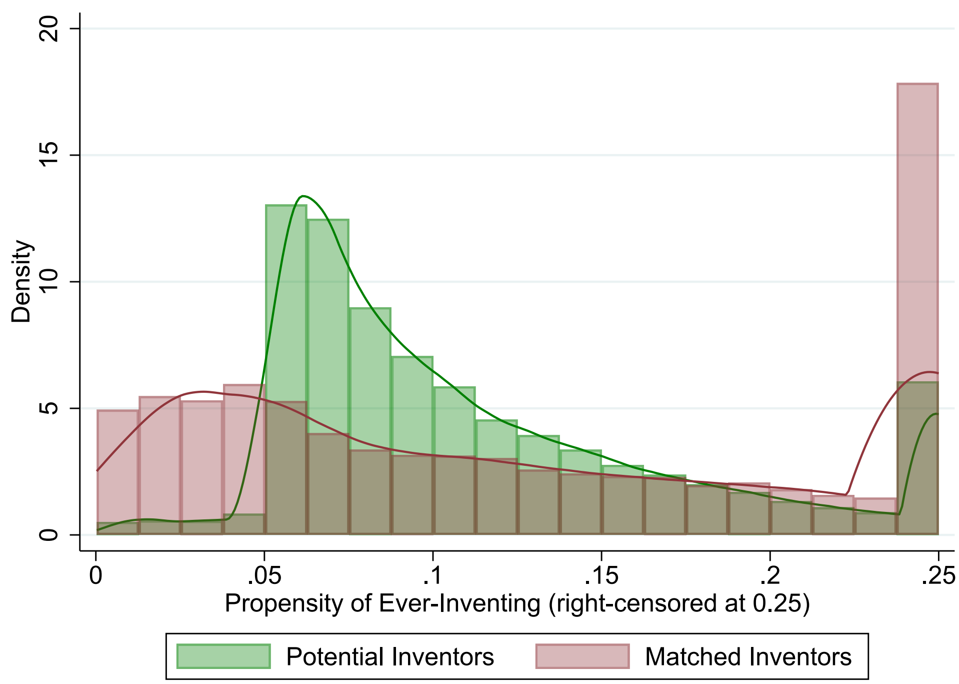
Notes: This figure plots the logit coefficients of becoming an inventor (first patent application) by age, relative to age 25. The estimation sample is at the (person, year) level, comprising the years in which a worker is aged between 18 and 60, has not applied for patents, or just submitted her first application. The logistic regression of becoming an inventor is estimated on a person $\times$ year panel that includes all potential inventors (see Section 2.2). We control for age dummies (ages 18-20 are grouped together), calendar year fixed effects, and gender.

Figure 3: Propensity Scores of Ever Inventing

(a) Full Sample

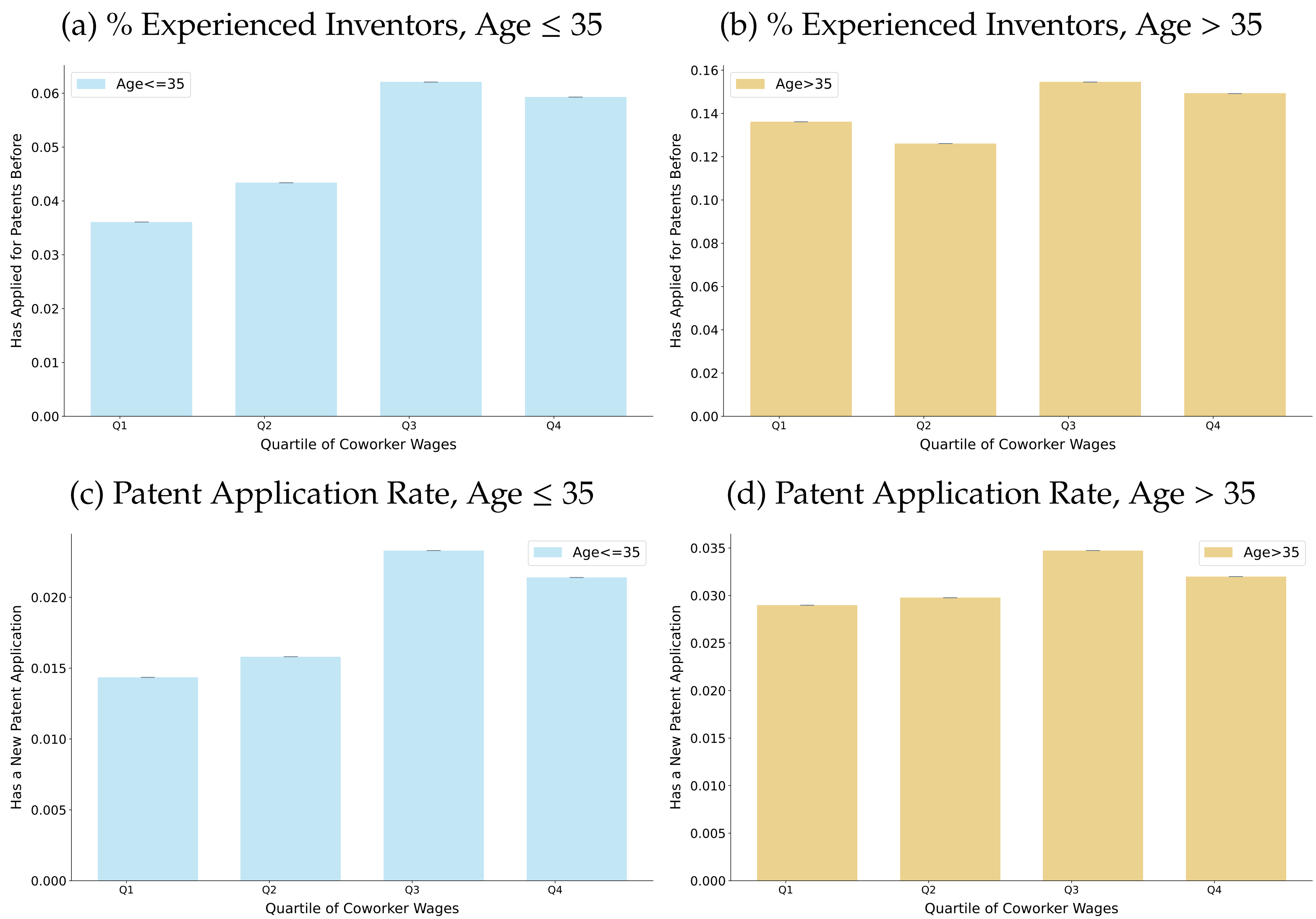


(b) Potential Inventors



Notes: This figure presents histograms of the estimated probability of a worker ever inventing, as specified in Poisson regression (2.1). For illustration, the p-scores are right-censored at 0.25. The estimation sample includes 1.5 million workers (see the notes under Table 1). Matched inventors are workers with at least one patent application matched to their employment in the INPS data 1987-2009. Potential inventors include all matched inventors and their coworkers whose estimated p-scores are above the median of the p-scores among matched inventors (Section 2.2).

Figure 4: Heterogeneity in Patenting by Age and Coworker Wages



Notes: This figure shows the fraction of employees who have already applied for a patent previously (the "experienced" inventors) in all potential inventors (panels (a) and (b)) and the share of the inventors with a new patent application at t in all potential inventors (panels (c) and (d)), by age group and firm quartile. Firms are ranked by mean coworker wages each year (excluding the focal employee).

7 Tables

Table 1: Sample Overview - Person Level

	Full Sample		Potential Inventors		Matched Inventors	
	mean	sd	mean	sd	mean	sd
Demographics						
Female	0.346	0.476	0.063	0.244	0.091	0.287
Yr of Birth	1960	11.923	1962	9.794	1958	10.836
INPS Sample (left-censored at 1987)						
First Yr in INPS	1991	5.162	1991	5.083	1990	4.886
Present in INPS in 1987	0.527	0.499	0.400	0.490	0.570	0.495
Patent Applications						
Any Patent App 1987-2009	0.010	0.100	0.138	0.344	1.000	0.000
Any Patent App Per Year	0.002	0.023	0.023	0.083	0.168	0.161
Any Patent App by Age 30	0.005	0.072	0.046	0.209	0.361	0.480
... by Age 35	0.009	0.095	0.081	0.273	0.586	0.493
... by Age 40	0.011	0.103	0.109	0.312	0.685	0.464
... by Age 45	0.011	0.106	0.145	0.352	0.760	0.427
... by Age 50	0.011	0.105	0.180	0.384	0.823	0.382
Job Characteristics						
Num. Employers (Firms)	2.089	1.337	2.726	1.492	2.150	1.414
Blue-Collar	0.055	0.123	0.049	0.115	0.018	0.067
White-Collar	0.935	0.145	0.949	0.118	0.980	0.070
Permanent Contracts	0.455	0.320	0.567	0.268	0.530	0.255
Temporary Contracts	0.101	0.224	0.061	0.146	0.036	0.105
Seasonal Contracts	0.002	0.025	0.001	0.011	0.000	0.007
Contract Type Missing	0.454	0.339	0.384	0.284	0.443	0.275
Wages						
Mean Log Wage	7.534	0.498	7.756	0.483	7.983	0.479
Log Wage at Age 30	7.376	0.442	7.515	0.337	7.585	0.294
... at Age 35	7.550	0.492	7.773	0.411	7.857	0.333
... at Age 40	7.678	0.499	7.960	0.493	8.072	0.424
... at Age 45	7.776	0.491	8.088	0.552	8.240	0.486
... at Age 50	7.850	0.493	8.171	0.593	8.384	0.543
Observations	1,537,000		112,000		15,000	

Notes: This table shows the summary statistics at the person level. The full sample includes inventors and their coworkers who 1) are in the INPS sample at age 14-55, 2) have at least five years of employment records in the sample between 1987 and 2009, and 3) worked in white-collar roles for at least 50% of their time in the sample. A worker is defined as a "matched inventor" if she has at least one patent application and at least an employment record in INPS in 1987-2009. We estimate the Poisson regression (2.1) that predicts if a person is a matched inventor on the estimation sample. Potential inventors include all matched inventors and any worker whose estimated propensity score of ever inventing is above the median p-score of the matched inventors (Section 2.2). The means of job characteristics, wages, and patenting rates are computed from the person-year panel.

Table 2: Firm Characteristics by Quartile of Coworker Wages

	Quartile 1		Quartile 2		Quartile 3		Quartile 4	
	mean	sd	mean	sd	mean	sd	mean	sd
Num. Unique Firms	12,239		6,862		5,893		7,158	
Log Wage	7.511	0.499	7.787	0.245	7.864	0.242	7.999	0.351
Num. Potential Inventors	14.668	78.561	27.684	147.763	31.249	141.079	22.856	112.887
Age of Employees	35.202	5.836	37.522	4.511	38.122	4.377	38.995	4.746
Age When Applying for a Patent	42.083	7.596	42.501	6.954	42.932	6.713	43.610	6.880
Patent Applications (per worker-year)								
Num. Patent Apps	0.011	0.047	0.015	0.045	0.016	0.050	0.015	0.057
Num. Patent Apps, Age<=35	0.005	0.038	0.007	0.036	0.008	0.037	0.007	0.045
Num. Patent Apps, Age>35	0.017	0.082	0.021	0.068	0.022	0.072	0.020	0.076
Any Patent App	0.007	0.025	0.009	0.025	0.010	0.026	0.009	0.030
Any Patent App, Age<=35	0.004	0.023	0.005	0.021	0.005	0.021	0.005	0.026
Any Patent App, Age>35	0.011	0.038	0.013	0.037	0.013	0.038	0.012	0.039
Industry (grouped by csc code):								
Electronics/Telecom	0.090	0.286	0.101	0.301	0.100	0.300	0.089	0.285
Pharmaceutical	0.032	0.175	0.049	0.216	0.057	0.232	0.059	0.236
Automobile	0.028	0.164	0.035	0.185	0.037	0.188	0.036	0.186
Other Manufacturing	0.471	0.499	0.530	0.499	0.518	0.500	0.491	0.500
Services and Others	0.380	0.485	0.285	0.451	0.288	0.453	0.325	0.468

Notes: This table summarizes the firm characteristics in each quartile of mean coworker wages. We rank firms by the mean coworker wage leaving out a person's own wage each year, and place them into quartiles (quartile 1 with the lowest wage on average). We keep the unique firms that have ever been in each quartile and summarize the firm-level characteristics above. Our INPS-PatStat sample comprehends all the INPS firms that have employed at least one inventor in the period 1987-2009. The INVIND sample includes firms that can be matched to INVIND by fiscal code or by firm name. See Appendix Table B.2 for a summary restricted to firms that are matched to INVIND.

Table 3: First Patent Application at the Current Employer, by Quartile of Firms and Age Group

	First Patent Application at the Current Employer					
	Age ≤ 35			Age > 35		
	(1)	(2)	(3)	(4)	(5)	(6)
Quartile of Coworker Mean Wage						
quartile 1	-0.2125***	-0.1627***	0.1132	0.0751*	-0.1133***	0.0245
	(0.0426)	(0.0372)	(0.1570)	(0.0440)	(0.0375)	(0.0625)
quartile 2	-0.0145	-0.1331***	0.3726***	-0.0242	-0.1132***	0.2294***
	(0.0401)	(0.0363)	(0.1233)	(0.0396)	(0.0348)	(0.0512)
quartile 3	0.1519***	-0.1027***	0.4162***	0.0333	-0.0707**	0.2614***
	(0.0390)	(0.0370)	(0.1182)	(0.0382)	(0.0344)	(0.0464)
quartile 4	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Mean |quartile 4	.0091846	.1205102	.062799	.0066348	.1619296	.0718585
N	644238	52843	5869	744670	34735	33170
Pseudo R^2	.0645567	.1083685	.0928058	.0399737	.0729711	.0838201

Notes: This table shows the estimated Poisson regression (3.1) of whether a worker files her first patent application at her current employer on the quartile of her employer, ranked by mean coworker wages (excluding her wage) in a year. The estimation sample is at the person × year level, including the years until each worker's first patent application at the current employer. All regressions control for sex, a cubic polynomial in age (relative to age 35), indicators for white/blue collar and permanent/temporary contract interacted with age, and fixed effects of the calendar year, 2-digit industry, and geographic region. Models (1) and (4) are estimated on potential inventors who have not applied for patents before. (2) and (5) are restricted to matched inventors who have not applied for patents yet but will do so during the sample period. (3) and (6) are restricted to experienced inventors, who have already applied for patents at former employers. Significance: * 0.10 ** 0.05 *** 0.010.

Table 4: Wage Returns to New Patent Application, by Quartile of Firms and Age Group

	Log Annual Wages					
	Age ≤ 35			Age > 35		
	(1)	(2)	(3)	(4)	(5)	(6)
Quartile of Coworker Mean Wage						
quartile 1	-0.1249***	-0.0847***	-0.0740***	-0.1145***	-0.0743***	-0.0953***
	(0.0016)	(0.0056)	(0.0142)	(0.0015)	(0.0055)	(0.0065)
quartile 2	-0.0671***	-0.0281***	-0.0495***	-0.0655***	-0.0381***	-0.0466***
	(0.0014)	(0.0048)	(0.0127)	(0.0011)	(0.0042)	(0.0052)
quartile 3	-0.0422***	-0.0133***	-0.0316***	-0.0382***	-0.0182***	-0.0156***
	(0.0012)	(0.0042)	(0.0099)	(0.0009)	(0.0037)	(0.0042)
Any New Patent Application						
y_{it}	0.0470***	0.0366***	0.0151	0.0309***	0.0086	0.0156*
	(0.0065)	(0.0068)	(0.0155)	(0.0050)	(0.0053)	(0.0088)
Excess Returns (relative to quartile 4)						
$y_{it}\times$ quartile 1	0.0388***	0.0219**	-0.0214	0.0214***	0.0100	0.0018
	(0.0087)	(0.0089)	(0.0376)	(0.0080)	(0.0082)	(0.0153)
$y_{it}\times$ quartile 2	0.0065	-0.0165*	0.0019	0.0116*	0.0026	-0.0102
	(0.0083)	(0.0086)	(0.0255)	(0.0070)	(0.0072)	(0.0129)
$y_{it}\times$ quartile 3	0.0017	-0.0150*	-0.0180	-0.0060	-0.0123*	-0.0271**
	(0.0083)	(0.0086)	(0.0252)	(0.0066)	(0.0068)	(0.0117)
Mean |quartile 4	7.678282	7.625638	7.870129	8.230651	8.215813	8.489231
N	646123	52411	5844	740741	34054	32585
Adjusted R^2	.7099518	.7429179	.7948655	.8650494	.9022971	.8760036

Notes: This table shows the estimated OLS regression (3.2) of log annual wages on whether a worker applies for a new patent and its interactions with the quartile of her current employer, ranked by mean coworker wages (excluding her wage) in a year. The estimation sample is at the person × year level. All models control for person-fixed effects, in addition to the covariates listed under Table 3. Models (1) and (4) are estimated on all potential inventors. (2) and (5) are restricted to matched inventors, and (3) and (6) are restricted to experienced inventors, who have already applied for patents at former employers. Significance: * 0.10 ** 0.05 *** 0.010.

Table 5: Between-firm Job Mobility in a Year, by Quartile of Firms and Age Group

	Move in 1 Year: $j(i,t+1) \neq j(i,t)$					
	Age ≤ 35			Age > 35		
	(1)	(2)	(3)	(4)	(5)	(6)
Quartile of Coworker Mean Wage						
quartile 1	-0.0397***	0.2106***	-0.1368	-0.0680***	-0.0282	-0.0386
	(0.0096)	(0.0454)	(0.0885)	(0.0116)	(0.0697)	(0.0475)
quartile 2	-0.1818***	-0.1719***	0.0996	-0.1710***	-0.1603**	-0.0210
	(0.0104)	(0.0509)	(0.0802)	(0.0109)	(0.0713)	(0.0454)
quartile 3	-0.0972***	-0.1608***	-0.0099	-0.1571***	-0.3080***	-0.0433
	(0.0104)	(0.0521)	(0.0840)	(0.0108)	(0.0740)	(0.0432)
quartile 4	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Any New Patent Application						
y_{it}	-1.3513***	-0.7851***	-0.4702***	-1.9613***	-1.3426***	-0.9691***
	(0.1557)	(0.1598)	(0.1356)	(0.2116)	(0.2203)	(0.0963)
Additional effect (relative to quartile 4)						
$y_{it}\times$ quartile 1	0.0469	-0.2539	-0.4722**	0.2072	-0.0034	-0.1722
	(0.2042)	(0.2082)	(0.2071)	(0.3105)	(0.3177)	(0.1612)
$y_{it}\times$ quartile 2	0.4909**	0.4651**	0.0321	0.7381***	0.6798**	0.3302**
	(0.1973)	(0.2030)	(0.1891)	(0.2696)	(0.2771)	(0.1344)
$y_{it}\times$ quartile 3	-0.0073	0.1437	0.1815	0.2875	0.5396*	0.2685**
	(0.2131)	(0.2185)	(0.1817)	(0.2875)	(0.2958)	(0.1308)
Mean |quartile 4	.1448382	.082274	.0678597	.1031698	.0559353	.046911
N	633858	53060	25046	671293	34578	105222
Pseudo R^2	.0397005	.0758365	.0342579	.0272517	.0439756	.0344894

Notes: This table shows the estimated Poisson regression (3.3) of any movement between firms in a year ($j(i,t+1) \neq j(i,t)$) on whether a worker applies for a new patent and its interactions with the quartile of her current employer, ranked by mean coworker wages (excluding her wage) in a year. The estimation sample is at the person × year level. Models (1) and (4) are estimated on all potential inventors. (2) and (5) are restricted to matched inventors, and (3) and (6) are restricted to experienced inventors, who have already applied for patents at former employers. Significance: * 0.10 ** 0.05 *** 0.010.

Appendix A: Model Details

A0. Model Timeline & Information Structure

There are two discrete periods in this model, as illustrated in Figure **??**.

1. (**$t = 1$**) All workers are on the labor market looking for jobs.
   (a) Given a common prior $\pi = Pr(\alpha_i = H)$ about a worker, employers (indexed by j) post contracts $\{\underline{w}_{i1j}, \gamma_{i1j}\, \tau_{i1j}\}$ simultaneously, comprising a base wage $\underline{w}$, a proportional bonus upon patent application γ, and (R&D) investment on the worker's innovation activity.
   (b) Each worker observes the contracts posted by employer, and draws EV-I distributed preferences (4.2) across firms, chooses an employer $j(i, 1)$ that maximizes her utility (4.4) at $t = 1$. Conditional on choosing $j = j(i, 1)$, she will make effort e_{i1j} on innovation that maximize her utility from wage at $t = 1$ and her option value on the market at $t = 2$, discounted by $\beta_W \in (0, 1]$.
   (c) Whether a person produces a patent application, $p_{i1} \in \{0, 1\}$, is realized by the end of $t = 1$. Worker i receives a bonus of $\gamma_{i1j} \times \underline{w}_{i1j}$ if $p_{i1} = 1$, and zero otherwise.
2. (**$t = 2$**) Information evolves at the beginning of the second period according to the patent production at $t = 1$:

$$\begin{aligned} p_{i1} &= 1 \rightarrow \text{public } \pi_{i2} = 1 \\ p_{i1} &= 0 \rightarrow \text{public } \pi_{i2} = Pr(\alpha_i = H | j(i, 1), p_{i1} = 0) \end{aligned} \tag{7.1}$$

   Workers who apply for patents are publicly known as H-ability inventors, while other workers are characterized by posterior belief conditional on not producing any patent at their $t = 1$ employer $j(i, 1)$'s.
   (a) Given the new belief about worker ability, firms post new contracts simultaneously by solving (4.6).
   (b) Workers may re-enter the job market with probability $\lambda \in [0, 1]$. If she is on the market, she observes the new contracts, draws new preferences from (4.2), and chooses the employer that maximizes her expected utility (4.3). Otherwise, $j(i, 2) = j(i, 1)$ and she makes effort that maximizes her utility conditional on staying.
   (c) Repeat 1(c). The model concludes.

A1. Backward Induction

We state the problems facing workers and firms in each period in Section 4.2. Now we provide details on the backward induction.

Optimization at $t = 2$

Worker's Problem. Given contract $(\underline{w}_{i2j}, \gamma_{i2j}, \tau_{i2j})$, conditional on being employed by j, the worker would choose effort that maximize:

$$\begin{aligned} e_{i2j} &= argmax_e\, E[b \times ln(w_{i2j}) - c(e)] = b\, ln(\underline{w}_{i2j}) + \pi\, h(\tau_{i2j}, e) \times b\, ln(1+\gamma_{i2j}) - \frac{c}{2}e^2 \\ &= \frac{\pi \times b\, ln(1+\gamma_{i2j})}{c} \times h_2(\tau_{i2j}, e) \end{aligned} \tag{7.2}$$

Applying Implicit Function Theorem on the first-order condition, we have

$$\begin{aligned} \frac{\partial e_{i2j}}{\partial \tau} &= \frac{\pi\, b/c\, ln(1+\gamma) \times \boldsymbol{h_{12}}}{1 - \pi\, b/c\, ln(1+\gamma) \times \boldsymbol{h_{22}}} \\ \frac{\partial e_{i2j}}{\partial \gamma} &= \frac{\pi\, b/c \times \boldsymbol{h_2}}{1 - \pi\, b/c\, ln(1+\gamma) \times \boldsymbol{h_{22}}} \times \frac{1}{1+\gamma} \end{aligned} \tag{7.3}$$

Note under the assumption $h_1, h_2 > 0$ and $h_{22} < 0$, we have the worker's effort to be increasing in wage incentive γ, and increasing in firm investment τ iff effort and firm investment are complementary ($h_{12} > 0$).

If not on the market, workers stay at their $t = 1$ employers, $j(i,2) = j(i,1)$. Otherwise, workers observe contracts posted by **all** employers, and solve:

$$\begin{aligned} j(i,2) =& argmax_j\, u_{i2j} + \epsilon_{i2j} = E[b\, ln(w_{i2j}) | \pi, \tau_{i2j}, e_{i2j}] - c(e_{i2j}) + \epsilon_{i2j} \\ & \text{where } e_{i2j} \text{ solves (7.2)} \end{aligned}$$

Given the EV-I distributed preferences (4.2), her probability of choosing firm j is:

$$s_{i2j} = \frac{exp(E[b \times ln(w_{i2j})] - c(e_{i2j}))}{\sum_{j'} exp(\boldsymbol{u_{i2j'}})} \tag{7.4}$$

Firm's Problem. Given public employer belief π at the beginning of $t = 2$, firms post optimal contracts that maximize their expected profit at $t = 2$, for incumbent ($\delta_{ij} = 1$) and new ($\delta_{ij} = 0$) employees, respectively (repeating equation 4.6):

$$\begin{aligned} & max_{(\underline{w}, \gamma, \tau)}\, s_{2j}^{(\delta)}(\underline{w}, \gamma, \tau) \times \left(E_\alpha[Y_j(\alpha, \tau, e)|\pi] - \underline{w}(1 + \gamma \times \pi h(\tau, e))\right) \\ & \qquad = \left(\phi_j \times (1 + \theta \times \pi \times h(\tau, e)) - \frac{\zeta}{2}\tau^2 - \underline{w}(1 + \gamma \times \pi h(\tau, e))\right) \end{aligned} \tag{7.5}$$

in which $\delta = 1[j = j(i,2)]$ equals to 1 for incumbent employees, 0 for workers from other firms. The expected labor supply from the worker:

$$s_{2j}^{(\delta)}(\underline{w},\gamma,\tau)=\begin{cases}1-\lambda\times(1-s_{2j}) & \delta=1\\ \lambda\times s_{2j}(\underline{w},\gamma,\tau) & \delta=0\end{cases} \tag{7.6}$$

$$\text{elasticity } \xi_{2j}^{(\delta)}=\frac{\partial\, ln\, s_{2j}^{(\delta)}(\underline{w},\gamma,\tau)}{\partial ln(\underline{w})}=\frac{\underline{w}}{s_{2j}^{(\delta)}}\times\lambda s_{2j}(1-s_{2j})\frac{b}{\underline{w}}=\frac{\lambda s_{2j}}{s_{2j}^{(\delta)}}\times b(1-s_{2j})$$

The first-order conditions are:

$$\begin{aligned}\frac{\partial}{\partial\underline{w}}&=\frac{\partial\, s_{2j}^{(\delta)}(\underline{w},\gamma,\tau)}{\partial\underline{w}}\times\left(E_\alpha[Y_j(\alpha,\tau,e)|\pi]-\underline{w}(1+\gamma\times\pi h(\tau,e))\right)-s_{2j}^{(\delta)}\times(1+\gamma\times\pi h(\tau,e))=0\\ \rightarrow&\xi_{2j}^{(\delta)}\left(E_\alpha[Y_j(\alpha,\tau,e)|\pi]-\underline{w}\times(1+\gamma\pi h(\tau,e))\right)=\underline{w}\times(1+\gamma\pi h(\tau,e))\end{aligned} \tag{7.7}$$

$$\begin{aligned}\frac{\partial}{\partial\gamma}&=\frac{\partial\, s_{2j}^{(\delta)}(\underline{w},\gamma,\tau)}{\partial\gamma}\times(\ldots)+s_{2j}^{(\delta)}\times\left(-\underline{w}\pi h+\pi(\phi_j\theta-\gamma\underline{w})\times h_2\frac{\partial e}{\partial\gamma}\right)=0\\ \rightarrow&-\frac{\gamma(1-\pi h)}{1+\gamma}h\,\underline{w}+(\phi_j\theta-\gamma\underline{w})\times h_2\frac{\partial e}{\partial\gamma}=0\end{aligned} \tag{7.8}$$

in which $\frac{\partial e}{\partial\gamma}>0$ is expressed in equation (7.3).

$$\begin{aligned}\frac{\partial}{\partial\tau}&=\frac{\partial\, s_{2j}^{(\delta)}(\underline{w},\gamma,\tau)}{\partial\tau}\times(\ldots)+s_{2j}^{(\delta)}\times\left(\pi(\phi_j\theta-\gamma\underline{w})\times\frac{dh(\tau,e)}{d\tau}-\zeta\tau\right)=0\\ \rightarrow&\pi\, h_1\, ln(1+\gamma_{2j})\times\underline{w}(1+\gamma\pi h)+\pi(\phi_j\theta-\gamma\underline{w})\times\left(h_1+h_2\frac{\partial e}{\partial\tau}\right)-\zeta\tau=0\end{aligned} \tag{7.9}$$

in which $\frac{\partial e}{\partial\tau}$ is expressed in equation (7.3).

Optimization at $t=1$

Worker's Problem. Workers are all on the market at $t=1$. They take into account the option value conditional on choosing j at $t=1$ defined as $\Omega_j(\pi_2)=\lambda E[max\{u_{i2j'}(\pi_2)+\epsilon_{i2j}\}]+(1-\lambda)\times u_{i2j}(\pi_2)$ when the posterior belief becomes π_2 after the first period. The expected option value given prior π_1 can therefore be expressed as $E[\Omega_j(\pi_2)|\pi_1,\tau,e]=\pi_1 h(\tau,e)\times\Omega_j(H)+(1-\pi_1 h)\times\Omega_j(\pi_2(0))$. The change in option value when one has a patent application versus not is: $\triangle_p\Omega_j:=\Omega_j(H)-\Omega_j(\pi_2(0))$.

$$j(i,1) = argmax_j\, u_{i1j} + \epsilon_{i1j} \tag{7.10}$$
$$= E[b\, ln(w_{i1j})|\pi, \tau_{i1j}, e_{i1j}] - c(e_{i1j}) + \beta_W E[\Omega_j(\pi_2)] + \epsilon_{i1j}$$

in which

$$\begin{aligned} e_{i1j} =& argmax_e\, \pi\, h(\tau_{i1j}, e) \times b\, ln(1+\gamma_{i1j}) - \frac{c}{2}e^2 + \beta_W E[\Omega_j] \\ =& \pi \times h_2(\tau_{i1j}, e) \times \frac{\left(b\, ln(1+\gamma_{i1j})\ + \beta_W \triangle_p \Omega_j\right)}{c} \end{aligned} \tag{7.11}$$

Applying Implicit Function Theorem on the first-order condition, we have

$$\begin{aligned} \frac{\partial e_{i1j}}{\partial \tau} &= \frac{\pi\,(b\, ln(1+\gamma) + \beta_W \triangle_p \Omega_j)/c\ \times \boldsymbol{h_{12}}}{1 - \pi\,(b\, ln(1+\gamma) + \beta_W \triangle_p \Omega_j)/c\ \times \boldsymbol{h_{22}}} \\ \frac{\partial e_{i1j}}{\partial \gamma} &= \frac{\pi\,(b/c) \times \boldsymbol{h_2}}{1 - \pi\,(b\, ln(1+\gamma) + \beta_W \triangle_p \Omega_j)/c\ \times \boldsymbol{h_{22}}} \times \frac{1}{1+\gamma} \end{aligned} \tag{7.12}$$

The labor supply to firm j at $t = 1$ can be written as:

$$s_{i1j} = \frac{exp\, \left(E[b \times ln(w_{i1j}) + \beta_W\, \Omega_j(\pi_2)]\right)}{\sum_{j'} exp\, \left(\boldsymbol{u_{i1j'}}\right)} \tag{7.13}$$

Firm's Problem. Given common prior π_1 about worker ability, firms solve for optimal contracts that maximize the flow profit at $t = 1$ and expected continuation value:

$$\begin{aligned} max_{(\underline{w},\gamma,\tau)}\, s_{1j}(\pi_1) &\times \left(E_\alpha[Y_j(\alpha,\tau,e)] - \underline{w}(1+\gamma\times\pi_1 h(\tau,e)) + \beta_J E[v_{2j}^{(1)}(\pi_2)|\pi_1,\tau,e]\right) \\ &= s_{1j} \times \left(\phi_j + \phi_j\theta\pi_1 h(\tau, e_{1j}) - \frac{\zeta}{2}\tau^2 - \underline{w}(1+\gamma\times\pi_1 h(\tau,e)) + \beta_J EV2\right) \end{aligned} \tag{7.14}$$

where $EV2 := v_{2j}^{(1)}(\pi_2(0)) + \pi_1 \boldsymbol{h(\tau,e)} \times \left(v_{2j}^{(1)}(1) - v_{2j}^{(1)}(\pi_2(0))\right)$

e_{i1j} solves (7.11)

The optimal contracts would satisfy the following first-order conditions in 7.15-7.17:

$$\frac{\partial}{\partial \underline{w}} = \frac{\partial s_{1j}}{\partial \underline{w}} \times \left(E_\alpha[Y_j] - \underline{w}\left(1+\gamma\times\pi_1 h(\tau,e_{1j})\right) + \beta_J EV2\right) - s_{1j} \times (1+\gamma\pi_1 h(\tau, e_{1j})) = 0$$
$$\xi_{1j}\left(E_\alpha[Y_j(\alpha,\tau,e)|\pi] + \beta_J EV2 - \underline{w} \times (1+\gamma\pi h(\tau,e))\right) = \underline{w} \times (1+\gamma\pi h(\tau,e)) \tag{7.15}$$

in which the labor supply elasticity at $t = 1$, $\xi_{i1j} = b(1 - s_{i1j})$.

$$\frac{\partial}{\partial \gamma} = \frac{\partial s_{1j}}{\partial \gamma} \times \left(E[Y_j - w_{1j}] + \beta_J EV2\right) + s_{1j} \times \left(-\underline{w} \times \pi_1 h(\tau, e_{1j}) + \frac{\partial(E[Y - w] + \beta_J EV2)}{\partial e} \times \frac{\partial e_{1j}}{\partial \gamma}\right) = 0$$

$$\rightarrow -\frac{\gamma(1-\pi h)}{1+\gamma} \times \underline{w}h + (\phi_j \theta - \gamma \underline{w} + \beta_J \triangle v_{2j}^{(1)}) \times \boldsymbol{h_2} \times \boldsymbol{\frac{\partial e}{\partial \gamma}} = 0 \tag{7.16}$$

$$\frac{\partial}{\partial \tau} = \frac{\partial s_{1j}}{\partial \tau} \times \left(E[Y_j - w_{1j}] + \beta_J EV2\right) + s_{1j} \times \left(\frac{\partial(E[Y_j - w_j] + EV2)}{\partial h} \times \frac{dh(\tau, e)}{d\tau}\right) \tag{7.17}$$

$$\rightarrow \pi \left(ln(1+\gamma) + \frac{\beta_W}{b} \triangle \Omega_j\right) \times h_1 \times \underline{w}(1 + \gamma \pi h) + \pi \underbrace{(\phi_j \theta - \gamma \underline{w} + \beta_J \triangle v_{2j}^{(1)})}_{\text{dynamic markup on patent}} \times \left(h_1 + h_2 \frac{\partial e}{\partial \tau}\right) - \zeta \tau = 0$$

A2. Proof of Propositions

Proof of Proposition 1: Positive Relationship between Firm Productivity and Base Wages

Proof (sketch):
From the first order conditons (7.7) and (7.15), we have the base wages at each period is marked down by the inverse labor supply elasticity, from the expected value of the worker to the firm:

$$\underline{w}_{i2j}^{(\delta)} = \frac{\xi_{2j}^{(\delta)}}{1 + \xi_{2j}^{(\delta)}} \times \frac{E_\alpha[Y_j(\alpha, \tau_{2j}^{(\delta)}, e*)|\pi]}{1 + \gamma \pi h(\tau_{2j}^{(\delta)}, e)}$$

$$\underline{w}_{1j} = \frac{\xi_{1j}}{1 + \xi_{1j}} \times \frac{E_\alpha[Y_j(\alpha, \tau, e)|\pi] + \beta_J EV2}{1 + \gamma \pi h(\tau, e)}$$

The expected output a worker can produce each period is increasing in ϕ_j, according to the definition of Y_j (4.1). At $t = 1$, the expected continuation value of a firm is also increasing in ϕ_j, as it faces less turnover. Although labor supply is less elastic (7.6) at larger firms, the growth of the expected value of a worker with ϕ_j is faster than the downward pressure on wages from the increasingly inelastic labor supply.

Proof of Proposition 2: Heterogeneity in Firm Investment on Innovation

Proof (sketch):
The optimal investment on innovation at $t = 2$ is solves the first-order condition in (7.9). The rent from an invention, $\phi_j \theta - \gamma \underline{w}$, is increasing in firm productivity ϕ_j. Under the assumption that $h_{12} > 0$ and $h_{22} < 0$, we have $\frac{\partial e}{\partial \tau} > 0$ (see 7.3), which implies $h_1 + h_2 \frac{\partial e}{\partial \tau} > 0$. Thus we have τ_{2j} increasing in ϕ_j. At $t = 1$, the investment τ_{1j} solves (7.17). It suffices to

show that the dynamic markup from an invention, $\phi_j\theta - \gamma \underline{w} + \beta_J \triangle_p v_{2j}^{(1)}$ is increasing in ϕ_j. The change in a firm's continuation value depends on the turnover of workers. Higher-ϕ_j firms with higher wages are less likely to lose workers to less productive counterparts; as a result, $\triangle_p v_{2j}^{(1)}$ increases in ϕ_j. The first-period investment is also increasing in ϕ_j.

Proof of Proposition 3: Heterogeneity in Wage Returns to Innovation

Proof (sketch):

At $t = 2$, define $K = \frac{\partial e_{i2j}}{\partial \gamma_{i2j}} * (1 + \gamma_{i2j}) = \frac{\pi\, b/c\ h_2}{1 - \pi\, b/c\, ln(1+\gamma_{i2j})\, h_{22}}$ according to the comparative statics (7.3). The FOC for γ (7.8) can be rewritten as:

$$
\begin{aligned}
(\phi_j\theta) \times h_2\boldsymbol{K} &= \gamma_{i2j}\underline{w}\,(h_2\boldsymbol{K} + (1-\pi h)h) \\
\gamma &= \frac{\phi_j}{\underline{w}} \times \frac{\theta \times h_2\boldsymbol{K}}{(h_2\boldsymbol{K} + (1-\pi h)h)} \\
\frac{\partial ln\gamma_{i2j}}{\partial \phi_j} < 0 \leftrightarrow \frac{\partial ln(\phi_j/\underline{w})}{\partial\phi_j} &< \frac{\partial}{\partial\phi_j} ln\left(1 + \frac{(1-\pi h)h}{h_2\boldsymbol{K}}\right)
\end{aligned}
\tag{7.18}
$$

The left-hand side of (7.18) is positive, and we break down the right-hand side (RHS):

1. $\frac{\partial(1-\pi h)h}{\partial\phi_j} = (1-2\pi h) \times \frac{\partial h(\tau,e)}{\partial\phi_j} = (1-2\pi h) \times \underbrace{\left(h_1 + h_2\frac{\partial e}{\partial\tau}\right)}_{>0} \times \underbrace{\frac{\partial\tau}{\partial\phi_j}}_{>0 \text{ Prop } 2} > 0$

   as long as $\pi h < 1/2$.
2. $\frac{\partial h_2(\tau,e)}{\partial\phi_j} = \frac{\partial\tau}{\partial\phi_j} \times \left(h_{12} + h_{22}\frac{\partial e}{\partial\tau}\right) \ll 0$ if $h_{22} \ll 0$.
3. $\frac{\partial \boldsymbol{ln\, K}}{\partial\phi_j} = \frac{\partial ln\,(\boldsymbol{h_2})}{\partial\phi_j} - \frac{\partial(1-\pi\, b/c\, ln(1+\gamma)\, h_{22})}{\partial\phi_j} \ll 0$ if $h_{22} \ll 0$.

Taken together, when employer belief π is bounded such that $\pi h < 0.5$ and h is sufficiently concave in worker effort with $h_{22} \ll 0$, we have the growth rate of the RHS with firm productivity ϕ_j is higher than the growth of the markup relative to base wage. In that case, we have the bonus contingent on patent application at $t = 2$ decreasing with firm productivity ϕ_j.

At $t = 1$, the optimal bonus solves the first-order condition in (7.16). Define $K = \frac{\partial e}{\partial\gamma} * (1+\gamma) = \frac{\pi\, b/c\ h_2}{1-\pi\,(b\, ln(1+\gamma) + \beta_W \triangle_p \Omega_j)/c\, h_{22}}$.

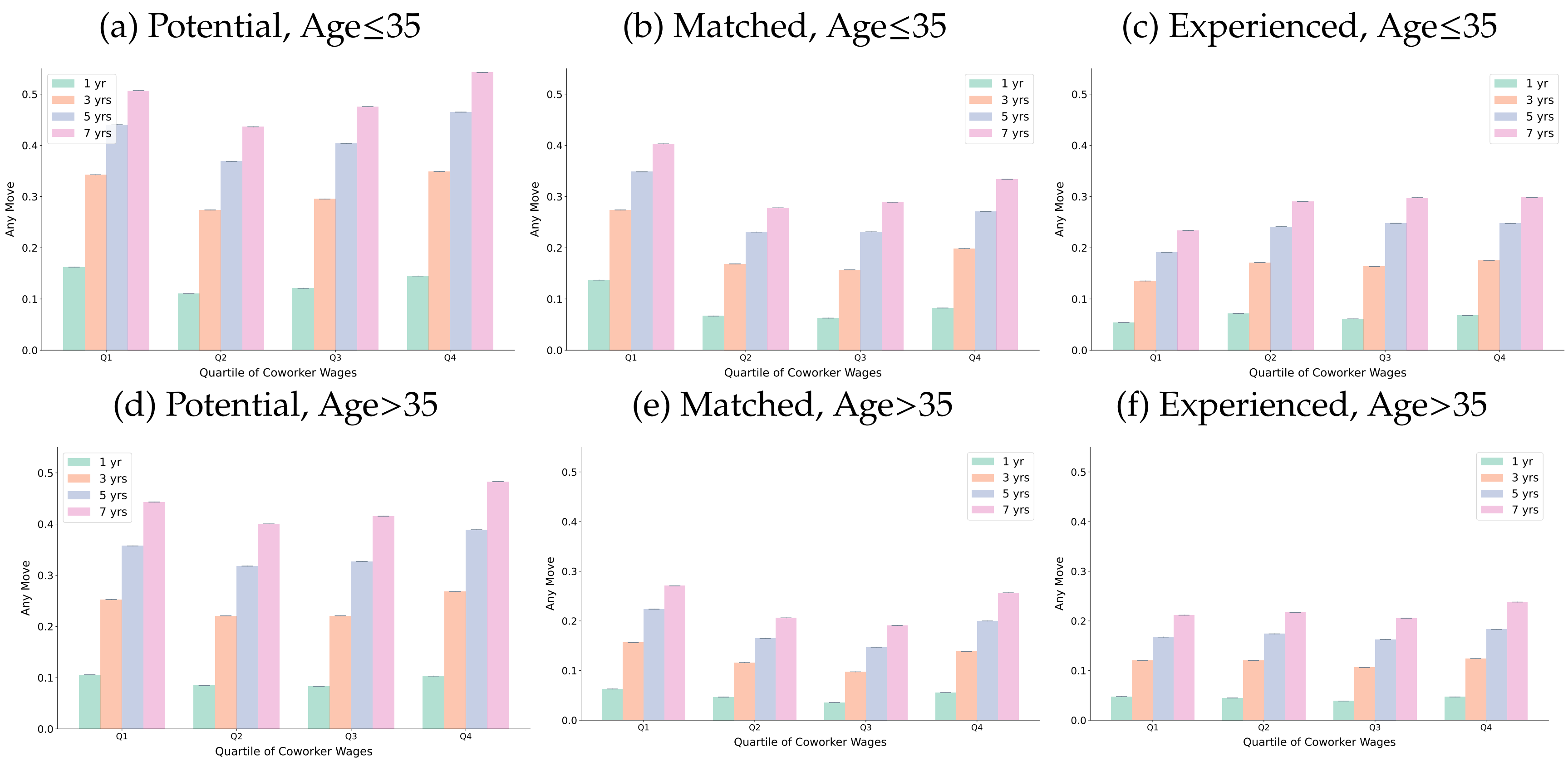
$$
\begin{aligned}
\gamma_{i1j} &= \frac{\phi_j\theta + \beta_J \triangle v_{2j}^{(1)}}{\underline{w}} \times \frac{h_2 K}{h_2\boldsymbol{K} + (1-\pi h)h} \\
\frac{\partial ln\gamma_{i1j}}{\partial\phi_j} < 0 &\leftrightarrow \underbrace{\frac{\partial ln(\frac{\phi_j + \beta_J \triangle v_{2j}^{(1)}/\theta}{\underline{w}})}{\partial\phi_j}}_{>0} < \frac{\partial}{\partial\phi_j} ln\left(1 + \frac{(1-\pi h)h)}{h_2\boldsymbol{K}}\right)
\end{aligned}
\tag{7.19}
$$

The LHS of (7.19) is positive, and the same breakdown of the RHS applies. For γ_{i1j} to be decreasing with ϕ_j, we need $\pi \times h < 0.5$, and that h_{22} is sufficiently negative such that the condition (7.19) holds.

Although there is no closed-form solution for the upper bound of h_{22} under which both (7.19) and (7.18) hold, the intuition is simple. With diminishing return to worker effort, higher-productivity firms can elicit sufficient effort from workers by investing more (Proposition 2). The less productive firms, in contrast, invest less and set a higher bonus to incentivize workers to invent. The condition that the likelihood of inventing $\pi h(\tau, e) < 0.5$ implies that $\frac{\partial \gamma}{\partial \tau} < 0$ would not hold for workers with an over 50% chance of inventing.

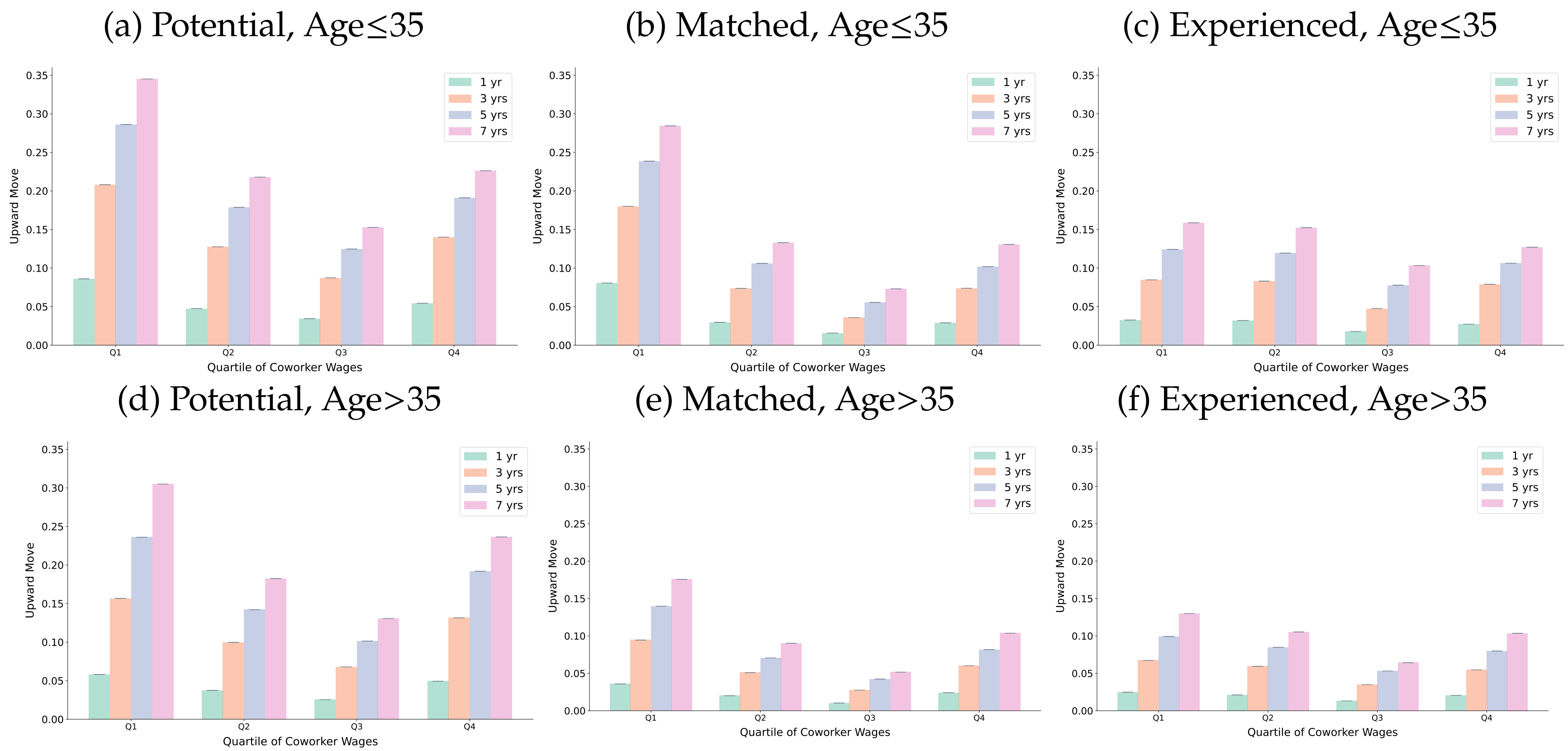
Appendix B: Additional Empirical Results

Figure B.1: Mobility by Firm Quartiles: Any Move between Firms



Notes: This figure shows the mean mobility of workers at each firm quartile, ranked by leave-out coworker wages each year. (a)-(c) focus on the fraction of workers younger than 35 at t employed by different firms, $j(i, t+k) \neq j(i, t)$, in $k \in \{1, 3, 5, 7\}$ years, while (d)-(f) shows the same for workers older than 35. Potential inventors are the workers who have not applied for any patent selected as described in Section 2.2. Matched inventors are the employees who have not yet applied for a patent but will eventually do so, and have been matched with their INPS employment records. And finally, experienced inventors are the workers who have already applied for a patent. The three groups are consistent with the definitions of estimation samples in Table 3.

Figure B.2: Upward Mobility by Firm Quartiles: Moving to a Higher Quartile



Notes: This figure shows the mean upward mobility of workers at each quartile of firms, ranked by leave-out coworker wages each year. Upward mobility is the movement of a worker into a higher-quartile firm, $j(i.t+k) \neq j(i,t)$ and $Q(i,t+k) > Q(i,t)$, in $k \in \{1,3,5,7\}$ years. For workers starting at the top, a move between firms within quartile 4 is also coded as an upward move. (a)-(c) focus on the fraction of workers younger than 35 at t employed by different firms, $j(i,t+k) \neq j(i,t)$, in $k \in \{1,3,5,7\}$ years, while (d)-(f) shows the same for workers older than 35. Potential inventors are the workers who have not applied for any patent selected as described in Section 2.2. Matched inventors are the employees who have not yet applied for a patent but will eventually do so, and have been matched with their INPS employment records. And finally, experienced inventors are the workers who have already applied for a patent.

Table B.1: Poisson Regressions of Ever Inventing

	Full Sample	
	(1)	(2)
Demographics		
Female	-1.29809	-1.22436
	(0.00849)	(0.00857)
Age (normalized at 35)	-1.18215	-0.49511
	(0.06283)	(0.06022)
Age^2, Age^3	X	X
Job Characteristics		
Tenure	0.16152	0.26883
	(0.03540)	(0.03514)
$Tenure^2$, $Tenure^3$	X	X
Blue Collar	-0.49502	-0.80953
	(0.03692)	(0.04304)
White Collar	1.25696	1.10266
	(0.04116)	(0.04033)
Blue/White × Age	X	X
Permanent Contract	0.45127	0.05251
	(0.03263)	(0.03210)
Temporary Contract	0.03128	0.01116
	(0.02861)	(0.02793))
Seasonal Contract	-1.58927	-1.19540
	(0.29588)	(0.34350)
Contract Type × Age	X	X
INPS Sample (1987-2009)		
Min(Yr | INPS)=1987	-0.17688	-0.15301
	(0.00974)	(0.00946)
Min(Age | INPS)	0.66709	0.50071
	(0.00971)	(0.00966)
(Min(Yr)=1987) × Min(Age)	0.02812	0.01559
	(0.00834)	(0.00809)
Constant	-4.74880	-3.51388
	(0.04737)	(0.04647)
Fixed Effects		
Year	X	X
Industry and Region	X	
Firm		X
N	1.25e+07	8,434,000
Pseudo R2	0.10132	0.22189

Notes: This table shows the estimated Poisson regression (2.1) of $Inv_i = 1$ if person i has any patent application and she is matched to INPS. About 1.5 million workers: have ≥ 5 years of employment in the INPS data between 1987 and 2009, entered the sample between age 14 and age 55, and have worked in more white-collar than blue-collar jobs (see summary statistics in Column 1 of Table 1). The estimation sample is at the person × year level. We use the estimated p-scores from column (2) conditional on firm fixed effects to select potential inventors (Section 2.2).

Table B.2: Firm Characteristics by Quartile of Coworker Wages, Restricted to Firms Matched to INVIND

	Quartile 1		Quartile 2		Quartile 3		Quartile 4	
	mean	sd	mean	sd	mean	sd	mean	sd
Num. Unique Firms	796		767		732		741	
Log Wage	7.797	0.262	7.848	0.208	7.907	0.202	7.967	0.238
Num. Potential Inventors	65.619	290.740	112.765	423.677	121.525	377.785	94.394	332.056
Age of Employees	37.638	3.676	38.143	3.199	38.604	3.054	39.026	3.324
Age of Employees When Applying for a Patent	43.092	6.968	43.072	6.295	43.533	6.150	43.959	6.319
Patent Applications (per worker-year)								
Num. Patent Apps	0.040	0.077	0.041	0.065	0.044	0.072	0.046	0.080
Num. Patent Apps, Age<=35	0.021	0.092	0.021	0.062	0.023	0.064	0.024	0.097
Num. Patent Apps, Age>35	0.056	0.119	0.057	0.095	0.058	0.100	0.061	0.117
Any Patent App	0.024	0.036	0.025	0.030	0.025	0.033	0.026	0.036
Any Patent App, Age<=35	0.013	0.046	0.013	0.029	0.014	0.030	0.014	0.046
Any Patent App, Age>35	0.033	0.056	0.033	0.045	0.033	0.046	0.035	0.052
Industry (grouped by csc code):								
Electronics/Telecom	0.117	0.321	0.126	0.332	0.142	0.350	0.097	0.296
Pharmaceutical	0.031	0.173	0.057	0.232	0.073	0.260	0.083	0.276
Automobile	0.053	0.223	0.078	0.268	0.063	0.243	0.050	0.219
Other Manufacturing	0.512	0.500	0.535	0.499	0.466	0.499	0.499	0.500
Services and Others	0.287	0.453	0.203	0.403	0.255	0.436	0.271	0.444
Characteristics from INVIND:								
Revenue (in thousands)	132	419	190	739	288	1,560	274	1,542
Num. Employees	695	5,428	711	2,092	888	3,108	812	3,025
Num. White-collar Employees	201	451	281	589	484	2,592	455	2,594
Num. Blue-collar Employees	296	502	404	1,437	480	1,665	442	1,617
Investment on Machinery	4891.837	18195.751	6635.252	28080.389	12693.249	134746.087	12231.338	133354.893
Investment on Material	144.780	464.780	296.684	3102.310	320.908	3150.547	309.891	3116.939
Investment on Immaterial	662.042	4900.004	1706.398	18997.465	2482.956	22626.553	2062.077	19192.780
Investment on Housing	915.557	4312.087	900.268	3907.318	1174.762	5736.162	1123.742	5706.287
Investment on R&D	1818.462	14984.238	4645.302	36650.753	4961.548	35389.903	4576.242	34768.882

Notes: This table is restricted to firms that are matched to INVIND by fiscal code or by firm name, and displays the mean characteristics of firms (to be compared to those shown in Table 2).

Table B.3: First Patent Application at the Current Employer, by Quartile of Firms and Age Group

	First Patent Application at the Current Employer					
	Age $\leq$ 35			Age > 35		
	(1)	(2)	(3)	(4)	(5)	(6)
Quartile of Mean Wage						
quartile 1	-0.4228***	-0.2131***	0.1361	-0.0640	-0.0963**	0.0034
	(0.0439)	(0.0382)	(0.1574)	(0.0453)	(0.0385)	(0.0670)
quartile 2	-0.1260***	-0.1734***	0.2363**	-0.1047***	-0.0931***	0.2169***
	(0.0403)	(0.0364)	(0.1184)	(0.0386)	(0.0339)	(0.0501)
quartile 3	0.1028***	-0.1179***	0.2093*	-0.0484	-0.0839**	0.2423***
	(0.0391)	(0.0372)	(0.1170)	(0.0372)	(0.0337)	(0.0452)
quartile 4	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Mean |quartile 4	.0103621	.1264715	.0707749	.0071	.1620197	.0734755
N	644238	52843	5869	744670	34735	33170
Pseudo R^2	.0659837	.1086511	.08996	.0399946	.0729018	.0836694

Notes: This table shows the estimated Poisson regression (3.1) of whether a worker files her first patent application at her current employer on the quartile of her employer, ranked by mean coworker wages (excluding her wage) in a year. The estimation sample is at the person $\times$ year level, including the years until each worker's first patent application at the current employer. All regressions control for sex, a cubic polynomial in age (relative to age 35), indicators for white/blue collar and permanent/temporary contract interacted with age, and fixed effects of the calendar year, 2-digit industry, and geographic region. Models (1) and (4) are estimated on potential inventors who have not applied for patents before. (2) and (5) are restricted to matched inventors who have not applied for patents yet but will do so during the sample period. (3) and (6) are restricted to experienced inventors, who have already applied for patents at former employers. Significance: * 0.10 ** 0.05 *** 0.010.

Table B.4: Wage Returns to New Patent Application, by Quartile of Firms and Age Group

	Log Annual Wages					
	Age ≤ 35			Age > 35		
	(1)	(2)	(3)	(4)	(5)	(6)
Quartile of Coworker Mean Wage						
quartile 1	-0.2228***	-0.1450***	-0.1796***	-0.3667***	-0.1918***	-0.3275***
	(0.0013)	(0.0043)	(0.0128)	(0.0019)	(0.0082)	(0.0084)
quartile 2	-0.1225***	-0.0697***	-0.1143***	-0.2597***	-0.1296***	-0.2209***
	(0.0012)	(0.0040)	(0.0113)	(0.0016)	(0.0074)	(0.0079)
quartile 3	-0.0794***	-0.0517***	-0.0926***	-0.1817***	-0.0869***	-0.1803***
	(0.0013)	(0.0040)	(0.0105)	(0.0016)	(0.0073)	(0.0075)
quartile 4	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Any New Patent Application						
y_{it}	0.0160**	0.0270***	0.0372	0.0592***	0.0076	-0.0160
	(0.0079)	(0.0083)	(0.0253)	(0.0128)	(0.0137)	(0.0178)
Excess Returns (relative to quartile 4)						
$y_{it}\times$ quartile 1	0.1348***	0.0518***	0.0426	0.1958***	0.0232	0.1411***
	(0.0102)	(0.0107)	(0.0419)	(0.0193)	(0.0203)	(0.0304)
$y_{it}\times$ quartile 2	0.0760***	0.0107	0.0053	0.1561***	0.0451**	0.1107***
	(0.0104)	(0.0107)	(0.0343)	(0.0170)	(0.0180)	(0.0260)
$y_{it}\times$ quartile 3	0.0584***	0.0114	-0.0190	0.0474***	-0.0098	0.0159
	(0.0100)	(0.0104)	(0.0320)	(0.0165)	(0.0174)	(0.0231)
Mean |quartile 4	7.6783	7.626333	7.877535	8.22946	8.212372	8.486808
N	649892	53108	6300	746369	34750	33402
Adjusted R^2	.4125289	.4444977	.3205998	.1985601	.2018522	.2287792

Notes: This table shows the estimated OLS regression (3.2) of log annual wages on whether a worker applies for a new patent and its interactions with the quartile of her current employer, ranked by mean coworker wages (excluding own wage) in a year. The estimation sample is at the person × year level. All models control for the covariates listed under Table 3, including year/region/2-digit ateco (industry) fixed effects, but no person effects as in Table 4. Models (1) and (4) are estimated on all potential inventors. (2) and (5) are restricted to matched inventors, and (3) and (6) are restricted to experienced inventors, who have already applied for patents at former employers. Significance: * 0.10 ** 0.05 *** 0.010.

Table B.5: Wage Returns to New Patent Application, by Lagged Quartile of Firms and Age Group

	Log Annual Wages					
	Age ≤ 35			Age > 35		
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged Quartile of Mean Wage						
quartile 1	-0.1177***	-0.0756***	-0.0496***	-0.0981***	-0.0653***	-0.0920***
	(0.0016)	(0.0054)	(0.0139)	(0.0014)	(0.0054)	(0.0064)
quartile 2	-0.0692***	-0.0306***	-0.0315***	-0.0605***	-0.0339***	-0.0447***
	(0.0014)	(0.0044)	(0.0120)	(0.0011)	(0.0041)	(0.0050)
quartile 3	-0.0467***	-0.0158***	-0.0130	-0.0383***	-0.0164***	-0.0170***
	(0.0013)	(0.0040)	(0.0095)	(0.0010)	(0.0038)	(0.0042)
quartile 4	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Any New Patent Application						
y_{it}	0.0360***	0.0310***	0.0462**	0.0294***	0.0085	0.0054
	(0.0063)	(0.0068)	(0.0224)	(0.0049)	(0.0052)	(0.0086)
Excess Returns (relative to quartile 4)						
$y_{it} \times$ quartile 1	0.0418***	0.0247***	-0.0726*	0.0264***	0.0167*	0.0043
	(0.0086)	(0.0088)	(0.0435)	(0.0085)	(0.0087)	(0.0179)
$y_{it} \times$ quartile 2	0.0166**	-0.0076	-0.0481	0.0106	0.0021	0.0109
	(0.0080)	(0.0083)	(0.0301)	(0.0069)	(0.0070)	(0.0130)
$y_{it} \times$ quartile 3	0.0094	-0.0093	-0.0209	-0.0056	-0.0118*	-0.0094
	(0.0080)	(0.0085)	(0.0294)	(0.0065)	(0.0067)	(0.0117)
Mean |quartile 4	7.721059	7.66655	7.890526	8.260885	8.249698	8.519439
N	600776	47589	4847	706316	31590	29095
Adjusted R^2	.7159351	.753993	.8123083	.8689091	.9072654	.8800531

Notes: This table shows the estimated OLS regression (3.2) of log annual wages on whether a worker applies for a new patent and its interactions with the quartile of her current employer, ranked by mean coworker wages (excluding own wage) in a year. The estimation sample is at the person × year level. All models control for the covariates listed under Table 3, including year/region/2-digit ateco (industry) fixed effects, but no person effects as in Table 4. Models (1) and (4) are estimated on all potential inventors. (2) and (5) are restricted to matched inventors, and (3) and (6) are restricted to experienced inventors, who have already applied for patents at former employers. Significance: * 0.10 ** 0.05 *** 0.010.

Table B.6: Between-Firm Job Mobility in 3 Years, by Quartile of Firms and Age Group

	Move in 3 Years: $j(i,t+3) \neq j(i,t)$					
	Age $\leq$ 35			Age > 35		
	(1)	(2)	(3)	(4)	(5)	(6)
Quartile of Coworker Mean Wage						
quartile 1	-0.1126***	0.1286***	-0.2028***	-0.1020***	-0.0057	-0.0687**
	(0.0057)	(0.0276)	(0.0564)	(0.0074)	(0.0425)	(0.0322)
quartile 2	-0.1644***	-0.1207***	0.0161	-0.1517***	-0.1212***	0.0056
	(0.0060)	(0.0305)	(0.0509)	(0.0069)	(0.0441)	(0.0303)
quartile 3	-0.0882***	-0.1159***	-0.0069	-0.1313***	-0.2031***	-0.0504*
	(0.0060)	(0.0312)	(0.0511)	(0.0067)	(0.0448)	(0.0287)
(base) quartile 4	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Any New Patent Application						
y_{it}	-0.7363***	-0.1297*	-0.3459***	-1.2551***	-0.5314***	-0.6719***
	(0.0705)	(0.0738)	(0.0798)	(0.0956)	(0.0998)	(0.0558)
Additional Effects (relative to quartile 4)						
$y_{it}\times$ quartile 1	-0.2259**	-0.4978***	-0.1903	0.2564*	-0.0031	-0.1387
	(0.1018)	(0.1052)	(0.1201)	(0.1408)	(0.1465)	(0.0950)
$y_{it}\times$ quartile 2	0.2215**	0.1790*	-0.0082	0.3814***	0.3087**	0.2371***
	(0.0940)	(0.0983)	(0.1160)	(0.1319)	(0.1377)	(0.0801)
$y_{it}\times$ quartile 3	0.0226	0.1308	0.1629	0.1592	0.3231**	0.2825***
	(0.0960)	(0.1005)	(0.1083)	(0.1332)	(0.1395)	(0.0760)
Mean |quartile 4	.348879	.1983226	.1758764	.2680996	.1389503	.1241034
N	588284	52714	21648	532345	33837	81894
Pseudo R^2	.0325828	.0551437	.0292374	.0272774	.03805	.0320218

Notes: This table shows the estimated Poisson regression (3.3) of any movement between firms in 3 years ($j(i,t+3) \neq j(i,t)$) on whether a worker applies for a new patent and its interactions with the quartile of her current employer, ranked by mean coworker wages (excluding own wage) in a year. The estimation sample is at the person × year level. Models (1) and (4) are estimated on all potential inventors. (2) and (5) are restricted to matched inventors, and (3) and (6) are restricted to experienced inventors, who have already applied for patents at former employers. Significance: * 0.10 ** 0.05 *** 0.010.

Table B.7: Upward Mobility in a Year, by Quartile of Firms and Age Group

	Upward Move in 1 Year					
	Age ≤ 35			Age > 35		
	(1)	(2)	(3)	(4)	(5)	(6)
Quartile of Coworker Mean Wage						
quartile 1	0.5518***	0.9397***	0.4546***	0.2734***	0.3331***	0.2401***
	(0.0157)	(0.0727)	(0.1353)	(0.0169)	(0.1009)	(0.0711)
quartile 2	0.0756***	0.1655**	0.3838***	-0.1468***	-0.0666	0.0922
	(0.0172)	(0.0829)	(0.1278)	(0.0166)	(0.1105)	(0.0693)
quartile 3	-0.3218***	-0.5089***	-0.2040	-0.5445***	-0.6808***	-0.2760***
	(0.0195)	(0.0999)	(0.1534)	(0.0188)	(0.1297)	(0.0724)
quartile 4	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Any New Patent Application						
y_{it}	-1.4982***	-0.8753***	-0.4985**	-2.1905***	-1.4364***	-1.0742***
	(0.2756)	(0.2839)	(0.2178)	(0.3526)	(0.3657)	(0.1510)
Additional Effect (relative to quartile 4)						
$y_{it}\times$ quartile 1	0.4659	0.0484	-0.0840	0.3461	0.0982	0.1816
	(0.3158)	(0.3228)	(0.2823)	(0.4725)	(0.4829)	(0.2204)
$y_{it}\times$ quartile 2	0.8597***	0.7748**	0.0465	0.9401**	0.8586*	0.5611***
	(0.3211)	(0.3305)	(0.2956)	(0.4365)	(0.4482)	(0.1994)
$y_{it}\times$ quartile 3	0.2087	0.4255	0.1752	0.3857	0.6585	0.2827
	(0.3833)	(0.3946)	(0.3172)	(0.5165)	(0.5327)	(0.2183)
Mean |quartile 4	.0545131	.0290004	.0270464	.0494281	.0246957	.0204835
N	620048	52445	24749	661445	33853	104243
Pseudo R^2	.0502368	.0990209	.0425966	.0366167	.0643001	.0417684

Notes: This table shows the estimated Poisson regression (3.3) of upward mobility in 3 years ($Q(i,t+1) > Q(i,t)$ or $Q(i,t+1) = Q(i,t) = 4$) on whether a worker applies for a new patent and its interactions with the quartile of her current employer, ranked by mean coworker wages (excluding her wage) in a year. The estimation sample is at the person × year level. Models (1) and (4) are estimated on all potential inventors. (2) and (5) are restricted to matched inventors, and (3) and (6) are restricted to experienced inventors, who have already applied for patents at former employers. Significance: * 0.10 ** 0.05 *** 0.010.

Table B.8: Upward Mobility in 3 Years, by Quartile of Firms and Age Group

	Upward Move in 3 Years					
	Age ≤ 35			Age > 35		
	(1)	(2)	(3)	(4)	(5)	(6)
Quartile of Coworker Mean Wage						
quartile 1	0.5234***	0.9021***	0.2748***	0.3102***	0.4395***	0.2741***
	(0.0097)	(0.0451)	(0.0839)	(0.0110)	(0.0618)	(0.0479)
quartile 2	0.1080***	0.1705***	0.1699**	-0.1247***	-0.0179	0.1444***
	(0.0105)	(0.0515)	(0.0796)	(0.0110)	(0.0694)	(0.0464)
quartile 3	-0.3338***	-0.5742***	-0.3914***	-0.5275***	-0.6068***	-0.3411***
	(0.0121)	(0.0636)	(0.0930)	(0.0124)	(0.0822)	(0.0497)
(base) quartile 4	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Any New Patent Application						
y_{it}	-0.7775***	-0.1119	-0.6006***	-1.2580***	-0.3970***	-0.8307***
	(0.1210)	(0.1264)	(0.1359)	(0.1446)	(0.1520)	(0.0914)
Additional Effects (relative to quartile 4)						
$y_{it}\times$ quartile 1	-0.1547	-0.5008***	0.1048	-0.1443	-0.4514**	0.0772
	(0.1527)	(0.1590)	(0.1782)	(0.2195)	(0.2291)	(0.1366)
$y_{it}\times$ quartile 2	0.2864*	0.2776*	0.2795	0.4102**	0.2869	0.4336***
	(0.1531)	(0.1609)	(0.1834)	(0.1998)	(0.2102)	(0.1234)
$y_{it}\times$ quartile 3	-0.0593	0.2620	0.3361*	0.2454	0.4311*	0.4316***
	(0.1817)	(0.1913)	(0.1995)	(0.2211)	(0.2342)	(0.1303)
Mean |quartile 4	.1402386	.0739971	.0789845	.1315743	.0610061	.0548166
N	567938	51977	21333	518716	33287	80667
Pseudo R^2	.0506328	.0954508	.038297	.0412972	.064989	.0378604

Notes: This table shows the estimated Poisson regression (3.3) of upward mobility in 3 years ($Q(j(i,t+3)) > Q(i,t)$ or $Q(j(i,t+3)) = Q(i,t) = 4$) on whether a worker applies for a new patent and its interactions with the quartile of her current employer, ranked by mean coworker wages (excluding own wage) in a year. The estimation sample is at the person $\times$ year level. Models (1) and (4) are estimated on all potential inventors. (2) and (5) are restricted to matched inventors, and (3) and (6) are restricted to experienced inventors, who have already applied for patents at former employers. Significance: * 0.10 ** 0.05 *** 0.010.