Intellectual Property Protection and Staying Private Longer

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Abstract

Why are U.S. firms staying private longer? I analyze how the legal protection of a specific type of intellectual property – trade secrets – affects a firm's decision to undergo an initial public offering (IPO). My identification strategy exploits the staggered adoption of the Uniform Trade Secret Act (UTSA) in 50 U.S. states and the Federal enactment of the Defend Trade Secret Act in 2016 (DTSA). Between 1980 and 2015, the UTSA delayed IPOs and prolonged private tenure by 9 to 13 months. This accounts for approximately 15% to 21% of the overall larger increase in the duration of firms remaining private in the U.S. during the same timeframe. The DTSA made firms to stay private for 16 months longer. The primary factor driving these findings is the enhanced appeal of trade secrets over the other types of intellectual property protection including patents. Unlike patents, trade secrets do not require disclosure of information and offer the greatest advantages when the firm is private.

Keywords: Trade Secret, Intellectual Property Protection (IP Protection), Initial Public Offering (IPO), Staying Private, Private Firms

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1 Introduction

U.S. firms are staying private longer. Ewens and Farre-Mensa (2020) report that the median age of VC-backed startups at the time of their IPO has doubled from four to eight years between 1992 and 2016. This trend holds beyond the VC-backed firms' sample, as there is a prominent decline in IPO volumes as documented by Doidge et al. (2013) and Gao et al. (2013), while the number of IPO-eligible private firms has not decreased as emphasized by Chemmanur et al. (2022). Staying private longer can have negative consequences, such as disadvantaging public investors who lack access to private markets,[1,2] increasing financing costs for private firms' R&D and positive NPV projects, and limiting the government's ability to guarantee market stability due to the opaque nature of private firm operations and financial conditions.[3]

This paper explores a novel mechanism to explain the decision to stay private longer: changes in intellectual property protection. In particular, the paper focuses on the staggered adoption of the Uniform Trade Secret Act (UTSA) by states, and the federal adoption of the Defend Trade Secret Act (DTSA) in 2016. Both the UTSA and the DTSA heightened the legal protection of a specific type of intellectual property – trade secrets – the confidential, non-public information that provides a firm with a competitive advantage. Trade secrets can include a wide range of information such as processes, designs, customer lists, business strategies, and any other information that is kept secret to maintain a competitive edge in the marketplace. For example, the recipe for Coca-Cola remains a closely guarded trade secret. Importantly, unlike other types of intellectual property, trade secrets are protected through confidentiality measures, not publicly disclosed, withholding critical information from market competitors.

The main alternative mechanism firms use to protect their intellectual property is patents that offer superior protection compared to vulnerable to reverse engineering trade secrets. A patent is a legal document granted by a government authority, that provides an inventor with exclusive rights to their novel, non-obvious, and useful invention for a limited period.

[1] The growth of private markets has coincided with a corresponding decrease in U.S. public markets. Maureen Farrell, "America's Roster of Public Companies Is Shrinking Before Our Eyes", *Wall Street Journal*, January 6, 2017. Jonathan Macey, "As IPOs decline, the market is becoming more elitist", *Los Angeles Times*, January 10, 2017.

[2] The Concept Release highlights the SEC's recognition that retail investors' limited access to private companies and fund investments may economically disadvantage them. The document also explores granting retail investors access to private markets. SEC, "Concept Release on Harmonization of Securities Offering Exemptions", June 26, 2019.

[3] "Why the decline in the number of listed American firms matters", *The Economist*, April 22, 2017.

This exclusive right prohibits others from making, using, selling, or importing the patented invention without the permission of the patent holder. In contrast to trade secrets, an inventor must disclose the details of their invention in a patent application, and if the patent is granted, it provides inventors with a time-limited monopoly. Interestingly, trade secrets are by far the most popular IP protection tool among both regular firms and R&D-intensive firms, as noted by Hall et al. (2014).[4]

To illustrate the economic effects of a change in trade secrets protection, I first introduce a theoretical framework. The framework focuses on the decision to stay private. The benefit of going public lies in the prospect of a lower cost of capital. However, going public comes at the expense of sacrificing competitive advantage and revenue due to increased information disclosure. I model a change in trade secrets protection as increasing the value of innovation, with the increase greater if a firm stays private. This is because the cost of capital reduction with going public depends on the level of information disclosure, and there is a lower benefit if a firm goes public and continues to use trade secrets. As a result, firms with higher proportions of trade secrets find it optimal to remain private for a longer duration.

The key contribution of this paper is the empirical estimation of the impact of staggered changes in trade secrets protection on firm age at IPO. I find that the increase in trade secrets protection has a statistically significant and economically meaningful impact on the decision to stay private longer. An advantage of focusing on the UTSA is that its introduction was staggered across the U.S. and plausibly exogenous as argued by Png (2017a). Model estimates suggest that the UTSA alone contributes to an extended staying private duration of 9 to 13 months on average, accounting for up to one-fifth of the increased duration of firms staying private.

The estimates of the positive impact of the UTSA on the decision to remain private are robust. I find similar results using a variety of approaches to measure the change in trade protection, when I restrict the time period to 1980 – 2000 when the bulk of USTA changes took place, and when I exclude California that accounts for many IPOs from the analysis. Results persist when I employ two contemporary methodologies to address potential concerns raised in recent econometrics literature regarding the event study methodology (Sun and Abraham (2021); Borusyak et al. (2023)). A Cox semiparametric proportional hazard model and a binary hazard-like regression analysis also support the effect of the UTSA on staying

[4] Publicly traded U.S. companies own $5 trillion in trade secrets, equivalent to approximately 20% of the total market capitalization of these firms. U.S. Chamber of Commerce, "The Case for Enhanced Protection of Trade Secrets in the Trans-Pacific Partnership Agreement.", *Covington*, 2016.

private for longer.

I supplement the UTSA analysis with the recent federal regulation, the DTSA of 2016. An advantage of focusing on the DTSA is its complementarity, as the DTSA primarily impacted states that were least affected by the UTSA. This helps to identify a causal effect of trade secrets protection on the duration of staying private. The average treatment effect of the DTSA corresponds to an increase in staying private by 16 to 22 months. The estimates of the positive impact of the DTSA are also robust to excluding California, considering the pre-COVID-19 period, and restricting to the VC-backed firms only.

This paper contributes to three strands of literature. Most directly, it contributes to the relatively limited body of research on the impact of trade secrets protection on companies' decisions and outcomes. Prior studies have firmly established the influence of enhanced trade secrets protection on R&D expenditure (Png (2017a)), on the allocation of innovations between patents and trade secrets (Png (2017b), Ganglmair and Reimers (2022)), on the choices regarding capital structures (Klasa et al. (2018)), on the frequency of court cases (Lerner (2006)), and on the level of firm disclosure (Glaeser (2018), Li et al. (2018)).

Second, the paper contributes to the literature that explores the staying private longer phenomenon, and the listing gap in the U.S. (Doidge et al. (2013); Gao et al. (2013); Chemmanur et al. (2022); Bowen III et al. (2023)), by offering a complementary explanation to those already present in the literature. Doidge et al. (2017) emphasize the decline in the net benefits of going public in the U.S. Kahle and Stulz (2017) highlight increased market concentration and increased demand for large stocks due to institutional investors' dominance in public markets channels. De Fontenay (2017) hypothesize that the deregulation of securities laws in the 1990s facilitated the process of raising capital privately, while Ewens and Farre-Mensa (2020) and Kwon et al. (2020) show that this capital allowed firms to stay private for longer.

Third, the paper contributes to the literature on the costs and benefits of being a publicly listed entity (Doidge et al. (2017); Stulz (2019); Caskurlu (2022)). The choice between trade secrets and patents has differing effects on the revenue and cost of capital for public and private entities, as these two types of intellectual property involve varying levels of information sharing. Importantly, this channel is different from the direct effect of disclosure requirements on the tendency of firms to go public (Aghamolla and Thakor (2022), Dambra et al. (2015), Dathan and Xiong (2022), Casella et al. (2023)) or private (Yost (2023)).

2 Staying Private Longer and IP Protection Changes

This section provides context for the subsequent analysis of the relationship between changes in trade secret protection and a firm's decision to stay private. I start by introducing key facts about the intellectual property protection rights regime and then present stylized facts about firms staying private longer.

There are four main types of intellectual property (IP) in the U.S.: patents, trade secrets, trademarks,[5] and copyrights.[6] While copyrights protect authorship of creative works and trademarks protect identification of goods and services, neither of these IPs cover ideas, methods, or functionality of a product. For material innovations that involve novel processes, methods, or functional features, patents and trade secrets are the only appropriate IPs.

A trade secret is a confidential and valuable piece of information that provides a business or an individual with a competitive advantage over others who do not possess or know about it. Maintaining the secrecy of trade secrets is crucial for preserving their competitive edge and legal protection. Unlike other types of intellectual property, trade secrets are protected through confidentiality measures and are not publicly disclosed, thereby withholding critical information from market competitors. Despite trade secrets possessing a crucial advantage in terms of assumed disclosure levels, they offer inferior protection compared to patents as trade secrets are vulnerable to reverse engineering.

A patent is a legal document granted by a government authority that provides an inventor with exclusive rights to their novel, non-obvious, and useful invention for a limited period. These exclusive rights prohibit others from making, using, selling, or importing the patented invention without the permission of the patent holder, within the geographical boundaries of the issuing authority. In contrast to trade secrets, an inventor must disclose to public the details of their invention in a patent application, and if the patent is granted, it provides inventors with a time-limited monopoly.

There is an important difference between various IP enforcement that I exploit in this paper for identification purposes. Trademarks, copyrights, and patents are governed primarily by federal statutes, while trade secrets, by contrast, are governed by fifty state statutes and the

[5] A trademark is a legally registered symbol, logo, name, or phrase used to uniquely identify and distinguish goods or services of one business from those of others, providing exclusive rights to the owner and preventing unauthorized use by competitors.

[6] Copyright is a legal concept that grants the creator of an original work exclusive rights to its use and distribution, usually for a limited time, with the aim of encouraging the creation of new and creative works. This protection covers a wide range of creative expressions, including literature, music, art, and software.

common law. Thus, trade secrets are the only major type of intellectual property primarily governed by state law. The result is that trade secret law differs from state to state. This makes changes in trade secrets protection on a state level to be a natural candidate of source of variation for the difference-in-difference analysis.

Throughout the history of the United States, the regulation of trade secrets has been rooted in the common law – the accumulated stock of case precedents. The Restatement (First) of Torts (1939)[7] provides the following characterization of a trade secret: "A trade secret may consist of any formula, pattern, device or compilation of information which is used in one's business, and which gives him an opportunity to obtain an advantage over competitors who do not know or use it." Additionally, the Restatement outlined the circumstances that would render an individual liable for misappropriating a trade secret when used or disclosed.

Given that the Restatements of the law are not binding legal authority, the Uniform Trade Secrets Act (UTSA) of 1979 was published and recommended to individual U.S. states for adoption by the National Conference of Commissioners on Uniform State Laws. The primary objective of the UTSA is to clarify and standardize the legal protection of trade secrets across all U.S. states. The UTSA defines a trade secret, outlines the meaning of misappropriation and statute limitations, and prescribes remedies for trade secret owners in case of a violation. The term "Uniform" refers to the act being a model statute that individual states can adopt or adapt when forming their laws related to trade secrets. The adoption dates and protection levels of the UTSA vary across states, with some states adopting it as early as 1981 (five states) and others as late as 2018 (Massachusetts). By 2023, all U.S. states except New York have enacted the UTSA. Thus, different states have adopted various modifications of the Uniform Trade Secrets Act (Table 4.1, column *UTSA*), and some states relied on state common laws addressing trade secrets before the UTSA enactment (Table 4.1, column *Common Law*).

Figure 1 illustrates the increase in trade secret protection associated with the adoption of the UTSA across various states. The dashed black line, corresponding to the left-hand axis, shows the equally weighted average level of trade secret protection across U.S. states. Meanwhile, the solid gray line, corresponding to the right-hand axis, demonstrates the number of states that have adopted the UTSA. As depicted in the figure, there is a noticeable upward trend over time in both the number of states adopting the UTSA and the average trade secret protection index. Notably, the majority of this increase occurred before the year 2000, with 45 states having adopted the UTSA by that time.

[7] Comment b to section 757.

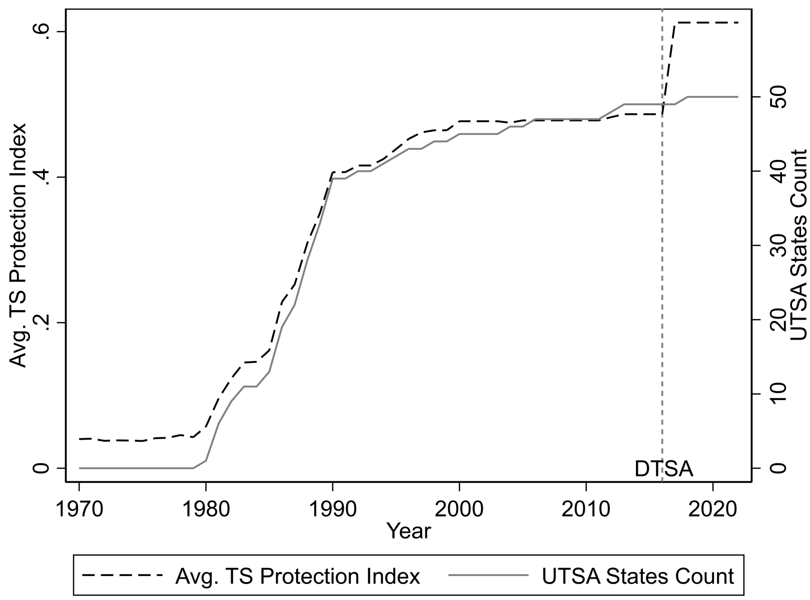


Figure 1: UTSA Adoption Across U.S. States and Increase in Trade Secret Protection

Note: The solid gray line corresponds to the right-hand axis and demonstrates the number of states that have adopted the UTSA. The dashed black line corresponds to the left-hand axis and shows the increase in the average state trade secret protection index. The average index starts from a positive value because some states originally relied on the common law. In the 1980s, different states began enacting various modifications of the UTSA, thereby increasing their trade secret protection. By 2000, 45 states had adopted the UTSA in some form. In 2016, the DTSA impacted states that had adopted weak versions of the UTSA or had not adopted it at all.

The UTSA is different from the Restatement (First) of Torts in several ways. In contrast to the Restatement (First) of Torts, the UTSA does not necessitate that the information be business-related or in continuous use. The UTSA also protects the results of research which proves that a certain process will not work. In addition, it covers work in progress and treats both acquisition, utilization, and disclosure equally in the context of misappropriation. Besides, the UTSA requires trade secret owners to initiate legal proceedings within three years of the misappropriation occurring. Moreover, the UTSA stipulates that injunctions can be issued for a duration sufficient to nullify any advantages gained through misappropriation. In cases of deliberate and malevolent misappropriation, the UTSA permits punitive damages of up to twice the amount of actual damages.

As the UTSA was not adopted in its entirety by all states, further uniformization of trade secrets was required. On May 11, 2016, President Barack Obama signed into law the Defend Trade Secrets Act (DTSA), providing a federal legal framework for the protection of trade secrets across the United States. The DTSA defines a trade secret, details the meaning of misappropriation, and sets forth the statute of limitations and remedies available to trade secret owners in case of a violation. Unlike the UTSA, which serves as a model statute for states to adopt or adapt, the DTSA establishes a uniform federal standard that operates alongside state laws. This allows trade secret owners to file civil lawsuits in federal court, thereby enhancing the consistency, predictability, and cohesiveness of trade secret litigation. The DTSA supplements existing state laws, offers an additional layer of security for intellectual property rights, and strengthens trade secret protection in states with relatively weak post-UTSA protection levels.

I hypothesize that an increase in trade secrets protection may lead to an increase in the duration of staying private. First of all, the enhanced trade secrets protection prompts firms to retain more innovations as secrets to enhance future revenues (Png (2017b)). However, trade secrets probably are not nearly as effective as patents in reducing the cost of capital in the public state unless these secrets are completely disclosed. However, disclosed trade secrets are no longer secrets and lose most of their value. Some portions of the trade secrets are indeed disclosed to the public and competitors because the public state presumes significant levels of disclosure and this undermines the benefits of secrets. Thus, being a privately owned firm with lower corporate disclosure may become more attractive in the presence of heightened trade secrets protection. As a result, firms with higher proportions of trade secrets find it optimal to remain private for a longer duration.

What is the connection between trade secrets and public corporate disclosure? First of all, managers can disclose trade secrets through 10-K filings to reduce the information asymmetry between the firm and investors. However, disclosing trade secrets would result in them losing their secret status. This implies that managers might avoid using 10-K filings to disclose any trade secrets or at least redact all the trade secrets mentioned in their disclosure filings.[8] However, Glaeser (2018) finds that when trade secret protection improves, firms redact their 10-K reports more. This indicates that they are disclosing to the public at least part of their trade secrets in these reports, as otherwise, it would be impossible to redact reports more frequently. But why would they include trade secrets and then redact them in the first place? This is because firms want the SEC to be aware of their cutting-edge technologies and business activities, ensuring they are not accused of theft in the future by another firm that might independently develop the same innovations.[9]

[8] When a firm's 10-K filing is redacted, it means that certain information within the document has been obscured or withheld from public disclosure as a result of SEC approval.

[9] Firms might also use this to prove in court that their trade secrets had material value and were included

In Figure 2 I utilize the data from 1980 to 2021 to show that there is a trend of staying private longer for both VC-backed and non-VC-backed firms.[10] I analyze firms headquartered in the U.S. at the time of their IPO using data from the Field-Ritter dataset of company founding dates.[11] I identify the age at IPO as the difference between the IPO and founding dates.[12] Figure 2 illustrates the evolution of the age at IPO for firms in my sample. The figure consists of two panels: the right panel focuses on VC-backed firms, while the left panel depicts non-VC-backed firms. Notably, both panels exhibit a distinctive pattern of prolonged private tenure.

In the right panel, a typical VC-backed firm, which exited through IPO at the age of 5.9 years in 1980, has undergone substantial growth in its age at IPO, reaching 9.8 years in 2021. This represents a notable 3.9-year or 65% increase in the age at IPO over the specified period. In the left panel, a typical non-VC-backed firm, which exited through IPO at the age of 8.5 years in 1980, has observed a significant 6.8-year or 80% increase in its age at IPO, reaching 15.3 years in 2021. These calculations stem from median regression analysis conducted on U.S.-headquartered firms. The results are visually depicted with a gray solid line, accompanied by dashed 95% robust confidence intervals for accuracy.[13]

Figure 3 shows the distribution of non-VC-backed and VC-backed IPOs across these years. There are 10,168 IPO events in the dataset, of which 6,539 are conducted by non-VC-backed firms and 3,629 are conducted by VC-backed firms.[14] Two noticeable patterns emerge. Firstly, the frequency of IPOs dropped substantially after the year 2000, as documented by Doidge et al. (2013) and Gao et al. (2013). Secondly, before 2000 only 32% of IPOs were conducted by VC-backed firms, while after 2000, this proportion increased to 47%.

in the redacted 10-K report.

[10] Prior research already established that the firms in the U.S. are staying private longer. For example, Ewens and Farre-Mensa (2020) report that the median age at IPO of VC-backed startups was growing from four in 1992 to eight in 2016, where age is defined as the number of years since the startup's first financing round.

[11] While Figure 2 effectively illustrates the prolonged private tenure pattern for firms, conditionally on their exit through IPO, it is important to acknowledge the broader context of the firm decision to stay private longer. Firms opting for acquisition tend to do so at a later stage in their lifecycle. Moreover, certain firms deliberately choose to maintain an indefinite private status, without pursuing an IPO or acquisition.

[12] This explains the divergence between the median ages at IPO of the VC-backed in my sample and the ages reported by Ewens and Farre-Mensa (2020).

[13] Additionally, the figure includes the evolution of the median firm age at IPO, depicted by a solid black line, providing a clear visual representation of the overall positive trend.

[14] The observation-weighted increase in the duration of staying private is calculated as $\frac{6{,}539}{10{,}168} \times 6.8 + \frac{3{,}629}{10{,}168} \times 3.9 = 5.8$ years. The observation-weighted increase in the duration of staying private longer during 1980 − 2015 is computed as $\frac{35}{41} \cdot 5.8 \approx 5$ years.

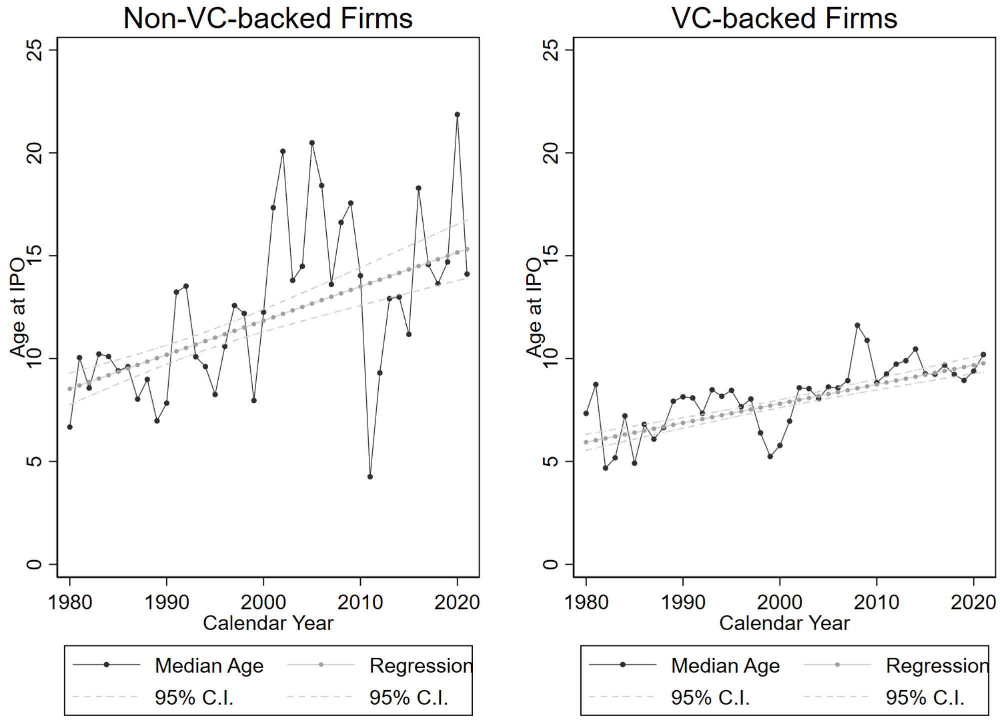


Figure 2: Firm Age at IPO in the US

Note: Both panels illustrate the "staying private longer" phenomenon. The left panel depicts the aging trend of non-VC-backed firms at their IPO date, while the right panel portrays a similar pattern observed in VC-backed firms. In both cases, the gray solid line represents a median regression, enclosed by a 95% robust confidence interval depicted by gray dashed lines. The solid black line reports the median age of firms at the time of their IPO.

3 Theoretical Framework

This section introduces a theoretical framework that links the level of IP protection to the optimal length of staying private. The key intuition is as follows. The primary cost of staying private is that a firm faces a higher cost of capital. The primary benefit of staying private is the limited disclosure, which I assume translates into higher revenues due to lower knowledge spillovers to competitors. Firms can choose to protect their intellectual property either through trade secrets or by patenting. Increases in the strength of trade secret protection benefit firms in both their private and public states, but the benefit is greater in the private state. This is because if firms protect their IP through trade secrets, they gain less from being public (i.e., there is a complementarity between the level of disclosure and the benefits of being public).

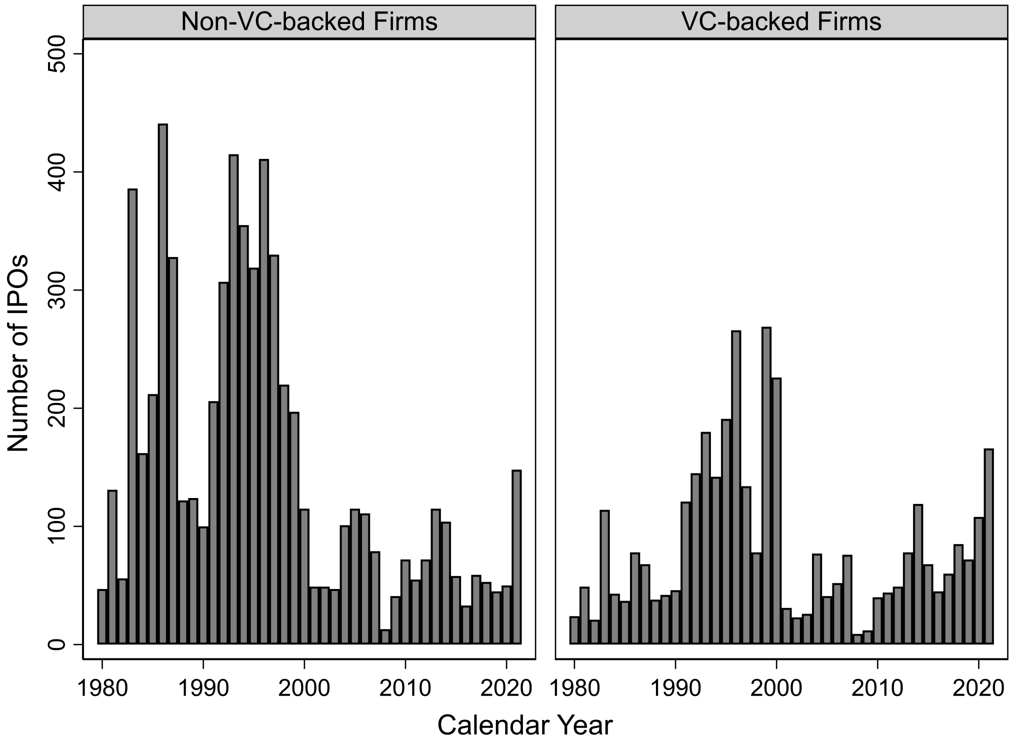


Figure 3: Annual Number of VC- and Non-VC-backed IPOs in the US

Note: The diagram displays the distribution of U.S. IPOs over time. It notably showcases a considerable decrease in the total number of IPOs after 2000. Furthermore, there is a marked increase in the ratio of VC-backed firm IPOs to those that are not backed by VC.

Primitives.

There is a single firm that is initially privately owned. At time $t = 0$, the firm makes two choices. First, it determines what proportion of its continuum unit of innovation to patent $(1 - \alpha)$ and what portion to keep as a trade secret (α). Second, the firm decides the optimal length of staying private $(T \geq 0)$ after which it becomes public and benefits from the lower cost of capital. The firm's objective is to maximize the present value of the lifetime profit $\pi(T, \alpha)$:

$$\pi(T, \alpha) = \text{PV of Revenue} - \text{PV of Costs}.$$

$f(\alpha, p, s)e^{-\Delta_i t}$ represents the per unit time revenue of the company. $p > 0$ is the patent protection level[15] and $s > 0$ is the trade secrets protection level.[16] I assume that any improvement in both trade secrets and patent protection levels has a positive impact on firm revenue: $\frac{\partial f}{\partial s} > 0$ and $\frac{\partial f}{\partial p} > 0$. Moreover, I assume that $\frac{\partial^2 f}{\partial s \partial \alpha} \geq 0$ and $\frac{\partial^2 f}{\partial p \partial (1-\alpha)} \geq 0$. In other words, I assume that the marginal benefit of improved protection of trade secrets (patents) does not diminish as more innovations are protected through secrets (patents). k is the per unit time cost of operating the company when it is private[17] and $e^{-\delta t}$ is the discount factor.

At time T the firm becomes public. Δ_1 is the amount of information leakage of a private firm and Δ_2 is the amount of information leakage of a public firm. I assume that the public firm discloses more strategic information: $\Delta_1 < \Delta_2$. Information leakage is harmful for a firm revenue. $e^{-\Delta_i t}$ represents the loss of competitive advantage and revenues associated with information leakage. The loss is severe initially but decays exponentially as a revelation of additional unit of information is marginally less harmful for the firm. Finally, $c(\alpha, \Delta_2)$ is the per unit time cost of operating the company when it is public. Abstracting from other costs I call $c(\alpha, \Delta_2)$ the cost of capital.

$$\pi(T, \alpha) = \underbrace{\int_0^T \left(f(\alpha, p, s) e^{-\Delta_1 t} - k \right) e^{-\delta t} \mathrm{d}t}_{\text{Discounted profit from 0 to T (private state)}} + \underbrace{\int_T^\infty \left(f(\alpha, p, s) e^{-\Delta_2 t} - c(\alpha, \Delta_2) \right) e^{-\delta t} \mathrm{d}t}_{\text{Discounted profit from T to } \infty \text{ (public state)}} . \quad (1)$$

There is a non-trivial trade-off the firm faces when choosing whether to stay private or not, so that under certain conditions it is optimal to become public. On the one hand, the firm exposes its secrets and by that negatively impacts the revenue. On the other hand, the firm's cost of capital declines as a result of listing on the exchange. I make assumptions on functions $f(\alpha, p, s)$ and $c(\alpha, \Delta_2)$, their derivatives, and impose boundary conditions on these functions so that the equilibrium always exists (sufficient conditions). These restrictions by no means are necessary and do not affect the main comparative statics predictions of the model. The full set of imposed conditions is provided in system (19). In addition to two boundary conditions, I assume $f(\alpha, p, s) > 0$, $f_\alpha(\alpha, p, s) \geq 0$, $f_{\alpha\alpha}(\alpha, p, s) < 0$, $0 \leq c(\alpha, \Delta_2) \leq k$, $c_\alpha(\alpha, \Delta_2) > 0$, and $c_{\alpha\alpha}(\alpha, \Delta_2) > 0$.

[15] The probability that a patent infringement is prosecuted. Patents do not give a certain right to exclude competitors from using the innovation as documented by Lemley and Shapiro (2005).

[16] The probability that a trade secret steal is prosecuted.

[17] For simplicity assume that k is a constant that incorporates all possible costs including the cost of capital, any production costs, and any other operating costs.

Equilibrium.

Under the sufficient conditions given by the system (19) the below firm maximization problem has the interior solution:[18]

$$\begin{cases} \max\limits_{\alpha,T} \pi(T,\alpha) \\ \text{s.t. } \alpha \in [0,1],\, T \geq 0. \end{cases} \tag{2}$$

It is optimal for the firm to staying private for $T^* \in (0,\infty)$. I investigate how the optimal duration of staying private T^* changes in response to variations in the level of IP protection. In essence, I am conducting a comparative statics analysis.

Proposition 1. *The optimal duration of staying private is positively associated with an increase in trade secrets protection:* $\dfrac{\mathrm{d}T^*}{\mathrm{d}s} > 0$*. The optimal duration of staying private may exhibit both positive and negative dependencies on patent protection levels:* $\dfrac{\mathrm{d}T^*}{\mathrm{d}p}$ *alternates in sign.*

The positive derivative of the optimal duration of staying private with respect to the trade secrets protection level implies that an increase in trade secrets protection leads to a delay in the firm going public. Hence, the firm stay private longer.

Intuition of Proposition 1: IP protection and Staying Private Longer.

The firm stays private longer as a result of enhanced trade secrets protection. If the firm experiences an increase in trade secrets protection ($s \uparrow$), its revenue increases mechanically while the cost of capital remains unaffected. As a result of higher trade secret protection, the firm behavior changes and it keeps more innovations secret ($\alpha^* \uparrow$), which increases the cost of capital in the public state ($c(\alpha^*, \Delta_2) \uparrow$), does not impact the cost of capital in the private state (k), and increases revenues in both states.[19] However, the revenue in the private state increases by more than in the public state in absolute terms. Therefore, going public becomes marginally inferior to staying private due to lower growth in revenue and increase in the cost of capital. Hence, the firm stays private longer.

The firm might or might not stay private longer as a result of enhanced patent protection. Similarly to the increase in trade secrets protection, if the firm experiences an increase in patent protection ($p \uparrow$), its revenue increases mechanically while the cost of capital remains unaffected. Differently from the increase in trade secrets protection, if the firm experiences

[18] The necessary and sufficient conditions are given by the system of equations (15).

[19] $f(\cdot) \uparrow$; if the allocation $(\alpha^*, 1-\alpha^*)$ remains the same then the cash flows grow due to $s \uparrow$

an increase in patent protection, the firm behavior changes and it patents more innovations ($\alpha^* \downarrow$), which decreases the cost of capital in the public state ($c(\alpha^*, \Delta_2) \downarrow$) as the firm discloses more innovations to the public. The cost of capital in the private state (k) remains unchanged. Thus, the public state becomes marginally more attractive. However, the elevation in revenues occurs in both public and private states but by more in absolute terms in the private state. Thus, depending on the difference in the change in revenues between the private and public states, the firm may or may not choose to stay private for a longer duration. Consequently, the effect on the firm's staying private duration (T^*) is ambiguous.

Proposition 1 predicts that the optimal duration of staying private positively depends on the level of trade secrets protection. When the protection of trade secrets increases, the firm relies more on secrecy. Trade secrets are more valuable when the firm is private for two reasons. Firstly, the firm's revenue increases more in the private state than in the public state when the protection of secrets increases and the firm relies more on them. This happens because trade secrets' value in the public state is lower due to increased information disclosure. Secondly, the cost of capital in the public state rises when the firm prefers to protect its intellectual property through secrets rather than patents. This occurs because patents disclose more information and are valued more by investors. Thus, the firm stays private longer as a result of increased trade secrets protection. However, the patent protection does not have monotone effect on the optimal duration of staying private.

Other Channels Affecting the Optimal Duration of Staying Private.

Using current theoretical framework and comparative statics analysis I characterize the other potential drivers that affect the firm's decision to stay private longer. I also find support for these mechanisms in the literature, which emphasizes the model richness despite its simplicity.

Proposition 2. *The optimal duration of staying private is negatively associated with an increase in the cost of capital when private and information leakage when private:* $\frac{\mathrm{d}T^*}{\mathrm{d}k} < 0$ *and* $\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_1} < 0$*. The optimal duration of staying private may exhibit both positive and negative dependencies on the public disclosure requirements:* $\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_2}$ *alternates in sign.*

De Fontenay (2017) conjecture and Ewens and Farre-Mensa (2020) show that the abundance of private capital has led firms to stay private for longer periods in the U.S. If injecting more capital into the private market increases competition among investors and lowers the cost of capital in the private sector ($k \downarrow$), then the model predicts $\frac{\mathrm{d}T^*}{\mathrm{d}k} < 0$.[20] Thus, the model is consistent with empirical evidence and provides support for a documented explanation for firms staying private for longer due to the deregulation of private capital markets.

Aghamolla and Thakor (2022) demonstrate that the introduction of mandatory disclosure requirements for private biopharmaceutical firms increases their propensity of going public. Consistent with these findings, if we increase private information leakage ($\Delta_1 \uparrow$), the model predicts that the firm will stay private for less time: $\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_1} < 0$.

The model does not provide a definitive answer to whether an increase in public disclosure requirements ($\Delta_2 \uparrow$) encourages firms to stay private longer. On the one hand, the model predicts that an increase in public disclosure requirements makes firms more vulnerable to competition. On the other hand, an increase in public disclosure lowers the cost of capital when public. Surprisingly, the available empirical evidence is also inconclusive. For example, Dambra et al. (2015) and Dathan and Xiong (2022) find the opposite effects of the JOBS Act of 2012 on the IPO volumes in the US.

4 Data

A. IPO Data

I utilize the Field-Ritter dataset of company founding dates.[21] My main sample includes all US initial public offerings (IPOs) from January 1975 to December 2022. I began with 13,945 observations. After including only the first IPO observations for firms that underwent multiple IPOs, I dropped 16 observations. Additionally, 403 observations were lost due to missing CRSP permanent IDs, and 1,926 more were lost due to missing founding dates. Further, I supplement these data with historical headquarters state data from three different sources and restrict my sample to the US-headquartered firms that underwent IPO after 1980.[22] By imposing these restrictions I am left with 10,046 observations. For further details please refer to Appendix.

[20] More precisely, $\frac{\mathrm{d}T^*}{\mathrm{d}(-k)} > 0$.

[21] Accessed in March 2023: https://site.warrington.ufl.edu/ritter/ipo-data/. Field and Karpoff (2002) and Loughran and Ritter (2004).

[22] Accurate headquarters data is crucial for this study because trade secret cases are typically tried according to the laws of the plaintiff's "principal place of business," which is commonly understood as the firm's headquarters. (Almeling et al. (2010)).

B. Trade Secret Data

I use data on the US Uniform Trade Secret Act (UTSA) and the corresponding trade secret protection index from Png (2017a) and Png (2017b). These papers develop an annual index measuring the strength of trade secrets' legal protection at the state level from 1976 to 2008. The constructed index hinges upon six factors. These include whether a trade secret necessitates continuous utilization in business operations, whether the owner is obligated to take reasonable measures to protect the secret, and whether a mere acquisition of the secret constitutes a misappropriation. Additionally, the index considers limitations on the timeframe within which the owner can pursue legal action for misappropriation, the scope of injunctions in nullifying the advantages gained from misappropriation, and the multiplier applied to calculate punitive damages in relation to actual damages. These factors collectively determine the level of protection afforded to trade secrets within each state and are used to measure the trade secret protection index.

On average, the implementation of the UTSA resulted in a 42-point increase in the index across states, compared to the pre-UTSA median index value of 47. In most states, the UTSA led to an enhancement of trade secrets protection. However, in two states, Arkansas and Pennsylvania, the pre-UTSA common law protection for trade secrets was stronger. Notably, there was no apparent pattern in the magnitude of changes in trade secrets' legal protection over time and across states. Additionally, Png (2017a) cites anecdotal evidence suggesting that the enactment of these bills often occurred for "whimsical" reasons.

Although the original trade secret protection index spans from 1970 to 2008, I extend the sample to the year 2022 based on the author's definitions. Next, I define the shock to the trade secret protection index as the difference between the UTSA trade secret protection index and the pre-UTSA protection level under common law. I also discretize the shock in three different ways using three threshold lines, as displayed in Figure 4.[23] The summary of UTSA adoption by the US states, including the magnitudes of trade secret protection levels and shocks to them, is presented in Table 4.1.

C. State-level Controls Data

I utilize US Census data to construct state-level control variables for the period from 1980 to 2021 (Table 4.2). The set of controls includes the log of state population size, Gross

[23] I categorize the shocks in three ways: positive shock versus non-positive shock (*Shock 0* in the Figure), shock smaller than 0.35 versus larger than 0.35 (*Shock A* in the Figure), and shock smaller than 0.55 versus larger than 0.55(*Shock B* in the Figure).

Table 4.1: Trade Secret Act Adoption in the U.S.

State	Year	Common Law	UTSA	UTSA Shock A	UTSA Shock B
Alabama	1987	0.03	0.21	0	0
Alaska	1988	0.00	0.47	1	0
Arizona	1990	0.25	0.22	0	0
Arkansas	1981	0.50	-0.10	0	0
California	1985	0.22	0.25	0	0
Colorado	1986	0.00	0.77	1	1
Connecticut	1983	0.00	0.47	1	0
Delaware	1982	0.00	0.47	1	0
District of Columbia	1989	0.00	0.47	1	0
Florida	1988	0.10	0.37	1	0
Georgia	1990	0.00	0.70	1	1
Hawaii	1989	0.00	0.47	1	0
Idaho	1981	0.00	0.47	1	0
Illinois	1988	0.00	0.70	1	1
Indiana	1982	0.00	0.47	1	0
Iowa	1990	0.00	0.47	1	0
Kansas	1981	0.00	0.47	1	0
Kentucky	1990	0.00	0.47	1	0
Louisiana	1981	0.00	0.40	1	0
Maine	1987	0.00	0.50	1	0
Maryland	1989	0.22	0.25	0	0
Massachusetts	2018	0.27	0.20	0	0
Michigan	1998	0.25	0.15	0	0
Minnesota	1980	0.00	0.47	1	0
Mississippi	1990	0.00	0.57	1	1
Missouri	1995	0.00	0.63	1	1
Montana	1985	0.00	0.57	1	1
Nebraska	1988	0.00	0.43	1	0
Nevada	1987	0.00	0.47	1	0
New Hampshire	1990	0.03	0.44	1	0
New Jersey	2012	0.33	0.23	0	0
New Mexico	1989	0.00	0.47	1	0
New York	.	0.31	.	0	0
North Carolina	1981	0.00	0.73	1	1
North Dakota	1983	0.00	0.47	1	0
Ohio	1994	0.25	0.28	0	0
Oklahoma	1986	0.03	0.44	1	0
Oregon	1988	0.00	0.47	1	0
Pennsylvania	2004	0.24	-0.11	0	0
Rhode Island	1986	0.00	0.47	1	0
South Carolina	1992	0.00	0.47	1	0
South Dakota	1988	0.00	0.47	1	0
Tennessee	2000	0.00	0.63	1	1
Texas	2013	0.27	0.20	0	0
Utah	1989	0.00	0.47	1	0
Vermont	1996	0.00	0.57	1	1
Virginia	1986	0.03	0.44	1	0
Washington	1982	0.00	0.47	1	0
West Virginia	1986	0.00	0.47	1	0
Wisconsin	1986	0.00	0.47	1	0
Wyoming	2006	0.50	0.00	0	0

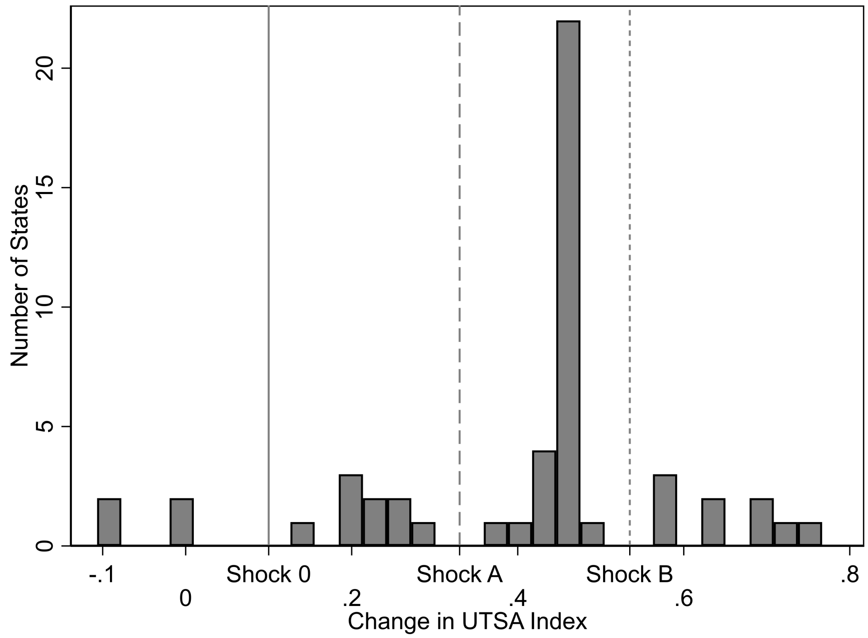


Figure 4: Distribution of Trade Secret Index Shock

Note: Trade secret protection was provided through common law provisions prior to the implementation of the Uniform Trade Secret Act (UTSA). A quantifiable index, as outlined in Png (2017a), measures the level of legal protection offered under both the common law and the UTSA. The increase in protection granted by the UTSA, beyond that provided by the common law, is referred to as the *Index Shock*.
The three thresholds *Shock 0*, *Shock A*, and *Shock B* depict various levels of impact on trade secret protection caused by the UTSA adoption. *Shock 0* marks the threshold where the UTSA adoption either reduced trade secret protection or left it unchanged. *Shock A* designates the threshold below which UTSA adoption did not significantly increase trade secret protection. Similarly, *Shock B* provides an alternative threshold below which UTSA adoption did not significantly enhance trade secret protection. Both *Shock A* and *Shock B* serve to define a discretized index function for the *Index Shock*.

State Product (GSP) growth, average income per capita, and the maximum personal income state tax rate. All the controls are lagged by one year. These variables describe state-level economic conditions that may affect new business entry and going public decisions.

D. Firm-level Controls Data

I employ Standard Industrial Classification (SIC) codes to categorize firms into the 12 Fama-French industries.[24] The summary statistics for the industries are presented in Figure 5.

[24]1. Consumer non-durables – food, tobacco, textiles, apparel, leather, toys. 2. Consumer durables – cars, TVs, furniture, household appliances. 3. Manufacturing – machinery, trucks, planes, off furn, paper, computer printing. 4. Oil, gas, and coal extraction and products. 5. Chemicals and allied products. 6. Business Equipment – computers, software, and electronic equipment. 7. Telephone and television transmission. 8. Utilities. 9. Wholesale, retail, and some services (laundries, repair shops). 10. Healthcare,

Table 4.2: Summary Statistics of State Controls

	Mean	SD	p25	Median	p75	Min	Max	N
UTSA (1980 – 2015)								
Log of Population	14.98	1.03	14.10	15.10	15.64	12.91	17.47	1,836
GDP Growth	0.06	0.04	0.04	0.05	0.08	-0.27	0.43	1,836
Log of Income per Capita	10.06	0.49	9.68	10.10	10.46	8.80	11.18	1,836
Maximum Income Tax Rate	5.29	3.20	3.21	5.86	7.50	0.00	14.10	1,836
DTSA (2012 – 2021)								
Log of Population	15.16	1.03	14.39	15.31	15.77	13.25	17.49	510
GDP Growth	0.03	0.03	0.02	0.03	0.05	-0.10	0.25	510
Log of Income per Capita	10.78	0.18	10.65	10.77	10.90	10.39	11.40	510
Maximum Income Tax Rate	5.16	3.14	3.31	5.51	7.08	0.00	14.10	510

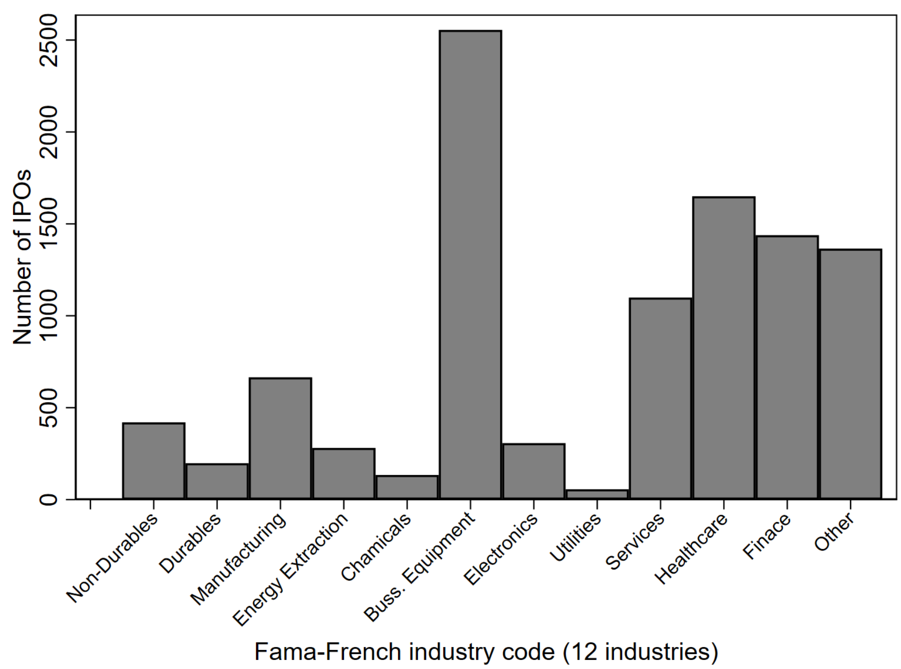


Figure 5: Industry Classification of U.S. Firms that Underwent IPO

Note: The figure above illustrates the distribution of IPOs across 12 Fama-French industries, with the number of IPOs corresponding to each industry depicted on the vertical axis.

medical equipment, and drugs. 11. Finance. 12. Other – mines, construction, building Management, transportation, hotels, bus service, entertainment.

5 Empirical Analysis

A. Empirical Design

My empirical approach is a differences-in-differences design that exploits the staggered adoption of the Uniform Trade Secret Act in 51 U.S. states.[25] Given that not all states fully embraced the provisions of the UTSA and some states weakened their state-level common law protection by adopting less stringent versions of UTSA, I account for varying treatment intensities. I estimate one model with heterogeneous treatment intensity and two models employing binary discretized treatment intensity. Specifically, I estimate the following specifications

$$\text{Age at IPO}_i = \beta_{ts}\text{TS Index}_{s,t} + \beta_{vc}VC_i + \beta_x X_{s,t-1} + \alpha_s + \alpha_{jt} + \varepsilon_{ist}, \tag{3}$$

$$\text{Age at IPO}_i = \beta_{ts}\text{TSA Shock}_{s,t} + \beta_{vc}VC_i + \beta_x X_{s,t-1} + \alpha_s + \alpha_{jt} + \varepsilon_{ist}, \tag{4}$$

where $\text{TS Index}_{s,t}$ is a trade secret protection index of state s in year t and $\text{TSA Shock}_{s,t}$ is an indicator variable equal to one if state s adopted significantly improving protection provision of UTSA before or in year t. The dependent variable is firm age at IPO. β_{ts} is the parameter of interest, capturing the effect of a unit increase in the trade secret protection measure on the firm age at IPO. VC_i is an indicator variable equal to one if a firm i is a VC-backed firm. The vector $X_{s,t-1}$ contains state-year controls.[26] The specification also includes state (α_s) and industry varying time (α_{jt}) fixed effects. Standard errors are two-way clustered by state and year.

A key identifying assumption for my empirical design is that, in the absence of UTSA, there would be parallel trends in states that adopted the UTSA relative to those that have not adopted the UTSA. To test for parallel trends and study the immediacy of any effects, I estimate the following dynamic differences-in-differences specifications:

[25] The United States consists of 50 States and the District of Columbia.

[26] In particular, I include the following state-year controls, which are lagged by one year: gross state product (GSP) growth, log income per capita, log population, and maximum state personal income tax rate.

$$\text{Age at IPO}_i = \beta_{-6}\Delta\text{TS Index}_{s,\geq t+6} + \sum_{n=-5}^{5} \beta_n \Delta\text{TS Index}_{s,t-n} + \beta_6 \Delta\text{TS Index}_{s,\leq t-6} \\ + \beta_{vc} VC_i + \beta_x X_{s,t-1} + \alpha_s + \alpha_{jt} + \varepsilon_{ist}, \tag{5}$$

$$\text{Age at IPO}_i = \beta_{-6}\text{TSA Shock}_{s,\geq t+6} + \sum_{n=-5}^{5} \beta_n \text{TSA Shock}_{s,t-n} + \beta_6 \text{TSA Shock}_{s,\leq t-6} \\ + \beta_{vc} VC_i + \beta_x X_{s,t-1} + \alpha_s + \alpha_{jt} + \varepsilon_{ist}, \tag{6}$$

where TSA $\text{Shock}_{s,t-n}$ are indicator variables for each year around the UTSA that caused significant improvement in trade secret protection index. TS $\text{Index}_{s,t-n}$ are changes in trade secret index protection for each year around the UTSA adoption.[27] The year before the treatment is normalized to zero. I group years that are more than six years before or after the shock change (ΔTS $\text{Index}_{s,\geq t+6}$, ΔTS $\text{Index}_{s,\leq t-6}$, TSA $\text{Shock}_{s,\geq t+6}$, TSA $\text{Shock}_{s,\leq t-6}$).

B. Effect of Trade Secret Protection on Age at IPO

Table 5.1 depicts a notable impact of increased trade secret protection on firm private tenure, both statistically and economically significant. Column (1) presents findings without state controls, while Columns (2) and (3) incorporate controls with differing winsorization levels for the dependent variable, *Age at IPO*. A one standard deviation rise in the *TS Index* corresponds to an extension of 4.4 to 6.8 months in private state duration.[28] Moreover, the change caused by the UTSA is responsible for around 15% to 21% of the overall increase of 5 years in private tenure between 1980 and 2015 for the representative firm in the sample.[29,30]

[27] If a state's trade secrets protection index was recorded as 0.2 before the implementation of the UTSA and rose to 0.5 after its adoption, the change in the protection index within this state is quantified as 0.3. TS $\text{Index}_{s,t-n}$ essentially represents the multiplication of this constant 0.3, signifying the change, by the corresponding indicator variable denoting TSA introduction, TSA $\text{Adoption}_{s,t-n}$.

[28] The preferred estimates are drawn from Columns (2) and (3). The coefficient in row *TS Index* represents the additional years spent in private corresponding to a unit change in *TS Index*. With a standard deviation in *TS Index* of 0.1930, this equates to $2.260 \cdot 0.1930 \approx 0.44$ years (5.3 months) in Column (2) and $3.304 \cdot 0.1930 = 0.64$ years (7.8 months) in Column (3) of extra private state time.

[29] The average change in *TS Index* pre- and post-UTSA adoption demonstrates a change of $0.5023 - 0.1792 = 0.3231$, resulting in $2.260 \cdot 0.3231 = 0.73$ years (8.8 months) in Column (2) and $3.304 \cdot 0.3231 = 1.07$ years (12.8 months) in Column (3) of extra private state time.

[30] It is worth noting that the subsample of VC-backed firms does not yield significant results. This outcome is likely attributable to the challenges in accurately identifying VC-backed firms from the late 20th century.

Table 5.1: TSA Index Shock

	All Firms			Before 2000	Excluding CA
	(1)	(2)	(3)	(4)	(5)
TS Index	2.412***	2.260***	3.304**	2.336***	1.488**
	(3.08)	(3.08)	(2.72)	(2.86)	(2.50)
VC-backed	−4.715***	−4.711***	−6.039***	−4.127***	−4.618***
	(−10.17)	(−10.17)	(−9.94)	(−7.79)	(−8.11)
Observations	9083	9083	9083	7277	7007
Industry × Year FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
State FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Controls	*No*	*Yes*	*Yes*	*Yes*	*Yes*
Winsorization	10%	10%	5%	10%	10%

Enhanced trade secret protection increases firm private tenure. The main independent variable is the continuous trade secret protection index *TS Index*. *VC-backed* is the level effect of being a VC-backed firm. Column (1) presents findings without state controls, while Columns (2) and (3) incorporate controls with differing winsorization levels for the dependent variable, *Age at IPO*. A one standard deviation rise in the TS Index corresponds to an extension of 4.4 to 6.8 months in private state duration. Columns (4) and (5) exclude IPOs after 2000 and all California-headquartered firm IPOs, respectively. T-statistics in parentheses are based on two-way clustered standard errors: by state and by year. *, **, and *** denote significance at 10%, 5%, and 1% respectively.

Columns (4) and (5) exclude IPOs after 2000 and all California-headquartered firm IPOs, respectively. Column (4) validates that the outcomes are not merely due to coincidental correlations long after the statute's adoption. Notably, the UTSA was embraced by 44 states before 2000 (refer to Figure 1). Meanwhile, Column (5) demonstrates that the results aren't predominantly driven by California, the most populous state for IPOs.

Table 5.2: TSA Discretized Index Shock A

	All Firms			Before 2000	Excluding CA
	(1)	(2)	(3)	(4)	(5)
UTSA Shock A	1.384**	1.554**	2.470***	1.589**	1.017**
	(2.17)	(2.67)	(3.30)	(2.55)	(2.16)
VC-backed	−4.713***	−4.710***	−6.038***	−4.126***	−4.615***
	(−10.04)	(−10.19)	(−9.72)	(−7.97)	(−8.14)
Observations	9083	9083	9083	7277	7007
Industry × Year FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
State FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Controls	*No*	*Yes*	*Yes*	*Yes*	*Yes*
Winsorization	10%	10%	5%	10%	10%

Enhanced trade secret protection increases firm private tenure. The main independent variable is the indicator variable for a significant change in trade secret protection index *UTSA Shock A*. *VC-backed* is the level effect of being a VC-backed firm. Column (1) presents findings without state controls, while Columns (2) and (3) incorporate controls with differing winsorization levels for the dependent variable, *Age at IPO*. The treatment effect corresponds to an increase of private tenure by 1.6 – 2.5 years in private state duration. Columns (4) and (5) exclude IPOs after 2000 and all California-headquartered firm IPOs, respectively. T-statistics in parentheses are based on two-way clustered standard errors: by state and by year. *, **, and *** denote significance at 10%, 5%, and 1% respectively.

Table 5.2 depicts a notable impact of increased trade secret protection on firm private tenure, both statistically and economically significant. The main dependent variable is a discretized shock to the trade secret protection index (see *Shock A* threshold in Figure 4). Column

(1) presents findings without state controls, while Columns (2) and (3) incorporate controls with differing winsorization levels for the dependent variable, *Age at IPO*. The treatment effect corresponds to an increase of private tenure by 1.6 – 2.5 years between the control and treatment groups. Columns (4) and (5) exclude IPOs after 2000 and all California-headquartered firm IPOs, respectively.[31]

Table 5.3: TSA Discretized Index Shock B

	All Firms			Before 2000	Excluding CA
	(1)	(2)	(3)	(4)	(5)
UTSA Shock B	0.783**	1.029***	1.505**	0.850	0.553**
	(2.67)	(3.63)	(2.34)	(1.48)	(2.36)
VC-backed	−4.711***	−4.707***	−6.033***	−4.121***	−4.611***
	(−9.94)	(−10.25)	(−10.04)	(−7.66)	(−8.10)
Observations	9083	9083	9083	7277	7007
Industry × Year FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
State FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Controls	*No*	*Yes*	*Yes*	*Yes*	*Yes*
Winsorization	10%	10%	5%	10%	10%

Enhanced trade secret protection increases firm private tenure. The main independent variable is the indicator variable for a significant change in trade secret protection index *UTSA Shock B*. *VC-backed* is the level effect of being a VC-backed firm. Column (1) presents findings without state controls, while Columns (2) and (3) incorporate controls with differing winsorization levels for the dependent variable, *Age at IPO*. The treatment effect corresponds to an increase of private tenure by 1.0 – 1.5 years in private state duration. Columns (4) and (5) exclude IPOs after 2000 and all California-headquartered firm IPOs, respectively. Column (6) restricts only to the VC-backed firms. T-statistics in parentheses are based on two-way clustered standard errors: by state and by year. *, **, and *** denote significance at 10%, 5%, and 1% respectively.

Table 5.3 depicts a notable impact of increased trade secret protection on firm private tenure, both statistically and economically significant. The main dependent variable is a discretized shock to the trade secret protection index (see *Shock B* threshold in Figure 4). Column (1) presents findings without state controls, while Columns (2) and (3) incorporate controls with differing winsorization levels for the dependent variable, *Age at IPO*. The treatment effect corresponds to an increase of private tenure by 1.0 – 1.5 years. Columns (4) and (5) exclude IPOs after 2000 and all California-headquartered firm IPOs, respectively.[32]

[31] Column (4) validates that the outcomes are not merely due to coincidental correlations long after the statute's adoption. Notably, the UTSA was embraced by 44 states before 2000 (refer to Figure 1). Meanwhile, Column (5) demonstrates that the results aren't predominantly driven by California, the most populous state for IPOs.

[32] Column (4) validates that the outcomes are not merely due to coincidental correlations long after the statute's adoption. Notably, the UTSA was embraced by 44 states before 2000 (refer to Figure 1). Meanwhile, Column (5) demonstrates that the results aren't predominantly driven by California, the most populous state for IPOs.

C. Robustness Tests

To assess the dynamic impacts of a treatment, researchers frequently employ two-way fixed effects regressions that incorporate both leads and lags of the treatment. The coefficients in this event study specification can be written as a linear combination of cohort-specific effects from both its own relative period and other relative periods. Occasionally, the weights in this linear combination may be negative, indicating that the treatment effects lack economic meaning. Even the static iteration of the two-way fixed effect regression is susceptible to this issue. To effectively tackle this problem, I employ contemporary advanced methodologies.

Tables 5.4 and 5.5 report regression results for discretized shocks to the trade secret protection index (see *Shock A* and *Shock B* thresholds in Figure 4) using advanced techniques proposed by Borusyak et al. (2023) and Sun and Abraham (2021) respectively. Columns (1), (3), and (5) use *Shock A*, and Columns (2) and (4), and (6) use *Shock B* as the main independent variable. Columns (1) and (2) utilize the whole sample, Columns (3) and (4) consider IPOs before the year 2000, and Columns (5) and (6) exclude California-based firms.[33]

Table 5.4: Age at IPO and Discretized Trade Secret Protection Index (Borusyak et al. (2023))

	All Firms		Before 2000		Excluding CA	
	(1)	(2)	(3)	(4)	(5)	(6)
UTSA Shock	2.245***	0.686**	2.256***	0.699**	1.758**	0.221
	(3.52)	(2.00)	(3.61)	(2.16)	(2.35)	(0.71)
Observations	8628	8969	6908	7194	6549	6894
Shock	*ShockA*	*ShockB*	*ShockA*	*ShockB*	*ShockA*	*ShockB*
Industry × Year FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
State FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Winsorization	10%	10%	10%	10%	10%	10%

Enhanced trade secret protection increases firm private tenure. All the regressions employ Borusyak et al. (2023) event study estimation technique. The dependent variable is *Age at IPO*. Two main independent variables are indicator variables for a significant change in trade secret protection index. Columns (1) and (2) use *UTSA Shock A* and *UTSA Shock B* over the whole sample of firms. The treatment effect corresponds to an increase of private tenure by 0.7 – 2.2 years in private state duration. Columns (3) and (4) use *UTSA Shock A* and *UTSA Shock B* over the sample of IPOs before the year 2000. Columns (5) and (6) exclude all California-headquartered firm IPOs. T-statistics in parentheses are based on two-way clustered standard errors: by state and by year. *, **, and *** denote significance at 10%, 5%, and 1% respectively.

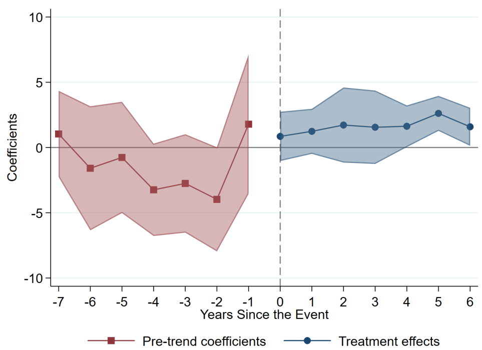
Conventional OLS regressions with leads and lags of treatment suffer from contamination of the tests by treatment effect heterogeneity shown (Sun and Abraham (2021)). Therefore, the estimation of the treatment effects should be conducted separately from the test of the parallel trends assumption. For this test, I apply Borusyak et al. (2023) test of the identifying assumptions (parallel trends and no anticipation effects) that is based on OLS regressions

[33]Columns (3) and (4) validate that the outcomes are not merely due to coincidental correlations long after the statute's adoption. Notably, the UTSA was embraced by 44 states before 2000 (refer to Figure 1). Meanwhile, Columns (5) and (6) demonstrate that the results are not predominantly driven by California, the most populous state for IPOs.

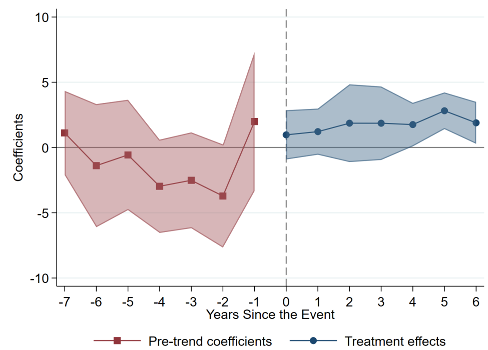
Table 5.5: Age at IPO and Discretized Trade Secret Index (Sun and Abraham (2021))

	All Firms		Before 2000		Excluding CA	
	(1)	(2)	(3)	(4)	(5)	(6)
UTSA Shock	1.729**	0.604***	1.757**	0.604**	1.138	0.226
	(2.68)	(4.71)	(2.66)	(2.32)	(1.57)	(1.40)
Observations	9083	9083	7277	7277	7007	7007
Shock	*ShockA*	*ShockB*	*ShockA*	*ShockB*	*ShockA*	*ShockB*
Ind. × Year FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
State FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Winsorization	10%	10%	10%	10%	10%	10%

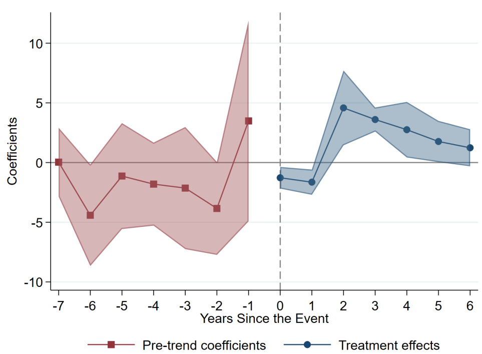
Enhanced trade secret protection increases firm private tenure. All the regressions employ Sun and Abraham (2021) event study estimation technique. The dependent variable is *Age at IPO.* Two main independent variables are indicator variables for a significant trade secret protection index change. Columns (1) and (2) use *UTSA Shock A* and *UTSA Shock B* over the whole sample of firms. The treatment effect corresponds to an increase of private tenure by 0.6 — 1.7 years in private state duration. Columns (3) and (4) use *UTSA Shock A* and *UTSA Shock B* over the sample of IPOs before the year 2000. Columns (5) and (6) exclude all California-headquartered firm IPOs. T-statistics in parentheses are based on two-way clustered standard errors: by state and by year. *, **, and *** denote significance at 10%, 5%, and 1% respectively.



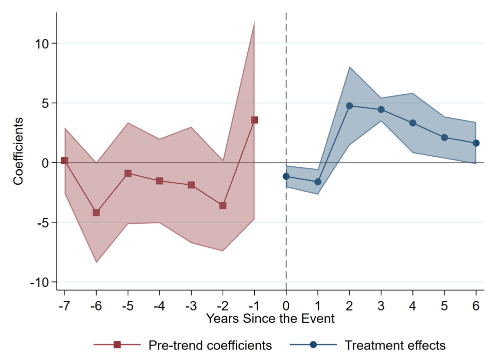
(a) Shock A: 1980 – 2021



(b) Shock A: 1980 – 2000



(c) Shock B: 1980 – 2021



(d) Shock B: 1980 – 2000

Figure 6: Event Study Plots (Borusyak et al. (2023))

Note: The figures above depict four event study plots using Borusyak et al. (2023). The top left panel corresponds to *Shock A* during 1980 to 2015 time period, the top right panel corresponds to *Shock A* during the 1980 to 2000 time period, the bottom left panel corresponds to *Shock B* during 1980 to 2015 time period, and the bottom right panel corresponds to *Shock B* during 1980 to 2000 time period. The treatment effects after the shocks are economically significant. The parallel trends and no anticipation hypotheses cannot be rejected according to the tests (identifying assumptions are satisfied).

with untreated observations only.

The parallel trend and no anticipation assumptions tests, conducted using discretized shocks (see *Shock A* and *Shock B* thresholds in Figure 4), do not find significant pretrends. The event study plots for the sample 1980 – 2015 and for the sample 1980 – 2000 (before the year 2000) are depicted in Figure 6.

D. Survival Analysis – Linear Probability Model

In this part, I shift the focus from a repeated cross-section to a panel data model, utilizing an indicator variable for an IPO as the dependent variable. The initial step involves estimating a linear regression model using a staggered difference-in-difference approach. In particular, I estimate the following specifications

$$\text{IPO}_{it} = \beta_{ts}\text{Protection}_{s,t} + \beta_x X_{s,t-1} + \alpha_i + \alpha_{jt} + \varepsilon_{ist}, \tag{7}$$

where $\text{Protection}_{s,t}$ is trade secrets protection of state s in year t. I employ different measures of trade secrets protection: trade secrets protection index $\text{TS Index}_{s,t}$, a change in trade secrets protection index as a result of the UTSA adoption $\Delta\text{TS Index}_{s,t}$, or one of the two discretized shocks to trade secrets protection index $\text{UTSA Shock A}_{s,t}$ and $\text{UTSA Shock B}_{s,t}$. The dependent variable is an indicator variable for an IPO of firm i in year t. The vector $X_{s,t-1}$ contains state-year controls. The specification also includes firm (α_i) and industry varying time (α_{jt}) fixed effects. Standard errors are two-way clustered by state and year. Table 5.6 shows the results.

Columns (1) to (3) of Table 5.6 utilize $\text{TS Index}_{s,t}$ as the primary independent variable and demonstrate that a unit increase in trade secrets protection index reduces the probability of undergoing an IPO in a given year by 3.0% for the entire sample of firms, by 4.1% for the subset of firms that conducted an IPO before reaching the age of 40, and by 6.3% for young firms that IPOed before reaching the age of 20.[34] Columns (4) to (6) use a change in the trade secrets protection index resulting from the UTSA adoption, denoted as $\Delta\text{TS Index}_{s,t}$, and two discretized shocks to the trade secrets protection index, $\text{TSA Shock A}_{s,t}$ and $\text{TSA Shock B}_{s,t}$, as their primary independent variables, respectively. All columns demonstrate that an increase in trade secrets protection decreases the likelihood of firms undergoing an IPO in a given year. So, if the firms stayed private for 10 years before the UTSA, it caused them to

[34] The average change in TS Index pre- and post-UTSA is 0.3198. Thus, this corresponds to 1%, 1.3%, and 2% reduction in probability of undergoing an IPO in a given year as a result of UTSA adoption in columns (1), (2), and (3), respectively.

Table 5.6: Trade Secret Protection and IPO decision

	(1)	(2)	(3)	(4)	(5)	(6)
TS Index	-0.030***	-0.041**	-0.063***			
	(-5.15)	(-2.49)	(-6.14)			
ΔTS Index				-0.027***		
				(-4.38)		
UTSA Shock A					-0.011**	
					(-2.72)	
UTSA Shock B						-0.023***
						(-3.93)
Observations	55101	44788	34258	55101	55101	55101
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
End Year	2005	2005	2005	2005	2005	2005
IPO Age Restriction	No	40	20	No	No	No

Note: Enhanced trade secret protection decreases a firm's probability of undergoing an IPO in a given year. A linear probability model: $\text{IPO}_{it} = \beta_{ts}\text{Protection}_{s,t} + \beta_x X_{s,t-1} + \alpha_i + \alpha_{jt} + \varepsilon_{ist}$. The dependent variable is an indicator variable for IPO of firm i in year t. The main independent variable in Columns (1) – (3) is a trade secret protection index TS $\text{Index}_{s,t}$, in Column (4) – a change in trade secret protection index ΔTS $\text{Index}_{s,t}$, in Columns (5) and (6) – indicator variables for a significant change in trade secret protection index UTSA Shock A and UTSA Shock B respectively. All Columns include firm and industry-by-year fixed effects. All Columns include state-level control variables. *Terminal Year* denotes the year at which I cut the sample to avoid bias caused by the fact that I do not observe the records of firms that have not undergone an IPO by 2021. *IPO Age Restriction* imposes restriction on the sample by selecting the firms that were no older than *IPO Age Restriction* years at IPO. One noticeable feature of this specification is that the likelihood of undergoing an IPO is assumed to be independent of the firm age unlike in hazard rate models. All columns demonstrate a negative impact of enhanced trade secret protection on the firm likelihood to exit through IPO. T-statistics in parentheses are based on two-way clustered standard errors: by state and by year. *, **, and *** denote significance at 10%, 5%, and 1% respectively.

stay private for 1.1 to 2.5 years longer, which constitutes an 11% to 25% increase in age at IPO.[35]

E. Survival Analysis – Hazard Rate Model

An alternative way to estimate the shift in the likelihood of undergoing an IPO is through a hazard rate model. In contrast with a linear regression, this approach does not assume the independence between the age of a firm and the likelihood of an IPO occurrence. The hazard function, $h(t)$, is the instantaneous rate of failure equal to the limiting probability that the failure event occurs in a given interval, conditional upon the subject having survived to the beginning of that interval, divided by the width of the interval:

$$h(t) = \lim_{\Delta t \to 0} \frac{\mathbb{P}[t + \Delta t > T > t | T > t]}{\Delta t}. \tag{8}$$

For instance, if the hazard rate is a constant equal to 5/day, then one would expect 5 failures a day or to wait 1/5 of a day until witnessing a failure.

The Cox semiparametric proportional hazard model (Cox (1972)) estimates the hazard function of a process assuming it consists of two separable components: general form baseline hazard $h_0(t)$ (a proxy for effects that cannot be measured through covariates x_j) and exponential (proportional) component $\exp(x_j \beta_x)$. The hazard rate for subject j is given by:

$$h(t|x_j) = h_0(t) \exp(x_j \beta_x). \tag{9}$$

The stratified Cox estimation is an analog of a regression with fixed effects. In this case, the assumption that everyone faces the same baseline hazard is relaxed in favor of

$$h(t|x_j) = \begin{cases} h_{01}(t) \exp(x_j \beta_x), \text{ if j is in group 1,} \\ h_{02}(t) \exp(x_j \beta_x), \text{ if j is in group 2.} \end{cases} \tag{10}$$

The results of the hazard rate model estimation are given in Table 5.7. The exponentiated coefficients have the interpretation of the ratio of the hazards for a one-unit change in the corresponding covariate. For example, if the coefficient on variable *TS Index* is -0.524, then

[35] $3\% \times 0.3231 \approx 1\%$ and $6.3\% \times 0.3231 \approx 2\%$. 10 years $= \frac{1}{p_0}$ gives us $p_0 = 0.1$. Decreasing the probability of exit by 1 or 2 percentage points leads to $p_1 = 0.09$ and $p_2 = 0.08$, which corresponds to 11.1 and 12.5 years at IPO.

Table 5.7: Cox Proportional Hazard Rate model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔTS Index	-0.524*	-0.671**						
	(-1.84)	(-2.21)						
TS Index			-0.410	-0.605**				
			(-1.53)	(-2.13)				
UTSA Shock A					-0.169**	-0.223***		
					(-2.23)	(-2.93)		
UTSA Shock B							-0.182	-0.228*
							(-1.53)	(-1.95)
Observations	56034	35163	56034	35163	56034	35163	56034	35163
Strata	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Terminal Year	2005	2005	2005	2005	2005	2005	2005	2005
IPO Age Restriction	No	20	No	20	No	20	No	20

Note: Enhanced trade secret protection decreases a firm's probability of undergoing an IPO in a given year. The dependent variable is an indicator variable for IPO of firm i in year t. The main independent variable in Columns (1) – (2) is a change in trade secret protection index ΔTS $\text{Index}_{s,t}$, in Column (3) – (4) – trade secret protection index TS $\text{Index}_{s,t}$, in Columns (5) and (6) – an indicator variable for a significant change in trade secret protection index UTSA Shock A, and in Columns (7) and (8) – an indicator variable for a significant change in trade secret protection index UTSA Shock B. All Columns include state-industry stratification. All Columns include state-level control variables. *Terminal Year* denotes the year at which I cut the sample to avoid bias caused by the fact that I do not observe the records of firms that have not undergone an IPO by 2021. *IPO Age Restriction* imposes restrictions on the sample by selecting the firms that were no older than *IPO Age Restriction* years at IPO. On the one hand, the hazard model does not incorporate any time-fixed effects and the estimates are not difference-in-difference. On the other hand, the hazard model allows the likelihood of undergoing an IPO to depend on the firm age. All columns demonstrate a negative impact of enhanced trade secret protection on the firm likelihood to exit through IPO. T-statistics in parentheses are based on two-way clustered standard errors: by state and by year. *, **, and *** denote significance at 10%, 5%, and 1% respectively.

a one unit increase in *TS Index* decreases the hazard by 41% because $\exp(-0.524) \approx 0.59 = 1 - 0.41$. Overall, the UTSA is responsible for 16% drop in the hazard.[36] The median firm in the sample, which is not backed by venture capital, is based in California, and operates in the Business Equipment industry, remains private for 11% longer due to the average UTSA change when average values for control variables are applied.[37]

The first two columns of Table 5.7 employ a change in the trade secrets protection index resulting from the UTSA adoption, denoted as $\Delta\text{TS Index}_{s,t}$ as the primary independent variable. Columns (3) and (4) utilize trade secrets protection index $\text{TS Index}_{s,t}$ as the main independent variable. Columns (5) to (8) use two discretized shocks to the trade secrets protection index, $\text{UTSA Shock A}_{s,t}$ and $\text{UTSA Shock B}_{s,t}$, as their primary independent variables. The odd columns do not impose any restrictions on the sample, while the even columns restrict the sample to relatively young firms that conducted IPO before reaching the age of 20. All columns demonstrate that an increase in trade secrets protection decreases the likelihood (or hazard) of firms undergoing an IPO in a given year.

The estimates in the first two columns correspond to a decrease in the hazard rate by 16% and 19% respectively.[38] It is important to note that younger firms respond more strongly to the change in trade secrets protection as we care more about the firms that have shorter private lives and as they are more affected by the regulation. Columns (3) and (4) illustrate the similar phenomenon of a drop in the hazard rate by 12% and 18% respectively.[39]

F. Quasi-Exogeneity of the UTSA Enactment

As argued by Png (2017a) the UTSA was often enacted for "whimsical" reasons. Ribstein and Kobayashi (1996) provide evidence that the enactment of uniform laws, such as the UTSA, is not influenced by lobbying interests but rather by the initiatives of the Uniform Law Commission. Their findings imply that the adoption of the UTSA was largely independent of the performance of firms based in the states that implemented these laws. Importantly, firms were not relocating their headquarters to different states due to the enactment of the UTSA, as examined by Glaeser (2018).

To gain further insights into the factors influencing the enactment of the Uniform Trade Secret Act, Table 5.8 explores whether a state's macroeconomic conditions can predict the

[36] The average change in TS Index pre- and post-UTSA is 0.3231. $\exp(-0.524 \times 0.3231) \approx 0.84 = 1 - 0.16$.

[37] For that I integrate two survival functions, each reflecting different levels of trade secret protection index, estimated using a Cox model with fixed effects, similar to the regression from column (1).

[38] $exp(-0.534 * 0.3231) \approx 0.84 = 1 - 0.16$ and $exp(-0.671 * 0.3231) \approx 0.81 = 1 - 0.19$.

[39] $exp(-0.609 * 0.3231) \approx 0.82 = 1 - 0.18$.

adoption and level of protection of the UTSA. Four lagged variables from the previous year capture the economic conditions: the logarithm of population size, GSP growth, the logarithm of average per capita income, and the maximum personal income tax rate – variables known to influence firm entry and exit decisions. Columns (1) and (2) indicate that none of these factors predict the passage of the UTSA. Similarly, columns (3) to (6) reveal that these factors do not influence the magnitude of the UTSA protection. While population size emerges as a strong predictor of a higher UTSA protection index in column (4), it does not predict a greater increase in the UTSA protection index beyond common law protection, as seen in column (6).

Table 5.8: Economic Conditions and UTSA Passage

	UTSA Act		UTSA Protection		Total Protection	
	(1)	(2)	(3)	(4)	(5)	(6)
Log-Population	−0.009	0.094	−0.004	0.045	−0.010	0.141***
	(−1.42)	(0.89)	(−1.41)	(1.10)	(−0.41)	(3.75)
GDP Growth	0.090	0.158	0.017	0.048	−0.028	0.117
	(0.80)	(1.22)	(0.34)	(0.75)	(−0.29)	(1.64)
Per capita log-Income	−0.044	−0.270	−0.015	−0.115	0.086	−0.185
	(−1.06)	(−0.97)	(−1.04)	(−0.91)	(0.94)	(−1.05)
Max Income Tax	0.003	0.006	0.001	0.003	−0.003	0.000
	(1.31)	(0.30)	(1.30)	(0.40)	(−0.63)	(0.02)
Observations	980	980	980	980	980	980
Year FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
State FE	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*

UTSA predictive regressions. This table examines whether state-level economic conditions predict the adoption and the level of protection of the Uniform Trade Secret Act (UTSA). The dependent variable in columns 1 and 2 is an indicator equal to one if a state has passed UTSA in that year. The dependent variable in columns 3 and 4 is an additional protection that the UTSA granted to trade secrets beyond the protection granted by the common law. The dependent variable in columns 5 and 6 is the total UTSA and common law protection indexes in a given year (Png (2017a)). The controls are lagged by one year. State-level macroeconomic controls: the logarithm of population size, GSP growth, the logarithm of average per capita income, and the maximum personal income tax rate. There is no evidence that the adoption and strength of the provision were influenced by macroeconomic conditions. T-statistics in parentheses are based on two-way clustered standard errors: by state and by year. *, **, and *** denote significance at 10%, 5%, and 1% respectively.

G. The Defend Trade Secrets Act of 2016

As a result of the federal enactment of the Defend Trade Secrets Act of 2016 (DTSA), some states experienced an increase in trade secrets protection. I applied the Png (2017b) approach to quantify the protection index of the DTSA solely and found it to be equal to 0.6. Then, I subtracted the state-level trade secret protection granted by the UTSA from 0.6

(the DTSA protection index) to compute the change in the trade secret protection index for each state, which I call ΔTS Index. Whenever the difference was negative, I set it equal to zero as the DTSA cannot lower the trade secret protection.[40] The distribution of ΔTS Index is depicted in Figure 7.

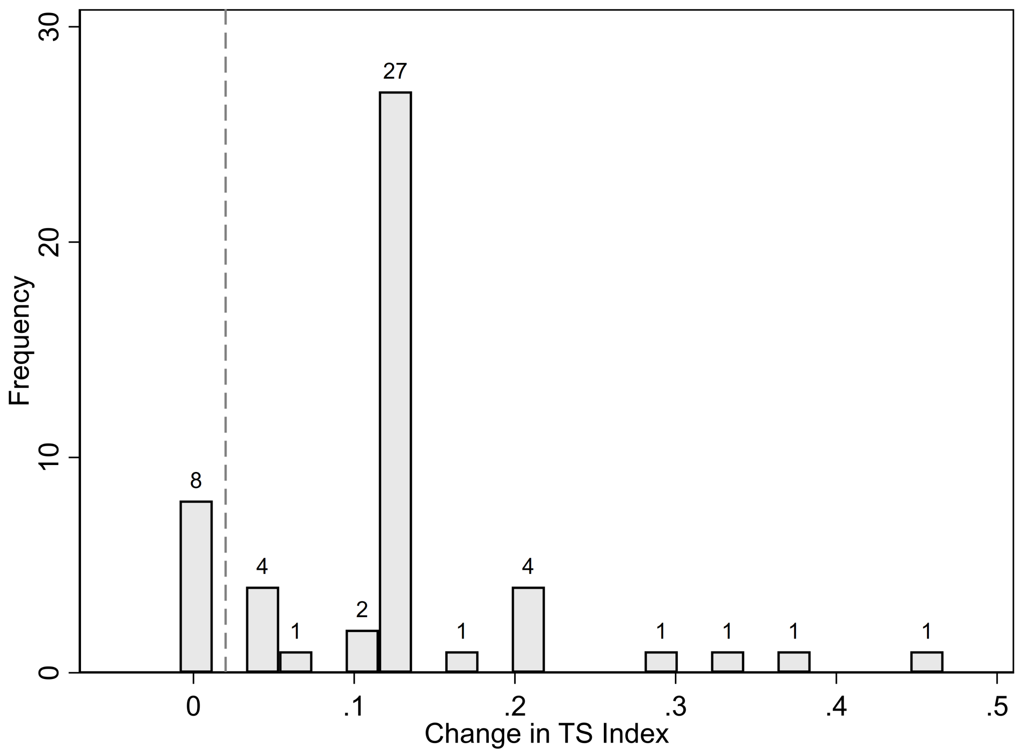


Figure 7: Impact of DTSA Enactment on Trade Secrets Protection Across 51 US States

Note: The histogram displays the number of states that experienced different changes in trade secret protection as a result of the DTSA enactment. The number above each bin indicates the number of observations in that bin. Eight states to the left of the dashed line did not experience any enhancement in trade secrets protection. The remaining forty-three states experienced varying levels of changes in their protection.

I use the DTSA as an additional shock to test whether improvements in trade secrets protection make firms stay private longer. Complementary to the UTSA analysis, the DTSA strongly affected states that were less impacted by the UTSA. Therefore, this framework implicitly refutes the view that the UTSA enactment was endogenous, resulting from firms lobbying to stay private longer. I causally identify the effect of trade secrets protection im-

[40] These 8 states consist of 6 states that had TS Index > 0 at the moment of UTSA enactment (Colorado, Georgia, Illinois, Missouri, North Carolina, and Tennessee. See Table 4.1.) as well as Minnesota, which increased protection in 2005 in *Wyeth v. Natural Biologics, Inc., 395 F. 3d 897*, and South Carolina *Code Ann. §39-8-10 et seq.* in 1997 (both as a result of permanent injunction).

provement on firms' decisions to stay private longer, leveraging the fact that different states had varying levels of trade secrets protection just before the DTSA enactment in 2016 and were affected differently by the federal enactment of the DTSA. Specifically, I estimate the following regression model:

$$\text{Age at IPO}_i = \beta_{ts}\Delta\text{TS Index}_{s,t} + \beta_{vc}VC_i + \beta_x X_{s,t-1} + \alpha_s + \alpha_{jt} + \varepsilon_{ist}, \tag{11}$$

where ΔTS Index$_{s,t}$ is a change in the trade secret protection index of state s in year t. The dependent variable is firm age at IPO. β_{ts} is the parameter of interest, capturing the effect of a unit increase in the trade secret protection index on the firm age at IPO. VC_i is an indicator variable equal to one if a firm i is a VC-backed firm. The vector $X_{s,t-1}$ contains state-year controls.[41] The specification also includes state (α_s) and industry varying time (α_{jt}) fixed effects. Standard errors are clustered by state.

A key identifying assumption for my empirical design is that, in the absence of DTSA, there would be parallel trends in states that adopted the DTSA relative to those that have not adopted the DTSA. To test for parallel trends and study the immediacy of any effects, I estimated several dynamic differences-in-differences specifications and did not find any pre-trends in these tests.

Table 5.9: Impact of DTSA on Firm Age at IPO

	All Firms		Excl. CA	Pre-Covid	VC-backed
	(1)	(2)	(3)	(4)	(5)
Δ TS Index	8.602***	8.307**	9.625**	10.561**	8.049***
	(2.75)	(2.60)	(2.71)	(2.40)	(3.68)
Observations	1567	1567	1089	1097	823
Industry × Year FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
State FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Controls	*No*	*Yes*	*Yes*	*Yes*	*Yes*

Enhanced trade secret protection prolongs the time firms remain private. The dependent variable is *Age at IPO*. The main independent variable is the change in the trade secrets protection index caused by the Defend Trade Secrets Act adoption in 2016: Δ *TS Index*. The average treatment effect corresponds to an increase in staying private by 16 to 22 months. Columns (1) and (2) correspond to specifications with and without control variables, respectively, and use all IPO events within the event window from 2012 to 2021. Column (3) excludes IPOs of firms headquartered in California. Column (4) excludes the COVID-19 period, covering the years 2012 to 2019. Column (5) considers only IPOs by VC-backed firms, which constitute the majority of firms during the event window. T-statistics in parentheses are based on clustered-by-state standard errors. *, **, and *** denote significance at 10%, 5%, and 1% respectively.

Table 5.9 illustrates how the DTSA caused firms to stay private longer in the treated states.

[41] In particular, I include the following state-year controls, which are lagged by one year: gross state product (GSP) growth, log income per capita, log population, and maximum state personal income tax rate.

The dependent variable is *Age at IPO*. The main independent variable is the change in the trade secrets protection index caused by the DTSA: Δ *TS Index*. The main specification without and with controls in Columns (1) and (2), respectively, reveals that the DTSA made an average treated firm stay private for 17 months longer.[42] The results are not driven by any specific state, as the DTSA made an average treated firm headquartered outside California stay private for 22 months longer, according to Column (3).[43] The results are not driven by the COVID-19 crisis as DTSA made an average treated firm during the pre-COVID-19 era stay private for 22 months longer, according to Column (4).[44] Furthermore, Column (5) highlights the significant impact of the DTSA on VC-backed firms, showing that they stay private for an additional 16 months.[45]

To elucidate the potential mechanism behind the result, I show that the effect is driven by firms that heavily utilize trade secrets. As a cross-sectional test, I split the sample into two groups to conduct a triple difference-in-difference estimation. One group consists of firms belonging to the ten Fama-French 48 industries that are most likely to pursue trade secrecy, while the other group consists of firms from the adjacent set of industries that are least likely to use trade secrets.[46] Specifically, I estimate the following regression model:

$$\begin{aligned}\text{Age at IPO}_i = \beta_{tsl}\Delta\text{TS Index}_{s,t} + \beta_{tsh}\Delta\text{TS Index}_{s,t} \times \text{High Secrecy}_j + \beta_{vc}VC_i + \\ +\beta_x X_{s,t-1} + \alpha_{s,1} + \alpha_{s,2} \times \text{High Secrecy}_j + \alpha_{t,1} + \alpha_{t,2} \times \text{High Secrecy}_j + \alpha_j + \varepsilon_{ist},\end{aligned} \tag{12}$$

where $\Delta\text{TS Index}_{s,t}$ is the change in the trade secret protection index of state s in year t, and $\Delta\text{TS Index}_{s,t} \times \text{High Secrecy}_j$ is its interaction with a high trade secrecy intensity indicator variable. The dependent variable is the firm age at IPO. β_{tsh} is the parameter of interest, capturing the difference in the effect of a unit increase in the trade secret protection index on the firm age at IPO between high and low trade secret-intensive industries. VC_i is an indicator variable equal to one if firm i is a VC-backed firm. The vector $X_{s,t-1}$ contains state-year controls lagged by one year: gross state product (GSP) growth, log income per capita,

[42] The average treated firm experienced an increase in the trade secret index by 0.1703. $8.602 \cdot 0.1703 \approx 1.47$ years and $8.307 \cdot 0.1703 \approx 1.41$ years.

[43] The average treated firm outside the state of California experienced an increase in the trade secret index by 0.192. $9.625 \cdot 0.192 \approx 1.85$ years.

[44] The average treated firm during the 2016 to 2019 period experienced an increase in the trade secret index by 0.176. $10.561 \cdot 0.176 \approx 1.86$ years.

[45] The average treated VC-backed firm experienced an increase in the trade secret index by 0.164. $8.049 \cdot 0.164 \approx 1.32$ years.

[46] The industries that are most likely to pursue trade secrecy include: Pharmaceuticals, Computers, Measuring & Control Equipment, Medical Equipment, Business Services, Electronic Equipment, Recreation, Electrical equipment, Machinery, and Rubber & Plastic Products as identified by Glaeser (2018).

log population, and the maximum state personal income tax rate. The specification also includes state (α_s) and time (α_t) fixed effects, different for high and low trade secret intensity industries. The model also includes 48 Fama-French industry fixed effects. Standard errors are clustered by state.

Table 5.10: Impact of DTSA on Firm Age at IPO by Industry Trade Secrecy Intensity

	All Firms		Excl. CA	Pre-Covid
	(1)	(2)	(3)	(4)
Δ TS Index	−6.161	−7.650	−10.741	2.626
	(−0.72)	(−0.92)	(−1.43)	(0.19)
Δ TS Index × High Secrecy	19.500**	19.647**	23.700***	9.050
	(2.05)	(2.03)	(2.80)	(0.61)
Observations	1571	1571	1091	1094
FF48 Industry FE	*Yes*	*Yes*	*Yes*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*	*Yes*
State FE	*Yes*	*Yes*	*Yes*	*Yes*
Controls	*No*	*Yes*	*Yes*	*Yes*
F-test p-value	0.00	0.02	0.03	0.12

Enhanced trade secret protection prolongs the time firms remain private, but only for trade secrecy-intensive industries. The dependent variable is *Age at IPO*. The main independent variables are the change in the trade secrets protection index caused by the Defend Trade Secrets Act of 2016 (Δ *TS Index*) and its interaction with a high trade secrecy intensity indicator variable (Δ *TS Index* × *High Secrecy*). Δ *TS Index* shows how low trade secret-intensive industries responded to the DTSA. Δ *TS Index* × *High Secrecy* shows how high trade secrecy intensive industries responded to the DTSA compared to low trade secrecy industries. All four columns indicate that the effect originates from high trade secret-intensive industries. Columns (1) and (2) correspond to specifications with and without control variables, respectively, and use all IPO events within the event window from 2012 to 2021. Column (3) excludes IPOs of firms headquartered in California. Column (4) excludes the COVID-19 period, covering the years 2012 to 2019. I do not show results for IPOs undergone by VC-backed firms as there are few of VC-backed firms from low trade secrecy industries. The number of observations varies slightly as I apply *industry* and *time* fixed effects separately and extend the set of industries to 48 Fama-French industries to compute triple differences. The *F-test p-value* indicates the significance level of the response of high trade secrecy intensive industries to the DTSA, or equivalently, tests whether $\beta_{tsl} + \beta_{tsh} = 0$. T-statistics in parentheses are based on clustered-by-state standard errors. *, **, and *** denote significance at 10%, 5%, and 1% respectively.

Table 5.10 illustrates that the DTSA mostly affected trade secret-intensive firms, causing them to stay private longer. The dependent variable is *Age at IPO*. The main independent variable is the interaction between the change in the trade secrets protection index caused by the DTSA and a high trade secret intensity industry indicator: Δ *TS Index* × *High Secrecy*. The main specification, without and with controls, is presented in Columns (1) and (2). Columns (3) and (4) conduct the same tests but exclude firms headquartered in California and the COVID-19 period (after 2019).

6 Conclusion

In conclusion, this study delves into the impact of intellectual property protection laws on companies' decisions regarding their public or private status. My findings strongly suggest that the adoption of the Uniform Trade Secret Act by various states and the Federal enactment of the Defend Trade Secret Act of 2016 significantly prolonged the duration that companies remained private. This indicates that the regulation of intellectual property protection might have unintended impacts on firms' choices between remaining private or going public. This results in shareholder "autocracy" so that fewer firms are available for public investors. Besides, this reduces firms' regulation and could potentially destabilize the economy in the future.

Between 1980 and 2015, the implementation of the UTSA contributed notably to companies prolonging their status as private entities, accounting for roughly 15% to 21% of the overall increase in private company durations within the United States. The implementation of the DTSA caused firms from states weakly affected by the UTSA to remain private for at least 16 months longer on average.

To ensure the robustness of these conclusions, I conducted thorough analyses accounting for diverse state-specific characteristics and employed varied measures of trade secret legal protection changes. I also considered different samples of firms. Consistently, the results demonstrated the substantial impact of the UTSA and DTSA adoption on companies' decisions to remain private for longer.

This phenomenon can be explained by companies' strategic response to enhanced trade secrets protection. When companies perceive that their trade secrets are better guarded under the UTSA or the DTSA, they tend to favor maintaining secrecy over resorting to patents (or disclosing information about intangible capital as a public firm), despite the inherent vulnerability of trade secrets to reverse engineering. This preference for trade secrets' confidentiality over patent disclosure makes the route of remaining privately held more attractive than going public.

In essence, this research underscores the significance of IP protection laws in shaping corporate behavior, specifically in influencing the delicate balance between decisions regarding public and private status. It sheds light on the strategic implications these laws have on companies' choices, offering valuable insights into how legal frameworks concerning intellectual property guide the decision-making processes of firms.

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8 Appendix I: Model Proofs

Discussion of Assumptions.

The decision to stay private or become public is multifaceted, influenced by various forces that shape the firm's strategic choices. Doidge et al. (2017) extensively discusses numerous costs and benefits associated with being a public company. I discuss the relevance of these forces to the IP protection context and motivate their inclusion and non-inclusion below.

The most prominent costs to consider are regulatory compliance costs and *competitive costs related to mandatory disclosures*.[47] Although the regulatory compliance costs were increasing in the U.S. (Trebbi and Zhang (2022)) they are not complementary to firm revenue and hence irrelevant to the IP protection channel.[48] Therefore, the only complementary effect comes from the loss of competitive advantage due to disclosure: $e^{-\Delta t}$.[49] In addition, there are noticeable fixed costs of going public that include exchange listing fees and administrative expenses for filing preparations. However, we abstract from these costs for the same reason as with regulatory compliance costs.

On the benefits side, the key advantages include access to public markets for fund-raising, which provides a *cheaper source of equity and debt capital*. This motivates having high costs k in the private state and lower costs $c(\cdot) < k$ in the public state. Intuitively, publicity lowers the cost of capital for the firm as the diversified public has lower required returns. The other benefits encompass the ability to use shares for acquisitions, price discovery, and enhanced liquidity for the company's stock, allowing pre-IPO shareholders to sell their shares. Again, I abstain from incorporating other benefits of being a public entity for tractability and due to incremental non-importance in the light of increased IP protection.

In the theoretical framework, I explore the firm trade-off when choosing whether to remain private or go public. Initially, the firm operated as a private entity. The motivation behind considering the transition to a public status is *to reduce the cost of capital*. However, this strategic move comes with costs: the firm must *increase information disclosure, which harms its competitive advantage and results in lower revenue*.

[47] In a different study Doidge et al. (2018) highlight challenges posed by strict disclosure requirements and U.S. GAAP accounting rules, especially for firms heavily invested in intangible assets.

[48] The derivatives of these costs with respect to IP protection, share of secrets, and time in the private state are zero.

[49] The effect of disclosure is detrimental at first but fades away across time with negative exponent. The negative exponential form is assumed for tractability. This behavior is intuitive because every additional unit of disclosed information leads to lower marginal competitive advantage loss.

I impose several assumptions on the cost of capital when public. First, I assume that when the firm chooses to reveal its secrets by protecting its IP with patents this lowers the cost of capital: $c_\alpha(\cdot) > 0$. Kogan et al. (2017) find that news about patents has a positive impact on stock prices, which supports my assumption. I also make a classical economic assumption of convex costs: $c_{\alpha\alpha}(\cdot) > 0$. This assumption is not a necessary condition but it is sufficient to solve for the interior equilibrium.

The main prediction of the model is that an increase in trade secrets protection incentivizes the firm to rely on trade secrets more heavily, which leads to the firm staying private longer. This behavior is internally consistent as any patentable innovation can potentially be protected by trade secrets and many firms use trade secrets to protect their most valuable IP (Hall et al. (2014)).[50] Moreover, Png (2017b) and Ganglmair and Reimers (2022) establish that firms do respond to trade secrets protection enhancement and prefer secrecy over patents.

The general support for thinking of intellectual property and its protection in the context of being private or public stems from Kahle and Stulz (2017) that emphasizes the increasing relative importance of R&D over capital expenditures[51] and associated with the challenges of raising equity in public markets. Companies with high investments in intangible assets may appear to be losing value for uninformed investors. On the contrary, disclosing too many details about R&D programs to the public can lower the competitive advantage according to the authors.

Profit function

The lifetime profit can be rewritten in the following form:

$$\pi(T,\alpha) = f(\alpha,p,s)\frac{1-e^{-(\delta+\Delta_1)T}}{\delta+\Delta_1} - k\frac{1-e^{-\delta T}}{\delta} + f(\alpha,p,s)\frac{e^{-(\delta+\Delta_2)T}}{\delta+\Delta_2} - c(\alpha,\Delta_2)\frac{e^{-\delta T}}{\delta}. \quad (13)$$

[50] Not every trade secret is patentable though. Besides, it is not recommended to use trade secrets for IP that is easy to reverse engineer.

[51] In accounting, expenses are costs incurred in the normal course of business that are expected to be consumed or used up within a short period, usually one year. Assets, on the other hand, are resources that a company owns or controls that have economic value and are expected to provide future benefits. Assets are recorded on the balance sheet, while expenses are recorded on the income statement. Unlike capital expenditures, accounting rules treat R&D expenditures as expenses rather than assets. Therefore, R&D expenditures reduce a company's net income for the period, even though they can be a critical factor in determining a company's long-term success and profitability. As a result, companies with high intangible assets may appear to be losing value for uninformed investors, even though they may have significant potential for future growth and earnings.

Further, I determine the conditions under which there exists an interior equilibrium for the moment to undergo an IPO T and the share of innovations to keep secret α. After that, I discuss the assumptions imposed on the revenue function and do a comparative statics exercise concerning the levels of protection of trade secrets and patents.

The maximization problem and model trade-off

If the firm stays private longer it enjoys higher revenue in the model. However, the firm's cost of capital is higher when it is private. So, for some firms, it is optimal to get public at some point. Below, I find necessary and sufficient conditions for the existence of the interior equilibrium.

$$\begin{cases} \max\limits_{\alpha,T} \pi(T,\alpha) \\ \text{s.t. } \alpha \in [0,1],\, T \geq 0. \end{cases} \tag{14}$$

The solution is interior if and only if the following system of equations is satisfied:

$$\begin{cases} FOC_T : f(\alpha^*,p,s)(e^{-\Delta_1 T^*} - e^{-\Delta_2 T^*}) - (k - c(\alpha^*,\Delta_2)) = 0, \\ SOC_T : A = f(\alpha^*,p,s)(-\Delta_1 e^{-\Delta_1 T^*} + \Delta_2 e^{-\Delta_2 T^*}) < 0, \\ FOC_\alpha : f_\alpha(\alpha^*,p,s)\left[\dfrac{1-e^{-(\delta+\Delta_1)T^*}}{\delta+\Delta_1} + \dfrac{e^{-(\delta+\Delta_2)T^*}}{\delta+\Delta_2}\right] - c_\alpha(\alpha^*,\Delta_2)\dfrac{e^{-\delta T^*}}{\delta} = 0, \\ SOC_\alpha : C = f_{\alpha\alpha}(\alpha^*,p,s)\left[\dfrac{1-e^{-(\delta+\Delta_1)T^*}}{\delta+\Delta_1} + \dfrac{e^{-(\delta+\Delta_2)T^*}}{\delta+\Delta_2}\right] - c_{\alpha\alpha}(\alpha^*,\Delta_2)\dfrac{e^{-\delta T^*}}{\delta} < 0, \\ SOC_{\alpha,T} : AC - B^2 > 0, \\ B = \dfrac{\partial^2}{\partial\alpha\partial T}\pi(\alpha,T)|_{\alpha^*,T^*} = f_\alpha(\alpha^*,p,s)\left[e^{-\Delta_1 T^*} - e^{-\Delta_2 T^*}\right] + c_\alpha(\alpha^*,\Delta_2). \end{cases} \tag{15}$$

Notice that the original first-order condition for T is given by:

$$f(\alpha^*,p,s)(e^{-(\delta+\Delta_1)T^*} - e^{-(\delta+\Delta_2)T^*}) - (k - c(\alpha^*,\Delta_2))e^{-\delta T^*} = 0.$$

However, we can multiply both sides of the equation above by $e^{\delta T^*} \neq 0$ to get a modified condition:

$$f(\alpha^*,p,s)(e^{-\Delta_1 T^*} - e^{-\Delta_2 T^*}) - (k - c(\alpha^*,\Delta_2)) = 0.$$

Also, the modified second-order condition for T (equivalent to the original second-order condition under the first-order condition) is provided in the system (15) and given by:

$$f(\alpha^*, p, s)(-\Delta_1 e^{-\Delta_1 T^*} + \Delta_2 e^{-\Delta_2 T^*}) < 0.$$

Notice that for $\Delta_2 > \Delta_1$ the expression $e^{-\Delta_1 T} - e^{-\Delta_2 T}$ always positive and reaches maximum at

$$\overline{T} = \frac{1}{\Delta_2 - \Delta_1} \ln\left(\frac{\Delta_2}{\Delta_1}\right),$$

$$e^{-\Delta_1 \overline{T}} - e^{-\Delta_2 \overline{T}} = \left[\frac{\Delta_2 - \Delta_1}{\Delta_1}\right] e^{-\frac{\Delta_2}{\Delta_2 - \Delta_1} \ln\left(\frac{\Delta_2}{\Delta_1}\right)} > 0$$

The expression $-\Delta_1 e^{-\Delta_1 T} + \Delta_2 e^{-\Delta_2 T}$ is positive at $T = 0$ and approaches zero from below as $T \to \infty$. Moreover,

$$-\Delta_1 e^{-\Delta_1 T} + \Delta_2 e^{-\Delta_2 T} \begin{cases} > 0, \text{ if } T < \overline{T} \\ = 0, \text{ if } T = \overline{T} \\ < 0, \text{ if } T > \overline{T} \end{cases}$$

Sufficient Conditions for the Interior Solution.

The easiest way is to start with SOC_α:

$$f_{\alpha\alpha}(\alpha^*, p, s)\left[\frac{1 - e^{-(\delta+\Delta_1)T^*}}{\delta + \Delta_1} + \frac{e^{-(\delta+\Delta_2)T^*}}{\delta + \Delta_2}\right] - c_{\alpha\alpha}(\alpha^*, \Delta_2)\frac{e^{-\delta T^*}}{\delta} < 0.$$

By assuming $f_{\alpha\alpha}(\alpha, p, s) < 0$ and $c_{\alpha\alpha}(\alpha, \Delta_2) > 0$ we guarantee that SOC_α is satisfied. Therefore, the system of equations (16) are sufficient for the SOC_α to be satisfied.

$$\begin{cases} f_{\alpha\alpha}(\alpha, p, s) < 0 \\ c_{\alpha\alpha}(\alpha, \Delta_2) > 0 \end{cases} \tag{16}$$

We proceed with FOC_α:

$$f_{\alpha}(\alpha^*, p, s)\left[\frac{1 - e^{-(\delta+\Delta_1)T^*}}{\delta + \Delta_1} + \frac{e^{-(\delta+\Delta_2)T^*}}{\delta + \Delta_2}\right] = c_{\alpha}(\alpha^*, \Delta_2)\frac{e^{-\delta T^*}}{\delta}$$

The RHS of FOC_α monotonically decreases with T, while the LHS monotonically increases with T. At the same time, the RHS of FOC_α monotonically increases with α, while the LHS monotonically decreases with α. This implies that if you try to increase RHS you will be decreasing the LHS and vice versa. In this case, we need to prove that the maximum of LHS is higher than the minimum of the RHS and that the minimum of the LHS is lower than the maximum of the RHS under $T \geq \overline{T}$. Then there will always exist be equilibrium (α^*, T^*) that satisfy FOC_α and $T^* > \overline{T}$.

$$\begin{cases} f_\alpha(0,p,s)\left[\dfrac{1}{\delta+\Delta_1}\right] > c_\alpha(0,\Delta_2)\lim\limits_{T\to\infty}\dfrac{e^{-\delta T}}{\delta} \\ f_\alpha(1,p,s)\left[\dfrac{1-e^{-(\delta+\Delta_1)\overline{T}}}{\delta+\Delta_1}+\dfrac{e^{-(\delta+\Delta_2)\overline{T}}}{\delta+\Delta_2}\right] < c_\alpha(1,\Delta_2)\dfrac{e^{-\delta\overline{T}}}{\delta} \end{cases}$$

We could have used $\dfrac{f_\alpha(1,p,s)}{\delta+\Delta_2} < \dfrac{c_\alpha(1,\Delta_2)}{\delta}$ instead but we would like to make sure that $T^* > \overline{T}$ and not just $T^* > 0$. Therefore, the sufficient conditions for FOC_α to be satisfied are provided below by system (17):

$$\begin{cases} f_\alpha(0,p,s) > 0 \\ c_\alpha(0,\Delta_2) < \infty \\ f_\alpha(1,p,s)\left[\dfrac{1-\left(\frac{\Delta_1}{\Delta_2}\right)^{\frac{\delta+\Delta_1}{\Delta_2-\Delta_1}}}{\delta+\Delta_1}+\dfrac{\left(\frac{\Delta_1}{\Delta_2}\right)^{\frac{\delta+\Delta_1}{\Delta_2-\Delta_1}}}{\delta+\Delta_2}\right] < c_\alpha(1,\Delta_2)\dfrac{1}{\delta}\left(\dfrac{\Delta_1}{\Delta_2}\right)^{\frac{\delta}{\Delta_2-\Delta_1}} \end{cases} \tag{17}$$

Rewrite FOC_T as follows:

$$f(\alpha^*,p,s)(e^{-\Delta_1 T^*}-e^{-\Delta_2 T^*}) = (k-c(\alpha^*,\Delta_2))$$

We assume that $f(\alpha,p,s) > 0$ and $0 \leq c(\alpha,\Delta_2) \leq k$. We also assume that $f_\alpha(\alpha,p,s) > 0$ and $c_\alpha(\alpha,\Delta_2) \geq 0$. Under these circumstances, the LHS of FOC_T increases with α and the RHS decreases with α. Besides, the RHS is independent of T, while the LHS approaches maximum at $T = \overline{T}$ and minimum of 0 at $T = 0$ and $T \to \infty$. So, the LHS decreases with T if $T > \overline{T}$. We impose the boundary constraints under which there are always exist (α^*, T^*) that satisfy the FOC_T:

$$\begin{cases} f(1,p,s)(e^{-\Delta_1 \overline{T}} - e^{-\Delta_2 \overline{T}}) > (k - c(1,\Delta_2)) \\ \lim\limits_{T\to 0} f(0,p,s)(e^{-\Delta_1 T} - e^{-\Delta_2 T}) < (k - c(0,\Delta_2)) \end{cases}$$

This system is equivalent to the following system of equations:

$$\begin{cases} f(1,p,s)\left[\dfrac{\Delta_2-\Delta_1}{\Delta_1}\right] e^{-\frac{\Delta_2}{\Delta_2-\Delta_1}\ln\left(\frac{\Delta_2}{\Delta_1}\right)} > (k - c(1,\Delta_2)) \\ c(0,\Delta_2) < k \end{cases} \tag{18}$$

We next investigate SOC_T:

$$SOC_T : f(\alpha^*,p,s)(-\Delta_1 e^{-\Delta_1 T^*} + \Delta_2 e^{-\Delta_2 T^*}) < 0$$

Due to $f(\alpha,p,s) > 0$ we need to establish conditions under which $-\Delta_1 e^{-\Delta_1 T^*} + \Delta_2 e^{-\Delta_2 T^*} < 0$. We already did so. SOC_T is equivalent to: $T^* > \overline{T}$. And this is trivially satisfied because for any $T_1 < \overline{T}$ that satisfies FOC_T there exists $T_2 > \overline{T}$ that satisfies FOC_T as well. Besides that, we imposed conditions in system (17) that makes $T^* > \overline{T}$. Therefore, additional restrictions are not required to satisfy SOC_T.

Finally, we would like to establish the boundary conditions that force $SOC_{\alpha,T}$ to be satisfied.

$$f(\alpha)\left(\Delta_1 e^{-\Delta_1 T} + \Delta_2 e^{-\Delta_2 T}\right)\left(c_{\alpha\alpha} + \frac{-f_{\alpha\alpha}}{f_\alpha}c_\alpha\right)\frac{e^{-\delta T}}{\delta} > \left(f_\alpha \frac{k-c(\alpha)}{f(\alpha)} + c_\alpha\right)^2$$

Notice that neither FOC_α nor FOC_T depend on $c_{\alpha\alpha}$ and $-f_{\alpha\alpha}$. For any pair (α^*, T^*) that solves FOC_α and FOC_T we can arbitrary increase $c_{\alpha\alpha}$ and $-f_{\alpha\alpha}$ to satisfy $SOC_{\alpha,T}$ without violating SOC_T and SOC_α.

Overall, the conditions that guarantee the existence of the interior solution look as follows:

$$
\begin{cases}
f(\alpha, p, s) > 0 \\
f_\alpha(\alpha, p, s) \geq 0 \\
f_{\alpha\alpha}(\alpha, p, s) < 0 \\
0 \leq c(\alpha, \Delta_2) \leq k \\
c_\alpha(\alpha, \Delta_2) > 0 \\
c_{\alpha\alpha}(\alpha, \Delta_2) > 0 \\
f(1, p, s) \left[\dfrac{\Delta_2 - \Delta_1}{\Delta_1} \right] e^{-\frac{\Delta_2}{\Delta_2 - \Delta_1} \ln\left(\frac{\Delta_2}{\Delta_1}\right)} > (k - c(1, \Delta_2)) \\
f_\alpha(1, p, s) \left[\dfrac{1 - \left(\frac{\Delta_1}{\Delta_2}\right)^{\frac{\delta + \Delta_1}{\Delta_2 - \Delta_1}}}{\delta + \Delta_1} + \dfrac{\left(\frac{\Delta_1}{\Delta_2}\right)^{\frac{\delta + \Delta_1}{\Delta_2 - \Delta_1}}}{\delta + \Delta_2} \right] < c_\alpha(1, \Delta_2) \dfrac{1}{\delta} \left(\dfrac{\Delta_1}{\Delta_2}\right)^{\frac{\delta}{\Delta_2 - \Delta_1}} \\
-f_{\alpha\alpha}(\alpha, p, s) \text{ and } c_{\alpha\alpha}(\alpha, \Delta_2) \text{ are sufficiently high}
\end{cases}
\tag{19}
$$

Further, we will assume that we have an interior solution that satisfies system (15):

$$
(\alpha^*, T^*) \in \arg\max_{\alpha, T} \pi(\alpha, T, s, p, k, \delta, \Delta_1, \Delta_2).
$$

The supermodularity of the profit function

If $\frac{\partial^2}{\partial\alpha\partial s} f(\alpha, p, s) \geq 0$, $\frac{\partial}{\partial s} f(\alpha, p, s) > 0$, $-\frac{\partial^2}{\partial\alpha\partial p} f(\alpha, p, s) \geq 0$, and $\frac{\partial}{\partial p} f(\alpha, p, s) > 0$ then the profit function $\pi(\alpha, T, s, p, k, \delta, \Delta_1, \Delta_2)$ is supermodular in pairs (α, s), (T, s), (α, p), and (T, p).

$$
(\alpha^*, T^*) \in \arg\max_{\alpha, T} \pi(\alpha, T, s, p, k, \delta, \Delta_1, \Delta_2).
$$

$$
\begin{cases}
\dfrac{\partial^2 \pi}{\partial\alpha\partial s} = f''_{\alpha s}(\alpha, p, s) \left[\dfrac{1 - e^{-(\delta + \Delta_1)T}}{\delta + \Delta_1} + \dfrac{e^{-(\delta + \Delta_2)T}}{\delta + \Delta_2} \right] \geq 0, \\
\dfrac{\partial^2 \pi}{\partial T \partial s} = f'_s(\alpha, p, s) \left[e^{-(\delta + \Delta_1)T} - e^{-(\delta + \Delta_2)T} \right] \geq 0, \\
\dfrac{\partial^2 \pi}{\partial\alpha\partial p} = f''_{\alpha p}(\alpha, p, s) \left[\dfrac{1 - e^{-(\delta + \Delta_1)T}}{\delta + \Delta_1} + \dfrac{e^{-(\delta + \Delta_2)T}}{\delta + \Delta_2} \right] \leq 0, \\
\dfrac{\partial^2 \pi}{\partial T \partial p} = f'_p(\alpha, p, s) \left[e^{-(\delta + \Delta_1)T} - e^{-(\delta + \Delta_2)T} \right] \geq 0.
\end{cases}
\tag{20}
$$

The partial derivatives with respect to T above show the *short-term effect.* If α is fixed then both increases in p and s (patent and trade secret protection levels) should result in a firm staying private longer (T increases). If T is fixed then an increase in p lowers α and an increase in s increases α.

Proof of Proposition 1: Comparative Statics (Part 1)

Trade Secrets protection increase. If the firm experiences an increase in trade secret protection ($s \uparrow$), its revenue increases while the cost of capital remains unchanged in the short term. As a result of higher trade secret protection, the firm keeps more innovations secret ($\alpha^* \uparrow$) in the long-term, which leads to an increase in the cost of capital in the public state ($c(\alpha^*, \Delta_2) \uparrow$) and increase of revenues in both states ($f(\cdot) \uparrow$; if the allocation ($\alpha^*, 1-\alpha^*$) remains the same then the cash flows grow due to $s \uparrow$). However, the revenue in the private state increases by more than in the public state and the cost of capital in the public state increases as well. Therefore, the firm stays private longer.

Patents protection increase. If the firm experiences an increase in patent protection ($p \uparrow$), its revenue increases while the cost of capital remains unchanged in the short term. As a result of higher patent protection, the firm discloses more innovations through patents ($1-\alpha^* \uparrow$ and $\alpha^* \downarrow$), which leads to a decline in the cost of capital in the public state ($c(\alpha^*, \Delta_2) \downarrow$) and but disproportionately positively affects revenues in both states. The cost of capital in the public state decreases while remaining the same in the private state. Depending on the difference in the change in revenues in the private and public, the firm might or might not stay private longer. Hence, the effect on the time the firm stays private (T^*) is ambiguous.

Assume that we found $\alpha^* = \alpha(p, s, \delta, \Delta_1, \Delta_2, k)$ and $T^* = T(p, s, \delta, \Delta_1, \Delta_2, k)$. Take the derivative of FOC_T and FOC_α with respect to p:

$$B\frac{\mathrm{d}\alpha^*}{\mathrm{d}p} + A\frac{\mathrm{d}T^*}{\mathrm{d}p} + f_p(\alpha^*, p, s)\left[e^{-(\delta+\Delta_1)T^*} - e^{-(\delta+\Delta_2)T^*}\right] = 0, \tag{21}$$

$$C\frac{\mathrm{d}\alpha^*}{\mathrm{d}p} + B\frac{\mathrm{d}T^*}{\mathrm{d}p} + f''_{\alpha p}(\alpha^*, p, s)\left[\frac{1-e^{-(\delta+\Delta_1)T^*}}{\delta+\Delta_1} + \frac{e^{-(\delta+\Delta_2)T^*}}{\delta+\Delta_2}\right] = 0, \tag{22}$$

$$\frac{\mathrm{d}T^*}{\mathrm{d}p} = \frac{Bf''_{\alpha p}(\alpha^*)\left[\frac{1-e^{-(\delta+\Delta_1)T^*}}{\delta+\Delta_1} + \frac{e^{-(\delta+\Delta_2)T^*}}{\delta+\Delta_2}\right] - Cf_p(\alpha^*)\left[e^{-(\delta+\Delta_1)T^*} - e^{-(\delta+\Delta_2)T^*}\right]}{AC - B^2}. \tag{23}$$

Notice that from FOC_α it follows that $B > 0$. From $SOC_{\alpha,T}$ it follows that $AC - B^2 > 0$. From SOC_α it follows that $-C > 0$. Overall, $\frac{\mathrm{d}T}{\mathrm{d}p}$ could be both positive and negative and the effect of patent protection increase on the timing of IPO is ambiguous.

Next, take the derivative of FOC_T and FOC_α with respect to s:

$$B\frac{\mathrm{d}\alpha^*}{\mathrm{d}s} + f_s(\alpha^*, p, s)\left[e^{-(\delta+\Delta_1)T^*} - e^{-(\delta+\Delta_2)T^*}\right] + A\frac{\mathrm{d}T^*}{\mathrm{d}s} = 0, \tag{24}$$

$$C\frac{\mathrm{d}\alpha^*}{\mathrm{d}s} + f''_{\alpha s}(\alpha^*, p, s)\left[\frac{1 - e^{-(\delta+\Delta_1)T^*}}{\delta+\Delta_1} + \frac{e^{-(\delta+\Delta_2)T^*}}{\delta+\Delta_2}\right] + B\frac{\mathrm{d}T^*}{\mathrm{d}s} = 0, \tag{25}$$

$$\frac{\mathrm{d}T^*}{\mathrm{d}s} = \frac{Bf''_{\alpha s}(\alpha^*)\left[\frac{1 - e^{-(\delta+\Delta_1)T^*}}{\delta+\Delta_1} + \frac{e^{-(\delta+\Delta_2)T^*}}{\delta+\Delta_2}\right] - Cf'_s(\alpha^*)\left[e^{-(\delta+\Delta_1)T^*} - e^{-(\delta+\Delta_2)T^*}\right]}{AC - B^2} > 0. \tag{26}$$

The derivative of age at IPO with respect to the trade secrets protection level is positive ($\frac{\mathrm{d}T}{\mathrm{d}s} > 0$). This implies that an increase in the trade secrets protection level leads to firms staying private longer.

Proof of Proposition 2: Comparative Statics (Part 2)

We start with establishing $\dfrac{\mathrm{d}T^*}{\mathrm{d}k} < 0$. By differentiating FOC_T and FOC_α we obtain the following system of equations:

$$\begin{cases} B\dfrac{\mathrm{d}\alpha^*}{\mathrm{d}k} + A\dfrac{\mathrm{d}T^*}{\mathrm{d}k} - 1 = 0 \\ \\ C\dfrac{\mathrm{d}\alpha^*}{\mathrm{d}k} + B\dfrac{\mathrm{d}T^*}{\mathrm{d}k} = 0 \end{cases} \tag{27}$$

By solving the system and given that $AC - B^2 > 0$ and $C < 0$ we conclude the following:

$$\frac{\mathrm{d}T^*}{\mathrm{d}k} = \frac{C}{AC - B^2} < 0 \tag{28}$$

Next, let's prove that $\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_1} < 0$. By differentiating FOC_T and FOC_α we obtain the following system of equations:

$$\begin{cases} B\frac{\mathrm{d}\alpha^*}{\mathrm{d}\Delta_1} + A\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_1} - f(\alpha^*, p, s)T^* e^{-\Delta_1 T^*} = 0 \\ \\ C\frac{\mathrm{d}\alpha^*}{\mathrm{d}\Delta_1} + B\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_1} + f_\alpha(\alpha^*, p, s)\frac{(\Delta_1+\delta)T^* e^{-(\Delta_1+\delta)T^*} - (1 - e^{-(\Delta_1+\delta)T^*})}{(\Delta_1+\delta)^2} = 0 \end{cases} \tag{29}$$

Notice that the expression below is negative:[52]

$$T^*(\Delta_1+\delta)e^{-(\Delta_1+\delta)T^*} - (1 - e^{-(\Delta_1+\delta)T^*}) < 0$$

By solving the system and given that the term $((\Delta_1+\delta)T^*+1)e^{-(\Delta_1+\delta)T^*} - 1 < 0$, $AC - B^2 > 0$, $B > 0$, and $C < 0$ we conclude the following:

$$\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_1} = \frac{Bf_\alpha(\alpha^*, p, s)\frac{((\Delta_1+\delta)T^*+1)e^{-(\Delta_1+\delta)T^*} - 1}{(\Delta_1+\delta)^2} + Cf(\alpha^*, p, s)T^* e^{-\Delta_1 T^*}}{AC - B^2} < 0. \tag{30}$$

Next, let's prove that $\frac{\mathrm{d}T^*}{\mathrm{d}\delta}$ alternates in sign. By differentiating FOC_T and FOC_α we obtain the following system of equations:

$$\begin{cases} B\frac{\mathrm{d}\alpha^*}{\mathrm{d}\delta} + A\frac{\mathrm{d}T^*}{\mathrm{d}\delta} = 0 \\ \\ C\frac{\mathrm{d}\alpha^*}{\mathrm{d}\delta} + B\frac{\mathrm{d}T^*}{\mathrm{d}\delta} + f_\alpha(\alpha^*, p, s)\phi(T^*, \delta, \Delta_1, \Delta_2) + c_\alpha(\alpha^*, \Delta_2)\frac{(T^*+1)e^{-\delta T^*}}{\delta^2} = 0 \\ \\ \phi(T^*, \delta, \Delta_1, \Delta_2) = \frac{((\Delta_1+\delta)T^*+1)e^{-(\Delta_1+\delta)T^*} - 1}{(\Delta_1+\delta)^2} - \frac{((\Delta_2+\delta)T^*+1)e^{-(\Delta_2+\delta)T^*}}{(\Delta_2+\delta)^2} < 0 \end{cases} \tag{31}$$

[52]We have an expression like $y(x) = -1 + (x+1)e^{-x}$ and we consider $x > 0$. Notice that $y'(x) = -xe^{-x} \leq 0$. So, the supremum of function $y(x)$ for $x > 0$ is $y(0) = -1 + 1 = 0$. Thus, $y(x) < 0$ for all $x > 0$.

By solving the system we get the following expression for the derivative:

$$\frac{\mathrm{d}T^*}{\mathrm{d}\delta} = \frac{B}{AC - B^2}\left[f_\alpha(\alpha^*, p, s)\phi(T^*, \delta, \Delta_1, \Delta_2) + c_\alpha(\alpha^*, \Delta_2)\frac{(T^* + 1)e^{-\delta T^*}}{\delta^2}\right]. \tag{32}$$

The sign alternates because two terms in square brackets have different signs. The only way how the discount factor affects the timing of the IPO decision is through the choice of amount of innovations to keep secret. On the one hand, when the discount factor increases ($\delta \uparrow$) the present value of the benefits of having more secrets decreases (increased benefits decline – negative effect on the present value). On the other hand, the present value of an increase in the cost of capital due to having more secrets declines (increased costs decline – positive effect on the present value). The overall effect is ambiguous.

Finally, let's prove that $\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_2}$ alternates in sign. By differentiating FOC_T and FOC_α we obtain the following system of equations:

$$\begin{cases} B\frac{\mathrm{d}\alpha^*}{\mathrm{d}\Delta_2} + A\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_2} + f(\alpha^*, p, s)T^*e^{-\Delta_2 T^*} + c_{\Delta_2}(\alpha^*, \Delta_2) = 0 \\ C\frac{\mathrm{d}\alpha^*}{\mathrm{d}\Delta_2} + B\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_2} - f_\alpha(\alpha^*, p, s)\frac{((\Delta_2 + \delta)T^* + 1)e^{-(\Delta_2+\delta)T^*}}{(\Delta_2 + \delta)^2} - c_{\alpha\Delta_2}(\alpha^*, \Delta_2)\frac{e^{-\delta T^*}}{\delta} = 0 \end{cases} \tag{33}$$

$$\frac{\mathrm{d}T^*}{\mathrm{d}\Delta_2} = -\frac{C\left(f \cdot T^*e^{-\Delta_2 T^*} + c_{\Delta_2}\right) + B\left(f_\alpha \cdot \frac{((\Delta_2+\delta)T^*+1)e^{-(\Delta_2+\delta)T^*}}{(\Delta_2+\delta)^2} + c_{\alpha\Delta_2} \cdot \frac{e^{-\delta T^*}}{\delta}\right)}{AC - B^2} \tag{34}$$

Due to the fact that disclosure positively affects the cost of capital ($c_{\Delta_2}(\alpha^*, \Delta_2) < 0$) the derivative above might have positive and negative signs.

Example of $f(\alpha, p, s)$. Consider $f(\alpha, p, s) = \alpha\left[(1 - \alpha)p + \alpha s\right]$, where $p > s > 0$ and $\alpha \in [0, 1]$.

$$f_\alpha(\alpha, p, s) = 1 - 2\alpha(p - s)\begin{cases} > 0, \text{ if } \alpha < \frac{1}{2(p-s)} \\ = 0, \text{ if } \alpha = \frac{1}{2(p-s)} \\ < 0, \text{ if } \alpha > \frac{1}{2(p-s)} \end{cases}$$

$f_p(\alpha, p, s) = \alpha(1-\alpha) \geq 0$ and $f_s(\alpha, p, s) = \alpha^2 \geq 0$.
$f_{\alpha p}(\alpha, p, s) = -2\alpha \leq 0$ and $f_{\alpha s}(\alpha, p, s) = 2\alpha \geq 0$.
Finally, $f_{\alpha\alpha}(\alpha, p, s) = -2(p-s) < 0$.

Example of $c(\alpha, \Delta)$. Consider $c(\alpha, \Delta) = k\dfrac{1+\alpha^2}{1+\Delta}$, where $\Delta \geq 1$ and $\alpha \in [0,1]$.
$c(1, \Delta) = \dfrac{2k}{1+\Delta} \leq k$, $c(0, \Delta) = \dfrac{k}{1+\Delta} > 0$.
$c_\alpha(\alpha, \Delta) = \dfrac{2\alpha k}{1+\Delta} \geq 0$.
$c_\Delta(\alpha, \Delta) = -k\dfrac{1+\alpha^2}{(1+\Delta)^2} < 0$.
$c_{\alpha\alpha}(\alpha, \Delta) = \dfrac{2k}{1+\Delta} > 0$.

9 Appendix II: Headquarter Merge with IPO Data

I supplement IPO data with firm headquarters data. After excluding duplicated IPOs and IPOs with missing dates, my sample resulted in a total of 11,600 observations. The Compustat database provides information about a firm's states of incorporation and its headquarters location. However, Compustat only retains the latest headquarters information. To identify historical headquarters states, I use three sources of data. Firstly, I access augmented 10-X header data to retrieve business addresses of US firms for the period of 1993 to 2021 from Bill McDonald's homepage.[53] Secondly, I utilize historical headquarters data from Bai et al. (2020) for the years 1969 to 2003.[54] Finally, I supplement the data with information from CRSP–Compustat regarding the state of the headquarters location. After I restrict my sample to the US-headquartered firms that underwent IPO after 1980 I am left with 10,046 observations.

I began by merging IPO data (11,600 observations) with the CRSP–Compustat database. I successfully merged 10,300 observations using *permno* and *year*, and for the remaining observations, I matched an additional 915 by using the closest year to the IPO. Therefore, out of the 11,600 observations, 11,215 were successfully matched with the CRSP–Compustat

[53] Accessed in March 2023: https://sraf.nd.edu/data/augmented-10-x-header-data/.
[54] "Therefore, we supplement Compustat headquarters data in two ways. First, for firm-years that are after the availability of machine-readable SEC filings (beginning in 1994), we extract the actual state of headquarters from WRDS SEC Analytics Suite. For firm-years prior to the availability of machine readable SEC filings, we hand-collect the historical headquarters locations from the Moody's Manuals (later Mergent Manuals) and Dun&Bradstreet's Million Dollar Directory (later bought by Mergent)." Bai et al. (2020).

database.

Then, I merged the IPO matched with CRSP–Compustat file from above with headquarters data from Bai et al. (2020). I successfully merged 156 observations using *gvkey* and *year*, and for the remaining observations, I matched an additional 5,179 by using the closest year to the IPO. This resulted in a total of 5,335 matched observations. Among these, the headquarter states coincided in 4,185 cases (78%).

Finally, I merged the matched file from above with Bill McDonald's data. I successfully merged 4,207 observations using *cik* and *year*, and for the remaining observations, I matched an additional 4,374 by using the closest year to the IPO. This resulted in a total of 8,581 matched observations. Among these, the headquarter states coincided in 6,820 cases (79%) between CRSP–Compustat and McDonald's data. The headquarter states coincided in 93% of cases between Bai et al. (2020) and McDonald's data.

Initially, the IPO data consisted of 11,600 observations. Among these, 8,498 firms' headquarters states are based on McDonald's data, 1,016 observations use data from Bai et al. (2020), and 972 observations rely on CRSP–Compustat data. In total, 10,486 observations have identified state variables. After I restrict my sample to the US-headquartered firms only I am left with 10,168 observations.