Investing in Human Capital Incubation*

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Abstract

Using U.S. Census Bureau employee-employer matched data, we provide the first direct empirical evidence that firms' intangible investments raise their employees' portable human capital, designating these firms as "human capital incubators." We introduce a model where workers' preferences for skill development shape labor supply, giving incubators a labor-market advantage and an additional motive to invest in intangibles. Consistent with the model, incubation correlates positively with firm profitability, market power, and inflows of young workers. For top-tercile incubators, the present value of incubation is worth about 13% of firm value: roughly 43% of this value is internalized by incubating firms as wage savings, while 57% accrues as a spillover to workers and downstream employers. The aggregate externality across the whole distribution is worth 7% of total income. In a counterfactual equilibrium where workers cannot differentially price firms' incubation capacity, diminished investment incentives lead to losses in aggregate income, intangible capital stock, and average worker skill.

Keywords: human capital, wage growth, AKM model, intangible investment, labor market power, labor flow, knowledge spillover

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1. Introduction

Theories of intangible capital emphasize the interplay between intangible capital and the workforce, whereby intangible investments can raise the productivity of key employees (Eisfeldt and Papanikolaou, 2013; Sun and Xiaolan, 2019; Crouzet, Eberly, Eisfeldt, and Papanikolaou, 2022). Despite strong theoretical agreement that a significant component of intangible capital may be embodied in the skills of a firm's workforce, direct empirical evidence linking employers' intangible investment to improvements in worker-level human capital is scant. We help fill this gap by documenting that firms' intangible capital investment is indeed strongly associated with increased growth in the portable skill level of their employees. We refer to such investment as "human capital incubation," and the firms engaging in this investment as "human capital incubators."

Survey evidence consistently shows that employees place great importance on the opportunities employers provide to develop their skills, and often make career choices based on such considerations.[1] As such, workers should value opportunities to work for these *human capital incubators*. Building on this insight and our empirical results, we develop a model that examines the interaction between firms and workers, highlighting how workers' preference for human capital growth shapes their career decisions, firms' recruitment and retention outcomes, and ultimately, firms' incentives to invest in intangible assets.

Why might intangible investment increase portable human capital? Recent history is replete with examples of "incubator" firms whose periods of heavy intangible investment coincided with bursts of outgoing talent that seeded entire industries. For example, Bell Labs during its heavy basic-research era at AT&T (roughly the 1940s through the 1970s) produced alumni who anchored the transistor and semiconductor industries, and Xerox PARC in its peak research years (1970–82) produced engineers and computer scientists

[1]For example, the 2021 Gallup American Upskilling Survey found that, "Most workers (57%) are very or extremely interested in participating in training to upgrade their skills or to learn new skills that could help them advance their career." Further, "Nearly three-in-four workers (71%) who have participated in upskilling agree or strongly agree that it has enhanced their satisfaction with work."

who went on to found firms such as Adobe and 3Com and to seed the founding teams and product designs of others, including Apple's Macintosh. More recently, OpenAI has generated alumni cohorts that have founded or led a substantial share of the contemporary frontier AI firms. These cases are suggestive that R&D-intensive environments build portable, productive skills in the workers who pass through them. Consistent with this pattern, Babina and Howell (2024) document that workers employed at firms that increase their R&D spending are more likely to subsequently leave and found startups. While R&D capital investments most clearly generate this kind of skill spillover, we confirm that organizational capital investments—which may generate improvements in workers' knowledge of portable business and management practices, customer acquisition skills, and so on—also generate similar skill spillovers.

Our contribution is twofold: first, we document a systematic relationship between firms' intangible investments and subsequent worker human capital growth; second, we introduce a dynamic model featuring imperfectly competitive labor markets and an endogenous relationship between worker skill growth and firm intangible investment. In the model, intangible investments play a dual role, as both a direct productive input and a source of spillover benefits for worker skill improvement. We use the model to quantify the total value that top incubators generate from their skill growth provision, as well as the share of this value that the firms internalize. We further demonstrate how firms' ability to internalize the impact of their investments endogenously affects total skill in the economy and aggregate output.

We start by providing new empirical evidence that firms' intangible investments drive workers' human capital growth using the U.S. Census Bureau's employee-employer matched data from the Longitudinal Employer-Household Dynamics (LEHD). We link the employer-employee data to information on investment in intangibles reported by publicly-traded Compustat firms. To measure worker skill and its growth, we follow a long literature in labor economics, starting with Abowd, Kramarz, and Margolis (1999), by decomposing log earnings into firm- and worker-specific components, where the worker-specific component can be interpreted as unobserved worker ability stemming from *portable* human capital. We follow Lachowska, Mas, Saggio, and Woodbury (2023) by estimating these components in a time-varying manner over short-T moving window panels. While Lachowska et al. (2023) focus on time-variation in the firm effects, we instead shift the focus onto time-variation in the worker-specific component of earnings—a within-worker measure of human capital growth.

We confirm that our human capital growth measure does indeed capture improvements in per-worker productive capacity: firm-level human capital growth is strongly associated with growth in labor productivity, output, and profits. This strong association is quantitatively larger when instrumenting for firm-level human capital growth, which we do by leveraging firms' differential exposure to cross-firm human capital growth spillovers via hiring networks. After instrumenting, we find that firm human capital growth passes through more than one-for-one to firm growth outcomes.

Motivated by theories of the human element of intangible capital, we average worker-level human capital growth at the firm-level, and analyze the relationship of average human capital growth with employers' intangible investments. Since the literature on intangibles emphasizes their complementarity with skilled workers, we focus on employees who are between the age of 25 and 54 and predicted to have a bachelor's degree or above in the LEHD. Consistent with the notion that intangible investment makes skilled workers more productive, we uncover a robust, highly-significant positive relationship between intangible investment per worker and human capital growth.

In terms of magnitudes, ordinary least squares estimates imply that a standard deviation increase in intangible investment per worker is associated with a 1.1 to 2.6% increase in human capital measured over the next 2 years. Instrumental variables estimates using tax incentives for R&D from (Bloom, Schankerman, and Van Reenen, 2013; Lucking, Bloom, and Van Reenen, 2019) support a causal interpretation of this relationship, and imply a roughly 2.5% marginal effect. Moreover, since intangible investment is both right-skewed and persistently different across firms, these estimates imply that a small set of high-investing firms contribute greatly to the overall distribution of worker skill in the economy.

Firms' investments that enhance workers' skill levels lead to higher productivity and wage growth for those workers. In turn, this benefits the focal firm by granting it greater market power, given its unique role in fostering workers' human-capital growth. At the same time, it can generate a positive externality for workers and other firms in the labor market, since human capital accumulation is both nonrival and nonexcludable. We next study the implications of these firm–worker and cross-firm interactions in a structural model, which we use to quantify the value firms gain from their own investments into human capital incubation, as well as the positive externalities such investments generate to other firms.

In the model, firms face productivity shocks and hire inexperienced and experienced workers to produce. Intangibles not only serve as a productive input, but also help promote human-capital growth and "incubate" inexperienced workers, as we document in our empirical evidence. Workers make their career decisions by considering two factors: the first is current wage income, and the second is the expected path of their future wage, which is influenced by the growth of their human capital. This, in turn, suggests that workers are more willing to supply labor to firms with higher intangible investment and greater ability to incubate them, allowing these firms to attract workers at a lower cost. Put differently, firms invest in their labor-market power via intangible investment.

We estimate the model to match the averages of firms' intangible investment, profitability, and hiring decisions. In particular, to pin down how firms' intangible capital influences workers' human-capital accumulation, we perform an exercise that matches the regression coefficient of workers' human-capital growth on firms' intangible investment. We further discipline the labor-market-power channel by also targeting the cross-sectional regression of firm HC growth on log labor-market markdowns. Our model suggests that firms with a greater ability to incubate workers can attract workers at a lower cost via a compensating differential for skill growth provision; they also charge higher wage markdowns. Using our estimates, we quantify this channel: for human-capital incubators, defined as firms in the top tercile of workers' human-capital growth, the present value of the MPL gain from incubation amounts to roughly 13% of firm value, of which incubator firms internalize about 43% of the value through wage savings (about 5.7% of firm value).

The remaining 57%—about 7.7% of firm value among top-tercile incubators—accrues as positive spillovers to the workers themselves and to the firms that subsequently hire them, since all firms in the model possess labor market power and can extract some rents from the human capital their workers have accumulated. Cumulating these spillovers across the full distribution of firms in the simulated economy, the aggregate externality represents about 7% of total income (profits plus labor earnings). A counterfactual general equilibrium in which workers treat incubation capacity as a constant across firms delivers a 2.9% decline in total income and a 17.4% contraction in the aggregate intangible capital stock, even though it reduces the cross-firm standard deviation of log MPK by 22.9%. Thus in the economy apparent static capital misallocation (in the vein of Hsieh and Klenow (2009)) misses out on dynamic investment externalities supported by cross-firm variation in investment in human capital incubation.

Our model also yields several other predictions. First, as intangibles serve a dual role—functioning as a productive investment input and fostering human-capital growth—our model suggests that firms with higher productivity, and thus a stronger incentive to invest in intangibles for production purposes, would also have a greater ability to grow their workers' human capital. Firms with stronger incubation ability also tend to experience higher profitability, valuations, and market power. Second, our model naturally produces systematic patterns in firm hiring: firms with higher incubation ability tend to have a comparative advantage in hiring novice workers with limited experience, training them, and, as these workers gain experience, they move to other firms, creating a knowledge-spillover effect. Although we do not directly target these qualitative features of the model in our estimation, we verify that they are supported in the data.

1.1. Related Literature

Our paper primarily contributes to three strands of literature. First, it is closely related to the literature on intangible capital (see Corrado, Haskel, Jona-Lasinio, and Iommi (2022) and Crouzet et al. (2022) for recent reviews).[2] One area has emphasized the relationship between intangible capital, market concentration/market power, and investment (Crouzet and Eberly, 2019, 2023; De Ridder, 2024); we contribute here by documenting a link between intangible investment and market power over skilled workers via the impact of intangible investment on human capital growth. Our work is also motivated by prior work that emphasizes theoretical predictions that key employees are both an important input to and benefit from intangible investments (Eisfeldt and Papanikolaou, 2013; Sun and Xiaolan, 2019; Crouzet et al., 2022; Gozen and Ozkara, 2024). We contribute to this literature by providing the first direct estimates demonstrating that firms' intangible investments are associated with within-worker labor productivity increases. In addition, through the structural model, we quantify the importance of intangible investment not only in production, but also in labor markets, where individuals prefer working for a firm that can increase their human capital. This model allows us to document the total value that firms appropriate from their intangible investments, as well as the positive externalities intangible investment generates for other firms by improving the distribution of worker skill.

Adjacent work in finance focuses on the measurement and value of intangibles, especially organizational capital (Eisfeldt and Papanikolaou, 2013, 2014); customer capital (Gourio and Rudanko, 2014; Dou, Ji, Reibstein, and Wu, 2021; Baker, Baugh, and Sammon,

[2] See also Kogan and Papanikolaou (2019) for a review of the role of intangibles in asset pricing specifically.

2023; He, Mostrom, and Sufi, 2024), separating organizational from knowledge capital (Peters and Taylor, 2017; Ewens, Peters, and Wang, 2025); and valuing the contribution of intangible capital types to firm value (Belo, Gala, Salomao, and Vitorino, 2022). We do not attempt to innovate on the measurement of intangible capital, instead adopting existing methods from the prior literature (in particular Peters and Taylor 2017). However, our paper contributes to understanding what constitutes the measured value of intangibles. We argue that intangible capital creates value not only because it serves as a productive input, but also because it directly augments workers' skills, which in turn strengthens firms' distinctiveness in the labor market. Moreover, these gains in worker skill spill over to other firms who subsequently hire these workers.

Additional related work in corporate finance examines the relationship between corporate investment and skilled labor mobility (Jeffers, 2023; Ma, Wang, and Wu, 2023; Chen, Zhang, and Zhang, 2025; Sanati, 2025), and how contracts and financial incentives are constructed to facilitate intangible asset creation (Chen, Li, Thakor, and Ward, 2023; Chen, Kakhbod, Kazemi, and Xing, 2025; Ladika, Döttling, and Perotti, 2025). Relative to this work, we offer a direct lens into how intangible investment is associated with worker-level human capital growth, and in turn how it influences the flow of workers into human capital incubating firms.

Second, this paper contributes to the literature on firms' contribution to workers' human capital. Firms play an important role in workers' human capital development and future earnings trajectories as emphasized by Bagger, Fontaine, Postel-Vinay, and Robin (2014); Gregory (2020); Acabbi, Alati, and Mazzone (2022); Gao, Wang, and Wu (2024); Arellano-Bover and Saltiel (2026). Similarly in our model, firms increase investments in general human capital because workers grant compensating differentials and labor market rents to incubating firms. While these papers acknowledge that firms may play a pervasive role in human capital trajectories, they do not characterize the endogenous determinants of human capital growth. We contribute to this literature by documenting that firms' investment decisions play a first-order role in human capital creation.

Several previous papers identify channels on how firms affect employees' human capital, such as firms' training (Almeida and Carneiro, 2009; Bapna, Langer, Mehra, Gopal, and Gupta, 2013; Riley, Michael, and Mahoney, 2017; Ma, Nakab, and Vidart, 2024, 2025), and coworkers (Nix, 2020; Jarosch, Oberfield, and Rossi-Hansberg, 2021; Ma, Nakab, and Vidart, 2022; Herkenhoff, Lise, Menzio, and Phillips, 2024). An earlier classical literature, dating back to Becker (1962, 1964), asks why firms would invest in *general*, portable human capital. Acemoglu and Pischke (1998, 1999a,b) resolve this with labor-market frictions, where workers pay firms for human capital investments by accepting lower wages. We contribute here by empirically documenting a new channel whereby firms' intangible investments have spillover effects of increasing workers' human capital. The dual role of intangible investment in our model—a direct productive input, with spillovers to worker skill–is distinct from the single purpose training investments studied in this prior work.

Finally, our work connects to research in labor economics which decomposes earnings into worker and firm-specific components, which began with the seminal work of Abowd, Kramarz, and Margolis (1999). Recent influential papers using the Abowd, Kramarz, and Margolis (1999) methodology include Card, Heining, and Kline (2013); Card, Cardoso, Heining, and Kline (2018); Sorkin (2018); Song, Price, Guvenen, Bloom, and Von Wachter (2019); Di Addario, Kline, Saggio, and Sølvsten (2023). Other work extends the Abowd, Kramarz, and Margolis (1999) framework by either allowing for worker-firm interactions (Bonhomme, Lamadon, and Manresa, 2019) or allowing for more flexible time-variation in the firm components (Engbom, Moser, and Sauermann, 2023; Lachowska et al., 2023). We shift the focus to time series changes in the worker-specific component of earnings, providing a framework to measure human capital growth of a worker.[3]

[3]Our approach also borrows methodology introduced in Bonhomme, Lamadon, and Manresa (2019) to mitigate known biases in the Abowd, Kramarz, and Margolis (1999) framework stemming from limited observed mobility of workers across firms (Andrews, Gill, Schank, and Upward, 2008; Bonhomme, Holzheu, Lamadon, Manresa, Mogstad, and Setzler, 2023).

The rest of the paper proceeds as follows. Section 2 explains the data and describes the measures. Section 3 provides evidence that the proposed human-capital growth measure captures within-worker skill accumulation. Section 4 presents results showing that intangible investments increase employees' human capital. Section 5 introduces our model and Section 6 explores the model implications for internalized profits and externalities generated by human capital incubation. Section 7 concludes.

2. Data and Measurement

In this section, Section 2.1 describes data sources, Section 2.2 explains how we measure human capital, and Section 2.3 summarizes the data.

2.1. Data Sources

We primarily use restricted-use microdata from the US Census Bureau for firms' employees and employment information, and Compustat for firms' financial fundamentals and market information. The Longitudinal Employer-Household Dynamics (LEHD) is an employer-employee matched dataset that records workers' wage information and their employment history.[4] Therefore, we observe the distribution of wages within a firm and the inflow and outflow of labor forces of a firm. In addition, we also have access to the demographic information (age, gender, race/ethnicity, and education level) of workers. We have earnings information from 29 states.[5] Since we do not have access to every state in the United States, we use the Longitudinal Business Database (LBD), which provides payments and employment information of private, non-farm business establishments in the US, to supplement the information on firms' payments to workers.[6] The two datasets

[4]See Abowd, Stephens, Vilhuber, Andersson, McKinney, Roemer, and Woodcock (2009) and Vilhuber et al. (2018) for details regarding the LEHD.

[5]AZ, CA, CO, CT, DE, IN, KS, MA, MD, ME, MT, ND, NE, NJ, NM, NV, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, WA, WI, WY. See Appendix Figure A1 for the start year by state.

[6]See Chow, Fort, Goetz, Goldschlag, Lawrence, Perlman, Stinson, and White (2021) for details regarding the LBD.

can be linked using the crosswalk between the State Employer Identification Number (SEIN) and the federal Employer Identification Number (EIN).

We collect annual data on firm fundamentals from the Compustat North America database. We construct intangible (organizational and knowledge investment), following Peters and Taylor (2017) and Ewens, Peters, and Wang (2025), with physical investment. In addition, we measure labor productivity and markup similar to Donangelo, Gourio, Kehrig, and Palacios (2019) and De Loecker, Eeckhout, and Unger (2020), respectively, as well as profitability and Peters and Taylor (2017) Total Q. We also observe a firm's total assets, employment, cash and short-term investments, total debt in current liabilities, long-term debt, and dividends. All variables are converted to 2017 real dollars using the GDP implicit price deflator and are winsorized cross-sectionally at the 1% level. We link the Compustat information to Census datasets using the Compustat-SSEL Bridge.

2.2. Measuring Human Capital Growth

We focus on employees aged between 25 and 54 with a bachelor's degree to measure the effects of firms' investments on the human capital growth of their employees.[7] We apply the minimum earnings criterion, which equals the Social Security Administration (SSA) cutoff for receiving a full year of credits toward SSA retirement benefits. We assign the worker's primary firm as the firm that pays the highest wage in the year (Seegmiller, 2021). We first residualize the log of real wage by running the following regression specification

$$log(W_{it}) = Age_{it} + Gender_i + Race_i + Ethnicity_i + \gamma_t + w_{it}, \tag{1}$$

where W_{it} is the total real wages an individual i received from all firms in year t. Thus, we include five fixed effects (age, gender, race, ethnicity, and year) to calculate the residuals of log total real wages w_{it}.

[7] Education is not directly observable for all individuals in the LEHD, so we make use of LEHD education imputations for individuals aged 25+ in the LEHD individual characteristics files.

Then, we decompose residual earnings into worker and firm heterogeneity, along the lines of Abowd, Kramarz, and Margolis (1999) (AKM henceforth), with two departures. First, following Lachowska et al. (2023), we estimate time-varying firm effects by estimating the decomposition using moving window 2-year panels. However, unlike Lachowska et al. (2023), our primary focus will be on analyzing time-series changes in the *worker* component of earnings, rather than the firm component. Next, we follow Bonhomme, Lamadon, and Manresa (2019) by clustering firms into classes based on their earnings distribution. This mitigates challenges related to limited mobility bias, which pushes down covariances between estimated worker and firm effects and inflates the firm component contribution to earnings inequality (Andrews et al., 2008).[8] For panel time period T (consisting of the years t and $t-1$), we run the following regression specification:

$$w_{it} = X_{iT} + X_{g(c)t} + \epsilon_{it} \tag{2}$$

where X_{iT} is the individual fixed effects for year group T and $X_{g(c)t}$ is firm group ($g(c)$)-AKM components of firm c in year t. For the firm groups, we keep firms with more than 50 LEHD employees within the year group, and we cluster firms into 100 groups using K-means clustering using ten deciles from the empirical CDF firms' residual earnings (w_{it}) distribution (Bonhomme, Lamadon, and Manresa, 2019).[9]

Note that the AKM model rests on the assumption that earnings are additively separable into worker and firm heterogeneity, and that mobility across firms is uncorrelated with the wage residuals. Prior work exploring the validity of these assumptions has found that the AKM model represents a good approximation of the earnings process in advanced economies.[10] Since AKM worker fixed effects capture the earnings component driven by

[8] Bonhomme et al. (2023) document that this bias becomes small as the number of movers across firms increases. Because we work with large publicly-traded firms, there are more movers to begin with, which further mitigates this potential bias.

[9] We restrict the sample to the largest connected set of employee-groups of employer-year (Engbom, Moser, and Sauermann, 2023). Since we group firms into classes which have many workers, the restriction does not change the sample in practice.

[10] Bonhomme, Lamadon, and Manresa (2019) relaxes the additive separability assumption to allow for worker-firm match effects, finding that while systematic worker/firm-type match effects are detectable,

unobserved worker ability that is portable across all firms (Card, Heining, and Kline, 2013; Card, Cardoso, and Kline, 2016; Song et al., 2019), we proxy for the individual's human capital growth at year t by taking

$$\text{H.C. Growth}_{i,T\to T+2} \equiv X_{i,T+2} - X_{i,T}, \tag{3}$$

which is the change in the worker component of earnings across adjacent, non-overlapping 2-year panels. Since our analysis takes place at the firm-year level, we compute the firm-level average of H.C. Growth$_{i,T\to T+2}$ of all workers in our sample at firm f:

$$\text{H.C. Growth}_{f,T\to T+2} = \frac{1}{N_f}\sum_{i\in f}\text{H.C. Growth}_{i,T\to T+2}. \tag{4}$$

The above equation constitutes our measure of firm-level human capital growth.

2.3. Summary Statistics

The final LEHD-Compustat merged data set spans from 1990 to 2020. The first panel of Table 1 reports the summary statistics for the financial characteristics of firms. Panel A presents the firm's human capital incubation measure along with average pay per worker. There is meaningful dispersion in human capital growth, at about 10%; the mean of the human capital incubation measure is about 2.6%; this mean should be interpreted with some caution, as the fixed effects for each non-overlapping adjacent panels are identified relative to an unobserved intercept that may not be strictly comparable.[11] Since we measure human capital growth by comparing worker effects in adjacent non-overlapping 2-year windows, these growth rates can be interpreted as per 2-years, and dividing by 2 converts to annualized magnitudes.

they explain a very small portion of earnings variation relative to worker effects, so that earnings are approximately log-additive in practice. Card, Heining, and Kline (2013) and Song et al. (2019) provide evidence in support of the conditional random mobility assumption.

[11] The inclusion of year fixed effects in all specifications nets out this "missing intercept," making this a non-issue for our empirical results, which are identified off cross-sectional differences in investment and human capital growth.

Panel B shows financial characteristics, including investment, labor productivity, profitability, log markups, and valuation measures. Our main investment-related variable is the intangible investment per worker, which is the sum of organizational and knowledge investment per worker. We construct organizational and knowledge investment following Peters and Taylor (2017). Firms in our sample spend about $40,000 in intangible investments per worker on average, although this is highly right-skewed, with the median being half of the mean. See also the table notes for definitions of these variables.

Panel C shows the labor market characteristics. We define young workers as employees aged 25-34. Also, we measure inflow (hiring) and outflow (separation) of workers over two years, since our human capital growth measures calculate changes over the two future years relative to the two adjacent previous years.[12] For the differences in inflow and outflow shares of young and old workers in the economy, we first calculate a firm's share of young (old) inflow (outflow) in the economy as the young (old) inflow (outflow) to a firm relative to total young (old) inflow (outflow) in the economy. Then, we take the difference between a firm's share of young inflow (outflow) and its share of old inflow (outflow). These measures are conceptually related to the degree centrality measure.

3. Human Capital Growth and Firm Outcomes

Ahead of our main empirical analysis, it is useful to confirm a central hypothesis about our human capital growth measure: it captures within-worker changes in skill, rather than say, some other change in worker-level earnings ability that is constant across firms (like bargaining power or other worker-specific rent extraction abilities). If our human capital growth measure is indeed associated with within-worker productivity improvements, then firms experiencing human capital growth should experience increases in productivity

[12]In our data, the net worker flow has a right-skewed distribution. The sizable inflow from corporate mergers and acquisitions affects the distribution. In addition, due to the age restrictions on the employee sample, we do not include retirements, and for modeling purposes, we do not include involuntary outflow (i.e., transitioning from employment to nonemployment).

and output, all else constant. Additionally, if workers capture all the benefits of human capital growth, it may be associated with productivity and output gains, but not growing firm profits. Accordingly, we examine the relationship between firm human capital growth and growth in labor productivity (value added per worker), sales, net output (value-added), and gross profits.

We do so in Table 2, which examines the relationship between the firm-level human capital growth measure defined in equation (4) and the growth in these firm outcomes. Panel A of the table presents the raw OLS estimates. Consistent with our main hypothesis, we find that firm-level human capital growth has a highly significant and positive relationship with contemporary growth in labor productivity, sales, value-added, and gross profits, with coefficients ranging from 0.55 to 0.98.

While this correlational result supports our measurement, it may also be driven by unobserved correlates of firm growth that may also drive changes in the worker-specific component of earnings, or there could be some reverse causality where growing firms' workers experience better human capital growth. We now leverage a key operating assumption of the AKM-style decomposition in equation (2), which is that the worker fixed effect for the time-T panel, $X_{i,T}$ are equally applicable across firms, meaning that worker-level human capital growth may spill over across firms when workers switch employers. Accordingly, we now devise an instrumental variables strategy that leverages cross-firm spillovers that are not mechanically driven by unobserved shocks to firm growth that operate from non-human capital channels.

Specifically, we construct a shift-share instrument which leverages spillovers from exposure to many shocks from other firms, in the style of Borusyak, Hull, and Jaravel (2021). Define $\alpha_{f'\to f,t}$ as the share of firm f's total hires over the years $t-3$ to t coming from firm f', and H.C. $\text{Growth}^{Stayer}_{f',T\to T+2}$, the human capital growth of workers employed in firm f' who remain at the firm f' between the current and next period. We refer to the firm f' as the upstream firm in the hiring network, and the focal firm f as the downstream firm. Our cross firm human capital spillover measure is then defined as

$$\text{Cross-Firm H.C. Spillover}_{f,T,T+2} = \sum_{f' \neq f} \alpha_{f' \to f,t} \times \text{H.C. Growth}^{Stayer}_{f',T \to T+2} \tag{5}$$

While our analysis sample focuses on Compustat firms, because we estimate firm and worker effects for all LEHD firms, we include spillovers from the universe of public and private firms f' in the LEHD, giving a more complete picture of cross-firm spillovers. This shift-share instrument leverages two ideas. First, pre-existing hiring patterns across firms strongly predict contemporary hiring flows, implying that the firm-level average human capital growth of focal downstream firm f is exposed to shocks to the within-worker human capital growth of upstream firm f' when workers flow from f' to f. Second, a worker's human capital growth could be affected both by the firm they end up at and the firm they start at, so there is a potential endogeneity concern when including within-worker human capital growth for all workers at the other firm f'. For this reason, we proxy for the human capital growth of workers who flow out of f' by instead only considering the human capital growth of workers who *stay* at the firm, H.C. Growth$^{Stayer}_{f',T \to T+2}$.

The identifying assumption is that the human capital growth of workers who stay at upstream firms, H.C. Growth$^{Stayer}_{f',T \to T+2}$, affects firm outcomes through its effect on the growth in human capital of downstream firm f through cross-firm worker flows. One concern could be that hiring networks may expose the downstream firm f to other shocks. For example, firms may benefit from being connected to growing firms for other reasons. Following common recommendation for shift-share designs leveraging exposure to many shocks (Borusyak, Hull, and Jaravel, 2021, 2025), we construct a shift-share control for hiring network exposure to growing firms, where we replace human capital growth H.C. Growth$^{Stayer}_{f',T \to T+2}$ in (5) with firm f' employment growth.

Do cross-firm spillovers directly predict firm-level outcomes? In Panel B of Table 2, we examine the reduced form relationship between growth in labor productivity, sales, value-added, and profits. Consistent with human capital growth generating positive cross-firm benefits, we continue to find a positive and highly significant relationship, with coefficients that range from 0.2 to 0.33. In Panel C of Table 2, we complete the analysis by now instrumenting for firm-level human capital growth with cross-firm spillovers, and the highly positive and highly significant relationship continues to be robust. Note also that upon instrumenting, all coefficients are greater than 1: that is, human capital growth induced by cross-firm spillovers generates a more than one-for-one increase in the growth of firm outcomes. This strongly works against the concern that our human capital growth measure merely reflects rents captured by the worker–instead, it directly benefits the firms who employ workers with growing human capital.

Additionally, in Appendix Table A1, we show that whether we do or don't include the firm-level controls (including the shift-share control for exposure to cross-firm employment growth spillovers) has no effect on the sign and significance of the reduced form relationship, and coefficient magnitudes remain similar. This suggests that exposure to other cross-firm shocks that operate outside human capital spillover channels are not likely to be driving this positive relationship.

This analysis confirms that human capital growth greatly benefits firms, not just workers. Because improved human capital results in higher per-worker productivity and overall output, the measure captures genuine within-worker changes in labor productive capacity. Additionally, because firm profits grow more than one-for-one along with human capital growth, the measure does not appear to reflect increases in workers' rent-extraction abilities, leading workers to gain all the surplus from their skill-induced improvements in earnings ability.

4. Intangible Investment and Human Capital Growth

In this section, we present evidence that a firm's intangible investments increase its employees' human capital growth. We first estimate the relationship between employees' human capital growth and firm investments using the following regression specification:

$$\text{H.C. Growth}_{f,T\to T+2} = \beta\ \text{Investment}_{f,t} + \gamma_t + \eta_{\text{ind}(f)} + X_{f,t} + \epsilon_{f,t} \tag{6}$$

where $\text{Investment}_{f,t}$ is a firm f's intangible investment per employee in year t, γ_t is year-fixed effects, $\eta_{\text{ind}(f)}$ is industry-fixed effects,[13] and $X_{f,t}$ is firm-year level controls. Standard errors are clustered at the firm level.

Table 3 reports the coefficient estimates for β in the specification (6). Column (1) presents estimates with year-fixed effects. Column (2) includes year and industry fixed effects. Column (3) includes year and industry fixed effects, along with firm-year-level controls. We control for firm size (log of total assets and employment) and variables plausibly related to financial constraints (log of firm age, an indicator of whether the firm pays dividends, cash and short-term investments, and total long-term debt divided by total assets). Column (4) includes year-by-industry fixed effects and firm-year level controls; this is our preferred specification. We standardize intangible investment per employee so that the coefficients can be interpreted as the effect of a one-standard-deviation increase in intangible investment per employee on employees' human capital growth.

The results show that an increase in intangible investments is associated with a significant correlation with employees' human capital growth. Estimates from our preferred most saturated specification in column (4) show that one standard deviation increase of intangible investment per employee increases the average employee's human capital growth measure by 1.2%, and also about 12% of a standard deviation of firm-level human capital growth. While less saturated specifications tend to have larger coefficients, the positive relationship is always highly significant, with t-statistics clustered at the firm level always above 10 no matter the specification.

While this strong association between the average human capital growth of a firm's employees and their intangible investment is compelling, it is still possible that some

[13]Our base industry definition is NAICS-4 digit.

unobserved characteristic is affecting both firms' investment and the growth in workers' human capital. To support our interpretation that this is a causal relationship, we exploit tax treatment of R&D to generate plausibly exogenous variation in firms' propensity to engage in intangible investment. Specifically, Bloom, Schankerman, and Van Reenen (2013) show that firms have heterogeneous exposure to both state-level and federal R&D tax policies, and this generates variation in the propensity for firms to spend on R&D, and hence boost intangible investment. Additionally, Bloom, Schankerman, and Van Reenen (2013) show that this variation can affect firm investment in two ways: first, by directly promoting R&D spending through the firm's own exposure to tax credits; and second, through cross-firm spillovers stemming from knowledge flows driven by increased R&D spending among technologically-connected firms, or from product market spillovers from competitors induced to change their R&D schedules. We use the updated version of the data provided by Lucking, Bloom, and Van Reenen (2019) on Nick Bloom's website.

Table 4 presents the results from the instrumental variable estimation. Because the instruments are only available for a subset of firms the sample is smaller. We focus on our preferred specification with firm controls and industry-year fixed effects. In Panel A, we instrument for intangible investment using both the set of spillover (technological and product market) and direct (firm-level federal and state) tax IVs on intangible investments per worker, so that there are four instruments in total. The instruments jointly explain intangible investment, with a first-stage F-stat of about 25. A standard deviation increase in instrumented intangible investment per worker is now associated with 2.5% increase in human capital growth, about double the coefficient when compared to the same specification in the last column of Table 3, and similar to the OLS specifications with industry fixed effects but without firm-level controls. In Panels B and C, we use separate spillover and tax IVs, respectively. Each set of IVs individually predicts a similar marginal effect on firm human capital growth, and also with a similar first stage strength. Overall, this suggests a robust causal relationship between firms' intangible investments and human capital growth, which is if anything understated by our OLS estimates.

We next examine how different subcomponents of firm intangible investments relate to workers' human capital growth, and Table A2 illustrates the results. Defining organizational capital and knowledge capital investments as in Peters and Taylor (2017), we find that, per standard deviation increase, organizational capital investments have a slightly stronger relationship than knowledge capital investments. For comparison, we also examine the impact of physical capital investment per worker, finding a strongly positive relationship, but with smaller coefficient. This is potentially consistent with the productivity of physical capital also being partly embodied in workers' skill. The final column shows that each separate investment component retains the same significantly positive relationship when included together with the other components. The results show that each type of investment may have different channels to influence employees' human capital.

In addition, we validate the relationship between intangible investment and human capital growth with measures of perceived career advancement opportunities. Instead of using our human capital incubation measure, we use Glassdoor's career opportunities rating, which employees assign on a scale of 1 to 5. Table A3 shows that intangible investments are positively associated with employees' ratings of career opportunities: a standard deviation increase in intangible investment per worker predicts a highly-significant 0.10 to 0.15 increase in the Glassdoor career opportunity rating. This provides independent validation that not only is intangible investment associated with growth in worker human capital, but also that workers are likely to be aware of such an association. Our model, presented in the next section, explores the quantitative implications of an economy where workers supply labor to firms who have heterogeneous ability to grow their human capital. Finally, we estimate the relationship between different investment components and the Glassdoor career opportunities rating separately in Table A4. Both knowledge capital investments and organizational capital investments are associated with employees' perceived career growth opportunities, whereas the relationship with physical investments is statistically insignificant, in line with our primary focus on the relation between intangible investments and human capital growth.

4.1. Alternative Interpretations

Before proceeding with the model, we briefly discuss threats to our interpretation of the above empirical results. One concern could be that intangible investments are associated with back-loaded wage contracts that are used to incentivize effort of skilled employees who are involved in the production of intangible capital (Chen et al., 2023, 2025). Thus, increases in earnings in response to intangible investments represent workers realizing these promised benefits. However, any such rents promised to the worker should be specific to the worker-firm match, whereas the AKM worker intercept is the component worker-specific earnings ability that is portable across *all* firms.[14] Instead, the residual component of earnings ϵ_{it} in equation (2) would tend to pick up such time-varying contractual worker-firm earnings effects if they are present (Song et al., 2019). This highlights part of the reason why we focus on changes in the worker-specific intercept in (2) rather than total earnings.

Any increase in the portable component of a worker's earnings that is related to their productivity—whether it's driven by new knowledge about a technology, increased understanding of production processes, industry domain expertise, trade secrets, and so on—is consistent with our mechanism. If intangible investment simply made workers better at extracting rents from employers, such changes in earnings intercepts may not only capture marginal productivity changes; however, such a change would have to make workers uniformly better at extracting rents from *all* firms. This would also have to be purely about workers getting better at redistributing existing output to themselves, and

[14] Many papers make this point about the interpretation of worker effects in the AKM setup: Card, Heining, and Kline (2013); Card, Cardoso, and Kline (2016); Card et al. (2018); Song et al. (2019); Kline (2024), to name just a few.

this seems a highly unlikely result of firms' intangible investments. Additionally, this interpretation strongly goes against the features of the human capital growth measure itself documented in Table 2, which shows that human capital growth benefits firms in terms of higher productivity and profits.

More likely is that intangible investments may endow workers with new knowledge that may be scarce because they are highly-specialized or expert, for which firms are willing to pay a premium to access. Since firms are simply paying a worker for some scarce valuable productive input that the worker now possesses, this still falls within the channels that we have in mind. Additionally, the fact that we find that human capital growth greatly benefits firms' profitability (as shown in Table 2 and Section 3) strongly works against this concern.

Given that a non-trivial component of spending categorized as "intangible investment" constitutes payments to specialized employees who are involved in the knowledge creation process (Eisfeldt, Falato, and Xiaolan, 2023), it is also possible that worker fixed effects increase because the workers who were involved in generating successful intangible capital investments are identified ex post.

Under this interpretation, some of the change in measured human capital may not be from actually increasing the skill of the given workers, but instead in simply revealing workers' underlying skill-level to the firms. To the extent that this facilitates a more efficient allocation of workers to firms, this channel also improves aggregate productivity. In such a world, productive workers would still be willing to forgo some current earnings for the opportunity to reveal their productivity, meaning the economic mechanism we highlight would still play out in a very similar way. Additionally, Table 2 strongly suggests that this channel is not a driving feature of our human capital growth measure, since human capital growth is strongly associated with improvements in firm output per worker, and human capital growth spillovers from cross-firm worker mobility improve firm labor productivity. Thus our empirical estimates establish a role for intangible investments in affecting the overall distribution of worker skill, generating positive productivity benefits.

A final concern could be that the AKM model does not allow for systematic interactions between worker and firm types, and intangible investment may affect the interaction. However, econometric estimates of such complementarities, while measurable in principle, have been found to explain a very small fraction of the variation in earnings compared to the common worker-specific component that is equally portable across all firms. Thus the log additivity of earnings in worker and firm heterogeneity imposed by the (slightly-modified) AKM framework we use turns out to be a very good approximation of the earnings distribution in practice. Evidence supporting the approximate log additivity of earnings has been documented by Bonhomme, Lamadon, and Manresa (2019) in Sweden; Card, Heining, and Kline (2013) in Germany; and Song et al. (2019) and Lamadon, Mogstad, and Setzler (2022) in the United States.

5. Model

We model two types of workers, "inexperienced" and "experienced". We assume all "inexperienced" workers have a human capital level of h^N, while experienced workers have a human capital level of $h^H > h^N$.

We model J firms in the industry. For an inexperienced worker i employed at firm $j \in [1, 2, ...J]$, the probability for his human capital increase from h^N to h^H in a given period is governed by $g_{j,t}$, where $g_{j,t}$ denotes firm j's propensity to grow its workers' human capital, which ranges in between 0 and 1. Some firms are better at growing workers' human capital and thus would be perceived to have higher $g_{j,t}$.

5.1. Workers' Career Path

In each period, a unit mass of new workers enters the economy. All entrants begin as inexperienced workers. Each period, new entrants together with incumbent inexperienced and experienced workers choose a firm j to supply their labor and receive per-period utility:

$$u_{i,j,t} = \theta \log w_{j,t}(h_{i,t}) + a_{j,t} + \epsilon_{i,j,t}, \tag{7}$$

where $w_{j,t}(h_{i,t})$ is the wage offered by firm j in period t to worker i with human capital level of $h_{i,t}$, which is chosen by the firm and discussed in detail in the next section. θ measures the sensitivity of workers' utility to their log wage income, and $a_{j,t}$ captures a common shock to workers' employment preference at time t regarding firm j, which can depend on, for example, unobserved amenities offered by company j.

We use $U(h_{i,t})$ to denote the expected lifetime utility of worker i with human capital of $h_{i,t}$:

$$\begin{aligned} U(h_{i,t}) &= \max_{\{j_{s=0,1,2,\ldots}\}\in J} \mathbb{E}\left(\beta^s \cdot u_{i,j,t+s}\right) \\ &= \max_{j_t\in J} \left[\theta \log w_{j,t}(h_{i,t}) + a_{j,t} + \max_{\{j_{s=1,2,\ldots}\}\in J} \mathbb{E}\left(\beta^s \cdot u_{i,j,t+s}\right) + \epsilon_{i,j,t}\right] \\ &= \max_{j_t\in J} \left\{\mathring{U}\left[h_{i,t}, w_{j,t}(h_{i,t}), g_{j,t}\right] + \epsilon_{i,j,t}\right\} \end{aligned} \tag{8}$$

where $\mathring{U}\left[h_{i,t}, w_{j,t}(h_{i,t}), g_{j,t}\right]$ represents the mean utility worker i derives from selecting firm j in period t, evaluated before the current-period preference shock is realized. The parameter $g_{j,t}$ captures firm j's ability to "incubate" inexperienced workers, and we model it as the probability that the firm upgrades such a worker to an experienced one, growing his human capital from h^N to h^H in the next period.

The mean utility $\mathring{U}\left[h_{i,t}, w_{j,t}(h_{i,t}), g_{j,t}\right]$, where $h_{i,t} \in h^N, h^H$, can be expressed in the following recursive form:

$$\mathring{U}\left[h^N, w_{j,t}(h^N), g_{j,t}\right] = \theta \log w_{j,t}(h^N) + a_{j,t} + \frac{1-\iota}{1+r}\left[(1-g_{j,t})U(h^N) + g_{j,t}U(h^H)\right] + \iota\underline{U} \tag{9}$$

$$\mathring{U}\left[h^H, w_{j,t}(h^H), g_{j,t}\right] = \theta \log w_{j,t}(h^H) + a_{j,t} + \frac{1-\iota}{1+r}U(h^H) + \iota\underline{U} \tag{10}$$

where ι is the probability that a given worker exits the market, and $\underline{U}$ is the discounted continuation value for an exiting worker.[15]

At the beginning of each period, firms post their wages, and each individual worker i makes his labor supply decisions to maximize his utility from working, which can be characterized by:

$$\mathbb{I}_{i,j,t} = \begin{cases} 1, & \mathring{U}\left[h_{i,t}, w_{j,t}(h_{i,t}), g_{j,t}\right] + \epsilon_{i,j,t} > \mathring{U}\left[h_{i,t}, w_{k,t}(h_{i,t}), g_{k,t}\right] + \epsilon_{i,k,t}, \forall k \in J \\ 0, & \text{otherwise.} \end{cases} \tag{11}$$

where $\{\epsilon_{i,j,t}\}$ represents a shock to the workers' utility from working for firm j, which we assume to follow a Type I Extreme Value distribution. Within this assumption, we can calculate the probability that a worker with human capital level $h_{i,t}$ ends up choosing to work for firm j before the realization of the preference shocks, which can be expressed as:

$$\Pr_{j,t}(h_{i,t}) = \frac{\exp\left\{\mathring{U}\left[h_{i,t}, w_{j,t}(h_{i,t}), g_{j,t}\right]\right\}}{\exp\left\{\mathring{U}\left[h_{i,t}, w_{j,t}(h_{i,t}), g_{j,t}\right]\right\} + \sum_{k\in J\setminus j}\exp\left\{\mathring{U}\left[h_{i,t}, w_{k,t}(h_{i,t}), g_{k,t}\right]\right\}} \tag{12}$$

Equation (12) suggests that firms face upward-sloping labor supply curves. A firm can recruit more workers if it posts higher wages in the current period or if it is better at helping workers to grow their human capital (reflected by a high $g_{j,t}$), which allows workers to attain higher wages in future periods. In other words, higher wages and higher $g_{j,t}$ act as substitutes in workers' labor-supply decisions. By investing in a higher g, firms can strengthen their future labor-market power because the substitutability implies that they will then need to raise wages by a smaller amount to recruit the same number of workers.

[15]The rate of exiting equals the fraction of new entrants each period. We normalize the value of the exiting workers, $\underline{U}$, to zero. This normalization is innocuous, as it does not affect choice probabilities.

5.2. Firm Production

Firms use capital and labor as their inputs to produce outputs. We use $K_{j,t}$ to denote the stock of intangible capital owned by the firm in period t; consistent with our empirical focus, this intangible stock is the single capital input in the model. $N_{j,t}$ and $H_{j,t}$ represent the number of inexperienced and experienced workers hired with skill levels of h^N and h^H, respectively. Therefore, the total skill-adjusted labor can be calculated as $h^N N_{j,t} + h^H H_{j,t}$ and the firm's per-period output is described as follows:

$$y_{j,t} = z_{j,t} K_{j,t}^{1-\alpha_L} (h^N N_{j,t} + h^H H_{j,t})^{\alpha_L}, \tag{13}$$

where we adopt a constant-returns-to-scale specification in capital and skill-adjusted labor, and $z_{j,t}$ is a firm-level productivity shock that follows an AR(1) process:

$$z_{j,t+1} = \rho_z z_{j,t} + \epsilon_{z,t+1}, \quad \text{where } \epsilon_{z,t+1} \sim N(0, \sigma_z^2) \tag{14}$$

Capital depreciates at rate δ_K, and the firm can make new investments, $I_{j,t}$, subject to a capital adjustment cost

$$\Phi_K = \phi^K \cdot \frac{I_{j,t}^2}{K_{j,t}}, \quad \text{where } K_{j,t+1} = K_{j,t} \times (1 - \delta_K) + I_{j,t} \tag{15}$$

In our model, investments play a "dual role"; on the one hand, they enter directly into the firm's productive function; on the other hand, they enhance the firm's ability to incubate its inexperienced workers, so that they will have a higher probability to "upgrade" their human capital:

$$\begin{aligned} g_{j,t+1} &= (1-\delta_g)\, g_{j,t} \; + \left[1 - (1-\delta_g) g_{j,t}\right] \left[1 - \exp\left(-\chi \frac{I_{j,t}^{+}}{N_{j,t} + H_{j,t}}\right)\right] \\ &= 1 - \left[1 - (1-\delta_g) g_{j,t}\right] \exp\left(-\chi \frac{I_{j,t}^{+}}{N_{j,t} + H_{j,t}}\right), \end{aligned} \tag{16}$$

where $I_{j,t}^{+}$ denotes positive values for intangible investment, truncated below at zero. This functional form guarantees that next period's g always lies between the natural depreciation-adjusted boundary, $(1-\delta_g)g_{j,t}$ and the upper bound of 1. In particular, $g_{j,t+1} = (1-\delta_g)g_{j,t}$ when the firm does not actively seek to invest in its intangibles to enhance its ability to incubate workers. When the firm does make positive intangible investments, $g_{j,t+1}$ increases monotonically with the scale of investment, which captures the core mechanism highlighted in Section 4.

Firms post wages for workers, conditional on their skill levels. We use $w^N = w(h^N)$ and $w^H = w(h^H)$ to denote wages paid to inexperienced and experienced workers, respectively. $g_{j,t}$, discussed above, depends on the firm's past intangible investment decisions, and thus serves as a signal observable to all participants in the labor market. As shown in equation (12), both a firm's wages and its $g_{j,t}$ enter into workers' utility function and thus will influence their labor supply decisions. Given the distribution of wages and the firms' $\{g_{k\neq j,t}\}$ in the economy, the number of inexperienced and experienced workers hired by j can be expressed as:

$$N_{j,t} = \mathrm{Pr}_{j,t}(h^N)N_t, \tag{17}$$

$$H_{j,t} = \mathrm{Pr}_{j,t}(h^H)H_t, \tag{18}$$

where N_t and H_t denote the total number of inexperienced and experienced workers in the economy. In every period, the firm pays an additional labor cost:

$$\Phi_w = \phi^w \cdot (N_{j,t} + H_{j,t}), \tag{19}$$

which captures the ongoing training expenses required to keep workers aligned with the firm's latest technologies, as well as broader administrative and overhead costs associated with maintaining the workforce.

To simplify notation, we drop the firm subscript and adopt a non-prime and prime notation, with the latter denoting variables in the next period. We can write the firm's

Bellman Equation as:

$$V(z,g,K) = \max_{\{w^N,w^H,K'\}} y - N\cdot w^N - H\cdot w^H - [K' - (1-\delta_K)K] - \Phi_K - \Phi_w \\ + \frac{1}{1+r}\mathbb{E}V(z',g',K') \tag{20}$$

5.3. Wage Setting: Markdowns and the Dynamic Dilution Wedge

Differentiating the firm's Bellman equation (20) with respect to w^N (and analogously with respect to w^H), and using the logit hiring elasticity $\partial N/\partial w^N = \theta\, N/w^N$ implied by equation (12), the firm's optimal wage for a worker of skill $h \in \{N, H\}$ can be written as a standard monopsony markdown applied to a *net* marginal product:

$$w^h(\omega) \;=\; \underbrace{\frac{\theta}{1+\theta}}_{\substack{\text{markdown rate}\\ \text{(supply elasticity)}}} \cdot \Big(\underbrace{\mathrm{MPL}^h(\omega) - \phi^w}_{\text{net MPL}} - \underbrace{\mathcal{D}(\omega)}_{\text{dilution wedge}} \Big), \tag{21}$$

where $\omega = (z, g, K)$ denotes the firm's state, $\mathrm{MPL}^h(\omega)$ is the static marginal product of a worker with skill h, ϕ^w is the per-worker maintenance cost, and the term $\mathcal{D}(\omega)$ is a novel *dynamic dilution wedge*:

$$\mathcal{D}(\omega) \;=\; \frac{1}{1+r}\,\mathbb{E}[V_{g'} \mid \omega]\,\big(1 - g'(\omega)\big)\,\frac{\chi\, I(\omega)}{\big(N(\omega)+H(\omega)\big)^2}. \tag{22}$$

The wedge arises directly from the law of motion (16) for g. Because next-period incubation capacity g' depends on intangible investment per worker, $I/(N+H)$, hiring an additional worker mechanically *dilutes* the per-worker stock of intangible investment, which in turn lowers g' and the future continuation value $\mathbb{E}V$. A forward-looking firm internalizes this dilution by paying the marginal hire less than the standard static-monopsony level. The wedge is larger at firms with (i) high marginal value of g tomorrow, $\mathbb{E}[V_{g'} \mid \omega]$, and (ii) high current intangible investment $I(\omega)$, with $1/(N+H)^2$ partially offsetting these effects at very large firms.

Equation (21) shows that human capital incubators may end up with wider or narrower revealed wage-to-MPL gaps than other firms in equilibrium, depending on the relative strength of the two terms. Incubators are the firms that have high $\mathbb{E}[V_{g'}]$ *and* high intangible investment I, which together push up $\mathcal{D}$. But this dynamic monopsony force is dampened by the fact that the same firms tend to attract more workers ($1/(N+H)^2$ is small for them); in our model calibration the net effect is nonetheless a meaningfully larger wedge between net MPL and the wage at incubating firms. We will return to this in Section 6 when quantifying the fraction of total value created by incubators that they internalize. Note also the intertemporal nature of the model-implied relationship between incubation and wage markdown heterogeneity: markdowns today vary with the dilution wedge, which is a function of next period's g and hence human capital growth. Accordingly, when we calibrate the model, we compare next period's human capital growth with current log markdowns.

5.4. Two Profitability Channels From Incubation

The forces generating incubating firms' labor market profits can be understood by writing the inexperienced-worker labor supply that firm j faces in Gumbel logit form (suppressing time subscripts). We now consider the limit of the model where the market contains a continuum of firms. See Appendix A for further details on the derivations.

$$N(\omega) \;=\; \bar{N}\,\frac{\exp\!\left\{\theta\log w^N(\omega) + a(\omega) + \frac{1-\iota}{1+r}\,U(h^N) + \frac{1-\iota}{1+r}\,g(\omega)\,\Delta U\right\}}{\bar{D}^N}, \tag{23}$$

where $\Delta U = U(h^H) - U(h^N)$ is the present-value gain of becoming experienced, $\bar{D}^N$ is the aggregate cross-firm logit denominator defined in Appendix equation (31), and $\bar{N}$ is the number of low skilled workers in the economy. The key observation is that $g(\omega)$ enters *additively* in the same exponent as the firm's wage offer and amenity $a(\omega)$. In other words, *incubation capacity acts as a produced amenity for inexperienced workers*, and the firm's intangible investment decisions endogenously shape that amenity.

This additive-amenity structure cleanly separates the firm's profitability gain from being a strong incubator into two distinct channels:

Channel 1: Scale (level effect). At any wage, a firm with higher g attracts more inexperienced workers and can do so while paying *lower* wages—an "amenity rent." Holding wages at all other firms fixed at their equilibrium values, the wage the firm would need to pay to maintain its inexperienced workforce, $w^{N,cf}(\omega)$, in a counterfactual world where workers do *not* price in the firm's g (treating all firms as having the same average $\bar{g}$) satisfies

$$\frac{w^{N,cf}(\omega)}{w^{N}(\omega)} = \exp\left(\frac{(1-\iota)\big(g(\omega)-\bar{g}\big)\,\Delta U}{(1+r)\,\theta}\right) > 1. \tag{24}$$

The ratio in (24) is the value of the per-worker compensating differential that a strong incubator receives from its workforce. This operates through the scale (level) channel, by increasing the level of the labor supply such that an incubating firm can hire the same number of employees at a lower cost.

Channel 2: Per-worker yield (markdown effect). Cross-firm dispersion in the wage-to-net-MPL ratio works through the dilution wedge $\mathcal{D}(\omega)$ from (22):

$$\frac{w^{h}(\omega)}{\mathrm{MPL}^{h}(\omega)-\phi^{w}} = \frac{\theta}{1+\theta}\left(1-\frac{\mathcal{D}(\omega)}{\mathrm{MPL}^{h}(\omega)-\phi^{w}}\right). \tag{25}$$

Firms with high $\mathcal{D}(\omega)$ retain a *larger share* of net MPL as per-worker profit. Together, Channels 1 and 2 imply that an incubator's profit advantage relative to a similar non-incubator comes from being able to hire more workers at lower wages (amenity rent) and from being able to charge wage markdowns on their workers. The decomposition in Section 6 quantifies these forces using the estimated model.

Note that while the scale channel operates only through inexperienced workers, the markdown channel is symmetric for *both* inexperienced and experienced workers, since the dilution wedge is the same for both worker types. When we calculate labor market counterfactuals for incubating firms, the value of the profits we calculate represent a mix of both of these effects.

5.5. Equilibrium

A stationary Markov Perfect Equilibrium consists of (i) the firm's value function V, (ii) the workers' utility function U; (iii) firm policy functions ; (iv) workers' labor supply decisions; and (v) a bounded sequence of firm and worker measures $\{\Gamma_t\}_{t=1}^{\infty}$, such that for all $t \geq 0$:

1. Firms' value and policy functions are solutions to the firm's optimization problem.
2. Workers' labor supply and utility are solutions to their utility maximization problem.
3. The labor market clears.
4. The probability law governing the evolution of the industry, P^{Γ}, is consistent with firms' and workers' optimal choices.
5. The distribution of firms and workers is stationary, $\Gamma_t = \Gamma_{t+1}$.

5.6. Mechanism

In Figure 1, we illustrate the solution to the model, highlighting how firms' production decisions interact with their role in growing workers' human capital. The blue curve depicts workers' indifference curves, which slope downward because workers substitute current-period wages for firms' ability to raise their human-capital growth rate g', which helps them to increase their wages in future periods.

The red curves represent firms' iso-cost curves that trade off wage payments and intangible investments. While wage payments are equally costly for all firms, the net cost of g'—defined as the out-of-pocket expenditure required to make the intangible investment necessary to raise g to g' in the next period, minus the productivity gain generated by this additional intangible capital—is given by:

$$\left[\frac{\partial g' - (1-\delta_g)g}{\partial I}\right] \cdot \left[1 + 2\phi^K \cdot \frac{I}{K} - \frac{1}{1+r}\frac{\partial \mathbb{E}V(z', g', K')}{\partial K'}\right] \tag{26}$$

For firms with low g, achieving any given level of next-period incubation ability g' requires substantial intangible investment. As a result, these firms rely more heavily on current wage payments rather than using human-capital growth as part of the compensation bundle. In contrast, firms with higher g can maintain or raise their incubation capacity with relatively modest investment. These firms, therefore, substitute away from wage payments and compensate workers partly through higher expected human-capital growth.

Similarly, firms with higher productivity z naturally invest more in intangibles for production purposes. This increases the marginal value of their intangible capital and, after subtracting this production-side benefit, lowers the *net* cost of g'. Consequently, high-z firms also find it optimal to rely less on current wages and more on the promise of future human-capital growth to attract and retain workers.

Taken together, these patterns—illustrated in Figure 1—highlight the dual role of intangible investment in our model: it directly enhances current production efficiency while simultaneously shaping firms' ability to incubate workers' human capital. More importantly, these two functions interact. A firm's production environment influences how it optimally positions itself in the labor market—whether by offering higher period wages or by relying more heavily on human-capital growth as a compensating mechanism for workers.

5.7. Estimation

In this section, we present the model estimation approach and discuss the intuition behind the estimation process. We estimate the model parameters using the Simulated Method of Moments (SMM), choosing the parameter values that minimizes the distance between model-generated moments and their empirical counterparts.

As shown in the first panel of Table 5, we pre-calibrate 7 parameters prior to estimation, as follows. First, we fix the agents' discount rate at 5%. We calibrate the worker exit rate ι to 6%, which combines a 2.5% baseline life cycle exit rate (the inverse of an approximately 40-year working life) with an additional 3.5% idiosyncratic career-disruption hazard based off the rates reported in Davis and von Wachter (2011) (1.9% in expansions and 5.0% in contractions). We also normalize the human-capital level of inexperienced workers to one, so the human capital assigned to experienced workers should be interpreted relative to this benchmark.

A regression of log output on log employment, controlling for log intangible capital stock, yields $\alpha_L = 0.77$. The parameters governing the firm TFP process, ρ_z and σ_z, are calibrated externally to the persistence and volatility of firm TFP estimates, which we estimate for Compustat firms using the İmrohoroğlu and Tuzel (2014) TFP measures over our 1990 to 2020 sample period. This delivers $\rho_z = 0.78$ and $\sigma_z = 0.31$. We calibrate workers' labor-supply elasticity θ externally to $\theta = 2.53$, the pooled homogeneous estimate for Compustat firms from Seegmiller (2021).

In Panel B of Table 5 we estimate 6 parameters to match 8 data moments, which data moments are listed in Table 6. We use average intangible investment rate to calibrate $\delta_K = 0.22$, and the standard deviation of firms' intangible investment to identify ϕ^K, the adjustment-cost parameter governing intangible investment. This gives $\phi^K = 0.64$. To identify the human-capital level of experienced workers, h^H, we match the within-firm dispersion in wage rates. A larger gap in human capital between experienced and inexperienced workers translates into greater within-firm wage dispersion, as firms equate the marginal benefit of employing a worker to the marginal wage cost. We estimate $h^H = 2.01$, implying that experienced workers are roughly twice as productive per unit of labor as inexperienced workers. The parameter ϕ^w is the per-worker cost of maintaining the workforce. A higher ϕ^w increases firms' effective labor costs. In equilibrium, firms respond by applying a larger wage markdown and lowering their hiring, which leads to a reduced labor share. The coefficient of human capital growth on log markdowns, together with the aggregate labor share, helps identify this parameter, which we calibrate to 0.109.

Additionally, we identify the parameters governing firms' ability to incubate workers—namely, χ, which captures how firms' intangible investment contributes to their incubation capacity, and δ_g, which governs the persistence of that capacity. Both parameters are disciplined using the empirical measure of firm HC growth constructed in Section 2.2. We construct an analogous measure in the simulated data by calculating the average wage growth of all workers employed by a given firm j at time t, which serves as the model counterpart to the firm HC growth measure.

The parameter χ is identified from the OLS regression coefficient β in equation (6). We target the coefficient 0.012, matched by running a regression of model-implied human capital growth on simulated standardized investment per worker. This yields $\chi = 0.012$ (the fact the empirical regression coefficient and calibrated χ align almost exactly in this calibration is purely coincidental, as the regression coefficient is not in general identical to the χ structural parameter). We target the OLS coefficient for a few reasons. First, while the IV coefficient is perhaps better identified, it doesn't capture the marginal effect for the whole population. Our IV estimates are only available for a 20% subsample of firms that are more highly innovative, and the instrument primarily shifts the R&D component of intangible investment, and so firms for which the treatment effect is identified may not be wholly representative. Furthermore, by simulating the model, we can match the endogenous model-implied relationship between intangible investment per worker and human capital growth to the analogous relationship captured in the data. The parameter δ_g is affected by several moments, and is calibrated to ensure an accurate joint fit of model-implied regression coefficients of human capital growth on log labor productivity, log markdowns, and investment per worker. This yields $\delta_g = 0.095$.

Table 6 shows the model fit for the 8 target moments. The fit is excellent, with most moments being very close to their empirical counterparts. The model matches the relationship between intangible investment per worker and firm average human capital growth almost exactly, and the other moments are quite close. A central prediction of the model is that intangible capital plays a dual role in production and worker development. Firms with higher productivity endogenously invest more in intangibles, which simultaneously enhances their ability to grow workers' human capital and lets them expand their workforce more effectively. We target the cross-sectional regression coefficient of firm HC growth on prior log labor productivity, which is 0.020 in the data and 0.027 in the model.

The other central prediction of our model, formalized in Sections 5.3 and 5.4, is that higher HC growth benefits the focal firm by enabling it to attract labor at a lower price and also endogenously impacts wage markdowns via the dynamic dilution wedge. To make sure the estimation respects this mechanism quantitatively, we also match the cross-sectional regression coefficient of firm HC growth on the firm's log markdown in the prior period (following the timing logic discussed in section 5.3)—the simulated model yields a value of 0.023, compared to the empirical coefficient of 0.017. This moment plays a dual role in identifying both δ_g and ϕ^w, since both parameters shape the equilibrium relationship between incubation and wage-setting.

5.8. Model Validation

Our identification strategy relies on a snapshot of firms that captures their key balance-sheet characteristics alongside the composition and wage structure of their workforce. Although the estimation does not directly target worker composition patterns, the model generates sharp predictions about them. In particular, firms with strong human-capital incubation ability optimally specialize in hiring relatively inexperienced, more junior workers. These workers benefit most from the firm's incubation capacity and are therefore willing to accept a compensating differential for being employed at incubating firms.

Although these job-flow patterns are not included among the targeted moments, they speak directly to the model's central mechanism. We therefore use them as an external validation to assess the model's ability to predict key features in the data. Panel B of Table 7 reports the corresponding empirical relationships. Consistent with the model's predictions, firms with stronger human-capital incubation ability employ a larger share of young workers. We also find a positive association between incubation ability and the net inflow of young workers relative to older workers. Additionally, in the first two columns of panel A we find that firms' labor productivity and market power are associated with higher firm human capital growth.[16] These coefficients were also directly targeted in the model calibration in Table 6. Further, in the next two columns we find that firm profitability and market valuations are positively associated with human capital growth; the model generates similar positive associations with profitability and valuations.

6. Internalized Profits and Externalities of Incubator Firms

In this section, we use the estimated model as a laboratory to quantify the value that firms can internalize by incubating workers, as well as the portion of workers' human-capital growth that becomes a knowledge spillover, increasing the wage of the incubated workers and the profits of firms that subsequently hire these workers.

To do so, we focus on the top tercile of firms ranked by their HC growth in our model simulation, which we label human-capital-incubating firms. For these firms, we construct three measures. The first is the "value of incubation." Conceptually, this measures how much value these firms generate for the economy as a whole by incubating workers, realizing a gain in their marginal productivity:

$$\text{MPL Gain}_{j,t} = g_{j,t} \cdot N_{j,t} \cdot \mathbb{E}\left(\text{MPL}_H - \text{MPL}_N\right), \tag{27}$$

[16]We note that while we estimate market power empirically for Compustat firms using revenue-based markup estimates following De Loecker, Eeckhout, and Unger (2020), in the model, the market power comes from the labor market side. However, as De Ridder, Grassi, and Morzenti (2025) shows, such revenue-based markups capture the *total* market power of the firm when firms jointly possess labor and product market power. Since market power in the model comes from the labor side, this is a model-consistent market power measure. Additionally, recent evidence suggests that labor market power is a large and increasingly important component of Compustat firms' total market power (Seegmiller, 2021; Ren and Zhang, 2025).

where $\mathbb{E}(\text{MPL}_H - \text{MPL}_N)$ captures the unconditional expected gain from upgrading a worker's human capital, irrespective of the worker's future employment.[17] This is consistent with our objective of measuring the total value created by incubation, without assigning the gains to specific parties at this stage. We then multiply the expected MPL gain by the firm's intensity of successfully incubating inexperienced workers, $g_{j,t}$, and its base of inexperienced workers, $N_{j,t}$. The result yields the expected MPL gain realized by the firm through incubation in a given period. We then take the present value of these gains to measure the total value created by the firm's incubation activities.

Our second measure captures firms' wage savings from incubation. For each firm, we consider a counterfactual scenario in which inexperienced workers do not "price in" the firm-specific component of incubation capacity.[18] Instead, they treat incubation capacity as a constant $\bar{g}$ across all firms when making labor-supply decisions in Equation (12). Note that, because $\bar{g}$ enters every firm's exponent in the logit choice probability additively, the *level* of $\bar{g}$ cancels out and is therefore immaterial; what matters is only that workers cannot differentially reward firms by their actual incubation capacity. We define the counterfactual wage as the wage that the human-capital-incubating firm j would need to offer to maintain its workforce under this counterfactual scenario. This is the wage $w_{j,t}^{cf}$ that equates the firm's labor hiring of inexperienced workers in the counterfactual environment to its realized employment in the simulation of our factual model:

$$\frac{\exp\left\{\mathring{U}\left[h_{i,t}, w_{j,t}^{cf}(h^N), \bar{g}\right]\right\}}{\exp\left\{\mathring{U}\left[h_{i,t}, w_{j,t}^{cf}(h^N), \bar{g}\right]\right\} + \sum_{k\in J\setminus j}\exp\left\{\mathring{U}\left[h_{i,t}, w_{k,t}(h_{i,t}), \bar{g}\right]\right\}} \cdot N_t = N_{j,t} \qquad (28)$$

The difference between this counterfactual wage and the baseline wage, therefore, represents these firms' wage savings from their ability to incubate. Conceptually, these savings arise because workers are willing to accept a compensating differential in exchange for

[17] We calculate as the MPL difference of an experienced and inexperienced worker for any given firm year, and we aggregate across all observations in the simulated economy to get at this unconditional expectation again.

[18] We only focus on inexperienced workers because experienced workers' labor supply decision does not depend on firms' ability to incubate.

faster human-capital growth. We then compute the present value of these per-period wage savings to quantify the total value gained by the firm.

The difference between the value of incubation and wage savings gives our measure of incubation spillover. In our model, spillovers arise because the gains from human-capital accumulation are not confined to the current period. While current-period gains are shared between the worker and the current employer, they also carry over to future periods, benefiting workers through higher future wages and future employers who hire these more experienced workers—since all firms in the model possess labor market power and would benefit from their workers' productivity gains. The latter represents an externality that benefits the firms that hire the worker after the worker becomes more experienced.

The results, reported in Table 8, show that incubator firms generate substantial value by raising workers' human capital and, in turn, their productivity. This value creation is then shared among the focal firm, the workers being incubated at the firm, and other firms that subsequently hire these workers. The present value of the MPL gain from incubation accounts for about 13% of firm value among top-tercile incubators.

Our decomposition results further suggest that firms internalize about 43% of the measured value creation through wage savings, with the per-period wage savings amounting to roughly 5.7% of firm value. This finding is consistent with the dual role of intangible investment from the firm's perspective: it enhances workers' human capital, part of which the firm can internalize, thereby strengthening its incentive to invest in intangibles for this purpose in the first place. The remaining 57% of the value created—about 7.7% of firm value among incubators—represents a positive spillover that flows to workers themselves and to future employers who subsequently hire the now-experienced workers, since all firms in the model possess labor market power and would benefit from their workers' productivity gains.

6.1. Heterogeneity Across the HC-Growth Distribution

The top-tercile averages discussed above mask substantial heterogeneity. Figure 2 plots the present value of incubation (marginal product gain) and the present value of wage savings, each scaled by firm value, against firm HC growth. The marginal product gain is monotonically increasing in HC growth, reaching about 18% of firm value for firms in the top of the HC-growth distribution. Wage savings, in contrast, are non-monotonic: they are essentially zero for firms with HC growth near zero, become *negative* (roughly −5% of firm value) for firms with intermediate HC growth around 0.03–0.05, cross zero around HC growth of 0.09–0.10, and rise to about 13% of firm value at the top.

The non-monotonicity in wage savings follows directly from how the counterfactual is constructed. The counterfactual has inexperienced workers treat firms' incubation capacity as a constant rather than as firm-specific. Critically, the *level* of that constant is irrelevant for the labor supply decision: it enters additively into every firm's logit exponent and cancels out of the choice probabilities. What matters is only that workers can no longer differentially price firms by their incubation capacity. Relative to the factual equilibrium, this is good news for firms whose $g(\omega)$ is low compared with their competitors (workers in the counterfactual stop penalizing them for being weak incubators, and so are willing to supply labor at a lower wage—wage savings turn negative), and bad news for firms whose $g(\omega)$ is high compared with their competitors (workers in the counterfactual stop rewarding them for being strong incubators, so the firm must pay more to maintain hiring—wage savings are positive). The crossover in Figure 2 therefore identifies the region of the HC-growth distribution where the firm's incubation capacity is close to the (share-weighted) average among its competitors, and the negative region for moderate HC-growth firms reflects firms that are below-average relative to that competitive benchmark.

Figure 3 reports the same information as a ratio: wage savings divided by the marginal product gain, which gives the share of created value that the firm internalizes. The ratio is roughly 0 at zero HC growth, plunges to about -1.1 around HC growth of 0.03–0.04 (these below-competitive-average incubators pay back *more* than the surplus they generate, because shutting down the within-distribution comparison removes a competitive disadvantage they currently bear), rises through zero near HC growth ≈ 0.10, and reaches about 0.65 at the top. The implication is that the strongest human-capital incubators are the firms that simultaneously create the most worker-level surplus *and* retain the largest share of it—consistent with the two reinforcing labor-market-power channels in Section 5.4. For these firms, almost two-thirds of the marginal-product gain is internalized as wage savings, with the remaining roughly one-third spilling over to workers and downstream employers.

6.2. Cumulative Externalities and the Aggregate Income Share

The firm-level decomposition above focuses on top-tercile incubators. To put the magnitudes in aggregate terms, we cumulate the value of incubation and the wage savings across the entire distribution of firms in the simulated economy and express totals relative to aggregate income (firm profits plus labor earnings). Figure 4 traces the cumulative externality (MPL gain minus wage savings) as we walk through the HC-growth distribution from the bottom to the top. The line is essentially flat at zero through the bottom two deciles, begins to rise around the 30th percentile, and accelerates through the upper part of the distribution, reaching 7% of aggregate income at the top.

The aggregate externality is therefore both meaningful in absolute size—an order of magnitude larger than the cross-sectional rent that any individual incubator internalizes—and highly concentrated in the right tail of the HC-growth distribution. Roughly 70% of the cumulative externality is generated by firms in the top three deciles of HC growth. Even though top incubators internalize the largest *share* of their own surplus (Figure 3), the absolute size of their marginal-product gains is so much greater than at the median firm that the unappropriated residual still dominates the aggregate.

6.3. General-Equilibrium Counterfactual

To go beyond the partial-equilibrium decomposition above, we also solve a counterfactual general equilibrium of the model in which inexperienced workers treat firms' incubation capacity as a constant when making their labor-supply decisions, rather than as firm-specific. As noted in Section 6.1, the level of that constant is immaterial: it cancels in the logit choice probabilities, and what matters is only that workers can no longer differentially price firms by their g. Re-solving the firm problem under this restriction and comparing aggregates to the baseline simulation delivers a set of clean economy-wide statistics that map the dynamic externality into general-equilibrium quantities.

Table 9 reports the full set of changes; the headline numbers are: total net income (profits plus labor earnings) declines by 2.9%; aggregate firm profits fall by 7.3%, while aggregate labor earnings are roughly flat at −0.1%; the skilled labor employment share falls by 6.7%; the aggregate stock of intangible capital contracts by 17.4%. Finally, despite the contraction in intangible capital and aggregate income, the cross-firm standard deviation of log marginal product of capital—a standard measure of static capital misallocation in the spirit of Hsieh and Klenow (2009)—also falls by 22.9%.

These results highlight a tension in evaluating the welfare consequences of firms' labor-market power when imperfect competition affects investment incentives. In a static sense, the baseline economy looks less efficient: the same workers and capital could in principle be reallocated to reduce the cross-firm dispersion in log MPK. But shutting down the channel through which workers reward incubators with cheaper labor also kills the dynamic incentive to invest in intangibles, which lowers the aggregate intangible-capital stock, the skill mix of the workforce, and total income. The implication is a tradeoff between apparent static misallocation and dynamic investment externalities: the cross-sectional dispersion in markdowns that traditional measures of labor-market power flag as a friction is, in this model, an equilibrium price signal that sustains firms' investment in workers' future productivity.

7. Conclusion

In this paper, we document a systematic and strongly-positive relationship between firms' intangible investments and the subsequent growth in the human capital of their skilled employees, consistent with a large theoretical literature that emphasizes the interplay between intangible capital and the productivity of skilled labor. Instrumental variables estimates based off direct and indirect firm exposure to R&D tax credits support a causal interpretation of this relationship. Surveys of workers' average subjective perception of firms' career growth opportunities are also positively associated with intangible investment, suggesting that workers are likely to be aware of this association.

We build a model featuring workers who supply labor to heterogeneous firms that endogenously choose their optimal investment into workers' skill growth. The model implies that productive, profitable, high-market power, and high-value firms should exhibit higher human capital growth, which we confirm in the data. Additionally, we find that young workers, who benefit the most from investments into their skills in the model, disproportionately flow into human capital incubating firms.

Quantitatively, for the top tercile of human-capital incubators, our model estimation reveals that firms' ability to incubate workers enables them to gain labor market power, obtaining wage savings as workers accept lower pay in exchange for the firm's incubation provision. The present value of the productivity gain from incubation amounts to roughly 13% of firm value among these incubators. Incubator firms internalize about 43% of this value through wage savings, while the remaining 57% accrues as positive spillovers to workers and to non-incubating firms that subsequently hire the now-experienced workers. Cumulating across the economy, these externalities represent about 7% of total income.

The general-equilibrium consequences of the mechanism are also sizable. In a counterfactual economy in which workers treat incubation capacity as a constant across firms, total income falls by 2.9% with aggregate profits falling by 7.3%. This stems from diminished investment incentives when firms cannot internalize benefits from human capital growth provision: intangible capital stock declines by 17.4%, and the share of skilled workers in the economy drops by 6.7%.

These findings uncover a novel mechanism for firms' pricing power in the labor market, where employers generate wage discounts because workers are willing to forgo wages today to benefit from firms' investments into their human capital growth. This further suggests that some of the firms' labor market power may not be strictly anti-competitive, but instead generates spillover benefits to workers and firms. Our findings also confirm theoretical models suggesting an intrinsic link between skilled labor and intangible capital, which is in part embodied in the skills of the workers themselves.

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Tables and Figures

Table 1. Summary Statistics

	Mean	SD	Q10	Q25	Q50	Q75	Q90
Panel A: Human Capital and Wage							
Firm Human Capital Growth	0.0259	0.0970	-0.078	-0.0268	0.0206	0.0723	0.137
Average Pay	81,050	54,060	29,970	48,310	68,310	97,710	142,900
Panel B: Financial Characteristics							
Intangible Investment per worker	40.31	61.39	0.6873	7.903	19.72	47.64	100.6
Organizational Investment per worker	21.72	22.76	0	6.434	14.94	30.12	49.23
Knowledge Investment per worker	18.11	48.22	0	0	0	13.34	55.01
Physical Investment per worker	39.22	148.3	2.116	4.579	9.434	21.62	61.44
Total Investment per worker	68.19	157.2	6.495	14.09	29.88	66.57	134.1
Log Labor Productivity	4.684	0.8508	3.597	4.175	4.672	5.191	5.739
Profitability	0.0205	0.1501	-0.1149	-0.0062	0.0394	0.0844	0.1386
Log Markup	0.5598	0.4646	0.1511	0.2539	0.4268	0.7203	1.16
Total Q	1.319	2.745	0.0272	0.3309	0.7226	1.381	2.803
Panel C: Labor Market Characteristics							
Young Worker Share	0.3058	0.1283	0.1579	0.2151	0.2895	0.378	0.4783
Net Flow Rate	0.1608	0.2766	-0.0262	0.0419	0.1067	0.209	0.3904
Young Worker Share of Firm Inflows	0.4032	0.1547	0.2176	0.3077	0.4	0.5	0.6
Young Minus Old Aggregate Inflow Share	4.42E-04	0.0238	-0.01049	-0.0027	-1.87E-04	0.0023	0.0114
Young Minus Old Aggregate Outflow Share	0.0017	0.0204	-0.0070	-0.0017	2.27E-04	0.0032	0.0122

Notes. This table presents summary statistics of firm characteristics. Panel A presents the human capital incubation measure (equation (4) in main text) and the average LEHD pay per worker. Panels B and C present the firm's financial and labor market characteristics, respectively. All dollar amounts are based on 2017 real dollars, and investment variables are reported in units of thousands of dollars per worker. We construct intangible investment following Peters and Taylor (2017), which we normalize by Compustat employees. Physical investment is given by capital expenditures. Labor productivity is given by log value added per worker, where value added is the sum of operating income before depreciation and total firm payroll calculated from the Longitudinal Business Database (LBD). Profitability is net income divided by prior year total assets; the log markup is estimated as the log of the ratio of sales to cost of goods sold, which is equivalent to log markups in De Loecker, Eeckhout, and Unger (2020) when industry fixed effects are included. We construct the Total Q valuation ratio as the ratio of enterprise value to total capital, following Peters and Taylor (2017). The labor market characteristics are defined as follows. The share of young workers are the fraction of LEHD employees in the firm who are between the ages of 25 and 34. The "Net Flow Rate" is given by the total number of workers who flow out of the firm over the next 2 years, minus total workers who flow into the firm, divided by total LEHD employment in the current year. The "Young worker Share of Inflows" is the total number of young workers who flow into the firm over the next 2 years, divided by total inflows into the firm over the next 2 years. The "Young Minus Old Aggregate Inflow Share" is the total number of young (25-34) workers who flow into the firm divided by total number of young workers who flow into *any* firm over the next two years, minus the total number of old (35-54) workers who flow into the firm divided by the total number of old workers who flow into *any* firm over the next two years; "Young Minus Old Aggregate Outflow Share" is defined analogously, except for workers flowing out of the firm. All numbers are rounded to satisfy the Census' disclosure guidelines.

Table 2. Human Capital Growth, Cross-Firm Human Capital Spillovers, and Firm Growth Outcomes

	Dependent variable: Growth rate in			
	(1) Labor Productivity	(2) Sales	(3) Value-Added	(4) Profits
Panel A: OLS				
Firm HC Growth	0.5526***	0.6132***	0.7515***	0.9832***
	(0.0406)	(0.0241)	(0.0314)	(0.0410)
Panel B: Reduced Form (Spillovers)				
Cross-Firm HC Spillover	0.2985***	0.1994***	0.2996***	0.3251***
	(0.0586)	(0.0329)	(0.0439)	(0.0551)
Panel C: IV (F-stats: 294.0)				
Firm HC Growth	1.595***	1.065***	1.601***	1.737***
	(0.3173)	(0.1715)	(0.2343)	(0.2907)
Industry-Year FE	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes
Observations	45,500	45,500	45,500	45,500

Notes. This table presents regressions of firm-level growth rates in labor productivity, sales, value-added, and profits, on firm-level human capital growth as defined in the main text. In panel A we show the raw ordinary least squares relationship; in panel B, we examine the relationship between firm-level growth outcomes using only spillovers from other firms, weighted by hiring network weights. The cross-firm spillover measure interacts the human capital growth of the workers who stay at other firms, weighted by the share of the focal firm's total hires from that firm over the past 3 years. In panel C, we instrument for firm-level human capital growth using only cross-firm spillovers. See main text for details. All specifications control for 4-digit NAICS by year fixed effects. We also control for firm size (log of total assets and employment) and variables plausibly related to financial constraints (log of firm age, an indicator of whether the firm pays dividends, cash and short-term investments, and total long-term debt divided by total assets). Reduced Form and IV specifications additionally control for a shift-share measure of exposure to cross-firm employment growth via the hiring network. The numbers are rounded to satisfy the Census' disclosure guidelines. Standard errors are clustered by firm. *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Table 3. Relationship between Intangible Investments and Human Capital Growth

	Dependent Variable: Firm HC Growth			
	(1)	(2)	(3)	(4)
Standardized Intangible Investment per worker	0.0260***	0.0211***	0.0110***	0.0120***
	(0.0010)	(0.0011)	(0.0011)	(0.0011)
Year FE	Yes	Yes	Yes	No
Industry FE	No	Yes	Yes	No
Industry-Year FE	No	No	No	Yes
Firm Controls	No	No	Yes	Yes
Observations	62,000	62,000	62,000	62,000

Notes. This table presents the relationships between firms' intangible investments and employees' human capital growth. The outcome variable is the firm's human capital incubation measure defined in equation (4), while the explanatory variable is the standardized intangible investment per worker. The numbers are rounded to satisfy the Census' disclosure guidelines. Standard errors clustered by firm are in parentheses. *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Table 4. Effects of Intangible Investments on Human Capital Growth - Instrumental Variables

	Dependent Variable: Firm HC Growth
Panel A. All IVs (F-stats: 25.03)	
Standardized Intangible Investment per worker	0.0245***
	(0.0089)
Panel B. Spillover IVs (F-stats: 26.63)	
Standardized Intangible Investment per worker	0.0243**
	(0.0114)
Panel C. Tax IVs (F-stats: 28.03)	
Standardized Intangible Investment per worker	0.0251*
	(0.0131)
Industry-Year FE	Yes
Firm Controls	Yes
Observations	13,000

Notes. This table presents the effects of firms' intangible investments on employees' human capital growth. The outcome variable is the firm's human capital incubation measure defined in equation (4). Panel A uses both spillover and direct tax instruments from Bloom, Schankerman, and Van Reenen (2013); Lucking, Bloom, and Van Reenen (2019), while Panels B and C separately use only the spillover and tax instruments, respectively. The numbers are rounded to satisfy the Census' disclosure guidelines. Standard errors clustered by firm are in parentheses. *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Table 5. Model Parameter Calibration

Panel A. Externally Calibrated Parameters

Parameter	Name	Value	Source
r	Discount rate	0.05	5% discount rate
ι	Worker exit rate	0.06	Lifecycle exit (2.5%) + idiosyncratic career (3.5%, Davis and von Wachter (2011)) hazards
h^N	Human capital of inexperienced workers	1	Normalization
ρ_z	Persistence of firm TFP shock	0.78	TFP persistence, İmrohoroğlu and Tuzel (2014)
σ_z	Std of innovation to firm TFP shock	0.31	TFP shock volatility, İmrohoroğlu and Tuzel (2014)
α_L	Curvature of output w.r.t. skill-augmented labor	0.77	Regression of log sales on log labor/capital
θ	Elasticity of labor supply	2.53	Seegmiller (2021)

Panel B. Internally Calibrated Parameters (SMM)

Parameter	Name	Value	Key Moment
δ_K	Depreciation rate of intangible capital	0.22	Mean intangible investment rate
ϕ^K	Cost of adjusting intangible capital	0.64	Volatility of intangible investment rate
h^H	Human capital of experienced workers	2.01	Within-firm wage dispersion
ϕ^w	Marginal cost of maintaining workforce	0.109	Coeff. of HC growth on log markdown
δ_g	Depreciation rate of incubation capacity	0.095	Several moments
χ	Dependence of firm incubation ability on intangible investment	0.012	Coeff. of HC growth on investment/worker

Notes. In this table, we report the model parameter estimates. Panel A presents externally calibrated parameters with their sources. Panel B presents the parameters estimated by SMM, with the key moment that primarily disciplines each parameter. With constant returns to scale in capital and skill-adjusted labor, the curvature of output with respect to intangible capital is $1 - \alpha_L = 0.23$.

Table 6. Moment Conditions

	Actual	Simulated
Mean intangible investment rate	0.22	0.23
Standard deviation of intangible investment rate	0.13	0.13
Aggregate labor share	0.55	0.51
Standard deviation of log wages within firm	0.60	0.65
Standard deviation of firm HC growth	0.097	0.093
Coefficient of firm HC growth on investment/worker	0.012	0.012
Coefficient of firm HC growth on log labor productivity	0.020	0.027
Coefficient of firm HC growth on log markdown	0.017	0.023

Notes. In this table, we report the moment conditions targeted in our simulated method of moments estimation. The actual moments are calculated using the observed data. The simulated moments are computed from model-simulated data using the parameter values reported in Table 5. The system is over-identified: there are more moment conditions than internally calibrated parameters in Panel B of Table 5. The coefficient of firm HC growth on log markdown disciplines the labor-market-power channel implied by the dynamic dilution wedge $\mathcal{D}(\omega)$ described in Section 5.3. The average aggregate labor share moment for Compustat firms is taken from Seegmiller (2021); the within-firm standard deviation of log wages is taken from Song et al. (2019).

Table 7. Relationships between Firm Characteristics and Human Capital Growth

	Dependent Variable: Firm HC Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Financial Characteristics						
Log Labor Productivity	0.0199***					
	(0.0010)					
Log Markup		0.0168***				
		(0.0017)				
Profitability			0.0375***			
			(0.0040)			
Tobin's Q				0.0028***		
				(0.0003)		
Panel B: Labor Market Characteristics						
Young Worker Share					0.0572***	
					(0.0060)	
Young Share of Inflows						0.0220***
						(0.0036)
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	62,000	62,000	62,000	62,000	59,000	59,000

Notes. This table presents the relationships between employees' human capital growth and the characteristics. The outcome variable is the firm's human capital incubation measure defined in equation (4). Panels A and B present financial and labor market characteristics, respectively. See notes to Table 1 for definitions and distributions of each characteristic. The numbers are rounded to satisfy the Census' disclosure guidelines. Standard errors clustered by firm are in parentheses. *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Table 8. The Value of Incubation: Rent versus Externality

	As % of Firm Value	As % of Value from Incubation
(1) PV from MPL gain	0.134	100%
(2) PV from wage savings	0.057	42.6%
(3) Externality	0.077	57.4%

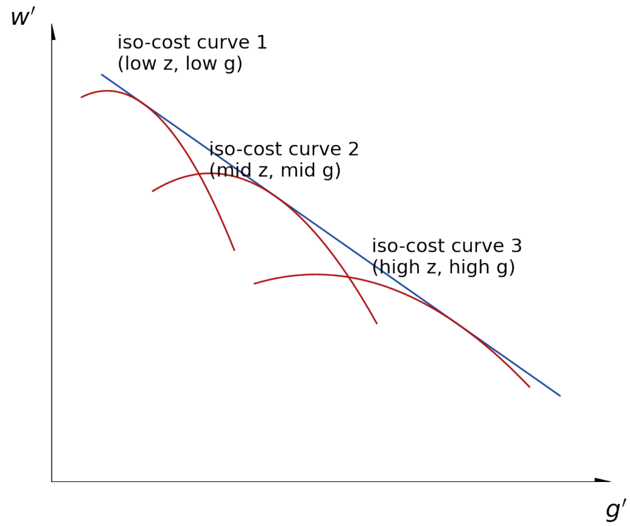
Notes. In this table, we report the value of incubation, focusing on firms in the top tercile of workers' HC growth. In row (1), we measure the present value of the increase in workers' marginal productivity when they experience human capital growth within their employer firm (i.e., when they are incubated). In row (2), wage savings capture the wage markdown that firms can charge due to their ability to incubate workers. In row (3), the externality is defined as the difference between (1) and (2). We report these quantities both as a percentage of incubating firms' market value and as shares of the total value generated by incubation. The wage-savings row corresponds to the cross-firm portion of the dilution-wedge effect derived in Section 5.3 combined with the amenity-rent effect derived in Section 5.4.

Table 9. Counterfactual General Equilibrium: Aggregate Effects of Shutting Down Cross-Firm Incubation Heterogeneity

Aggregate	% change relative to baseline
Total net income (profits + labor earnings)	−2.91%
Aggregate profits	−7.26%
Aggregate labor earnings	−0.13%
Skilled labor employment share	−6.74%
Aggregate intangible capital stock	−17.35%
Standard deviation of log MPK	−22.87%

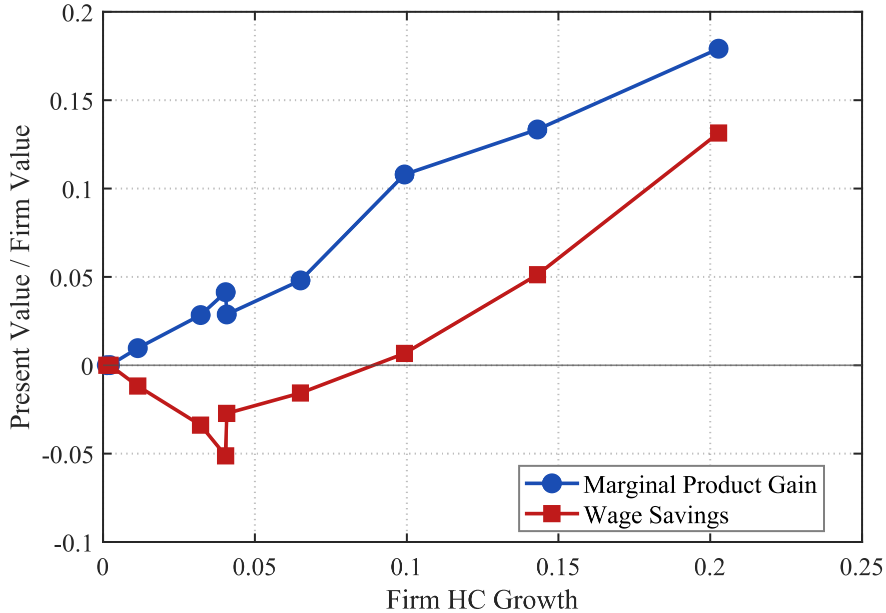
Notes. This table reports the percentage change in selected economy-wide aggregates between the baseline simulated economy and a counterfactual general equilibrium in which inexperienced workers treat firms' incubation capacity as a constant (rather than firm-specific) in their labor supply decisions. The level of that constant is immaterial because it enters every firm's logit exponent additively and cancels in the choice probabilities; the change in aggregates is driven entirely by the loss of cross-firm differentiation in incubation. Total income is the sum of firm profits and labor earnings. The skilled labor employment share is the share of the workforce represented by experienced workers in the model. The standard deviation of log MPK measures cross-firm dispersion in the (log) marginal product of intangible capital and is used here as a sufficient statistic for static capital misallocation in the sense of Hsieh and Klenow (2009): a lower value indicates less misallocation in the static sense. The counterfactual delivers *less* static misallocation but *lower* total income, intangible capital, skilled employment, and profits, illustrating the trade-off between static misallocation and the dynamic investment externalities supported by cross-firm variation in labor-market power.

Figure 1. Worker Preference and Firm Optimal Policy



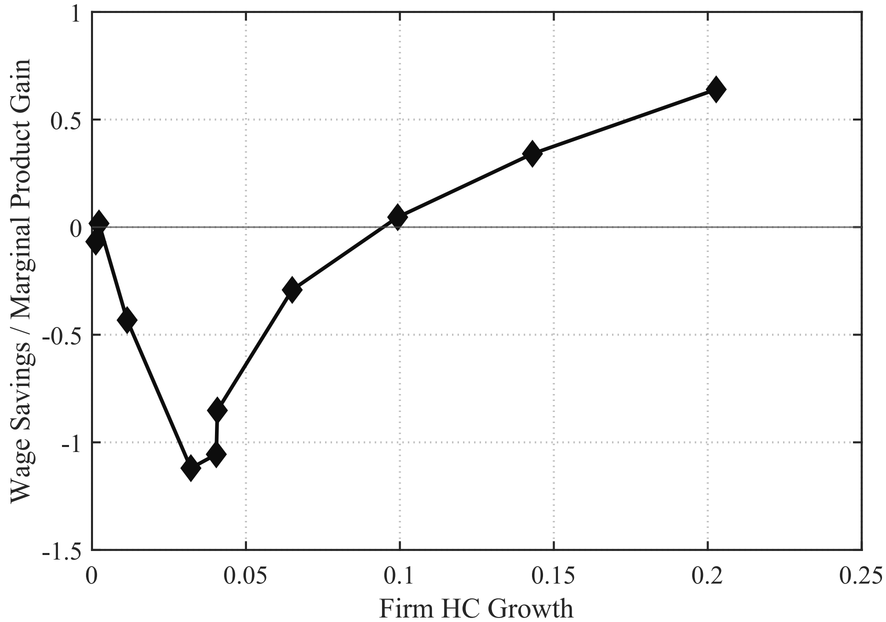
Notes. This blue line depicts workers' indifference curve with respect to their next-period wages, w', and their firms' next-period incubation capacity, g'. Firms can raise g' by incurring costs to invest in intangible capital today, as described in Equation (16). The red curves represent firms' iso-cost schedules: for each firm, they trace the combinations of future wage payments w' and next-period incubation capacity g' that entail the same total cost today. Because firms differ in their current incubation capacity g and productivity z, their cost trade-offs between raising g' and paying higher wages are heterogeneous, giving rise to differently shaped iso-cost curves.

Figure 2. Decomposition of Incubation Value: Marginal Product Gain vs. Wage Savings



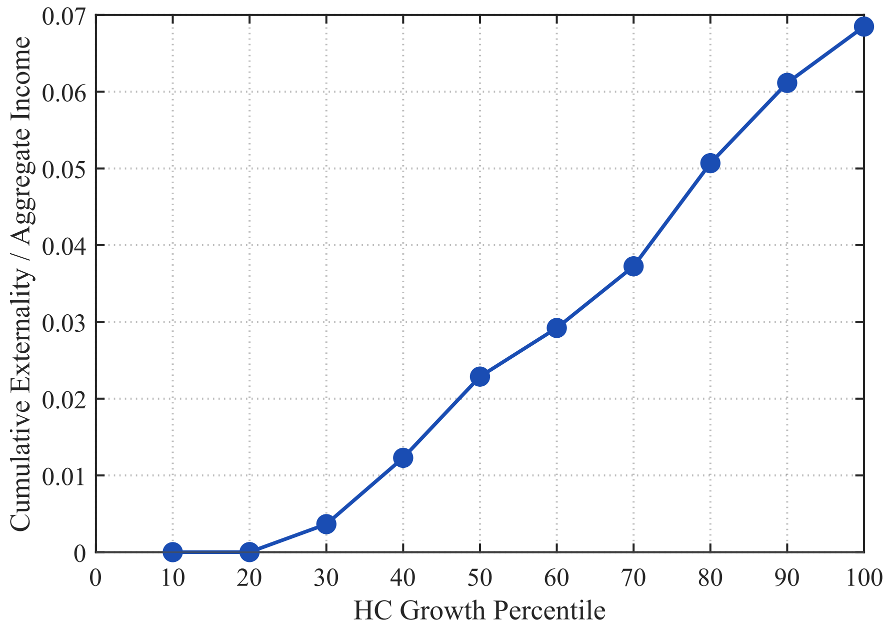
Notes. This figure plots the present value of incubation activities decomposed into two components, each scaled by firm value, against firm HC growth in the simulated economy. The blue line (with circles) reports the present value of the marginal product gain from incubating inexperienced workers: $\sum_t (1+r)^{-t} \, g_{j,t} \, N_{j,t} \, \mathbb{E}(\mathrm{MPL}_H - \mathrm{MPL}_N)$. The red line (with squares) reports the present value of wage savings, defined as the difference between the counterfactual wage that would prevail if inexperienced workers treated incubation capacity as constant across firms and the equilibrium wage in the baseline model. Because the common counterfactual incubation level enters every firm's logit exponent additively, its level cancels in the choice probabilities; what changes between the factual and counterfactual is only that workers can no longer differentially price firms by their incubation capacity. The gap between the blue and red lines is the externality.

Figure 3. Wage Savings as a Share of the Marginal Product Gain



Notes. This figure plots the ratio of the present value of wage savings to the present value of the marginal product gain from incubation, both defined as in Figure 2, against firm HC growth in the simulated economy. The ratio measures the share of the total value of incubation that the firm internalizes as wage savings rather than spilling over to workers and downstream employers. Negative values indicate firms whose realized wage cost exceeds the counterfactual cost they would face if workers could not distinguish them from the average-incubation firm.

Figure 4. Cumulative Incubation Externality as a Share of Aggregate Income



Notes. This figure plots the cumulative incubation externality (marginal product gain minus wage savings) generated by all firms up to a given percentile of the firm HC-growth distribution, scaled by aggregate income (firm profits plus labor earnings) in the simulated economy. The full-distribution total reaches approximately 7% of aggregate income, with the bulk concentrated in the upper deciles of HC growth.

Appendix

A. Equilibrium Derivations

This appendix characterizes the stationary equilibrium of the model of Section 5 in the limit of a continuum of firms. The continuum is not a computational convenience: with a non-atomic firm measure, the aggregate objects each firm conditions on are exactly constant rather than approximately so by a law of large numbers, and each firm is exactly a price-taker on those aggregates. The full equilibrium reduces to a fixed point in seven aggregate scalars coupled with a stationary three-dimensional firm Markov process.

A.1. Setup and Notation

Firms are indexed by $\omega \in \Omega = \mathcal{Z} \times \mathcal{G} \times \mathcal{K}$ with a σ-finite measure $\mu(d\omega)$ on Ω. A typical firm has state $(z(\omega), g(\omega), K(\omega))$. We write

$$\beta \equiv \frac{1-\iota}{1+r}, \qquad \Delta U \equiv U^H - U^N, \qquad L(\omega) \equiv h^N N(\omega) + h^H H(\omega).$$

For the per-period worker utility (7) we take the convention that θ is the coefficient on $\log w$ and $\epsilon \sim$ Gumbel$(0,1)$, so θ is both the wage coefficient in utility and the firm-level labor-supply elasticity. We normalize the exit-utility $\underline{U} = 0$; the normalization is shown to be innocuous in Section A.9.

Foundations for the additive-logit choice over a continuum of alternatives follow Dagsvik (1994): replace the i.i.d. Gumbel-shock primitive with the underlying Poisson point process whose intensity recovers the logit choice probabilities. The resulting choice probability that a worker selects a firm in $B \subseteq \Omega$ is

$$\Pr(\text{choice} \in B \mid h) = \frac{\int_B e^{\mathring{U}^h(\omega)}\,\mu(d\omega)}{\int_\Omega e^{\mathring{U}^h(\omega')}\,\mu(d\omega')},$$

and the log-sum expected-max formula carries over intact.

A.2. Worker Block

A.2.1. Mean Utilities

For a worker of type $h \in \{h^N, h^H\}$ contemplating firm ω, the mean utility prior to the realization of the Gumbel preference shock is

$$\mathring{U}^N(\omega) = \theta \log w^N(\omega) + a(\omega) + \beta U^N + \beta\, g(\omega)\, \Delta U, \tag{29}$$

$$\mathring{U}^H(\omega) = \theta \log w^H(\omega) + a(\omega) + \beta U^H. \tag{30}$$

Notice that g enters $\mathring{U}^N$ *additively*, exactly as the amenity term a does, and is absent from $\mathring{U}^H$ because experienced workers are already upgraded and have no further use for incubation capacity. This will be the source of an important structural observation below: firms' incubation capacity functions in the labor supply system as a *produced amenity* that benefits only inexperienced workers.

A.2.2. Continuation Values

The expected-max formula for Gumbel shocks over a continuum of alternatives yields

$$U^h \;=\; \log \bar{D}^h \;+\; \gamma, \qquad \bar{D}^h \equiv \int_\Omega e^{\mathring{U}^h(\omega)}\, \mu(d\omega), \qquad h \in \{N, H\}, \tag{31}$$

where $\gamma \approx 0.5772$ is the Euler–Mascheroni constant. The experienced premium therefore satisfies the identity

$$\Delta U \;=\; \log\!\left(\frac{\bar{D}^H}{\bar{D}^N}\right), \tag{32}$$

i.e., the worker's experienced-versus-inexperienced premium is exactly the log ratio of aggregate firm-side desirability for the two worker types.

A.2.3. Labor Supply and Wage Elasticity

The labor-supply density at firm ω (per unit firm measure) is

$$N(\omega) \;=\; \bar{N}\, \frac{e^{\mathring{U}^N(\omega)}}{\bar{D}^N}, \qquad H(\omega) \;=\; \bar{H}\, \frac{e^{\mathring{U}^H(\omega)}}{\bar{D}^H}. \tag{33}$$

Each firm faces a labor-supply curve with constant wage elasticity equal to θ:

$$\frac{\partial \log N(\omega)}{\partial \log w^N(\omega)} \;=\; \frac{\partial \log H(\omega)}{\partial \log w^H(\omega)} \;=\; \theta.$$

Because g enters $\mathring{U}^N$ additively, it does not enter this elasticity. The firm's incubation capacity therefore shifts the labor-supply curve for inexperienced workers without rotating it.

A.2.4. Aggregate Worker Stocks

With unit-mass entry of inexperienced workers each period and common exit rate ι, the stationarity of the worker measure gives

$$\bar{N} \;=\; \frac{1}{\iota + \bar{G}}, \qquad \bar{H} \;=\; \frac{\bar{G}}{\iota(\iota + \bar{G})}, \qquad \bar{N} + \bar{H} \;=\; \frac{1}{\iota}, \tag{34}$$

where the realized aggregate upgrade rate experienced by inexperienced workers is

$$\bar{G} \;=\; \int_{\Omega} g(\omega)\, \frac{e^{\mathring{U}^N(\omega)}}{\bar{D}^N}\, \mu(d\omega). \tag{35}$$

A.3. Firm Static Block: Wage FOCs

The firm's flow profit, conditional on choices (w^N, w^H, K') and realized labor levels, is

$$\Pi(\omega) \;=\; \pi(\omega) \;-\; w^N N(\omega) \;-\; w^H H(\omega) \;-\; \phi^w\big(N(\omega) + H(\omega)\big) \;-\; \big[K' - (1-\delta_K)K\big] \;-\; \phi^K \frac{I^2}{K}, \tag{36}$$

with $\pi(\omega) = zK^{1-\alpha_L}L(\omega)^{\alpha_L}$ and $I = K' - (1-\delta_K)K$. The Bellman equation is

$$V(z, g, K) \;=\; \max_{w^N, w^H, K'} \Pi \;+\; \frac{1}{1+r}\,\mathsf{E}\big[V(z', g', K') \,\big|\, z, g, K\big]. \tag{37}$$

Differentiating (37) with respect to w^N, using $\partial N / \partial w^N = \theta N / w^N$ and chain-ruling through $g' = 1 - [1 - (1-\delta_g)g]\exp(-\chi I/(N+H))$,

$$\mathrm{MPL}^N \;-\; w^N\big(1 + \tfrac{1}{\theta}\big) \;-\; \phi^w \;-\; \mathcal{D} \;=\; 0, \tag{38}$$

where $\mathrm{MPL}^h = \alpha_L\, zK^{1-\alpha_L}L^{\alpha_L - 1}h^h$ and the *dilution wedge* is

$$\mathcal{D}(\omega) \;\equiv\; \frac{1}{1+r}\,\mathsf{E}\big[V_{g'} \,\big|\, \omega\big]\; \big(1 - g'(\omega)\big)\, \frac{\chi\, I(\omega)}{\big(N(\omega) + H(\omega)\big)^2}. \tag{39}$$

The same derivation for w^H, using $\partial H/\partial w^H = \theta H/w^H$ and $\partial g'/\partial H = \partial g'/\partial N$ (since N and H enter the g'-law of motion only through their sum), gives the symmetric FOC

$$\mathrm{MPL}^H \; - \; w^H\big(1 + \tfrac{1}{\theta}\big) \; - \; \phi^w \; - \; \mathcal{D} \; = \; 0, \tag{40}$$

with the same $\mathcal{D}$.

Proposition 1 (Wage Markdowns) *The firm's optimal wages satisfy*

$$w^h(\omega) \; = \; \frac{\theta}{1+\theta}\Big(MPL^h(\omega) - \phi^w - \mathcal{D}(\omega)\Big), \qquad h \in \{N, H\}. \tag{41}$$

The constant markdown rate $\theta/(1+\theta)$ is applied to the net effective marginal product*: gross MPL less per-worker overhead ϕ^w less the dynamic dilution wedge $\mathcal{D}$.*

Remark 1 (Incubation enters as an amenity). Since g enters $\mathring{U}^N$ additively, an increase in g shifts the labor-supply curve for inexperienced workers up by a multiplicative constant but does not change its wage elasticity. The labor-market power firms gain from intangible investment is therefore *compensating-differential power* — workers accept lower wages in exchange for an attractive non-wage attribute — rather than a widened Lerner markdown over MPL. Equivalently, the wage-to-net-MPL ratio

$$\frac{w^h(\omega)}{\mathrm{MPL}^h(\omega) - \phi^w} \; = \; \frac{\theta}{1+\theta}\left(1 - \frac{\mathcal{D}(\omega)}{\mathrm{MPL}^h(\omega) - \phi^w}\right)$$

varies across firms only through the dynamic dilution wedge $\mathcal{D}$, not through the amenity term itself.

Remark 2 (Asymmetry in revealed markdowns). Although $\mathcal{D}$ enters both wage FOCs with the same absolute magnitude, $\mathrm{MPL}^N < \mathrm{MPL}^H$ since $h^N < h^H$. The fractional wedge $\mathcal{D}/(\mathrm{MPL}^h - \phi^w)$ is therefore larger for inexperienced workers, so $w^N/\mathrm{MPL}^N < w^H/\mathrm{MPL}^H$ within the same firm. High-$\mathcal{D}$ firms — typically high-g, high-$\mathsf{E}V_{g'}$ firms — have wider revealed markdowns specifically on their inexperienced workers.

A.3.1. Wage Savings from Incubation

Consider the counterfactual in which inexperienced workers replace $g(\omega)$ with a common $\bar{g}$ in their utility (i.e., do not price the firm's incubation capacity). To attract the same labor force $N(\omega)$, the firm must raise $\mathring{U}^N$ by $\beta(g-\bar{g})\Delta U$, i.e., raise $\theta \log w^N$ by the same amount. The counterfactual wage is therefore

$$\frac{w^{N,cf}(\omega)}{w^N(\omega)} = \exp\left(\frac{\beta\big(g(\omega)-\bar{g}\big)\Delta U}{\theta}\right), \tag{42}$$

and the per-period wage savings from incubation are

$$\text{Sav}(\omega) = N(\omega)\, w^N(\omega) \left[\exp\left(\frac{\beta(g(\omega)-\bar{g})\Delta U}{\theta}\right) - 1\right]. \tag{43}$$

The elasticity of savings to the firm's incubation capacity is $\beta\Delta U/\theta$ — the ratio of how much workers value upgrade opportunities to the wage elasticity of labor supply.

A.4. Firm Dynamic Block: Investment FOC and Marginal q

Differentiating (37) with respect to K', using $\partial g'/\partial I = (1-g')\chi/(N+H)$ and $\partial I/\partial K' = 1$,

$$1 + 2\phi^K \frac{I}{K} = q_K(\omega) + q_g(\omega), \tag{44}$$

where the two components of marginal q are

$$q_K(\omega) \equiv \frac{1}{1+r}\mathsf{E}\big[V_{K'}\,\big|\,\omega\big], \tag{45}$$

$$q_g(\omega) \equiv \frac{1}{1+r}\mathsf{E}\big[V_{g'}\,\big|\,\omega\big] \cdot \frac{\big(1-g'(\omega)\big)\chi}{N(\omega)+H(\omega)}. \tag{46}$$

Proposition 2 (Dual-Asset Hayashi q) *The firm's optimal investment rate is*

$$\frac{I(\omega)}{K(\omega)} = \frac{q_K(\omega)+q_g(\omega)-1}{2\phi^K}, \tag{47}$$

which generalizes the standard Hayashi q-theory result ($q_g = 0$) by adding an incubation-q *component. Each marginal dollar of investment buys two assets: a marginal unit of intangible capital (valued at q_K) and a marginal unit of incubation capacity (valued at q_g).*

A.4.1. Relation Between the Dilution Wedge and Incubation q

Comparing (39) and (46),

$$\mathcal{D}(\omega) = q_g(\omega) \cdot \frac{I(\omega)}{N(\omega)+H(\omega)}. \tag{48}$$

The wage dilution wedge equals the incubation marginal q times investment per body. The dynamic dilution effect on wages and the incubation premium on investment are therefore manifestations of a single underlying shadow price $\mathsf{E}V_{g'}$.

A.4.2. Size-Tilt of Incubation

Since $q_g \propto 1/(N+H)$, smaller firms get more incubation per dollar of investment. Combined with the labor-supply pull on high-g firms (which raises $N+H$), this generates an interior optimum for the firm's choice of g: the marginal incubation return decays with firm size, bounding how high g can be pushed even at high-productivity firms. The model therefore predicts that high-incubation firms remain interior to $g = 1$ in the stationary cross-section.

A.5. Labor Share

Aggregating the wage bill via (41) and using the identity $\text{MPL}^N N + \text{MPL}^H H = \alpha_L \pi$,

$$w^N N + w^H H \;=\; \frac{\theta}{1+\theta}\Big[\alpha_L \pi \;-\; (\phi^w + \mathcal{D})(N+H)\Big]. \tag{49}$$

Substituting (48), the labor share of output is

$$s_w(\omega) \;=\; \frac{\theta}{1+\theta}\left[\alpha_L \;-\; \frac{\phi^w\big(N(\omega)+H(\omega)\big) \;+\; q_g(\omega)\, I(\omega)}{\pi(\omega)}\right]. \tag{50}$$

The wedge below the competitive benchmark α_L decomposes into a per-body overhead piece, $\phi^w(N+H)/\pi$, and an *incubation-investment piece*, $q_g\, I/\pi$, which is the dollar value the firm internalizes from incubation expressed as a share of current output. This object is the structural counterpart to the labor-share/HC-growth correlation in Panel A of Table 7.

A.6. Aggregate Equilibrium

Definition 1 (Stationary Equilibrium) *A stationary markov perfect equilibrium consists of (i) a firm value function $V(z, g, K)$ and policy functions $\{w^N(\omega), w^H(\omega), K'(\omega)\}$; (ii) a stationary firm distribution μ on Ω; and (iii) seven aggregate scalars $(\bar{D}^N, \bar{D}^H, U^N, U^H, \bar{N}, \bar{H}, \bar{G})$ satisfying:*

1. *Worker continuation values: $U^h = \log \bar{D}^h + \gamma$ for $h \in \{N, H\}$.*

2. *Aggregate stocks: $\bar{N} = 1/(\iota + \bar{G})$, $\bar{H} = \bar{G}/[\iota(\iota+\bar{G})]$, and $\bar{G} = \int g(\omega)\, e^{\mathring{U}^N(\omega)}/\bar{D}^N\, \mu(d\omega)$.*

3. *Logit denominators:* $\bar{D}^h = \int e^{\mathring{U}^h(\omega)} \mu(d\omega)$ *for* $h \in \{N, H\}$*, evaluated using the firm's optimal wages.*

4. *Firm optimality: policies satisfy the wage FOCs (41) and the investment FOC (47), taking the seven scalars and* μ *as parametric.*

5. *Stationarity of* μ*:* μ *is the invariant distribution of the Markov chain on* (z, g, K) *induced by the AR(1) on* z*, the policy* $K'(\omega)$*, and the law of motion for* g*.*

Computationally, this is an outer-loop fixed point in seven scalars wrapping an inner-loop value-function iteration: given aggregates, solve the firm's Bellman to obtain V and policies; given policies and μ, integrate to update the seven aggregates; iterate to convergence.

A.7. Closed-Form Special Case: $\phi^w = 0$, Static Block

In the textbook limit with $\phi^w = 0$ and $\mathcal{D} = 0$ (i.e., shutting down the dynamic dilution), wages collapse to

$$w^h(\omega) = \frac{\theta}{1+\theta} \mathrm{MPL}^h(\omega), \qquad \frac{w^N}{w^H} = \frac{h^N}{h^H},$$

and the wage share of output is the firm-invariant constant

$$s_w = \frac{\theta\, \alpha_L}{1+\theta}. \tag{51}$$

Defining $\eta \equiv 1 + \theta(1-\alpha_L) > 0$ and $\nu(g) \equiv h^N + h^H \cdot H(g)/N(g)$, the firm's labor and output policies admit closed-form expressions as power functions of state:

$$L(\omega) \propto z^{\theta/\eta} K^{1-\alpha_L \theta/\eta} \exp\!\left[(a + \beta U^N + \beta g \Delta U)/\eta\right] \nu(g)^{1/\eta}, \tag{52}$$

$$\pi(\omega) \propto z^{(1+\theta)/\eta} K^{1-\alpha_L(1+\theta)/\eta} \exp\!\left[\alpha_L(a + \beta U^N + \beta g \Delta U)/\eta\right] \nu(g)^{\alpha_L/\eta}. \tag{53}$$

The composition of hires at firm ω satisfies

$$\frac{H(\omega)}{N(\omega)} = \frac{\bar{H}}{\bar{N}} \left(\frac{h^H}{h^N}\right)^{\theta} \left(\frac{\bar{D}^H}{\bar{D}^N}\right)^{\beta(1-g)-1}. \tag{54}$$

Since $\bar{D}^H > \bar{D}^N$ in equilibrium and $\beta(1-g) - 1 < 0$, the exponent is negative and H/N is decreasing in g: high-incubation firms have a comparative advantage in hiring inexperienced workers, which is the structural counterpart to the worker-flow patterns documented in Panel B of Table 7.

A.8. Steady-State Incubation Capacity

Holding g constant period to period (i.e., $g'(\omega) = g(\omega) = g$) requires intangible investment per worker

$$\frac{\chi I^{ss}(\omega)}{N(\omega) + H(\omega)} = \log\left(\frac{1 - (1 - \delta_g)g}{1 - g}\right) \approx \frac{\delta_g \, g}{1 - g}, \tag{55}$$

which diverges as $g \to 1$. The natural upper bound on a firm's incubation capacity is therefore strictly less than one, even at firms with arbitrarily high productivity; the value of g^* at which the marginal cost of maintaining g equates to the marginal value q_g pins down the firm's stationary location in $\mathcal{G}$ for given z and K.

A.9. Exit-Utility Normalization

The normalization $\underline{U} = 0$ adopted throughout is innocuous. Because the exit-utility term $\iota\underline{U}$ enters $\mathring{U}^N$ and $\mathring{U}^H$ *symmetrically* (with the same coefficient ι), shifting $\underline{U}$ by Δ shifts the fixed-point solution by

$$U^N \to U^N + \frac{\iota\Delta}{1 - \beta}, \qquad U^H \to U^H + \frac{\iota\Delta}{1 - \beta},$$

preserving the experienced premium ΔU and every choice probability $e^{\mathring{U}^h(\omega)}/\bar{D}^h$. Consequently, the aggregate scalars $\bar{G}$, $\bar{N}$, $\bar{H}$, the firm's wage and investment FOCs, the wage-savings expression (42), and the labor-share decomposition (50) are all invariant to the normalization. Within an equilibrium, only the worker's surplus from working, $U^h - \underline{U}$, has economic content, and that surplus is invariant by construction.

Appendix Tables and Figures

Table A1. Human Capital Growth, Cross-Firm Human Capital Spillovers, and Firm Growth Outcomes (Drop Shift-Share Control and other Firm Controls)

	Dependent variable: Growth rate in			
	(1) Labor Productivity	(2) Sales	(3) Value-Added	(4) Profits
Panel A: OLS				
Firm HC Growth	0.6359***	0.7705***	0.9029***	1.176***
	(0.0399)	(0.0260)	(0.0323)	(0.0419)
Panel B: Reduced Form (Spillovers)				
Cross-Firm HC Spillover	0.3294***	0.2473***	0.3490***	0.3877***
	(0.0590)	(0.0347)	(0.0449)	(0.0563)
Panel C: IV (F-stats: 343.9)				
Firm HC Growth	1.590***	1.194***	1.685***	1.872***
	(0.2875)	(0.1621)	(0.2150)	(0.2664)
Industry-Year FE	Yes	Yes	Yes	Yes
Firm Controls	No	No	No	No
Observations	45,500	45,500	45,500	45,500

Notes. This table presents regressions of firm-level growth rates in labor productivity, sales, value-added, and profits, on firm-level human capital growth as defined in the main text. In panel A we show the raw ordinary least squares relationship; in panel B, we examine the relationship between firm-level growth outcomes using only spillovers from other firms, weighted by hiring network weights. The cross-firm spillover measure interacts the human capital growth of the workers who stay at other firms, weighted by the share of the focal firm's total hires from that firm over the past 3 years. In panel C, we instrument for firm-level human capital growth using only cross-firm spillovers. See main text for details. All specifications control for 4-digit NAICS by year fixed effects, but drop the additional firm-level controls (including dropping the shift-share control for exposure to cross-firm growth spillovers in Table 2). The numbers are rounded to satisfy the Census' disclosure guidelines. Standard errors are clustered by firm. *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Table A2. Relationships between Investments and Human Capital Growth

	Dependent Variable: Firm HC Growth				
	(1)	(2)	(3)	(4)	(5)
Standardized Organizational Investment per worker	0.0088***				0.0085***
	(0.0008)				(0.0008)
Standardized Knowledge Investment per worker		0.0080***			0.0074***
		(0.0012)			(0.0012)
Standardized Physical Investment per worker			0.0057***		0.0043***
			(0.0011)		(0.0010)
Standardized Total Investment per worker				0.0102***	
				(0.00119)	
Industry-Year FE	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes
Observations	62,000	62,000	62,000	62,000	62,000

Notes. This table presents the relationships between firms' investments and employees' human capital growth. The outcome variable is the firm's human capital incubation measure defined in equation (4). The numbers are rounded to satisfy the Census' disclosure guidelines. Standard errors clustered by firm are in parentheses. *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Table A3. Relationships between Investments and Career Opportunities

	Dependent Variable: Career Opportunity			
	(1)	(2)	(3)	(4)
Standardized Intangible Investment per worker	0.1008***	0.1504***	0.1235***	0.1263***
	(0.0112)	(0.0151)	(0.0158)	(0.0162)
Year FE	Yes	Yes	Yes	No
Industry FE	No	Yes	Yes	No
Industry-Year FE	No	No	No	Yes
Firm Controls	No	No	Yes	Yes
Observations	25,056	24,716	24,563	24,189

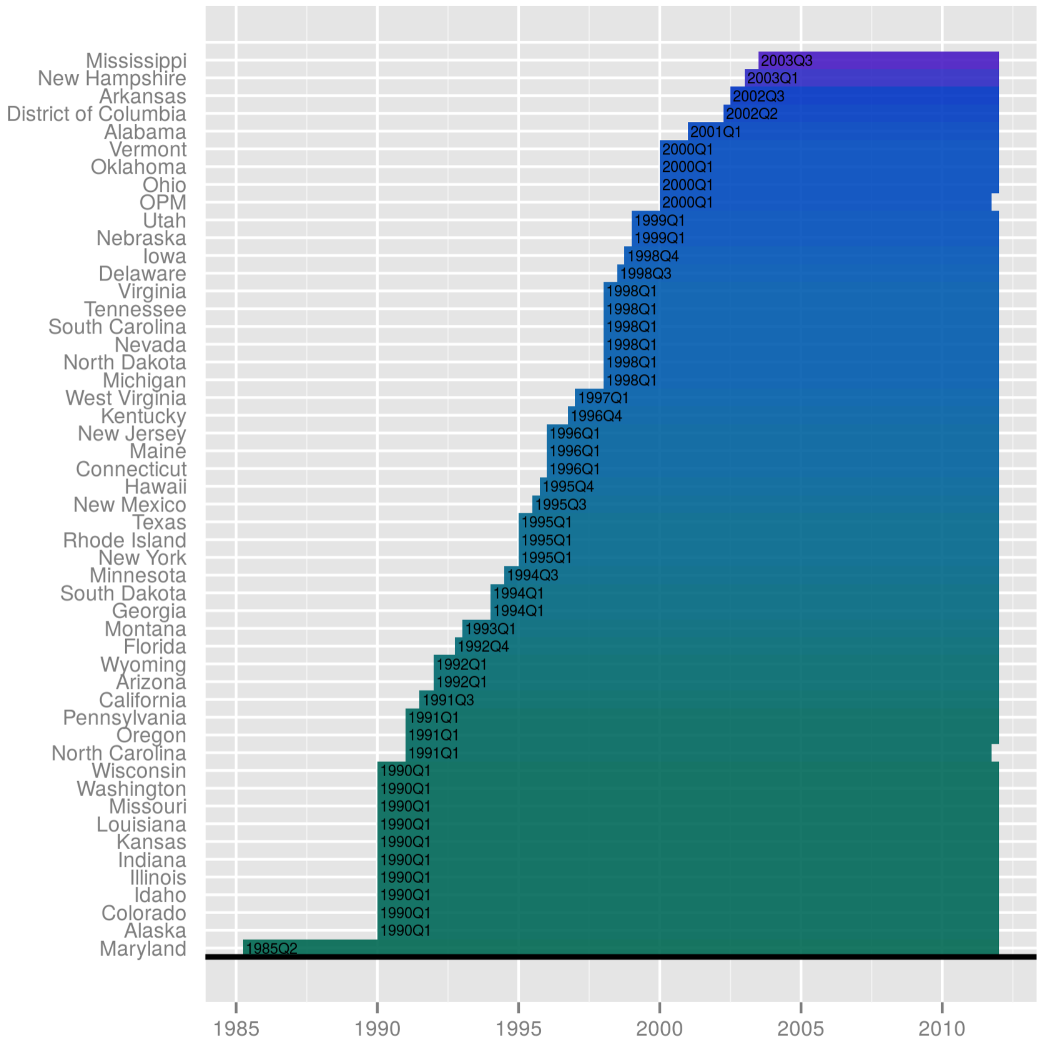
Notes. This table presents the relationships between firms' investments and Glassdoor's career opportunity ratings. The outcome variable is the firm's career opportunity ratings (scale from 1 to 5) from Glassdoor, where employees rate their employers' career opportunities. Standard errors clustered by firm are in parentheses.

Table A4. Relationships between Investment Components and Career Opportunities

	Dependent Variable: Career Opportunity				
	(1)	(2)	(3)	(4)	(5)
Standardized Organizational Investment per worker	0.0604***				0.0737***
	(0.0168)				(0.0173)
Standardized Knowledge Investment per worker		0.1021***			0.1079***
		(0.0142)			(0.0143)
Standardized Physical Investment per worker			0.0066		-0.0043
			(0.0260)		(0.0266)
Standardized Total Investment per worker				0.0728***	
				(0.0247)	
Industry-Year FE	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes
Observations	24,189	24,189	24,137	24,137	24,137

Notes. This table presents the relationships between firms' investments and Glassdoor's career opportunity ratings. The outcome variable is the firm's career opportunity ratings (scale from 1 to 5) from Glassdoor, where employees rate their employers' career opportunities. Standard errors clustered by firm are in parentheses.

Figure A1. LEHD Start Year by State



Notes. This figure reports the year-quarter that the state's LEHD data is available. Source: Census.