Disclosure Regulation, Intangible Capital, and the Disappearance of Public Firms†

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Abstract

Since the mid-1990s, the number of U.S. listed firms has halved while their performance has become harder to predict. We develop an analytically tractable general equilibrium model where firms choose between public and private markets and select disclosure levels. The rising intangible share endogenously generates substantial welfare and productivity losses through reduced knowledge spillovers. Disclosure regulation exhibits non-monotonic welfare effects: it reduces information frictions but contracts the pool of listed firms when too strict. We characterize the optimal disclosure policy, showing it balances investor protection against endogenous opacity. This trade-off sharpens as intangibles rise, making policy precision increasingly consequential.

Keywords: Intangible capital, corporate disclosure, technology diffusion, optimal policy.

JEL codes: E22, E61, G32, D83.

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1 Introduction

> *"As a smaller private company, Google kept business information closely held, and we believe this helped us against competitors... As a public company, we will of course provide you with all information required by law... But we will not unnecessarily disclose all of our strengths, strategies and intentions."*
>
> — Larry Page and Sergey Brin, *A letter from Google founders to the shareholders, 2004*

The U.S. public equity market has undergone a dramatic transformation: listed firms declined from around 8,090 in 1996 to 4,102 in 2012 — a 49% contraction — even as the overall firm population continued to grow. Concurrently, we document that analyst forecast errors for public firms nearly doubled, indicating deterioration in market transparency. What forces simultaneously reduce public listings and increase opacity among remaining firms? What are the aggregate welfare and productivity consequences?

This paper makes two contributions. First, we develop a closed-form framework that captures how firms' incentives to protect proprietary information and investors' preferences for transparency jointly shape the allocation of firms across listed and non-listed markets. Using this framework, we analyze the forces driving the observed patterns and their macroeconomic implications. Notably, our formulation yields an explicit analytical expression for the measure of listed firms, enabling general-equilibrium comparative statics with respect to key structural parameters. We show that, in general equilibrium, the number of listed firms strictly decreases in both intangible intensity and regulatory stringency.

Second, we qualitatively and quantitatively evaluate the effects of disclosure regulation on the number of listed firms and on welfare and derive the optimal policy, based on a tightly estimated model. Stricter regulation generates a welfare tradeoff: it improves investor information but drives firms toward non-listed markets, reducing the pool of transparent firms and knowledge spillovers.[1] Our decomposition reveals that rising intangible

[1] This is one of the core issues the SEC is concerned about. For example, in a February 2017 speech, SEC Commissioner Kara Stein questioned whether additional disclosure requirements should be extended to private-market firms: "We also need to understand why more companies are staying private for longer periods of time. Should we apply enhanced disclosure laws to these private companies? Or perhaps they require a unique set of rules." The full speech is available on the SEC's website. The concern is empirically grounded: Dambra et al. (2015) study Title I of the JOBS Act, which relaxed disclosure requirements for emerging growth companies during the IPO process. They find a 25% increase in IPO volume, driven largely by firms with high disclosure costs, such as those in the tech sector. Aghamolla and Thakor (2022) exploit a shock to disclosure requirements in the biopharmaceutical industry to show that increased mandatory disclosure requirements for private firms significantly increases their propensity of going public. Finally, Abuzov et al. (2023) document that tighter disclosure rules for public investors in 2002 prompted many top VCs to exclude such investors from their funds.

intensity has reduced welfare by 0.62 percent annually, while tighter disclosure regulation has increased welfare by 0.66 percent annually — albeit at the cost of a 0.25 percent annual productivity decline. The current regulatory regime slightly exceeds the welfare-maximizing level. Critically, we show that the welfare consequences of disclosure policy have become substantially more pronounced in the intangible-intensive economy.

Our model captures a fundamental tension in disclosure. Firms with intangible capital face spillover costs: disclosed knowledge — whether R&D, organizational practices, or business strategies — diffuses to competitors, directly reducing the disclosing firm's effective intangible stock.[2] Households, conversely, prefer to invest in transparent firms where information precision is higher. We model this as directed search across transparency submarkets, where funding supply increases with transparency (as households allocate more capital to better-understood firms) while funding demand decreases with required disclosure (as spillovers erode competitive advantage). In equilibrium, ex-ante identical firms endogenously sort into a continuous distribution of transparency levels, with the density characterized in closed form. Critically, rising intangible intensity amplifies firms' disclosure costs, shifting the equilibrium toward greater opacity and more private firms — consistent with the following observed patterns.

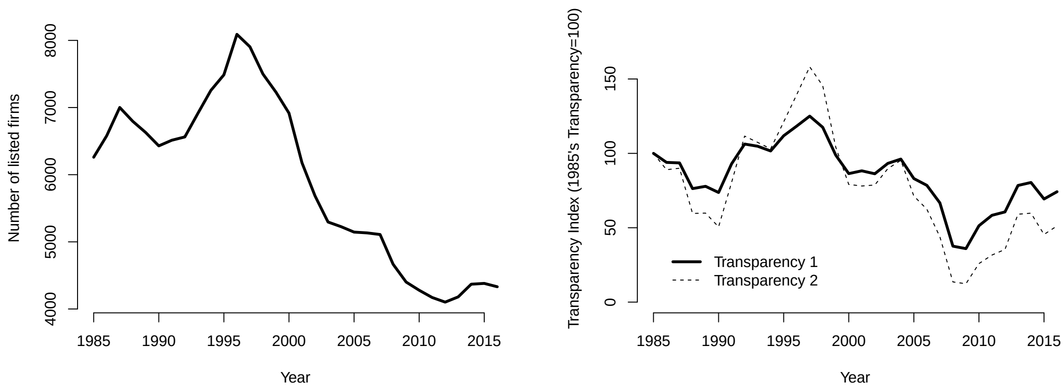
Figure 1 plots the time series for the number of listed firms in the U.S. (panel 1a) and the inverse forecast error (panel 1b), which proxies the overall transparency in the stock market.[3] According to panel (a), there has been a gradually rising trend in the number of listed firms until the mid-1990s. Then, after the peak in the mid-1990s, the number of listed firms steeply declined to almost half the level at the peak year: 8,090 listed firms in 1996 reduced to 4,102 listed firms in 2012. In Appendix A, we show that listed firms have been declining not only in absolute number, but also as a share of all firms in the U.S. In Appendix B, we show that the decline is substantially larger in industries like information and services, which are more intangible intensive. This is consistent with recent empirical evidence showing that firms with higher intangibility have a significantly lower propensity to become public, controlling for other characteristics (Celentano and Rempel, 2025).

Panel (b) plots the time series of the inverse forecast error. The overall patterns of

[2] We refer to those components of intangible capital whose property rights are not well protected by specific legal institutions and thus not necessarily patentable or patented yet. For example, software, research ideas, early stages innovation and R&D, and also certain novel business methods and organizational innovations, branding and marketing strategies, employee training, information such as some formulas, customer lists, and processes; more in general, firms' strategies and intentions that a public firm cannot selectively disclose (e.g., Regulation Fair Disclosure of 2000).

[3] The detailed measurement is available in Appendix A. Section 4 aims at explicitly connecting intangible capital and different transparency proxies, controlling for confounders. Additional analyses on industry-level time series are available in Appendix B.

Figure 1: Time series of aggregate variables.



(a) Number of listed firms

(b) Inverse forecast error

Notes: This figure shows the trend in the number and the inverse forecast error in the U.S. Data comes from the World Development Indicators, Compustat, and I/B/E/S. See Section Appendix A for details on measurement.

the series closely mimic those in the number of listed firms: the inverse forecast error has increased until the mid-1990s and decreased after the peak in 1996.[4] We show that the disappearance of public firms and overall greater opacity in financial markets substantially reduce productivity through the mitigated technological diffusion across firms, which partly explains the recently observed macroeconomic phenomena in the U.S. (Gordon, 2017; Bloom et al., 2020; Akcigit and Ates, 2023). According to our baseline model, it results in a substantial welfare loss in the economy.

Disclosure regulation fundamentally reshapes market equilibrium through two channels. Stricter requirements increase mandated transparency, directly improving information quality for listed firms. However, this intensifies competitive spillovers, inducing more firms to exit public markets. Our closed-form characterization reveals these channels generate an inverted-U welfare curve: insufficient regulation leaves investors with poor information, while excessive regulation hollows out the public market. We show this trade-off has intensified substantially: the welfare-maximizing policy in 2012-2016 is higher, and the welfare curve features a sharper peak than in 1992-1996, reflecting how rising intangible capital has made the disclosure decision more consequential. Productivity, by contrast, declines monotonically in regulatory stringency over the empirically relevant range, creating potential conflict between welfare and output objectives.

[4]Recessions and especially the Great Recession represent a big shock to earnings surprises. In order to take that into account, we also measure the inverse forecast error by excluding recession periods as measured by the NBER, and we still find that the time series has been declining.

Our decomposition analysis based on the estimated baseline model reveals that stricter SEC regulation and the rising share of intangible capital account for a large part of the decline in listed firms and transparency.[5] We also estimate that the same level of disclosure by firms translates into less information for investors in the more recent period. We interpret this as intangible capital being inherently more opaque and challenging to understand due to its nature, contributing to the reduced welfare.

Related Literature Three strands of the literature are closely related to this paper. The first is the literature that studies the rising importance of intangible capital for the macroeconomy. Early contributions, including Atkeson and Kehoe (2005), McGrattan and Prescott (2010), Eisfeldt and Papanikolaou (2014), and McGrattan (2020), highlight the importance of intangible capital as a key input factor for production. Recent research links the increase in intangible capital to several macroeconomic shifts: the slowdown of productivity growth and the rise of market power (Ridder, 2024); the rise in firm size and concentration (Chiavari and Goraya, 2025); rising cash holdings (Falato et al., 2022); financial globalization and shifts in international tax competition (Quadrini and Ríos-Rull, 2024); the corporate savings glut (Li, 2025).

We contribute to this literature by analyzing a novel macroeconomic implication of the rising share of intangible capital. Intangible capital has become an important source of competitiveness, leading firms to invest heavily in research and development (R&D) and organizational practices. However, many forms of intangible capital have strong spillover effects, benefiting competitors as well as the originating firm (Bloom et al., 2013; Haskel and Westlake, 2018; Crouzet et al., 2022). The rising importance of intangible capital has therefore increased firms' incentives to stay opaque in disclosure. Our model quantifies how this shift affects aggregate outcomes and welfare.

Within this literature, our paper is closely related to Celentano and Rempel (2025) and Ward (2025). Celentano and Rempel (2025) find that the rising share of intangible capital amplifies CEOs' private information relative to outside investors, increasing the cost of optimal truth-telling contracts and lowering the propensity to go public. Ward (2025) shows that intangibles exacerbate internal agency conflicts with specialists, generating

[5] Some changes in disclosure regulation since 1996, the end of our baseline period, include the implementations in 1997 on Regulation S-K of the recommendations of the Task Force on Disclosure Simplification, available at `http://www.sec.gov/rules/final/34-38850.txt` and `http://www.sec.gov/rules/final/34-38850a.txt`, the plain English initiative of 1998, the Regulation Fair Disclosure of 2000, the Sarbanes-Oxley Act of 2002, the newer disclosure requirements introduced by the Dodd-Frank act of 2010 available at `https://www.sec.gov/spotlight/dodd-frank/corporategovernance.shtml` and `https://www.sec.gov/securities-topics/dodd-frank-act`. We may also interpret the introduction of machine-readable data on Edgar combined with the ease of accessing that data as more transparency through lower frictions to access the same information.

underinvestment and rising compensation volatility. We abstract from these agency frictions and focus instead on a complementary channel: under SEC disclosure rules, public firms cannot selectively reveal information to investors without also disclosing it to competitors (Bhattacharya and Ritter, 1983), forcing a trade-off between funding access and *competitive spillovers*. Our closed-form general equilibrium framework enables normative analysis, characterizing optimal disclosure policy and quantifying welfare costs as intangible intensity rises.

Relative to Celentano and Rempel (2025), our main contribution lies in the general equilibrium spillover effects and the characterization of optimal disclosure policy. While Celentano and Rempel (2025) focus on the partial-equilibrium implications of intangibles for CEO compensation and listing incentives through agency frictions, our framework captures how disclosed intangible knowledge diffuses across firms, generating aggregate productivity externalities that feed back into welfare. This spillover channel is central to the non-monotonic welfare effects of disclosure regulation: the same policy that improves investor information also erodes the competitive advantage of disclosing firms, shrinking the pool of listed firms and reducing knowledge diffusion. Characterizing this trade-off analytically and quantifying the welfare-maximizing policy are distinctive contributions that require the general equilibrium structure we develop.

The second literature strand is the one that studies the incentive for information disclosure and its real impact. One of the seminal papers in the literature is Hirshleifer (1971), which studies how information disclosure can be incentivized through pecuniary motivation, which is closely related to the firms' incentive for transparent disclosure in our model. Subsequent theoretical work examines how disclosure interacts with firms' dynamic choices and with ownership structure (Bhattacharya and Ritter, 1983; Bhattacharya and Chiesa, 1995; Chemmanur and Fulghieri, 1999; Admati and Pfleiderer, 2000; Boot and Thakor, 2001; Boot et al., 2006, 2008; Chemmanur and He, 2011; Ferreira et al., 2014; Terry et al., 2022; Bertomeu et al., 2022). We contribute to this literature by showing that the rising share of intangible capital interacts with disclosure regulation to generate time-varying incentives for transparency. Embedding these incentives in general equilibrium allows us to quantify their macroeconomic implications on output and productivity and to characterize the welfare-maximizing disclosure policy.

The third literature is about the disappearance of listed firms. Different explanations have been put forward to shed light on this issue. For example, Gao et al. (2013) point to the increase in mergers and acquisitions (M&A) among U.S. firms; Doidge et al. (2017) conjecture that as markets have become more globally integrated, the net benefits of going public in the U.S. versus in other markets have decreased; Ewens and Farre-Mensa (2020) argue that the deregulation of securities laws (National Securities Markets Improvement Act of 1996) improved the private equity market, which reduced the incentives for firms to go public; Davydiuk et al. (2020) point to both a significant reduction in private firms' cost of capital and an increase in the costs of being public and undergoing an IPO.

We offer a complementary explanation. We argue that the rise of intangible capital, especially the components of intangible capital that could benefit competitors as well as the owner firm, has increased the cost of disclosing information and made staying private more attractive, which is exacerbated by stricter disclosure requirements. Our framework helps explain why the decline in public firms has been disproportionately concentrated in industries and firms with higher intangible intensity. The calibrated model also predicts that access to funds by venture capital firms, private equity funds, and other private investors has become easier, in line with the previous literature.

Roadmap The rest of this paper proceeds as follows. Section 2 presents an analytically tractable general equilibrium model. Section 3 analyzes the equilibrium. Section 4 provides empirical evidence supportive of the theory's predictions. Section 5 presents a quantitative analysis and analyzes the optimal disclosure policy. Section 6 concludes.

2 Model

We develop a static general equilibrium model, where a firm's decision of where to operate between the public and private financial market, household's portfolio choice, and the cross-sectional distribution of disclosure transparency are all analytically characterized.[6]

2.1 Household

A stand-in household decides on the asset portfolio and consumes the portfolio return. The household is given a wealth level $a > 0$. The household is risk-averse, and the utility takes the following constant absolute risk aversion form (CARA):

$$u(C) = -e^{-\Lambda C}, \tag{1}$$

where $\Lambda > 0$ is the absolute risk aversion parameter.

[6]The model is static and intended to capture a long-run equilibrium. The static setup delivers substantial tractability, yielding closed-form solutions characterized in Section 3. The tangible capital rental rate is exogenous rather than endogenously determined through household saving decisions, similar to a small open economy framework. This simplification allows us to focus on the disclosure and listing decisions while maintaining analytical tractability.

The household believes the stock return at submarket q follows an *iid* process as follows:

$$\widetilde{r}(q) \sim_{iid} N\left(\overline{r}(q), H(q;\overline{q})\right) \tag{2}$$

The true return $\overline{r}(q)$ is endogenously determined by the profit-to-price ratio as follows:

$$\overline{r}(q) = \frac{\pi(q)}{P(q)} \tag{3}$$

where $\pi(q)$ and $P(q)$ are the profit and price of a firm with transparency q. We assume that the information noise $H = H(q;\overline{q})$ strictly decreases in the level of transparency q and the mandated transparency $\overline{q}$, which is a policy parameter to be estimated. Throughout the paper, H is also referred to as household's forecast error in return prediction. For the analytical tractability, we assume the following parametric form of H:

$$H(q;\overline{q}) = \frac{1}{\xi + \psi(\overline{q} + q)} \tag{4}$$

where ξ is the minimum information level that is *commonly* included in disclosures from both listed and non-listed firms, and ψ is the marginal contribution of transparency to the household's information about the listed firm.[7]

Similar to the listed market, the household has the following belief about the non-listed firms:

$$\widetilde{r}^N \sim_{iid} N\left(\overline{r}^N, H(0;0)\right) \quad \text{with} \quad \overline{r}^N = \frac{\pi^N}{P^N}, \tag{5}$$

where π^N and P^N are the profit and price of a non-listed firm. As non-listed firms are assumed not to disclose any information publicly, the household does not distinguish a non-listed firm from another.

It is important to note that there is no aggregate risk in this economy. However, we assume an informational friction driven by opaque disclosure, which prevents the household from *certainly* understanding the performance of a firm. This is the key distinctive feature of our setup, compared to other portfolio choice problems under systematic risk.

[7] The parameter ψ may itself depend on intangible intensity θ: as intangibles become more important, the same disclosure conveys less information to investors. We do not impose structure on this relationship, instead identifying ψ directly from firm-level data. ξ captures baseline opacity, which may partly reflect strategic concealment as in Bertomeu et al. (2022). Our model treats ξ as exogenous, though the estimates incorporate any such endogenous channel in reduced form.

In summary, the household solves the following portfolio choice problem:

$$\max_{x(q),x^N} \quad \mathbb{E}(-e^{-\Lambda C})$$
$$\text{s.t. } C = \int x(\widetilde{q})\widetilde{r}(\widetilde{q})d\widetilde{q} + x^N\widetilde{r}^N, \quad \int x(\widetilde{q})d\widetilde{q} + x^N = a, \tag{6}$$

where $x(q)$ is the funding supply for firms with transparency level q, and x^N is the funding supply for non-listed firms. As the model does not include the inter-temporal decision of the household, all the payoffs from the equity investment are consumed within the same period. We assume the representative household has a large enough wealth a, as our interest is not in the household's constrained portfolio decision. Also, we assume that the wealth cannot be directly consumed.

2.2 Technology

A measure one of the ex-ante homogeneous firms produces output using two inputs: tangible capital (k_T) and intangible capital (k_I). In this economy, there are two types of production technologies. One is *listed* firms' production technology, and the other is *non-listed* firms' production technology. Before production, a firm chooses 1) which market to operate in between the listed and non-listed market and 2) the level of transparency q conditional on the choice of the listed market. We restrict the possible range of q to $[0, 1-\overline{q}]$.

2.2.1 Production function of listed firms

A listed firm i operates using the following production function:

$$f^L(k_i^T, k_i^I, q_i; \overline{q}, \Phi^{ex}) = (k_i^T)^\alpha (k_i^I(1-\overline{q}-q_i))^\theta (\Phi^{ex})^\gamma, \tag{7}$$

where $\overline{q}$ is the mandated portion of intangible disclosure imposed by the policy maker, q_i is the voluntarily disclosed portion of intangible, Φ^{ex} is the shared intangible capital from all other firms, γ is the scale parameter for the externality, and α and θ are the tangible and intangible capital shares, respectively. We assume $\alpha + \theta + \gamma \leq 1$.

Disclosed intangibles leave the firm's private stock and enter the public knowledge pool. This assumption is to let the revealed intangible capital be symmetrically used between the disclosing firms and the free-riding firms *without* double counting. If this symmetry is not assumed, the model allows partial knowledge sharing, which requires an additional intensive margin in the shared information on top of the transparency. We simplify the model by assuming pure symmetry to avoid such complications.

A firm's disclosed portion ranges from $\overline{q}$ to 1, which does not rule out the possibility of publicly sharing all intangibles. Therefore, the intangible in this model does not include intellectual properties that are legally protected in terms of ownership. In our model, we treat these assets as tangible assets.[8]

We assume a firm i's disclosed intangible q_i is perfectly substitutable by the other disclosed intangible. Therefore, the shared intangibles are aggregated in the following additive form:[9]

$$\Phi^{ex} = \int_0^1 1_{\{i \in \text{Listed}\}} \times k_{I,i} \left(\underbrace{\overline{q}}_{\text{Disclosure mandated by the policy maker}} + \underbrace{q_i}_{\text{Voluntary disclosure}} \right) di. \tag{8}$$

The ex-post profit of listed firm i with voluntary transparency q_i is obtained after paying out the operating costs $rk_i^T + pk_i^I$ from the revenue:

$$\pi(q_i; \overline{q}, \Phi^{ex}) := \max_{k_i^T, k_i^I} \quad (k_i^T)^\alpha (k_i^I(1 - \overline{q} - q_i))^\theta (\Phi^{ex})^\gamma - rk_i^T - pk_i^I, \tag{9}$$

where r is the capital rental rate, and p is the $R\&D$ cost per unit of intangible capital. For the notational brevity, we assume the levels of r and p already include the depreciation (amortization) rates.

2.2.2 Production function of non-listed (private) firms

If a firm is private, it does not publicly disclose the intangible capital. The production function of a non-listed firm i is as follows:

$$f^N(k_i^T, k_i^I; \Phi^{ex}) = (k_i^T)^\alpha (k_i^I)^\theta (\Phi^{ex})^\gamma. \tag{10}$$

[8]Given that these assets are even used as collateral in reality, excluding them from our definition of intangibles is appropriate for the focus of this paper. In our quantitative analysis, we estimate the intangible share parameter based on intangible-related expenditures rather than intangible stock, assuming that such expenditures are not immediately protected by law.

[9]More generally, one could allow for a finite elasticity of substitution $\lambda < \infty$ in the following setup:

$$\Phi^{ex} = \int_0^1 1_{\{i \in \text{Listed}\}} \times k_{I,i} \left(\overline{q}^{\frac{\lambda-1}{\lambda}} + q_i^{\frac{\lambda-1}{\lambda}} \right)^{\frac{\lambda}{\lambda-1}} di.$$

In our baseline setup, we take $\lambda \to \infty$. Allowing for a finite λ does not affect the theoretical predictions, however, because the equilibrium firm distribution is isolated from price and externality effects. Propositions 3 and 4, along with Corollary 2, make this independence explicit.

where the parameters are the same as in the listed-firms production function. The profit is also defined similarly to that of listed firms:

$$\pi^N(\Phi^{ex}) := \max_{k_i^T, k_i^I} \quad (k_i^T)^\alpha (k_i^I)^\theta (\Phi^{ex})^\gamma - r k_i^T - p k_i^I. \tag{11}$$

2.2.3 Market choice and the disclosure transparency

Firms choose between public and private markets to maximize value P, and if listing, select transparency level q. We model this choice problem based on the directed search protocol, borrowing from the macro-labor literature (Burdett and Judd, 1983; Burdett and Mortensen, 1998). Within the listed submarket, firms and the household's funding are frictionlessly matched. In contrast, the non-listed market features a friction that matches a pair with a probability, resulting in attrition in the number of funded firms. The firm-level decision is summarized as follows:

$$\max \left\{ \max_{q \in [0, 1-\overline{q}]} P(q), P^N \right\}. \tag{12}$$

where $P(q)$ is the price of the firm operating in the listed market with the transparency level at q, and P^N is the price of a non-listed firm, all of which are endogenously determined at the funding markets.

2.3 Funding markets

In this section, we characterize the financial market in the model. The funding supply is determined by the representative household's optimal portfolio choice. The funding demand is determined by each firm's price (value) maximization. For the notational brevity, we omit the aggregate policy and allocation $(\overline{q}, \Phi^{ex})$ in the argument.

The following proposition specifies the funding supplies of the household for listed firms and the non-listed firms.

Proposition 1 (Funding supply)**.**
The household's optimal funding supplies for listed firms with transparency q, $x^*(q)$, and for non-listed firms, x^{N*}, are as follows:

$$x^*(q) = \frac{\pi(q)/P(q)}{\Lambda/(\xi + \psi(\overline{q} + q))}, \quad x^{N*} = \frac{\pi^N/P^N}{\Lambda/\xi}. \tag{13}$$

Proof. See Appendix F. ∎

The optimal funding supply in each submarket increases in the profit and transparency and decreases in the price. The risk aversion parameter Λ increases the asset prices symmetrically for listed and non-listed firms.

In the funding submarket q for the listed firms, the price of a firm, $P(q)$, is determined at the level where funding supply in the number (measure) of firms $x^*(q)/P(q)$ meets funding demand in the number (measure) of firms $\mathcal{M}(q)$. Thus, the market-clearing condition is as follows:

$$\frac{x^*(q)}{P(q)} = \mathcal{M}(q). \tag{14}$$

Using Equations (13) and (14), the price maximization problem can be translated into an ex-ante profit maximization form as in the right-hand side formulation of the following line:

$$\max_{q\geq 0}\ P(q) \iff \max_{q\geq 0}\ \sqrt{\frac{\pi(q)}{\Lambda\frac{\mathcal{M}(q)}{\xi+\psi(\overline{q}+q)}}} \iff \max_{q\geq 0}\ \pi(q)\phi^L(q) \tag{15}$$

where $\phi^L(q) := (\xi + \psi(\overline{q} + q))/\mathcal{M}(q)$ is defined as net funding intensity. The solution to this problem characterizes the funding demand in the listed market.

The price of a non-listed firm, P^N, is determined at the level where funding supply in the number of firms, x^{N*}/P^N, is matched with the demand in a frictional private equity market. Especially, we assume the congestion in the non-listed market generates attrition in the funding opportunity in the following way:

$$\frac{1}{\nu_N}\frac{x^{N*}}{P^N} = M_N, \tag{16}$$

where M_N is the total number (measure) of non-listed firms applying for the non-listed market's funding and $\nu_N > 1$ is a structural parameter that captures the congestion effect in the non-listed financial market. The factor $1/\nu_N < 1$ captures the effective matching efficiency in the private market: a share $1/\nu_N$ of household funding reaches firms, while $1 - 1/\nu_N$ remains idle. From the perspective of the standard CRS matching function, this could be interpreted as the elasticity of the non-listed match with respect to the household's funding supply at unity. In summary, firms participating in the non-listed market face costly matching due to the matching rate being lower than one ($1/\nu_N < 1$) due to congestion. Consistent with the listed market setup, we define the funding intensity of the non-listed market as $\phi^N := \xi/(\nu_N M_N)$.

2.4 Summary of a firm's problem

Before production, each firm chooses whether to list (extensive margin) and, if listing, selects transparency level $q \geq 0$ (intensive margin). Non-listed firms avoid knowledge spillovers but face frictional funding where only $1/\nu_N < 1$ of capital reaches firms. Listed firms access frictionless funding but disclose intangibles, creating costly spillovers. A firm's problem is summarized as follows:

$$
\begin{aligned}
&[\textit{Entry decision}] \quad && \max\{J^L(\mathcal{M}), J^N(M_N)\}, \\
&[\textit{Listed firm}] \quad && J^L(\mathcal{M}) := \max_q \max_{k_T,k_I} \left(z k_T^\alpha (k_I(1-\overline{q}-q))^\theta (\Phi^{ex})^\gamma - r k_T - p k_I \right) \phi^L(q) \\
& && \text{s.t. } \phi^L(q) = \frac{\xi + \psi(\overline{q}+q)}{\mathcal{M}(q)}, \\
&[\textit{Non-listed firm}] \quad && J^N(M_N) := \max_{k_T,k_I} \left(z k_T^\alpha (k_I)^\theta (\Phi^{ex})^\gamma - r k_T - p k_I \right) \phi^N \\
& && \text{s.t. } \phi^N := \xi/(\nu_N M_N).
\end{aligned}
$$

2.5 Equilibrium

We define an equilibrium where the economy is given total intangible capital reserve K^I (fixed aggregate intangible supply). This equilibrium endogenously determines the unit cost of R&D. The cost increases if all the other firms increase their spending in R&D, so developing new intangible (knowledge) is harder if more firms seek new knowledge. The rental rate for the tangible capital r is exogenously given.

Definition 1. *A collection of functions* $(x^*, x^{N*}, k_T, k_I, k_T^N, k_I^N, q, \mathcal{M}, M_N, p, P, P^N, \Phi^{ex})$ *is an equilibrium given* K^I *if*

1. $\left(x^*, x^{N*}\right)$ *solves the household's problem.*

2. $\left(k_T, k_I, q, k_T^N, k_I^N\right)$ *solves the listed and non-listed firms' problem.*

3. *The measure of listed firms choosing a transparency level* q *is consistent with* $\mathcal{M}(q)$ *for all* $q \in [0, 1-\overline{q}]$.

4. *The measure of non-listed firms* M_N *satisfies*

$$\int_0^{1-\overline{q}} \mathcal{M}(q) dq + M_N = 1.$$

5. *The unit cost of R&D of intangible capital* p *is determined by the following equation:*

$$K^I = \int_0^1 k_{I,i} di.$$

6. *Aggregate shared knowledge satisfies*

$$\Phi^{ex} = \int_0^1 1_{\{i \in Listed\}} \times k_{I,i}(\overline{q} + q_i)di.$$

7. *The funding markets are cleared:*

$$\frac{x^*(q)}{P(q)} = \mathcal{M}(q) \quad \text{for } \forall q \quad \text{and} \quad \frac{1}{\nu_N}\frac{x^{N*}}{P^N} = M_N.$$

8. *Indifference in the extensive-margin decision:*

$$P(q) = P^N, \ \text{for } \forall q \in [0, 1 - \overline{q}].$$

The aggregate intangible capital market condition and the aggregation of the shared knowledge can be re-written with the equilibrium distribution $\mathcal{M}$:

$$K^I = \int_0^{1-\overline{q}} k_I(q, \mathcal{M})\mathcal{M}(q)dq + k_I^N M_N, \tag{17}$$

$$\Phi^{ex} = \int_0^{1-\overline{q}} k_I(q, \mathcal{M})(\overline{q} + q)\mathcal{M}(q)dq. \tag{18}$$

As specified by the indifference condition, the equilibrium of interest is the non-degenerate equilibrium where all the ex-ante homogeneous firms become indifferent over the choices of submarkets. In condition 8, we require the equilibrium distribution $\mathcal{M}$ takes the full range of q $[0, 1 - \overline{q}]$ as a support.[10] In the following section, we analytically characterize the equilibrium allocations along with its uniqueness.

2.6 Discussion of modeling assumptions

Several modeling choices deserve explicit discussion, as they shape the tractability and scope of our framework.

Equity-only financing. Our model focuses exclusively on equity financing, abstracting from debt and self-financing. This restriction is motivated by the observation that our mechanism operates through the *information content* of equity disclosure: listed firms must publicly reveal information that benefits competitors, creating a spillover cost that is specific

[10]Without this equilibrium condition, the model does not rule out the possibility of multiple equilibria with distributions taking singleton supports.

to the equity-market transparency channel. Debt financing, by contrast, typically relies on collateralized lending or bilateral relationships where information disclosure is private and targeted. Because tangible assets serve as the primary collateral base, the intangible-spillover channel we study is largely orthogonal to the debt margin. Moreover, our focus is on the *extensive margin* of going public — the listing decision itself — rather than the capital structure conditional on listing. Incorporating debt would enrich the model but would not alter the core trade-off between disclosure-induced spillovers and investor demand for transparency that drives our results.

Congestion friction in the private market. The private equity market features a matching friction parameterized by $\nu_N > 1$, where only a fraction $1/\nu_N$ of household funding reaches firms. This specification captures, in reduced form, the well-documented search and information frictions in private capital markets: venture capital and private equity funds face capacity constraints, due-diligence costs, and limited deal flow (Ewens and Farre-Mensa, 2020). The congestion friction is a standard device in the directed search literature (Burdett and Judd, 1983; Burdett and Mortensen, 1998) and serves a specific role in our model: it ensures that private markets are strictly less efficient than public markets in intermediating capital, so that the listing decision involves a meaningful trade-off between funding access and disclosure costs. Our results are robust to the level of ν_N within the empirically relevant range, as the equilibrium firm distribution is independent of ν_N conditional on the measure of non-listed firms (Proposition 3).

Equilibrium determinacy. Our equilibrium requires that the firm distribution $\mathcal{M}$ takes the full support $[0, 1 - \overline{q}]$, which pins down a unique equilibrium (Corollary 2). This full-support condition is standard in directed search models (Burdett and Judd, 1983): ex-ante identical firms randomize over the full range of transparency levels, and the resulting distribution equates the value of listing at every transparency level. Without this condition, degenerate equilibria with mass points could arise, but these are not robust to small perturbations in the firm's problem and are therefore excluded as a standard equilibrium refinement.

3 Equilibrium analysis in closed form

In this section, we analytically characterize the equilibrium allocations and study the model predictions. A listed firm's problem is as follows:

$$\max_{q} \overbrace{\left[\max_{k_T,k_I} \left(k_T^{\alpha}(k_I(1-\overline{q}-q))^{\theta}(\Phi^{ex})^{\gamma} - rk_T - pk_I\right)\phi^L(q)\right]}^{\text{Interim problem}}$$
$$\text{s.t. } \phi^L(q) = \frac{\xi + \psi(\overline{q}+q)}{\mathcal{M}(q)}. \tag{19}$$

where ϕ^L is the net funding intensity function from Equation (15). From the optimality conditions of the interim problem, we derive the analytical form of the intangible input demand as a function of transparency q and the regulation parameter $\overline{q}$ as follows:

Proposition 2. *(Intangibles and the transparency)*
The input demand of intangible capital k_I is as follows:

$$k_I(q, \mathcal{M}; \overline{q}) = \left(\left(\frac{\alpha(\Phi^{ex})^{\gamma}}{r}\right)^{\frac{1}{1-\alpha-\theta}} \left(\frac{r\theta}{p\alpha}\right)^{\frac{1-\alpha}{1-\alpha-\theta}}\right)(1-\overline{q}-q)^{\frac{\theta}{1-\alpha-\theta}}. \tag{20}$$

Proof.
See Appendix F. ■

If the intangible has to be transparently revealed to the public, a part of the intangible becomes a public good — it naturally dis-incentivizes firms to rely on intangible. Therefore, an increase in voluntary transparency leads to a decrease in intangible capital demand. This result predicts that the household's forecast error (variance) about a firm's return and the firm's intangible demand are positively correlated in the cross-section of firms. Corollary 1 states this model prediction. We empirically test this prediction in Section 4.

Corollary 1. *(Intangibles and the forecast error)*
Given the prices and the externality, the cross-sectional correlation between the household's forecast errors and the firm-level intangible capital demand is positive.

Proof.
The proof is immediate from Proposition 2, given that the forecast error of the household is $H(q;\overline{q}) = 1/(\xi + (\overline{q}+q)\psi)$. ■

From the indifference condition with respect to the transparency q, we derive the following condition:[11]

$$\mathcal{M}(q) = \pi(q)\frac{\xi + \psi(\overline{q} + q)}{\pi^N \phi^N} \tag{22}$$

Solving the equation, we characterize the transparency distribution $\mathcal{M}$ in the analytic form as in the following proposition:

Proposition 3. *(Transparency distribution)*
The unnormalized probability density function $\mathcal{M}$ of transparency q has the following analytic form:

$$\mathcal{M}(q) = \left(\xi + \psi(\overline{q} + q)\right)(1 - \overline{q} - q)^{\frac{\theta}{1-\alpha-\theta}} \frac{1}{\phi^N} \tag{23}$$

where $\phi^N = \frac{\xi}{\nu_N M_N}$.

Proof.
See Appendix F. ∎

The endogenous firm distribution $\mathcal{M}$ is composed of multiplicatively separable components, each of which have direct economic interpretations:[12]

$$\mathcal{M}(q) = \underbrace{\left(\xi + \psi(\overline{q} + q)\right)}_{\text{funding supply}} \underbrace{(1 - \overline{q} - q)^{\frac{\theta}{1-\alpha-\theta}}}_{\text{funding demand}} \quad \text{eq. } \underbrace{\frac{1}{\phi^N}}_{\text{normalizer}}. \tag{24}$$

The first component represents the household's preference for transparent firms. The household is willing to provide greater funding to firms (funding supply channel) with a higher q. This channel generates an incentive for a firm to choose high q. The second part captures a firm's incentive to reveal less information (funding demand channel), as a greater

[11] Equation (15) combined with the equilibrium condition 8 yields the indifference condition. Alternatively, it can be expressed as follows:

$$\frac{\phi^{L'}(q)}{\phi^L(q)} = \frac{\theta}{1 - \alpha - \theta}\left(\frac{1}{1 - \overline{q} - q}\right). \tag{21}$$

The boundary condition for this ordinary differential equation (ODE) is the total mass condition:

$$\int_0^{1-\overline{q}} \mathcal{M}(q)dq + M_N = 1.$$

An alternative proof based on the ODE is available in Appendix F.

[12] It is worth noting that the endogenous distribution is independent of the productivity level or the externality. Even if we are abstract from the firm-level productivity heterogeneity, our equilibrium and the key mechanism is unaffected by such heterogeneity.

revelation only benefits competitors at the firm's own cost. The third term is the equilibrium object that normalizes the measure of listed firms. The balance between first two channels shapes the indifference, leading to the endogenous non-degenerate firm distribution $\mathcal{M}$ in the equilibrium, as in Burdett and Judd (1983).

In the funding demand channel, the transparency terms interact with the intangible share θ. If the intangible share is higher, the negative effect on the transparency density becomes greater. This is because the disclosure becomes costlier when the intangible becomes a more important input factor in the production due to the competition. In Section 5, we show how the intangible share and the disclosure policy interplay to shape the macroeconomic equilibrium allocations.

The following corollary establishes that the equilibrium distribution is unique for the given support of the transparency $[0, 1-\overline{q}]$ and that, thus, the equilibrium is also unique.

Corollary 2. *(Equilibrium uniqueness)*
Given the support $[0, 1-\overline{q}]$, the equilibrium probability density function $\mathcal{M}$ is unique, so the equilibrium is also unique.

Proof.
The proof is immediate from the fact that the firm's profit optimality condition and the equilibrium indifference condition implies the unique distribution in Proposition 3. ■

Moreover, we show that the probability density function $\mathcal{M}(q)$ belongs to a variant of a well-known distribution class, Beta distribution, which eases the equilibrium analysis even further. The following corollary shows that $\mathcal{M}(q)$ follows a shifted and scaled transformation of a truncated beta distribution.

Corollary 3. *(Truncated normalized Beta distribution)*
The gross transparency, $y := q + \overline{q}$, is a shifted and scaled transformation of a random variable Y that follows a truncated Beta$(B+1, 2)$ distribution:

$$q + \overline{q} = 1 - (1 + \xi/\psi) \times Y \tag{25}$$

where $Y \sim Beta(B+1, 2)$ on $[0, \frac{1-\overline{q}}{1+\xi/\psi}]$, and $B := \theta/(1-\alpha-\theta)$.

Proof.
See Appendix F. ■

Using the definition of the net funding intensity $\phi^N = \frac{\xi}{\nu_N M_N}$, total mass condition in the equilibrium can be written as

$$\frac{\nu_N}{\xi} M_N \psi \int_0^{1-\overline{q}} \left(\frac{\xi}{\psi} + (\overline{q} + q) \right) (1 - \overline{q} - q)^B dq = 1 - M_N. \tag{26}$$

Equation (26) captures the relationships between the structural parameters and the total measure of non-listed firms, M_N. After rearranging the terms, we obtain the analytic form of the measure of non-listed firms as stated in Proposition 4

Proposition 4 (Non-listed firms' measure)**.**
In equilibrium, the measure of non-listed firms M_N is

$$M_N = \frac{1}{1 + \psi \frac{\nu_N}{\xi} (1 + \frac{\xi}{\psi})^{B+2} \mathcal{B}(B+1, 2) F\left(\frac{1-\overline{q}}{1+\xi/\psi}; B+1, 2 \right)}, \tag{27}$$

where $\mathcal{B}$ is the beta function, F is the cumulative distribution function of beta distribution, and $B := \theta/(1 - \alpha - \theta)$.[13]

Proof.
See Appendix F. ■

Notably, the analytic form of the non-listed firms' measure and the distribution of listed firms do not include either the price of the intangible or the externality. That is, the firm-level financing decision is independently determined by the intangible price and externality. The intuition behind this result is that changes in price and externality uniformly shift the operating profits of listed and non-listed firms — so they do not cross-sectionally affect the decision of how to finance their operating activities. This separation mimics the block-recursive nature of the dynamic equilibrium under the directed search (Menzio and Shi, 2010). Moreover, the analytical characterization does not depend on households' risk-aversion parameter — a level that is difficult to measure — implying that our results are robust to alternative specifications of risk aversion. M_N determines the funding intensity of private firm ϕ^N. Then, from Proposition 3, the firm distribution $\mathcal{M}$ is also fully characterized independent of the intangible price and the externality as follows:

$$\mathcal{M}(q) = \frac{\nu_N (\xi + \psi(\overline{q} + q)) (1 - \overline{q} - q)^{B(\theta)}}{\xi \left(1 + \psi \frac{\nu_N}{\xi} (1 + \frac{\xi}{\psi})^{B(\theta)+2} \mathcal{B}(B(\theta)+1, 2) F\left(\frac{1-\overline{q}}{1+\xi/\psi}; B(\theta)+1, 2 \right) \right)}. \tag{28}$$

[13] The beta function is defined as follows:

$$\mathcal{B}(a, b) := \frac{\Gamma(a)\Gamma(b)}{\Gamma(a+b)} = \frac{(a-1)!(b-1)!}{(a+b-1)!} = \int_0^1 x^{a-1}(1-x)^{b-1} dx.$$

3.1 Analytical comparative statics in general equilibrium

How do changes in intangible intensity and disclosure regulation affect the equilibrium number of listed firms? Our analytical framework permits closed-form comparative statics in general equilibrium, accounting for adjustments in both funding supply and demand — predictions that would require numerical methods in most models. The following proposition establishes monotone relationships between the measure of non-listed firms M_N and the structural parameters.

Proposition 5 (Drivers of listing decisions)**.**
For $\overline{q} \in (0, 1)$ and $\theta, \psi, \nu_N, \xi > 0$, the equilibrium measure of non-listed firms M_N strictly

(i) increases in $\overline{q}$ (mandated transparency),

(ii) increases in θ (intangible share),

(iii) decreases in ψ (transparency's information content),

(iv) decreases in ν_N (private market friction), and

(v) increases in ξ (baseline information level).

Proof.
See Appendix F. ■

Results (i) and (ii) formalize the paper's core mechanisms. Stricter mandated disclosure (higher $\overline{q}$) directly increases spillover costs, driving firms to private markets. Similarly, greater intangible intensity (higher θ) amplifies these costs, resulting in a greater measure of non-listed firms. Result (iii) shows that when disclosure becomes more informative (higher ψ), more firms choose to list since the funding benefit of transparency increases. Result (iv) is mechanical: worse private-market access makes listing relatively more attractive. Result (v) reflects that higher baseline information ξ reduces the relative information advantage of listed over private firms, shifting the equilibrium toward private markets. These sharp monotone predictions arise because the firm's problem exhibits increasing differences in listing incentives (Topkis, 1978; Milgrom and Shannon, 1994) that are preserved in the equilibrium (Acemoglu and Jensen, 2013).

In the following section, we analytically characterize the aggregate welfare, transparency, and productivity, which are the relevant scoreboards for the policy design. While the comparative statics for the measure of (non-)listed firms are sharply characterized, their implications for aggregate welfare, transparency, and productivity involve competing forces and cannot be signed analytically. We therefore turn to quantitative analysis in Section 5, where we discipline the model with data to evaluate these trade-offs.

3.2 Welfare, transparency and aggregate productivity

In this section, we analytically characterize key macroeconomic measures to evaluate the equilibrium. Based on these measures, Section 5 quantitatively assesses the macroeconomic implications of the rising intangibles and the disclosure policy. In the U.S., the SEC's objective is stated clearly in its mission: "The mission of the SEC is to protect investors, maintain fair, orderly, and efficient markets, and facilitate capital formation."[14] In line with the view of the SEC, we assess the effect of the disclosure regulation based on the investors' welfare and aggregate productivity.

First, we define the welfare measure. The representative investor's utility can be monotonically transformed into the following mean-variance form and, in turn, in the weighted sum of the expected profit form:[15]

$$Objective_{welfare} = \int_0^{1-\overline{q}} x(\widetilde{q})\frac{\pi(\widetilde{q})}{p(\widetilde{q})}d\widetilde{q} + x^N\frac{\pi^N}{P^N} - \frac{\Lambda}{2}\int_0^{1-\overline{q}} x(\widetilde{q})^2\frac{1}{\xi+\psi(\overline{q}+\widetilde{q})}d\widetilde{q} - \frac{\Lambda}{2}(x^N)^2\frac{1}{\xi}$$
$$= \frac{1}{2}\int_0^{1-\overline{q}} \mathcal{M}(\widetilde{q})\pi(\widetilde{q})d\widetilde{q} + \frac{\nu_N}{2}M_N\pi^N. \quad (29)$$

The second measure is the aggregate transparency defined as

$$\mathcal{T} := \int_0^{1-\overline{q}} (q+\overline{q})\mathcal{M}(q;\theta)dq. \quad (30)$$

The transparency change also affects the welfare through two channels. The first is information gain, which directly affects the household's utility. The second is through the shared knowledge that affects aggregate productivity.

The last measure is the productivity in the production sector:

$$Objective_{productivity} = (\Phi^{ex})^\gamma = \left(\int_0^{1-\overline{q}} (\overline{q}+q)k_I(q)\mathcal{M}(q)dq\right)^\gamma. \quad (31)$$

The productivity measure is equivalent to the externality effect, which is a function of the total shared knowledge. From the regulator's perspective, there is a productivity trade-off in increasing the strictness of the disclosure requirement. For higher $\overline{q}$, the amount of shared

[14] See "Our Goals," SEC website https://www.sec.gov/our-goals.

[15] The detailed derivation is available in Appendix E.

information is greater, while the pool of listed firms to share the information shrinks due to the firm-level extensive margin responses.

4 Empirical evidence

Our model predicts a negative cross-sectional association between firms' reliance on intangible capital and their willingness to disclose information. In this section, we test this prediction using firm-level data on publicly listed U.S. firms. We show that indeed, firms that depend more heavily on intangible capital exhibit lower transparency and are more difficult for analysts to forecast (Corollary 1), controlling for risk. Therefore, we can directly link the rise in intangible capital with a decline in investors' ability to forecast firm outcomes.

Two mechanisms may account for this finding. First, firms in the period of higher intangible intensity may disclose less information, leading to lower transparency. Second, even at comparable disclosure levels, firms that became more reliant on intangible capital may be intrinsically more complex to forecast due to the nature of their activities. The next section develops and estimates a structural model and conducts a decomposition exercise that can disentangle these two channels. Below, we describe our empirical exercise.

We use firm-level data from Compustat covering the period from 1985 to 2016 to measure firm-level intangible capital stock and other firm characteristics. We report the details on the measurement of internally generated intangible capital in Appendix A.

A clarification on measurement scope is warranted. In the model (Section 2), intangible capital refers specifically to knowledge whose property rights are not fully protected by legal institutions — excluding patents and other formally protected intellectual property, which we treat as tangible assets (footnote 2). Our empirical proxy, constructed via the perpetual inventory method applied to R&D and SG&A expenditures, does not make this distinction: it captures both legally protected and unprotected components of intangible investment. We view the empirical measure as an upper bound on the theoretically relevant stock. To the extent that legally protected intangibles (e.g., patents) are less subject to disclosure-induced spillovers, the negative association we document between intangible intensity and transparency is conservative — restricting attention to unprotected intangibles would likely strengthen the estimated relationship. In the structural estimation (Section 5), the intangible share parameter θ is identified from intangible-related *expenditures* rather than capitalized stocks, which better captures ongoing investment in knowledge creation that is not yet formally protected. To get a measure of forecast errors, we use the I/B/E/S to obtain data on earnings surprises. The dataset collects quarterly estimates made by professional financial analysts on the future earnings of publicly traded companies. From there, we closely follow Dellavigna and Pollet (2009) for the definition and calculation of earnings surprises. Specifically, earnings surprise $ES_{i,j,t}$ is defined as the difference between a firm's announced actual earnings per share $e_{i,t}$ and the earnings forecast per share $\epsilon_{i,j,t}$ made by an analyst for that firm, normalized by the price of a share $P_{i,t}$:

$$ES_{i,j,t} := \frac{\epsilon_{i,j,t} - e_{i,t}}{P_{i,t}}, \tag{32}$$

where t is the indicator of a quarter; i and j are firm and analyst indicators, respectively. Thus, the surprise is measured at the analyst-firm level.

Transparency is not directly observable. We therefore construct two complementary proxies based on the dispersion and accuracy of analysts' earnings forecasts, consistent with our model setup.[16] In Appendix D, we also explore a different measure of transparency that is not based on our model but uses content analysis of corporate filings, the S&P Composite Transparency and Disclosure Index.[17] We confirm our empirical results are robust to this alternative measure.

Our first proxy measures the extent of analysts' disagreement about firm performance. Specifically,

$$Transparency^1_{i,t} := \frac{1}{var(ES_{i,j,t})} \tag{33}$$

which is the inverse of the variance of earnings surprises for a firm i in a given quarter t. The intuition behind this proxy is that more transparent firms have lower dispersion (disagreement) in the earnings surprise among the analysts. This proxy is a direct measurement of inverse of the subjective uncertainty $H(q;\overline{q})$ in our model setup in Line (2) and (4). This proxy is measured only for firms with at least two analysts' forecasts available. In our dataset, the average number of analysts covering a firm is three.

The second is the inverse of the median distance between firm earnings and analyst forecasts:

$$Transparency^2_{i,t} := \frac{1}{median(|ES_{i,j,t}|)} \tag{34}$$

This proxy is based on the hypothesis that more transparent firms have lower absolute

[16] This approach also finds ground in the accounting literature, which directly links analysts' forecast accuracy and agreement to firms' disclosure quality and readability of financial reports. Lang and Lundholm (1996) finds that analysts' forecast agreement and accuracy are positively related to the levels of disclosure of the company; Lehavy et al. (2011) shows that analysts' earnings forecasts are less accurate when firms issue less readable 10-Ks.

[17] In 2002, as part of an initiative to introduce new analytical services on information, Standard & Poor produced a measure of corporate disclosure based on the analysis of annual reports, 10-Ks, and proxy statements. The measure is available for all firms in the S&P 500 index for the year 2002 only.

earnings surprises, on average.[18]

We limit the sample to firms in Compustat from 1985 to 2016 for which information on earnings forecasts by analysts is available. We exclude all financial firms. We further require firms to have information on assets, strictly positive sales and employment, and median earnings surprise lower than 100 (99.5 percentile). We report summary statistics of the sample in Appendix C.

We then estimate the relationship between transparency and intangible capital using the following specification:

$$\log \mathrm{y}_{i,t} = \alpha_t + FEs + \beta \times \text{Intangible over total assets}_{i,t} + \gamma \times X_{i,t} + \varepsilon_{i,t} \tag{35}$$

where $y_{i,t}$ is either our first or second transparency measure. α_t are year fixed effects and FEs include either industry and industry $\times$ year or firm fixed effects. $X_{i,t}$ contains standard firm controls, including book-to-market ratio, liquid capital (cash, inventory, and receivables), leverage (total debt over total asset), sales and employment in logs, age (measured since IPO), standard deviation of sales growth in the past three years, and the number of analysts covering the firm. Intangible and liquid capital are scaled by total assets.

Table 1: Regression of transparency proxies on intangibles

	Transparency 1		Transparency 2	
	(1)	(2)	(3)	(4)
Intangible	-.6572	-.5389	-.3246	-.2618
	(.0387)	(.0705)	(.0196)	(.0354)
Year FE	✓	✓	✓	✓
Industry FE	✓		✓	
Year x Industry FE	✓		✓	
Firm FE		✓		✓
Adj. R^2	0.311	0.644	0.303	0.628
Observations	72168	71484	70352	69663

Notes: This table reports the estimates of the coefficients from the following regression using our baseline sample, which includes all firms in Compustat from 1985 to 2016 for which information on earnings forecasts by analysts is available:

$$\log y_{i,t} = \alpha_t + FEs + \beta \times \text{Intangible capital over total assets}_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t}$$

where $y_{i,t}$ is either the inverse of variance of earning surprises when more than one analyst forecast is present, or the inverse median absolute value of earning surprises. α_t are year fixed effects and FEs include either industry and industry x year or firm fixed effects. $X_{i,t}$ represents firm controls. Standard errors are heteroskedasticity-robust.

[18]The median is used instead of the average; this is to rule out the outlier's level effect on the average.

A key concern is that firms with high intangible intensity may also be inherently riskier, which may lead to a spurious correlation between intangibles and forecast errors. To address this issue, we (i) include firm fixed effects and (ii) control for firm-specific risk using the historical volatility of sales growth, defined as the standard deviation of log sales growth over the previous five fiscal years (Campbell et al., 2001; Irvine and Pontiff, 2008). By including this measure in the control, along with year and firm (in our more demanding specification) fixed effects, we isolate the component of transparency variation that is not mechanically driven by differences in risk exposure. Moreover, to control for possible changes in analysts' skill, effort, and common changes in idiosyncratic and aggregate risk, we include industry $\times$ year and controls for firm's analyst coverage.

Table 1 reports the results for the coefficient on intangible capital asset ratio. We report the full regression table in Appendix C. Across all specifications, the coefficient on the ratio of intangible capital to total assets is negative and statistically significant. Quantitatively, a one–percentage point increase in the intangible capital over assets ratio reduces the first transparency measure by 0.66 percent and the second by 0.32 percent. The results are robust to the inclusion of firm fixed effects.

5 Quantitative analysis

We discipline our model by tightly matching the firm-level moments in the model with the data counterpart. Then, we quantitatively assess the drivers of the observed macroeconomic changes and the implications based on the disciplined model. We estimate our model using data from two distinct periods. The first period, spanning from 1992 to 1996, serves as our baseline, and the second period, from 2012 to 2016, is used for the post-change period.[19]

5.1 Estimation

In this section, we elaborate on how we fit the firm-level data into the model. We estimate the following parameters:

$$\{\theta, \overline{q}, \xi, \psi, \nu_N\}, \tag{36}$$

[19] We end our sample in 2016 for two reasons. First, the post-2016 period features compositional shifts in IPO activity — including the SPAC wave of 2020-2021 and pandemic-related disruptions — that introduce measurement challenges for our transparency proxies. Second, our static model is designed to capture long-run equilibria, and the 2012-2016 window provides a stable post-adjustment period roughly 15-20 years after the structural break in listings began. Extending the sample through 2019 does not materially affect our baseline estimates.

where θ is the intangible capital share; $\overline{q}$ is the mandated transparency of disclosure; ξ is the baseline information level a household has about both listed and non-listed firms; ψ is the transparency's contribution to the household's information about listed firms; and ν_N is the efficiency parameter of the private equity market.

The target moments and simulated moments are reported in Table 2. One of the important data moments we target is the portion of listed firms among the entire firms. Doidge et al. (2017) shows that a significant portion of the U.S. listing gap is explained by the mergers and acquisitions (M&As) by public firms. As our model does not have this channel, we adjust the data moment by residualizing the M&A effect. Starting from 1975, we sequentially updated the exit rate, which is the number of delisting firms minus M&As, over the number of listed firms, plus new entries and minus M&As. The total drop before the adjustment in listed firms was about 52%, but after accounting for M&As, the adjusted drop is 31%. This means that the adjusted fraction of listed firms went from 11.08% in the baseline period to 7.60% in the post-change period. Using the adjusted fraction of listed firms out of the total number of firms, we identify the parameter $\overline{q}$.[20]

In our model, the household has a belief on stock returns that follow a normal distribution:

$$\widetilde{r}(q) \sim N\left(\overline{r}(q), \frac{1}{\xi + \psi(\overline{q} + q)}\right). \tag{37}$$

Analysts' forecast dispersion is a natural data counterpart to the dispersion in the ex-ante stock return. Specifically, earnings surprise is defined as:

$$ES(q) := \overline{r}(q) - \widetilde{r}(q) \sim N\left(0, \frac{1}{\xi + \psi(\overline{q} + q)}\right). \tag{38}$$

Hence, in our analysis, we identify ψ using the average dispersion of the earning's surprise for each firm. We assume that opacity in non-listed firms is comparable to that of the top opaque firms among the listed, which allows us to identify ξ. In particular, we assume top 1% opaque firms share the same opacity as the non-listed firms. θ is identified from the intangible to tangible ratio. Lastly, we calibrate ν_N to target a 28.66% rate of private firms successfully accessing non-depository financial services, based on the 1993 Survey of Small Business Finances (Cole and Wolken, 1995). It reports that 28.66% of small businesses used non-depository financial services including finance companies, brokerage services, and other equity-related financing sources. For the post-change period, we use the 4.1 percentage points estimate of improvement in the non-listed equity market friction following Ewens and Farre-Mensa (2020).[21]

[20] We only consider firms with more than 100 employees following Kahle and Stulz (2017).

[21] They identified the propensity to raise capital from out-of-state investors around NSMIA (Table 1).

We use the method of simulated moments to estimate the parameters. The weight matrix is the identity matrix. Because the system is exactly identified — with five parameters matched to five moments — the estimator attains zero distance at the solution regardless of the weight matrix. Under exact identification, the choice of weight matrix does not affect point estimates, as the parameter vector that equates simulated and data moments is unique (Newey and McFadden, 1994).

Table 2: Fitted moments

Moments	Data	Model	Reference
Baseline (1992 $\sim$ 1996)			
Fraction of listed after M&A adj. (%)	11.08	11.08	Compustat & BDS
(*cf. without M&A adj. (%)*)	(8.30)		
Intangible Exp./Sale (%)	2.906	2.906	Compustat
Average $sd(\widetilde{r})$ (%)	12.53	12.53	Compustat & I/B/E/S
Average $sd(\widetilde{r})$ of top 1% (%)	19.80	19.80	Compustat & I/B/E/S
Portion of funded non-listed firms (%)	28.66	28.66	Cole and Wolken (1995)
Post-change (2012 $\sim$ 2016)			
Fraction of listed after M&A adj. (%)	7.60	7.60	Compustat & BDS
(*cf. without M&A adj. (%)*)	(4.01)		
Intangible Exp./Sale (%)	5.356	5.356	Compustat
Average $sd(\widetilde{r})$ (%)	28.00	28.00	Compustat & I/B/E/S
Average $sd(\widetilde{r})$ of top 1% (%)	84.81	84.81	Compustat & I/B/E/S
Portion of funded non-listed firms (%)	32.76	32.76	Ewens and Farre-Mensa (2020)

Notes: The sources of the data target moments are specified in the last column. We join the datasets of Compustat and I/B/E/S following Dellavigna and Pollet (2009).

Table 3 reports the estimated parameters along with fixed parameters. In the post-change period, the estimated mandated transparency parameter $\overline{q}$ increased from 0.982 to 0.995, indicating that information regulation has become stricter, consistent with the intended direction of post-1996 SEC reforms. The share of intangible assets θ increased by approximately 50% (from 0.029 to 0.054), reflecting the significant rise in the importance of intangible input documented in the aggregate data.

Two parameter changes warrant particular attention due to their magnitudes and implications. First, the transparency's marginal contribution to investor information ψ declined by 70% (from 38.5 to 11.4), meaning each unit of mandated disclosure provides

According to their analysis, NSMIA has increased the probability of raising capital from out-of-state investor by 4.1%.

substantially less information to investors in the post-change period. We interpret this as intangible capital being inherently more opaque than tangible assets: even when firms disclose R&D expenditures or organizational investments, investors face greater difficulty valuing these assets and assessing competitive implications. This reduced informativeness of disclosure contributes directly to the welfare losses we document, as investors must make decisions with less precise information despite stricter disclosure requirements. Second, the baseline information level ξ declined dramatically by 95% (from 25.5 to 1.4), indicating a substantial increase in aggregate uncertainty about firm performance that affects both listed and non-listed firms symmetrically.

The friction parameter ν_N decreased from 3.489 to 3.053, indicating an improvement in the private equity market consistent with the documented effects of the National Securities Markets Improvement Act of 1996 (Ewens and Farre-Mensa, 2020).

Table 3: Estimated parameters

Param.	Description	Baseline (1992 ∼ 1996)	Post-change (2012 ∼ 2016)
Estimated parameters			
$\overline{q}$	Mandated transparency	0.982	0.995
θ	Intangible share	0.029	0.054
ψ	Transparency's contribution to public info.	38.533	11.396
ν_N	PE market friction	3.489	3.053
ξ	Baseline information level	25.520	1.390
Fixed parameters			
α	Capital share	$0.40-\theta$	$0.40-\theta$
γ	Public intangible share	$=\theta$	$=\theta$
r	Capital rental cost	0.10	0.07
K^I	Total intangible supply	1	1

Notes: We first set the fixed parameters as reported at the bottom of the table. Then, structurally estimate the parameters of interest using the method of simulated moments based on the targets reported in Table 2.

Besides the estimated parameters, we fix the following parameters before the estimation:

$$\{\alpha, \gamma, r, K^I\}. \tag{39}$$

Capital share, α, is set to be $0.40-\theta$ for both baseline and post-change periods.[22] The

[22]Because our model abstracts from labor input, the capital share in the model needs to be interpreted as an after-labor-adjustment capital share, as in the following formulation:

$$k^{\alpha} = \max_{L} \ k^{\widetilde{\alpha}} L^{\epsilon} - wL = (1-\epsilon)\left(\frac{\epsilon}{w}\right)^{\frac{\epsilon}{1-\epsilon}} k^{\frac{\widetilde{\alpha}}{1-\epsilon}},$$

where $\widetilde{\alpha}$ and ϵ are capital and labor shares in two-factor Cobb-Douglas production function. Our model's α

public intangible share γ, is assumed to be equal to the private intangible share θ. We assume the baseline period's capital rental cost (including depreciation) is 0.10, and 0.07 for the post-change period, reflecting the lowered capital cost in the recent periods. The total intangible capital stock, K^I, is normalized to 1.

5.2 Decomposition analysis

In this section, we decompose the macroeconomic changes between periods into contributions from each structural parameter. Because the effect of a given parameter depends on the levels of all other parameters, the decomposition is order-dependent: the magnitude of a parameter's impact differs depending on whether baseline or post-change parameters are used as the reference point. To address this issue, we compute each parameter's contribution using a symmetric two-step procedure. First, beginning from the set of the baseline parameters, we adjust only one parameter to its post-change value and record the resulting change in the relevant outcomes (the number of listed firms, transparency, productivity, and welfare).[23] Second, starting from the set of the post-change parameters, we revert that parameter to its baseline value and compute the counterfactual change. The symmetric contribution of each parameter is then given by the average of these two effects.

Table 4: Decomposition of the channels in the macroeconomic changes

		Contribution to the change (p.a.):			
Param.	Channel	#listed	transparency	productivity	welfare
	Total change (%)	-1.89	-1.85	-0.42	-0.77
$\overline{q}$	Disclosure regulation	-6.04	-6.00	-0.25	0.66
θ	Rising intangible share	-1.03	-1.03	-0.37	-0.62
ψ	Harder to forecast public firms	-3.72	-3.72	-0.16	0.65
ν_N	PE market friction	-0.61	-0.61	-0.02	-0.12
ξ	Baseline information level	8.62	8.62	0.34	-0.35

Notes: Numbers are reported in percentage per year.

Table 4 presents the decomposition results in annualized percentage points.[24] The fraction of listed firms declined by 1.89 percent annually (log change) over the 20 years between sample periods. The other columns report the model-implied changes in transparency, productivity, and welfare, which exhibited annual declines of 1.85, 0.42, and

is equivalent to a standard model's $\frac{\widetilde{\alpha}}{1-\epsilon}$, resulting in $\alpha > \widetilde{\alpha}$ given $\epsilon < 1$.

[23] Welfare, productivity, and transparency are defined in Section 3.2.

[24] The two periods of comparison are 20 years apart from each other. So, we annualized the total change by a division of 20.

0.77 percent, respectively. The model shows that a decline in transparency is accompanied by a loss in productivity, as less knowledge is shared among firms. This model prediction aligns well with the secular decline in aggregate productivity in the U.S. (Gordon, 2017; Bloom et al., 2020; Akcigit and Ates, 2023).

The stricter SEC regulation accounted for annual 6.04% drop in the number of listed firms, which is the most significant contributing factor. The rising importance of intangible capital contributes to the declining transparency through two channels. One is through the direct effect of the firms' declining willingness for transparent disclosure, and the other is indirectly through the reduced marginal information gain from disclosure. Each intangible channel contributed -1.03% and -3.72%, marking the intangible as the second most important factor for the observed decline of the listed firms. We obtain similar decomposition outcomes for the declining transparency.

On the contrary, the decline in the household's baseline information level about listed and non-listed firms contributed positively to the changes by 8.62 percentage points. This is because the declined information level makes the household provide little funding to the non-listed market, which makes the firms tend to go listed.[25]

The stricter regulation and the rising intangible all contributed to the decline in the productivity. The most significant impact was from the intangible share in production function, followed by the regulation impact.

A 0.77% annual welfare reduction accompanied the observed changes. The drop was most significantly driven by the rising intangible share through the productivity reduction. The stricter disclosure regulation has significantly contributed to mitigating welfare loss (by 0.66%), despite its negative impact on other macroeconomic measures. Intuitively, stricter regulation (higher $\overline{q}$) forces remaining listed firms to disclose more, creating first-order information gains for investors while the second-order effect of firm exit reduces the listed pool. Similarly, lower ψ endogenously induces listed firms to choose higher voluntary transparency to attract funding.

An important interpretive point concerns the attribution of the ψ channel. While our decomposition treats the decline in ψ (the informativeness of disclosure) as a separate parameter shift, we view it as fundamentally driven by the same structural transformation — the rising importance of intangible capital in production. As firms' asset bases shift from tangible to intangible capital, the same unit of mandated disclosure conveys less decision-relevant information to investors: R&D expenditures and organizational investments are inherently harder to value than physical capital, regardless of how fully they are reported.

[25] The baseline information level reflects aggregate uncertainty which symmetrically affects the information on the firm's performance.

In this sense, the direct θ channel (-1.03% contribution to the listing decline) and the ψ channel (-3.72%) should be understood jointly as manifestations of the intangible economy. Taken together, these two intangible-related channels account for -4.75% annually — the dominant force behind the observed decline in listed firms and transparency when set against the positive ξ offset. This joint attribution reinforces the paper's core narrative: the rise of intangible capital is the primary structural transformation reshaping public markets, operating through both firms' disclosure incentives and the reduced informativeness of the information they do disclose.

5.3 Optimal disclosure policy and divine coincidence

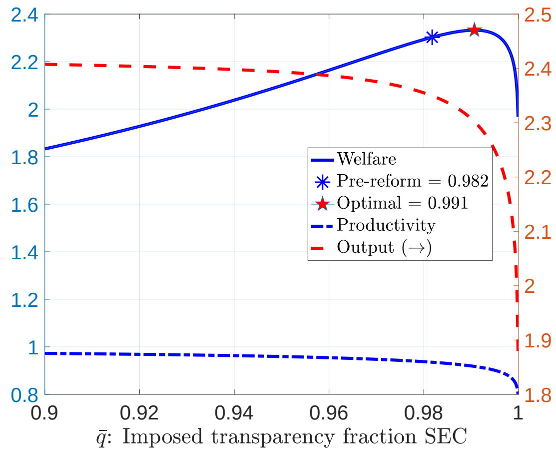
In this section, we use our model to analyze the optimal level of disclosure regulation for welfare maximization. The policy level $\bar{q}$ has two-sided effects on welfare. On the one hand, higher mandated transparency decreases the number of listed firms, resulting in productivity loss due to muted spillover. On the other hand, it provides a sharper understanding of the listed firms, increasing the utility of the household. Figure 2 shows that household welfare varies non-monotonically with regulatory stringency, exhibiting an inverted-U relationship reminiscent of a Laffer curve.[26] Panel 2a shows the baseline period (1992-1996); panel 2b shows the post-change period (2012-2016).

The estimated level of transparency in the pre-change period is 0.982 (Table 3) and the optimal level is 0.991, suggesting the mandated transparency was below the optimal level in the pre-change period. In the post-change period estimation, the results suggest that both the estimated and the optimal level of transparency increased to 0.995 and 0.993, respectively – the recent stricter disclosure policy only slightly overshoots the optimal welfare level. However, this welfare improvement is achieved after significant productivity loss.

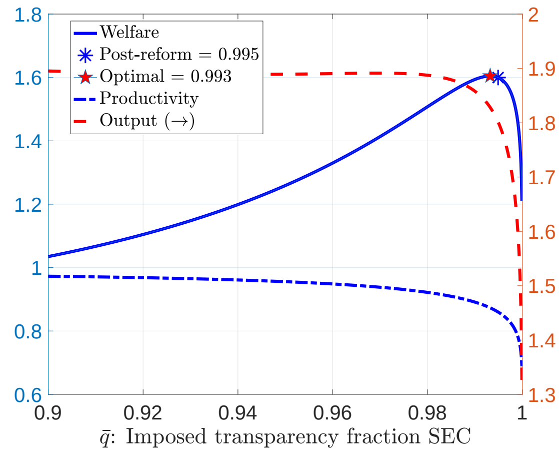
According to our model, depending on the contemporaneous policy level $\bar{q}$, moving $\bar{q}$ towards the welfare-optimal point could increase both output and productivity as well, achieving a *divine coincidence* (Blanchard and Galí, 2007). In the post-change period, such a *divine coincidence* happens when $\bar{q}$ is slightly decreased toward the optimum, increasing welfare, output, and productivity. However, this coincidence breaks down for $\bar{q}$ below the optimum, where further regulation reduces productivity despite welfare gains.

[26] When tax rates are too low, revenue is limited by the rate; when too high, revenue is limited by the tax base. Similarly, insufficient disclosure leaves investors poorly informed, while excessive disclosure drives too many firms private, shrinking the pool of transparent investment opportunities.

Figure 2: Optimal level of mandated transparency



(a) Baseline



(b) Post-change period

Notes: This figure plots welfare (solid line), productivity (dash-dotted line), and output (dashed line) levels along the disclosure policy variation for the baseline period (panel 2a) and the post-change period period (panel 2b).

5.4 Heightened policy effectiveness in the opaque economy

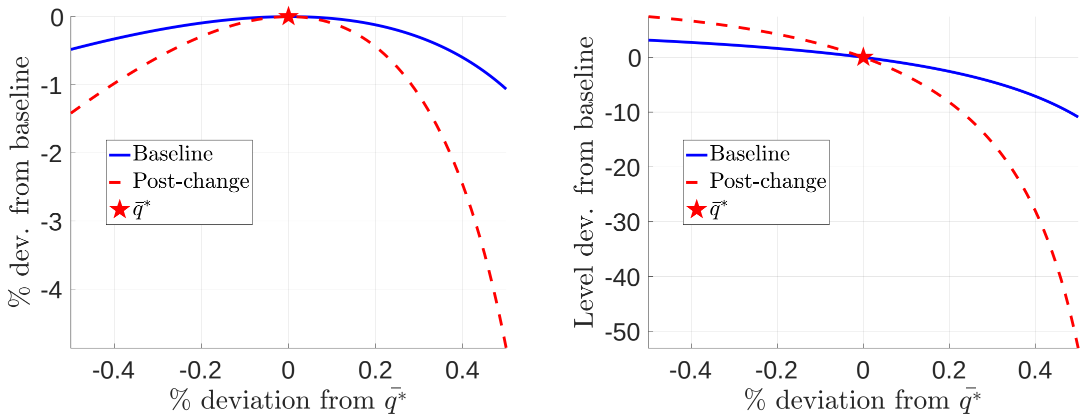
In this section, we analyze how the observed change affected effectiveness of the disclosure policy. Figure 3 plots the trajectories of the welfare (panel 3a) and marginal welfare (panel 3b) along the disclosure policy variation $\bar{q}$ for both periods. To visualize the sensitivity around the optimum $\bar{q}^*$, we normalize the horizontal variation in the % deviation from the optimum and overlay the curves from different periods. Similarly, we normalize the vertical variation in the % deviation for panel 3a and level deviation for panel 3b from the optimum welfare.

In terms of welfare level, the curves of the two different periods form a nested relationship — the baseline's curve nests the post-change period (panel 3a). This shows that in the post-change period, the marginal policy change more sharply affects the welfare of households compared to the baseline period (panel 3b), indicating *strengthened policy effectiveness in the opaque economy.*

There are two underlying forces in this model prediction. One is the enhanced convexity in the cost of losing productivity (concavity in the productivity gain) as visualized in Figure 2. When the intangible becomes more important in the production, the speed of knowledge spillover decays faster for a stricter disclosure.

The other is the enhanced concavity in the utility. Because higher opacity (a lower ψ and a lower ξ) depresses both expected output and perceived certainty, the economy operates

Figure 3: Welfare sensitivities to the disclosure policy changes



(a) Welfare

(b) Marginal welfare

Notes: This figure plots normalized welfare in percentage deviation from the baseline level (panel 3a) and marginal welfare in level deviation from the baseline (panel 3b) along the disclosure policy variation for the baseline period (solid line) and the post-change period (dashed line).

at a lower level of consumption utility. Given the concavity of utility, a policy change that slightly raises or lowers transparency then cuts across a region of the utility curve where equal consumption differences translate into larger welfare differences. In this sense, the same transparency shock produces a stronger welfare response when the economy is more opaque, making the welfare curve in Figure 3 appear steeper and the optimal policy more consequential.

6 Concluding remarks

The disappearance of U.S. public firms and the declining transparency of those that remain signal a fundamental tension between investor protection and knowledge diffusion in an intangible-intensive economy. This paper develops an analytically tractable framework to characterize this tension and derive optimal disclosure policy when firms face competing pressures: households demand transparency for informed investment decisions, while firms guard proprietary knowledge to maintain competitive advantage. Our analysis yields two central findings. First, the interaction between rising intangible capital share and stricter SEC disclosure requirements accounts for the majority of the observed decline in listed firms and market transparency between 1992-1996 and 2012-2016, imposing substantial productivity costs. The dramatic declines in baseline information quality and disclosure informativeness we estimate reflect not merely regulatory changes, but a deeper transformation: intangible assets are inherently more difficult to value and more vulnerable to competitive spillovers than traditional capital. Second, welfare exhibits an inverted-U relationship with regulatory stringency — insufficient disclosure leaves investors poorly informed, while excessive disclosure drives firms to opaque private markets. In the model, the recent disclosure environment lies close to the welfare-maximizing level. However, this optimum was reached only after significant productivity loss. Critically, the welfare curve has steepened dramatically: the same percentage deviation from optimal policy now generates substantially larger welfare losses than in the 1990s. As intangible capital becomes more central to production, precise policy calibration becomes increasingly consequential.

Looking forward, as intangible capital continues its secular rise, welfare trade-offs intensify, heightening the stakes of disclosure policy. Our analytical framework provides a foundation for understanding these trade-offs and characterizing optimal policy in an intangible-intensive economy.

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