Who Wins and Who Loses when Firms Stay Private Longer?

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Abstract

Does reducing the number of firms in public equity markets harm investors? How much has the value firms can get from going public changed in the past few decades? I develop a dynamic supply and demand model of the firm entry to and exit from public markets to relate firm benefits from being public to firm characteristics. Firms face a dynamic discrete choice problem on whether to be in public markets, with the benefits of being public a function of their characteristics, demand elasticities for their characteristics, and various regulatory and cost of capital changes. My structural analysis allows me to not only break down the causes of the transformation in U.S. public equity markets, but also say what the consequences of them have been for firms and investors. I find that investors would have had slightly higher excess returns but no change in their portfolio's Sharpe ratio if firms behaved as they did before Sarbanes-Oxley. I further find that a private firm's implied option value of going public has fallen by over half since the pre-Sarbanes era. The reduction is mostly caused by an increase to fixed costs of being a public company in the post-Sarbanes era.

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1 Introduction

In the past four decades, publicly traded companies in the United States have become much larger, and at the same time, the number of public companies has fallen by about half from its peak, even as initial public offerings (IPOs) became larger. Several hypotheses have been offered to explain what is causing the so-called "Listing Gap", including the rise of private equity and the subsequent fall in the cost of private capital,[1] an increase in mergers and acquisitions (M&A) activity,[2] and an increase in regulatory burdens on publicly traded companies such as Sarbanes-Oxley.[3] Each of these hypotheses will have distinct impacts on both public investors' well-being and firms' value of going public. Regulatory burdens may be a deadweight loss (outside of any fraud they prevent), whereas cheaper private capital can actually help firms. To investigate these consequences, I go beyond a reduced-form analysis and look at the listing gap and its causes using a structural model of supply and demand for public firms.

I will use this model to answer two key questions: "What is different about firms' choice to go public today?" and "What and how large are the welfare impacts of these differences for public investors and for firms themselves?" To answer the first question I estimate firm choice rules in the supply model responding to investor demand shifts in both the pre-Sarbanes and post-Sarbanes regime. This allows me to compute the firms' option value of going public in both periods. To answer the second question I will use the supply and the demand models together to both simulate a counterfactual set of securities in public markets and to estimate what investors' choices and outcomes would be for both their true and counterfactual securities choices.

[1] For example, Chernenko et al. [2021] uses the LBD restricted access dataset to look at a wide swath of private firms and their choices, and Ewens and Farre-Mensa [2020] examines the impact of the National Securities Market Improvement Act (NSMIA) on private equity investment in the US.

[2] For example, Doidge et al. [2017] finds that a large portion of delists from public markets are due to mergers.

[3] For example, Dambra et al. [2015] finds that the passage of the JOBS Act, which rolled back some Sarbanes-Oxley requirements for certain firms, increased the propensity of those firms to go public in the following years, while Ewens et al. [2024] uses a bunching estimator to directly estimate the costs imposed by Sarbanes.

I start from a demand curve for assets that borrows from the characteristics-based asset pricing setting of Koijen and Yogo [2019]. I innovate with a supply side that uses a dynamic discrete choice model of the firm's choice to go public or private. In equilibrium, supply must equal demand and responds accordingly. To capture the changes caused by the listing gap in a simple way, I add a shock to the regulatory regime and compute the before and after equilibria while allowing for trends in the cost of private capital. I estimate this model using the modern techniques laid out in Bajari et al. [2007], an indirect estimator that avoids cuse of dimensionality challenges. My three key results are: (1) Public investors do not see an improvement to their portfolios' Sharpe ratio in a no-listing-gap world; (2) the implied option value of private firms to become public has fallen, but especially so for smaller firms (over 90% in the most extreme case); (3) increased fixed costs in the post-shock regime, presumably representing increased regulatory burdens for public companies, drive most of the listing gap in my model. Changing relative costs of private and public capital play a minor role by comparison. Consider each of these key findings in turn.

First, I find that public market investors are almost completely unharmed by the rise of the listing gap. Going back to La Porta et al. [1997], increasing market completeness by having more public firms is seen as a good thing; others such as Simsek [2013] note that adding choices for investors can lead to a decrease in welfare. In my findings, estimating what investors' portfolio returns would be in the counterfactual where firms behaved as they did before Sarbanes-Oxley shows that while their monthly expected returns increase by up to 3 basis points[4], their portfolio volatility also increases, and their equilibrium Sharpe ratio is almost unchanged. The intuition for this is as follows: while many more firms are available for public investors to choose from in the hypothetical no-listing-gap world, those counterfactual firms are overwhelmingly small and marginal, which implies both higher expected returns and higher price volatility.

My second novel finding is that the implied option value a firm has from the ability to

[4]compared to their true returns in the 4th quarter of 2019

go public has fallen significantly for all firms, but especially so for smaller, weaker firms. The ability to go public can be thought of as similar to a call option on public equities markets, whereas the ability to go private can be thought of as similar to a put on public markets. Using a simulation-based estimator, I can estimate the relative values of this option in different regimes. I find that for the smallest firms, the option value of going public has fallen by over 90%, compared to a decline of around 60% for larger firms. In all cases, though, firms have less value from going public because of increased fixed costs, attributable to the increased regulation of public firms in the 21st century.

My third major result is shown in the breakdown in my model regarding how the different listing gap hypotheses affect different firms. My model shows that increased fixed costs facing public firms but not private ones is the main driver of these changes. In contrast to Gao et al. [2013] and Doidge et al. [2017], I find that the differential benefits of having a lower cost of capital as a public firm have actually increased slightly in the post-Sarbanes regime. While the cost of private capital has fallen, the cost of public equity market capital has fallen just as much if not more, an unambiguous benefit for all firms in the market. My estimates of the increase in fixed costs are likely higher than Ewens et al. [2024] since changing fixed costs can be due to more than just regulatory changes directly attributable to Sarbanes-Oxley.

To estimate my equilibrium model and find these results, I use methods developed by the industrial organization (IO) literature that are novel to finance. In particular, for estimating the supply-side model, I use the estimation technique developed in Bajari et al. [2007]. This is a two-stage simulation-based perturbation estimator for dynamic equilibrium models. In the first stage, I estimate the firm policy functions and state transition dynamics using reduced-form methods. In the second stage I can then recover the value function parameters by exploiting an optimality assumption on the estimated firm policies. Its innovation is that despite my supply-side model having high dimensionality, I do not need to estimate the entire value function, but need only simulate its evolution across many paths. This reduces an exponential scaling problem from the curse of dimensionality to a linear one which makes my model tractable. It also allows the feasibility of developing extensions with strategic interactions given the proper dataset.

Literature Review

This paper brings together many threads of literature across both finance and IO. Several papers have examined the listing gap to break down its possible causes. The titular paper, Doidge et al. [2017], finds that the effect is split almost in half between higher delists and lower new lists of firms. Some (Dambra et al. [2015]) have argued that the increased regulation of public firms relative to private ones, particularly from the Sarbanes-Oxley Act (SOX), explains much of this change. However, others (Gao et al. [2013]) note that these regulatory costs can only explain part of the observed change. Another large effect observed in the past few decades has been a fall in the price of private capital relative to public capital (Chernenko et al. [2021] among others). This change can explain the shrinking benefit of going public, logically leading fewer firms to do so. A third explanation is an increase seen in M&A activity that consolidates multiple public firms into one, as found in Doidge et al. [2017]. Changes to private markets, such as the National Securities Market Improvement Act (Ewens and Farre-Mensa [2020]), the increasing supply of private equity from various sources (Chemmanur et al. [2022]), and more M&A activity among private firms (Lattanzio et al. [2023]), have all been investigated and found to have an effect on firm choice and the listing gap.

In industrial organization, dynamic discrete choice models are a mainstay of analyzing firm behavior. They all ultimately descend from Rust [1987] and Rust [1994], and have been a workhorse in the IO literature. A recent application of this literature using empirical methods to mine is Sweeting [2013], which examines radio firms making discrete choices about format and product in a dynamic setting. This paper also uses the empirical methods from Bajari et al. [2007] to make its problem tractable. The estimation in Bajari et al. [2007] (hereafter, BBL) is new to finance, and I introduce its methods in this paper to the finance literature in solving the supply-side of my model.

A seminal paper in demand-based asset pricing using structural IO models is Koijen and Yogo [2019], which creates a demand system for public equities using a logit framework from the IO demand estimation literature. In recent years, it has seen many follow-up papers and extensions, such as Koijen et al. [2020], Haddad et al. [2021], Huebner [2023], Van der Beck [2022] and Jiang et al. [2022]. Dou et al. [2022] looks at common mutual fund flows and how they affect portfolio choices. Gabaix and Koijen [2021] extend the demand system to measure aggregate demand for stocks. Balasubramaniam et al. [2023] develop a factor model for public equity holdings. I add to this literature by making demand shifts drive the supply side choices that firms make when listing.

An extensive literature has examined the firm choice to be a private or publicly traded firm. The foundational paper of Jensen [1986] looks at principal agent problems and how they may influence the cost of capital. A few distinct threads of research have been extended from this foundation. On purely the cost of capital differences between public and private firms, Longstaff [1995] produces some basic theoretical results about the premium a private firm may pay. More recently, Asker et al. [2015] models manager incentive problems arising from borrowing. Abudy et al. [2016] develops a static model illustrating that firms will face heterogeneous changes in their cost of capital based on their characteristics. My model is both fully dynamic and incorporates rich heterogeneity in firm benefits from access to public capital markets.

This paper is also situated within a wider landscape of literature examining the economic drivers of a firm's choice of whether to be public. Ewens and Farre-Mensa [2022] provide a good overview of this literature and how it has approached this question over time. One theory is that entrepreneurs' desire to diversify their personal wealth and cash out drives entry (e.g., Bodnaruk et al. [2008]). Ritter [2011] directly examines the costs a firm pays to IPO. Denes et al. [2023] study angel investment tax credits and find they have little effect. Celikyurt et al. [2010] claim that going public confers the firm more flexibility in the M&A

market. Nguyen and Nielsen [2010] show that independent directors in public companies can improve corporate governance. A further view is that asymmetric information is a friction driving sales to public markets, where insiders believe they know better than the markets about the value of their firm and sell shares accordingly (e.g., Lowry [2003]). Compared to these papers, I focus solely on the cost of capital and differential regulatory burdens a firm faces driving its choice to be public or not.

The outline of the rest of the paper is as follows: In Section 2, I explain the supply-side and demand-side models for my equilibrium setting. In Section 3 I detail data sources used for both the reduced-form and descriptive exercises as well as for the estimation of the structural model from Section 2. In Section 4, I cover some reduced-form results of the relationship between firm entry and firm characteristics and regulatory shocks. Section 5 provides a quick overview of the solution to the demand side of the model, as well as a detailed empirical strategy for solving the supply side of the model. Section 6 presents the results of the supply-side estimation. Section 7 contains the analysis of firm option values and investor welfare derived from the estimated models of supply and demand. Section 8 concludes.

2 The Model

I develop an integrated model of supply and demand for publicly traded securities. Supply comes from firms that exogenously appear as private firms and then face a dynamic discrete choice problem of whether and when to switch from being a private firm to becoming public firm, and once they are public, vice versa. Once they are public, they become part of the possible choice set of public investors and thus enter into their portfolio choice problem on the demand side of the model. The goal is to model a dynamic setting where demand heterogeneously changes on firm characteristics over time, and firms respond with their strategies of whether and when to go public or get bought out and taken private. This means that

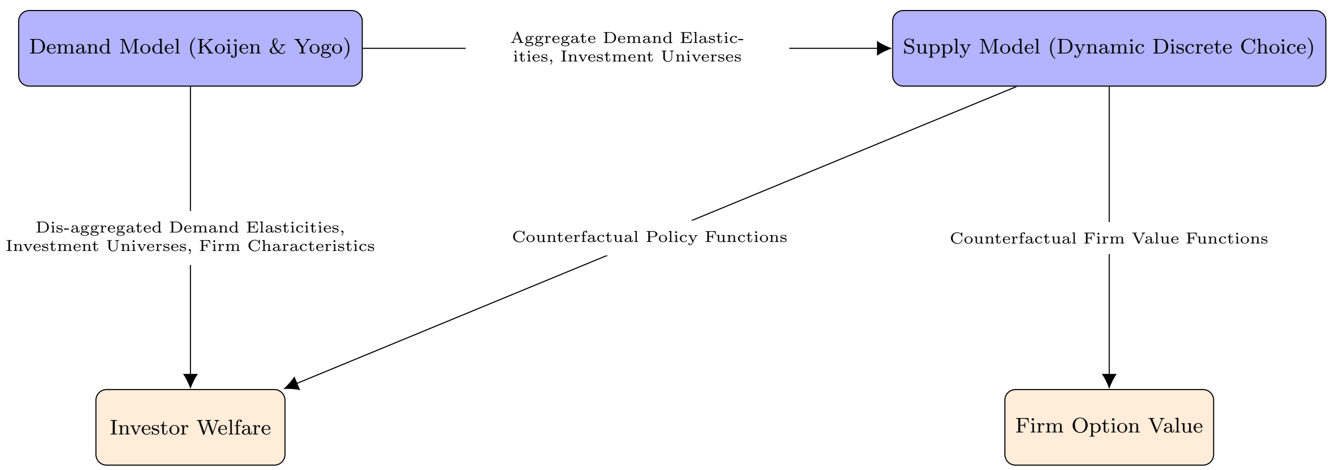

Figure 1: How the Model Elements Interact

by estimating the parameters of the firm's value function, I can break down the fixed costs versus the variable benefits of a firm being public, as well as examine the impact of both changing regulatory burdens and varying costs of private capital over time. Investors face the same portfolio choice problem as described in Koijen and Yogo [2019]. This approach is justified in a dynamic setting by assuming the absence of transaction costs and thus the ability to effortlessly rebalance their portfolios period by period. In that context, the dynamic investor problem reduces to one of a static problem estimated by their demand model.

2.1 Demand Side

On the demand side of the market is a need for heterogeneous demand for different firms based on observable characteristics. Koijen and Yogo [2019] (hereafter referred to as either KY or 2019) develop a demand-based asset pricing system with a logit model based on the Fama-French five factor model first developed in Fama and French [2015] and which is becoming increasingly adopted in the literature. I take their model of demand and use it for the demand side in my paper with minimal changes.

The characteristics of the firm in the demand model are market equity, book to market ratio, profitability, investment (growth in assets), and market beta. Market equity is the market value of the equity claim to the firm's cash flows (as opposed to the debt claim). For publicly traded firms this is clearly defined; for private firms, how to measure it can be less clear. The book to market ratio is the ratio of the book equity of the firm, which is the accounting value of the assets owned by the firm minus the debt owed by the firm, to the market equity. If we think of market equity as the price parameter in this model then book to market ratio is a measure of the size of the firm after controlling for the market equity of the firm. Profitability is the percentage of revenue the firm makes that is profit. This can be negative if the firm is losing money. Investment is defined in this setting as the year-over-year change in the book value of the assets of the firm. Note that this is not the same as the year-over-year change in the book equity of the firm because that measure also excludes debt value. Finally, market beta is a measure of how correlated the returns of a particular security are to the overall returns of the stock market. It can be thought of as a measure of the degree of aggregate risk in the stock versus idiosyncratic risk.

This demand system starts with investors choosing portfolio weights w_i to maximize expected log wealth A_i at some terminal time T. The investor also faces a short-sales constraint, so in every time period i and for every security n, $w_{it}(n) \geq 0$. This is equivalent to having mean-variance utility over the portfolio return of investor i in period t, the realized value of which can be written as

$$R_{it} = w_{it}(0)R_t(0) + \sum_{n=1}^{N} w_{it}(n)R_t(n) \ . \tag{1}$$

Here, $w_{it}(0)$ is the weighting on the outside asset, $R_t(0)$ is the return on that asset, and securities are indexed by n. This allows us to write each investor's utility, which he maximizes by choosing $w_{it}(n)$ for each security and in each time period as

$$U_i(R_{it}) = E_t[R_{it}] - \frac{1}{2}\eta \text{Var}(R_{it}) \ . \tag{2}$$

Each investor i solves the following in each period:

$$\max_{w_{it}} \quad U_i(R_{it}) \ . \tag{3}$$

$$\text{s.t. } \forall n \ w_{it}(n) \geq 0 \text{ and } w_{it}(0) + \sum_{n=1}^{N} w_{it}(n) = 1 \ .$$

This risk aversion means that investors care about both expected returns and the variance on those returns for every security. The investor chooses portfolio weights $w_{it}(n)$, which will generate a certain distribution of returns R_{it} to maximize this utility. This standard formulation leads to the expected return of the optimal portfolio in the next period, R_{t+1}, satisfying the Euler equation

$$E_t \left[\frac{A_{i,t}}{A_{i,t+1}} R_{t+1} \right] = 1 \ . \tag{4}$$

To get from this point to characteristics-based demand, the model then imposes the assumption that for every asset n, the covariance matrix Σ_{it} of its excess return over the risk-free return R_f is only a function of the vector of the Fama-French five-factor loadings of the investor Γ_{it} and idiosyncratic risk γ_{it}, which are independent and identically distributed (iid) across assets. Furthermore, the expectations of excess returns and factor loadings are polynomial functions $y_t(n)$ of the characteristics of the security $x_t(n)$ with coefficients Φ_{it} and Ψ_{it}, respectively. Formally, this is written as

$$\Sigma_{it} = \Gamma_{it}\Gamma_{it}^{-1} + \gamma_{it}\mathbf{I} \tag{5}$$

$$\mu_{it}(n) = y_t(n)'\Phi_{it} + \phi_{it} \tag{6}$$

$$\Gamma_{it}(n) = y_t(n)'\Psi_{it} + \psi_{it} \ . \tag{7}$$

Ultimately, the investor has preferences over the mean and variance of the return of his portfolio in this model. However, this functional form of the variance-covariance matrix and expected excess return means that both the mean excess return and the variance of any portfolio are entirely a function of the characteristics of the securities held in the portfolio and the idiosyncratic iid error draws for each of those securities. Because Φ_{it} and Ψ_{it} are constant across assets, the coefficients of the polynomial of characteristics for investor i don't factor into the choice problem except through how they influence security choices in the portfolio of investor i.

Because of this, portfolio weights for security n are a function solely of the characteristics of security n multiplied by the factor loading constants and expected return scaling constants for investor i in time period t. For some assets, the short-sales constraint will bind and $w_{it}(n) = 0$. For those assets without a binding short-sales constraint, the weights can formally be written as [5]

$$w_{it}(n) = y_t(n)' \left[\frac{1}{\gamma_{it}} \Phi_{it} - \Psi_{it} \kappa_{it} \right] + \pi_{it} \ , \tag{8}$$

where π_{it} is a constant across assets to allow the amount of the outside asset to vary across investors and over time, and κ_{it} is a constant across assets measuring the degree of investor i's risk aversion given his beliefs at time t. Finally, to get the portfolio weights $w_{it}(n)$ for each security to be the weights of the logit share formula, the model reverse-engineers a functional form for these constant matrices and parameters. If the degree of the polynomial $y_t(n)$ is taken in the limit to ∞, then instead of being a polynomial of characteristics, it becomes the Taylor expansion of $\exp(x_{it}(n)\beta_{it})$. This leads to a vector of characteristics multiplied by constant vectors β_{it}, leading to the demand elasticities β_{kit} for each characteristic. Finally, an indicator variable $I_i(n)$ denotes whether security n is in investor i's investment universe, which I will discuss shortly. Importantly, the demand elasticity β_{it} varies across both each investor and each time period, but the investment universe does not vary across time.

Therefore, each investor i is modeled as having log-linear relative demand (measured in

[5] For detailed proofs underlying the derivation of characteristics based-demand in the KY setting, please refer to Section II.C and Appendix A of Koijen and Yogo [2019]. In particular, the proofs of Proposition 1 and Corollary 1 in their paper are unchanged in the demand model in my setting.

portfolio weighting w) for security n with a vector of Fama-French characteristics $x_t(n)$ of

$$\frac{w_{it}(n)}{w_{it}(0)} = \exp\left\{\beta_{0it}\mathrm{me}_t(n) + \left[\sum_{k=1}^{K-1}\beta_{kit}x_{kt}(n)\right] + \beta_{Kit}\right\}\rho_{it}(n) \ . \tag{9}$$

A keen reader will notice that this is an exponential transformation of the standard logit demand function:

$$\log(w_{it}(n)) - \log(w_{it}(0)) = \beta_{0it}\mathrm{me}_t(n) + \left[\sum_{k=1}^{K-1}\beta_{kit}x_{kt}(n)\right] + \beta_{Kit} + \log(\rho_{it}(n)) \ . \tag{10}$$

This standard formulation has a weakness, though: It excludes the possibility of zero holdings. In the data, however, most investors have many publicly traded securities for which they own precisely zero shares. A second issue is the endogeneity of price, represented here as market equity as share price alone has no independent economic meaning. The instrument of long-lived investment mandates chosen by Koijen and Yogo [2019] solves both this endogeneity problem and the zero holdings problem at the same time.

The endogeneity problem is a classic one. Price (in this case, market equity) may be correlated with the error term $\rho_{it}(n)$ because of other characteristics of the security unobserved to the econometrician yet observed by investors. Also, investors cannot all be treated as atomistic. While the vast majority are small, some have well in excess of $100 billion of assets under management. Thus their idiosyncratic realized shocks can have a price impact on securities as well, thus making the error terms of other investors correlated with the market equity. The IO literature offers some popular IV strategies to alleviate this endogeneity concern, the most famous of which is the BLP instruments first formulated by Berry et al. [1995]. However, the exclusion restriction in BLP—that is, the unobserved characteristics are uncorrelated with the observed characteristics—may not be a suitable fit within an asset pricing context. Thus, an instrument based on the use of investment mandates is developed by Koijen and Yogo.

The idea is that many investors are institutional investors such as insurance companies, pension funds, or mutual funds with certain pre-defined investment strategies. These strategies can be anything from a risk reduction mandate to a sector fund mandate. The important condition is that the mandates do not change over time in response to market shocks. Formally, model $\mathbf{I}_i(n)$ as an indicator variable of whether security n is in investor i's investment universe, as defined by their investment mandate. If that variable is time-invariant, a weaker exclusion restriction can be created by computing the hypothetical market equity $\hat{\text{me}_i}(n)$ of security n if every investor other than investor i were to behave as a book-equity-weighted index fund within thier own investment mandate rather than behaving as they actually do. Specifically,

$$\hat{\text{me}}_i(n) = \log\left(\sum_{j\neq i} A_j \frac{\mathbf{I}_j(n)\text{BE}_t(n)}{1+\sum_{m=1}^{N}\mathbf{I}_j(n)\text{BE}_t(n)}\right) . \tag{11}$$

The important change I introduce is a strengthening of the exclusion restrictions relating to the concept of an investment universe. In addition to the idea that every investor takes their investment universe $\mathcal{N}_i$ as given today, they can also answer whether any hypothetical security would fall within their investment universe. This assumption sounds like a strong one but it is in line with the idea that these investment universes are the result of long-lived investment mandates. If, for example, an insurance company has a mandate to invest its funds in a fairly safe manner, then it will never purchase shares of a highly volatile tech startup, whether it is currently on the market today or enters the market at some period in the future. If the investor knows this, and any firms considering entry or exit also know this, then the exogeneity assumptions made by the Koijen-Yogo demand model can still hold in an environment with firms endogenously choosing to enter or exit. The important assumption underpinning this extension of the exclusion restriction is that while investors might not be atomistic, companies entering the market can be approximated as such. In 2019, the sum of the market capitalization of all publicly traded companies was approximately \$35 trillion. The largest IPO in US history, by contrast, was Alibaba going public in 2014 by raising \$22 billion, and most IPOs are far smaller than this. I continue to take the distribution of assets over different investors as exogenous, as in Koijen and Yogo [2019].

Because I strengthen the exclusion restrictions of the Koijen and Yogo framework, the same identification argument they make holds here. Using the instrument $\widehat{\text{me}}_i(n)$ for market equity, I estimate the demand elasticities for every investor i and each characteristic in every period t. My identification strategy faces some threats. The first one is covered in the previous paragraph and is real albeit numerically small. Another threat is that investors might not have as long-lived investment mandates as presumed. While this is unlikely for some categories of investor where the mandate is imposed by government regulations (e.g., banks and insurance companies), and other investment mandates amount to a sector exchange-traded fund saying they will stick to a specific sector, other investors, particularly more active investment managers, might be tempted to modify their investment mandates to chase a trend in the markets. Koijen and Yogo [2019] find a very high persistence in the holdings of investment advisors, with the median fund having 94% of the securities in their portfolio today also held by their portfolio sometime in the previous 11 quarters. Given that some of that variation is caused by the entry to and exit from public markets, this suggests that while trend chasing can (and probably does) happen, it is not a large component of investment mandates.

Another threat to identification introduced by an endogenous supply side is that investment mandates might influence what sort of companies entrepreneurs choose to form. Given that I do not model the process of firm formation, this could lead to a bias in the types of firms being created and eventually taken public. However, given that Jay Ritter's IPO age database (Ritter [2021]) says that the median IPO from 1980 to 2023 is nine years old, it is likely that there are far more factors more important to entrepreneurial choices than what public investors may or may not be mandated to invest in. By the time that is a realistic consideration, the firm is likely already several years old. Additionally, Chemmanur et al. [2022] examines US Census Longitudinal Business Dataset data and rejects changing early firm formation dynamics as being a significant contributor to the listing gap.

Using this demand framework, I estimate the demand elasticities β_{kit} for each investor and each characteristic over all time periods in the data sample. To develop a supply-side model, I then need to relate these elasticities to the benefits and costs a firm gets by choosing to become public or private. A logical way to do this is to think of these demand elasticities as directly influencing the cost of capital a firm j with characteristics x_{jk} faces in the public markets, relative to the cost it faces as a private firm. If the firm has a large amount of characteristic k, and many investors have a large β_{kit} in a given period, the firm will get relatively cheaper access to capital in that period on the public markets, as a result of investors competing with each other to provide that capital. This provides a highly intuitive linkage between the demand system estimates and a firm's dynamic decisions on the supply side.

A possible concern is that the demand framework I use is a static period-by-period model, whereas my supply-side model is a dynamic one, leading to a logical inconsistency between supply and demand modeling. However, I argue that as a first-order approximation, this is an appropriate method of modeling both choice problems. For investors in public equities in the US, transaction costs are very low, and easily re-balancing a portfolio from one period to the next is possible. For firms, on the other hand, capital structure choices are long-lived, which requires looking at the dynamic considerations the firm's manager faces when making the choice to enter or exit the public markets. For investment managers, for whom taxation concerns are a major input to their portfolio choice problem, it would be valuable in the future to have a dynamic characteristics based demand system to capture the long-lived nature of some of their decisions.

2.2 Supply Side

In my model, a firm deciding whether to enter public markets faces an important trade-off. On the one hand, it can get substantial benefits from accessing more sources of capital and paying a lower price for its equity financing needs. On the other hand, it will have to comply with many costly regulations from the SEC and will be exposed to fickle investor sentiments.

The firm also has to contend with the fact that the choice to enter is sticky one with meaningful adjustment costs. For a firm seeking to go public, significant costs are associated with going through with the IPO process[6], and if in the future the firm wants to leave the public markets and become private again, major expenses are also associated with that choice. Thus, developing a fully dynamic choice model to explain the listing behavior of the firm is necessary.[7]

Formally, firms on the supply side of the model are risk-neutral profit maximizers. A firm has its own characteristics x_{jt}. To make the model tractable, I assume that the firm only cares about its own characteristics and the observed aggregate market demand for characteristics, as well as the aggregate market capitalization, and not about the characteristics of any other firm. This assumption allows me to model the firm's choice as a single agent problem without considering the interactions with all of the other firms in the market. To the extent that firms are small compared to the overall stock market this choice is a reasonable one.[8]

The timing of the model is as follows. Firm j starts period t (which is one quarter) and observes its own characteristics x_{jt}, the aggregate market characteristic demand elasticities estimated from the Koijen-Yogo model β_t, and the aggregate market capitalization. Each firm j also draws iid normal profit shocks for each action it can take in a period: remain in its current state of being in or out of the public market, or change its state and enter or exit the public market. The firm observes those shocks at the start of each period as well. After this, the firm chooses to take an action and receives a period flow value from that action.

[6]See Chaplinsky et al. [2017]

[7]The discrete nature of the choice model comes from the jump change of a firm being public and having access to public markets. Before going public, a firm has very limited options for raising equity from non-institutional investors, and the markets for private equity are largely OTC in nature.

[8]While Aghamolla and Thakor [2022] have found some peer effects in firms' IPO decisions, they were largely limited to the biotech industry where unique dynamics between firms apply. Furthermore, they found only a significant effect between R&D peers, not between product market competitors. While peer effects may be important in some instances, to make the model more tractable, I will zero them out in the coming analysis.

One can think of this flow value as ex ante price of the the net difference above the choice of being private and staying private of the cash flow of the firm. In other words, the firm value as a private entity is normalized to zero. After this, the period ends and the next period begins. Firms discount the future at a constant rate δ.

The firm's problem is a dynamic one. The firm chooses whether to go public today based on its expectations of how the state of the world will play out in every future period. This means it is important to understand the transition dynamics of the firm's state and the state of the world for solving this model. For the firm's state, this is simple. The firm has an indicator variable s_t, which is 0 if the firm started the period as a private firm and 1 if it started as a publicly traded firm. The transition of this variable is deterministic based on the firm's choice.

For the state of the world the firm considers two different things: The aggregate demand elasticities for each characteristic $\bar{\beta_{tc}}$ and the log of aggregate market capitalization $\mathbf{ME}$. I denote the cost of private equity capital as r_{PE}. I model the demand elasticities as following an autoregressive process where all five characteristic demand elasticities tend to return toward their mean values. The process allows for the movements of different characteristics to influence one another as well as for the noise of the process to not be iid across characteristics. For a full description of the statistical process I use, refer to Section 5. Define $G(\bar{\beta_{tc}})$ as the probability density function of $\bar{\beta}_{t+1,c}$ given $\bar{\beta}_{tc}$, which is implicitly generated by this autoregression. This distribution is independent of $H(\mathbf{ME}_t, r_{\text{PE}})$ which is the probability density function of $\mathbf{ME}_{t+1}$ and r_{PE} given today's aggregate public market capitalization and cost of private equity capital. My choice allows absolute demand to not be dependent on any particular state of relative demand elasticities between characteristics. To ensure that the overall statistical process of state transitions is stationary, I detrend the market capitalization and then have it follow a Brownian motion process, in line with much of the asset pricing literature. These choices fit the observed aggregate elasticity estimates fairly well and are consistent with characteristics having a long-run constant effect.[9] It is also leads to the entire state space transition dynamics being weakly stationary, which is necessary for identification.

To model the firm's choice, I look at the price of the difference in cash flow that a firm will receive if it is a public company vs a private company. By normalizing the value of being private to zero, I implicitly assume that private demand does not shift over time. This assumption is likely false, but it is reasonable for two reasons. First, estimating demand for securities that are currently privately held is very difficult. Holdings data for such equities as well as detailed accounting information are hard to come by, especially for a broad set of privately held firms. Second, to the extent that private equity investor demand and public investor demand for characteristics have a positive covariance, this will lead to my estimates of the impact of the shifting demand for characteristics on firm value from assuming a constant private demand being conservative. I am explaining the same difference in firm behaviors being driven by a greater change in investor sentiment than is really the case. This assumption is reasonable to the extent that shifts in both public and private demand are driven by, for example, the same macro trends.[10]

I model the firm's choice of being private or public to affect the future cash flow a firm receives. Because I normalize the value of a firm that is private to zero, in all of the following supply model analysis, I am modeling the *marginal* value a firm gets by going public or having the option to go public.[11] Furthermore, this marginal value is a function of the characteristics of the firm x_j as well as macroeconomic variables. This is consistent with the demand model where firm characteristics are assumed to be sufficient to characterize the distribution of returns.

To get a difference that can be economically equivalent to period-by-period profits, I

[9]Precise estimates of this fit are in section 5.

[10]For instance, all else being equal, a rise in interest rates may lead to public and private investors both valuing the growth characteristic less.

[11]In the period value function, I control for private capital costs changing in the firm's *public* value, thus normalizing the private cost of capital to zero. This simplifies the firm option value calculations in Section 7.

model the period value function $v(\bar{\beta}_c, \cdot; x_j)$ as being the price ex ante of receiving the marginal cash flow over being private for a firm with characteristics x_j in market demand conditions $\bar{\beta}_c$. This price is also dependent on macroeconomic variables as well as the firm's state of being public or not. If the firm is not public, this marginal price will be zero. Then, I construct a Bellman equation V_j for a firm with characteristics x_j to be the price of all the future marginal cash flows a firm will receive when it is a public firm.

I denote $\theta = \{\alpha, \xi_{entry}, \xi_{exit}, \alpha_{\mathrm{PE}}, \mathcal{F}_{pub}\}$, which are the profit coefficients on the observable state variables interacted with the demand elasticity for those characteristics, the sunk cost of going public or going private, and the fixed cost of being a public firm, respectively. This θ contains all of the parameters of interest to be estimated in the supply-side model. I impose the structure of the period value function after suppressing the time index t as follows:

$$v(\bar{\beta}, \mathbf{ME}, a; s=0, x_j, \theta) = \begin{cases} \epsilon_j(a_0) & a=0 \\ \left[\sum_{c=1}^{5} \alpha_c \bar{\beta}_c x_{jc}\right] + \alpha_0 \log(\mathbf{ME}) - \alpha_{\mathrm{PE}} r_{\mathrm{PE}} - \mathcal{F}_{pub} - \xi_{entry} + \epsilon_j(a_1) & a=1 \end{cases}$$

$$v(\bar{\beta}, \mathbf{ME}, a; s=1, x_j, \theta) = \begin{cases} \left[\sum_{c=1}^{5} \alpha_c \bar{\beta}_c x_{jc}\right] + \alpha_0 \log(\mathbf{ME}) - \alpha_{\mathrm{PE}} r_{\mathrm{PE}} - \mathcal{F}_{pub} + \epsilon_j(a_0) & a=0 \\ -\xi_{exit} + \epsilon_j(a_1) & a=1 \end{cases}$$

Here, the action $a = 0$ or $a = 1$ represents the action of doing nothing or choosing to enter/exit, respectively, and the states $s = 0$ and $s = 1$ represent a firm starting period t as a private or public firm respectively. When this period profit function is combined with the state transition processes, the firm's dynamic choice problem thus becomes a simple dynamic programming problem:

$$V_{jt}(\bar{\beta}_t, \mathbf{ME}_t, r_{\text{PE},t}, s_t; x_j, \theta) = \max_{a_t} [v(\bar{\beta}_t, \mathbf{ME}_t, r_{\text{PE},t}, s_{jt}, a_{jt}; x_j, \theta) + \delta \int_{H(\mathbf{ME}_t, r_{\text{PE},t})} \int_{G(\bar{\beta}_t)} V(\bar{\beta}_{t+1}, \mathbf{ME}_{t+1}, r_{PE,t+1}, s_{t+1}; x_j, \theta) dG(\cdot) dH(\cdot)]. \quad (12)$$

Because this dynamic programming problem satisfies Blackwell's conditions, a unique solution for the value function and policy function $\sigma(\bar{\beta}_{kt}, \mathbf{ME}, s; x_j)$ exists. Thus, firm j's value function can be rewritten as

$$V_{jt}(\bar{\beta}_t, \mathbf{ME}_t, r_{\text{PE},t}, s_{jt}; x_j, \theta) = v(\bar{\beta}_t, \mathbf{ME}_t, r_{\text{PE},t}, s_{jt}, \sigma_j(\bar{\beta}_t, \mathbf{ME}_t, r_{\text{PE},t}, s_{jt}; x_j); x_j, \theta) + \delta \int_{H(\mathbf{ME}_t, r_{\text{PE},t})} \int_{G(\bar{\beta}_t)} V(\bar{\beta}_{t+1}, \mathbf{ME}_{t+1}, r_{\text{PE},t+1}, s_{t+1}; x_j, \theta) dG(\cdot) dH(\cdot). \quad (13)$$

By the definition of the period value function, because the value of being a private firm is normalized to zero, the expectation of V_{jt} given $s_{jt} = 0$ is equal to the NPV the firm gets from having the option to become a public firm in the future. Similarly, the expectation of V_{jt} given $s_{jt} = 1$ is equal to the net present value (NPV) of being a public firm while also having the option to go private in the future. This will allow me to compute in the estimation process numerical analogues for these value functions and therefore compute the firm's option value of going public given various policies.

This model logically leads to a decomposition between the cost of capital channel and the regulatory burdens channel. Regulatory burdens will show up as a step change in the fixed cost of being public $\mathcal{F}_{pub}$, whereas changing the cost of capital will change the estimates for the α_c coefficients on characteristics. Mergers and acquisitions are ignored in this model since it doesn't consider strategic interactions between firms. For the purpose of firm option value or investor welfare, though, it is likely that M&A is neutral overall. Firms that are public or private may be purchased by a public firm with the same relative difficulty. In particular, the degree of due diligence an acquirer will do is well beyond what could be gleaned from the filings public companies are required to make, which limits the relevance of that choice to the odds of being bought out, all else being equal. For investors, M&A doesn't change anything other than who owns what. An investor in a public company that is purchased may take the money he receives and purchase stock in the acquirer if he still wishes to have exposure to the acquired company.

2.3 Firm Option Value

As discussed earlier, it makes sense to think about the ability of a currently private firm to go public as an option, albeit one with poorly observable cash flow. This allows the value function V_j for firm j to be the NPV of the benefit the firm would receive by exercising that option, conditional on the firm being private at the beginning of the period. Similarly, I can look at V_j as representing the sum of the ongoing future cash flow from being public and the value of an option to leave the public markets and become a private company again. Furthermore, I can think of regulatory changes in public markets as affecting the strike price of this option and compute the change in the value of the options given the different regulatory changes and implied strike prices.

Intuitively, the firm's option of going public is a call option on public capital markets with a strike price that is equal to the sunk cost of going public plus the expected NPV of the cost of ongoing compliance and regulatory burdens. If those sunk costs or ongoing burdens are smaller, that equates to a lower strike price and therefore a higher option value. Similarly, by having the option to go private, a public firm is endowed with a put option on public capital markets at a certain strike price as well, represented by the costs it must pay to go through a leveraged buyout (LBO).

2.4 Investor Welfare

To conduct welfare analysis for public investors, I will first simply look at the combined effects of all of the channels changing the makeup of public firms. This is fairly straightforward since I have demand elasticity estimates for every investor in every period, as well as the universe of available public securities and their characteristics in each period. Combining this with the estimated Koijen-Yogo investment mandates allows me to compute the expected utility of each investor over time using standard methods.

Each investor has an observed investment universe $\mathcal{N}_i$, which is defined in Koijen and Yogo as being the set of all stocks held in any of the previous eight quarters by that investor. This forms the choice set for the investor's portfolio choice problem. The choice set, combined with the characteristic demand elasticities, is enough to calculate the expected utility of the investor's optimal portfolio in each time period where we observe that investor using the following logit utility formula:

$$E[U_{it}^*] = \gamma + \log\left(\sum_{n=1}^{|\mathcal{N}_i|} \exp\left\{\beta_{0it}\text{me}_t(n) + \left[\sum_{k=1}^{K-1}\beta_{kit}x_{kt}(n)\right] + \beta_{Kit}\right\}\right). \tag{14}$$

Here, γ is Euler's constant, and the expected portfolio utility is mathematically equivalent to the maximum choice expected utility under a discrete choice logit framework. However, unlike the standard analysis where consumers have preferences over observable characteristics that don't change over time, in the KY setting, investor preferences do update in a period-by-period manner. Therefore, to be able to quantify the impact of the choice set on investor welfare, I need to hold constant the investor's preferences while allowing the choice set to vary over time. To accomplish this I modify the above formula as follows:

$$E[U_{it}^*] = \gamma + \log\left(\sum_{n=1}^{|\mathcal{N}_i|} \exp\left\{\beta_{0is}\text{me}_t(n) + \left[\sum_{k=1}^{K-1}\beta_{kis}x_{kt}(n)\right] + \beta_{Kis}\right\}\right). \tag{15}$$

Here, β_{kis} is the investors' demand elasticity for characteristics in the first period the investor is observed in the data. This means that the analysis now looks at, if the investor hadn't changed how they valued characteristics over time, would they be better or worse off with the selection of public companies in their investment universe in one period vs another. I compute this analysis for every investor in every period using the observed investment universe as part of the analysis in Section 7.2.

The second, much more meaningful, investor welfare analysis, is to analyze how investors would have fared when faced with a counterfactual choice set. In Section 7.3 I describe how I construct the counterfactual investor choice set where firms behaved in the 4th quarter of 2019 as if they were in the pre-Sarbanes regime instead of the way that they actually behaved. Then, I will estimate the holdings of each investor when given both the true choice set of publicly traded securities, and when given the counterfactual set of securities, using equation (10). Finally, I construct a three-factor model of market equity, book to market ratio, and investment, and bin each counterfactual security to the portfolio with characteristics most similar to that counterfactual security's characteristics. This will allow me to estimate what the expected return and volatility of investor portfolios would have been in the counterfactual setting and compare it to the same measurements for the observed investor choices.

3 Data Sources

I have data on all holdings of large institutional investors with more than $100 million in assets under management (AUM) in publicly traded common stocks on the three major US exchanges (NYSE, NASDAQ, and ARCA), derived from SEC 13F forms for the years 1980-2019. This information only covers long positions in US traded equities, and all other assets are considered the outside asset, in line with the previous literature. I choose to exclude the years 2020-2023 from the analysis to exclude the impact of the pandemic in my data,[12]

[12] The problem is more nuanced than just the pandemic causing large amounts of variance in security characteristics. During the lockdowns, IPOs ground to nearly a halt, while special purpose acquisition companies (SPACs) boomed. This trend sharply reversed in 2022 as the SPAC boom ended abruptly. This means that any analysis of IPOs in 2020 and 2021 will be deeply misleading when compared to years either

which is not related to either the regulatory burdens or the cost of private capital that I wish to study and which would dominate the securities market dynamics in much of that period. I combine this with pricing, dividend, and shares outstanding data from CRSP and data on security fundamentals from Compustat. These data are sufficient to estimate the demand side of the model and will also be important in parts of the supply side estimation.

For the entry choice and the supply-side estimation I use Jay Ritter's IPO database, merged with CRSP and Compustat data to get the market equity, book equity, and profitability of entrants at the first time they report their accounting figures in the public markets. This aligns my supply-side data with the demand estimation data. However this discrepancy between reporting of data on public versus private companies leads to selection issues: I don't observe in this dataset the characteristics of firms that considered going public but ultimately declined to do so. To remedy this, I also incorporate a database of withdrawn IPOs supplied by S&P Capital IQ Pro, which contains data about the market equity, book equity, and profitability of firms that filed for an IPO but then didn't follow through with it. This choice to use withdrawn IPOs as a proxy for the counterfactual of firms considering an IPO and deciding against it is the same as in Bernstein [2015], and I use these data to represent the characteristics of firms who didn't choose to enter in a given time period. From the S&P data, I can impute firm profitability and book equity at the time of their filing, as well as the implied market value (based on the proposed offer price) the firm would have had if the IPO had gone through. This solves the selection issues because a firm observed withdrawing their IPO had characteristics that led them to file to go public, but the market was unwilling to bear the proposed price. This way, I essentially assume that firms that withdraw their IPO do so because "the price was wrong", whereas for completed IPOs the price was right.

I am not able to observe characteristics-based demand for private securities, as a result of not being able to comprehensively observe private holdings. Because of this limitation, I

before or after this time period.

Table 1:
Summary Statistics on Entry and Exit Events for Public Companies

Type	(1) Number of Obs.	(2) Mean ME	(3) Mean BE	(4) Mean Profitability	(5) Mean Investment	(6) Mean Market Beta
Completed IPO	2088	$1326M	$579M	-5.7%	-	-
Withdrawn IPO	728	$738M	$263M	-196.24%	-	-
Buyout	580	$1326M	$682M	8.35%	4.58%	1.36
Remain Public	3751	$5336M	$2694M	14.49%	8.85%	1.23

Table 1 presents summary statistics for the four different types of firms used in the supply-side modeling. Completed IPOs are firms that filed for an IPO and subsequently actually listed on one of the three big US exchanges. Withdrawn IPOs are firms that filed for an IPO and subsequently withdrew their filing before listing on a public exchange. Buyouts are purchases of whole public companies by private equity, as defined by S&P Capital IQ Pro. Remain Public are a random sampling of firms that spent the entire quarter as public firms. Withdrawn IPO profitability is heavily skewed by pre-revenue biotech firms.

use a cruder measure of private demand to proxy for the private cost of capital a firm faces, looking at the average Private Equity IRR in North America for each year in the data time period. These data, alongside total private equity investment volumes, are sourced from Preqin Venture Capital and are likely to be accurate. The data are from filings of pension funds who are required to truthfully report various elements of their private investment portfolios.

For the exit choice, I similarly use a database of whole company acquisitions with private equity involvement from S&P Capital IQ Pro as my dataset of buyouts. To measure the firms which considered being bought, out I sample 100 public firms every quarter who were public in the previous quarter and remained public throughout the entirety of the current quarter.[13] For both of these categories, I join the companies' identities with their accounting information from the CRSP and Compustat data at the time they were bought out. For the public firms that remained public, I limit my consideration to a random sample instead of looking at every public firm that did not get bought out primarily for performance reasons in the estimation. Table 1 details the summary statistics for my data on entry and exit events. All dollar values are inflation adjusted to constant 2022 dollars.

[13]This is for computational and numerical reasons. There is no economic reason that all public firms which did not go private couldn't be used here.

4 Descriptive and Reduced Form Evidence

Previous literature has examined how the listing gap breaks down over a number of suspected causes. Regulatory regime changes, macroeconomic variables, private equity benchmarks, and M&A activity indicators have all been used to explain parts of the change in firm behavior to go public. Doidge et al. [2017] conduct a multinomial logit regression on firm delists broken down between voluntary, merger, and for cause.[14] The independent variables in their analysis include firm characteristics such as size, profitability, and investment, as well as a dummy for being after 1996, the peak year for listed US firms. Their regressions find that only considering firm characteristics does not explain much of the change in delist behavior. They also find that interacting firm size with the post-peak dummy shows different-sized firms responding differently pre- versus post-peak.

Lattanzio et al. [2023] first found that macro variables measuring M&A volume, economic growth, and equity market maturity alone explained much of the quantity of listed firms across countries during the period of the rise of the US listing gap. In contrast to this paper, which seeks to explain directly the determinants of firm behavior in choosing to go public or private, their regressions focus on measuring the delta between the rate of listings in the US and the rate in other advanced economies worldwide. Consistent with the existing literature they choose three explanatory channels for the rise of the listing gap: M&A, private equity, and regulation. By regressing the quantity of listings on macro variables including M&A activity and private equity, they find that M&A and private equity (PE) both account for a roughly equal share of the listing gap without including any regulatory dummies. Including regulation such as the Sarbanes-Oxley Act in their analysis, they find that the increase in the listing gap is dependent on the regulatory dummies but that the effect is small, around half that of M&A. However, they do not consider any firm characteristics in this analysis as they are solely looking at the phenomenon from a macro level, a potential weakness for

[14]Here, merger would include both strategic M&A and buyouts by private equity, while voluntary usually means a firm listed overseas and delisted domestically. "For cause" implies a firm failing to meet minimum financial health requirements set by the exchange.

studying the heterogeneity of the impacts of each of these channels.

To link my work to the existing methodologies used to study the decline of public markets, I regress my controls on market demand, firm characteristics, PE costs, and macro and regulatory variables on a binary probit model of firm entry versus non-entry to public markets. I then do the same for the choice of firm exit vs. non-exit from public markets once it is public. Table 2 shows the results of the entry choice probit model estimation:[15][16]

The Baseline specification uses no demand information and is only including the firm characteristics and macro variables as regressors. I estimate the Baseline specification both as a probit model and as a linear probability model using OLS. The Baseline (OLS) specification finds the coefficient on Sarbanes-Oxley is small and not significant at the 5% level. This is consistent with some of the regressions in earlier papers such as Gao et al. [2013], which showed limited impact from Sarbanes-Oxley in regressions that include a time trend on IPO propensity. The All Controls specification includes controls for both the estimated Koijen-Yogo demand elasticities and the interactions between those elasticities and the firm characteristics. This specification shows significant macro variable impacts for both regulatory dummies and for private capital market benchmarks. This supports the idea that heterogeneous demand is critically important to control for in order to understand the impact of macro factors on the entry choice to public markets. This finding is robust to the model being estimated as either a probit or an OLS linear probability regression. The last two specifications are the ones I actually use in the policy function in the supply model. To reduce the number of variables in the policy function (and thus in the firm's value function), I only include the characteristic-elasticity interactions to capture the impact of both firm characteristics and market demand shifts. I also break the data into two time periods to estimate regulatory impacts to be compatible with the simulation-based estimator in the

[15] I conduct a similar exercise for firm exit in Appendix B.

[16] Standard Errors are clustered at the quarter level in line with the time period used everywhere else in the model. I don't cluster on firm because most firms are only observed once in the entry data.

Table 2:

Entry Probit Regressions on Characteristics and Macro Variables

	Baseline	**Baseline (OLS)**	**All Controls**	**All Controls (OLS)**	**Pre SOX**	**Post SOX**
SOX Dummy	−0.6362***	−0.1311*	−1.3392***	−0.2966***	-	-
	(0.1596)	(0.0720)	(0.2232)	(0.0726)		
JOBS Act Dummy	0.6593***	0.3080***	0.7163***	0.3048***	-	-
	(0.1735)	(0.0641)	(0.1918)	(0.0656)		
Market Equity	0.9469***	0.1447***	0.7201***	0.1153	-	-
	(0.0382)	(0.0080)	(0.0884)	(0.1626)		
Book to Market	−0.1370***	−0.0357***	−0.3747***	−0.0660***	-	-
	(0.0276)	(0.0077)	(0.0499)	(0.0121)		
Profitability	0.0022**	0.00001***	0.0154**	0.0008***	-	-
	(0.0009)	(0.0000)	(0.0053)	(0.0002)		
Market Equity x β_{me}	-	-	−1.8432***	0.0305	0.4220***	0.9137***
			(0.4388)	(0.1795)	(0.0838)	(0.0446)
Book to Market x β_{bmr}	-	-	−12.5514***	−1.4986**	4.7770*	1.7525
			(1.8659)	(0.6346)	(2.4653)	(3.1703)
Profitability x β_{profit}	-	-	−0.2037**	−0.0109**	0.0500***	0.0066*
			(0.0798)	(0.0034)	(0.0054)	(0.0034)
Market Cap	0.8382***	0.7687***	0.4595*	-0.0191	−4.2977***	1.2641***
	(0.1698)	(0.0842)	(0.1855)	(0.0824)	(0.4641)	(0.2693)
PE Cost	0.1438***	0.0116***	0.1360***	0.0063***	-0.0040	0.0705***
	(0.0128)	(0.0024)	(0.0162)	(0.0020)	(0.0147)	(0.0184)
Demand Controls	N	N	Y	Y	Y	Y
Time Trend	Y	Y	Y	Y	N	N
N	3346	3346	3346	3346	2002	1344
(Pseudo) R^2	0.5850	0.5010	0.6029	0.5190	0.6196	0.4373

Table 2 presents estimates for the entry decision regressed on various characteristics, market variables, and macro factors. The baseline regression uses only firm characteristics and macro variables to estimate a probit model of entry, with the IPO firms having a dependent variable of 1 and the withdrawn IPO firms having a dependent variable of 0. The baseline (OLS) regression is the same as baseline except estimated as a linear probability model with year fixed effects. All Controls is a probit regression that adds demand elasticities for characteristics and characteristic-elasticity interactions. All Controls (OLS) is the same regression as All Controls but done using OLS. The Pre SOX and Post SOX regressions are the probit policy functions estimated in the first stage of the BBL estimator for the pre- and post-Sarbanes-Oxley regimes respectively. Standard Errors are in parentheses.

*p $\leq$ 0.1; **p $\leq$ 0.05; ***p $\leq$ 0.001.

second stage of the supply model, instead of using a regulatory dummy.[17]

Because of the need in the structural model to have the entry and exit decisions depend on the same variables, coupled with the desire for a parsimonious model, I will only include the characteristic-elasticity interactions in the supply model in Section 2. This corresponds to the third and fourth specifications in Tables 2 and 3, for the pre-Sarbanes and post-Sarbanes model regimes, respectively. Entry decisions do not include data about investment or market beta because market beta is not defined for private companies, and investment (growth in assets) is not visible in the data for private companies that did not go public. This approach allows me to have entry and exit be based on the same variables while not losing very much explanatory power in the model of the policy functions. I will continue to use a probit model because having iid normal errors allows the computation to be greatly sped up.

5 Empirical and Computational Strategy

5.1 Demand Model

I follow the estimation strategy of Koijen and Yogo [2019] to estimate the characteristic demand elasticity for each investor in every quarter from 1980 to 2019. I merge parsed 13F data from Chris Conlon and other sources with CRSP and Compustat data on security characteristics. Investors who do not hold at least 100 securities, as well as those who do not hold at least 1 outside asset, are dropped, and the characteristics in the estimation sample are winsorized at the 5% level. Then I run the IV regression of equation (11) using the market equity instrument defined in equation (12) on the cross section of each investor's holdings. This computes the demand elasticities β_{kit} for each manager i in each quarter t for each of the five Fama-French characteristics k as well as the baseline demand elasticity

[17] Because the regulatory shocks are only observed one time, there is not a principled way to determine how to incorporate them into the firm's expectations. I therefore choose to treat them as essentially MIT shocks for simplicity.

β_{Kit}, which determines the amount of the outside asset the investment manager holds[18].

Once I have the investor elasticities, I need to determine the market-level elasticities for each characteristic. Weighting by assets under management (AUM), I average the demand elasticities across each period for all investors for each characteristic. This becomes $\bar{\beta}$, or the vector of overall market demand elasticities for each characteristic k. Implicit in this aggregation is the assumption that firms do not care about the identity of which investors are investing in them; they only care about the market demand for characteristics and how that will interact with their own characteristics.

5.2 Supply Model

Since I have quarterly demand elasticity estimates, I use quarterly periods for the supply model and aggregate the characteristics of both the firms that entered and those that did not over that period, as well as the institutional demand estimates for each characteristic. This dynamic programming model has a high-dimensional state space, since the firm is considering all five characteristics and their market elasticities, as well as multiple macro variables including aggregate market capitalization to allow some indication of absolute demand.[19] For identification in this setting, it is normally necessary to set the discount rate exogenously,[20] so I choose it to be $\delta = 0.99$, leading to a standard discount rate of just under 4% per year.

The primary estimation task on the supply side is to estimate $\theta = \{\alpha^5_{k=1}, \xi_{entry}, \xi_{exit}, \alpha_{\mathrm{PE}}, \alpha_0, \mathcal{F}_{pub}\}$, from equation (17). This contains the variable benefit parameters α on both macro variables and characteristic-demand interactions, as well as the fixed and sunk cost parameters. This results in nine different variables to estimate and runs into the curse of dimensionality. Therefore, to get around this serious problem and estimate the firm's value function parameters, I employ the method of Bajari et al. [2007] and use a two-stage simulation-

[18] Special thanks to Paul Huebner for giving me the parsed and cleaned holdings data from 2017-2022, from Huebner [2023].

[19] All of the KY demand estimates are for relative demand, as they regress on portfolio shares.

[20] See Rust [1994].

based perturbation estimator. In contrast to a traditional nested fixed point approach, this approach has the benefit that it never requires me to actually compute the value function grid, which would be impractical in a nine-dimensional setting for all but the very smallest of grids. It will also allow me to easily simulate counterfactual firm behavior in Section 7.

In the first stage of BBL estimation, I estimate the policy functions $\sigma_j(\bar{\beta}_t, \mathbf{ME}_t, s_{jt}; x_j)$ directly from the data on entries and exits using a reduced-form probit model. This allows me to estimate how the firm's choice depends on each of its characteristics as well as the macroeconomic variables I am modeling. I also estimate the parameters of the transition dynamics of the global state variables $\bar{\beta}_t$ and $\mathbf{ME}_t$ using an autoregressive process in this first stage. These reduced-form estimates will then be used in the second stage to simulate the state and choice paths of many firms on many different simulation paths.

The second stage of BBL estimation is based on a key assumption that the observed firm choices, and thus the policy functions $\sigma(\cdot)$ estimated from those choices, are optimal. This assumption means that in the BBL setting, any alternative policy function $\tilde{\sigma}_i(\cdot) \neq \sigma(\cdot)$ should give less value to the firm than the true policy function. BBL estimation uses this inequality to construct a minimum distance estimator for θ. The distance is defined based on the total deviations from this optimality condition across multiple different firms using a large number of alternative policy functions.

To begin with the first stage, I fit a VAR process to the difference between the average demand for characteristic μ_{β_k} and the current period aggregate elasticity $\bar{\beta}_{k,t}$. This allows demand elasticities to vary jointly with each other and is efficient computationally to both estimate and simulate. [21] This leads to the following formula for the demand elasticity transition dynamics:

$$(\bar{\beta}_{t+1} - \mu_\beta) = \Gamma(\bar{\beta}_t - \mu_\beta) + \Sigma\nu_t. \tag{16}$$

[21]In practice, the co-movement and noise covariance parameters are small, and the Granger causality test for most characteristic pairs is rejected.

This model of demand elasticity transition dynamics is implicitly assuming that in the long run, characteristics don't change their impacts on the mean and variance of expected returns and that all of the movement is driven by short-term shocks to investors' beliefs. If this is the case, then the diagonal of Γ will contain values between zero and one, which is the case as shown in Section 6.

An identification requirement of the BBL estimation process is that the transition dynamics of the state variables in the model must be weakly stationary. To model the behavior of the aggregate market capitalization evolution while satisfying this requirement, I use the detrended log of aggregate market capitalization and model its evolution as a Brownian motion process:

$$\mathbf{ME}_{t+1} = \mathbf{ME}_t + \sigma_0 \nu_{t0}. \tag{17}$$

Finally, to estimate the evolution of the parameter on the cost of private capital r_{PE}, I estimate it as following an autoregressive model independently from both the KY demand elasticities and the aggregate market capitalization:

$$(r_{\text{PE},t+1} - \mu_{r_{\text{PE}}}) = \gamma(r_{\text{PE},t+1} - \mu_{r_{\text{PE}}}) + \sigma_{\text{PE}} \nu_{t,\text{PE}}. \tag{18}$$

I estimate the firm's policy function in stage 1 of the BBL estimation by estimating a probit model on the Fama-French characteristics of the firm interacted with the demand elasticities in the period and the macroeconomic variables observed in the quarter. For entry, firms that successfully complete an IPO are compared with those that withdrew their IPO in the same period. For the exit choice, firms that were bought out in an LBO transaction are compared with a sample of 100 firms in that period that started the period as public firms and ended the firm as public firms. A slight complication is that I only observe some of the Fama-French characteristics for firms that are not currently public. Thus, some characteristics (investment and market beta) are estimated only on the set of firms that are bought out and firms which were public and chose not to be bought out, whereas the other characteristics are estimated between both the entry and exit choice. Finally, I adjust the constant parameters of the entry and exit probit policy functions to match the persistence of the public/private choice of firms observed in the data. This identifies the sunk costs $\xi = \xi_{exit} = \xi_{entry}$ relative to the fixed costs $\mathcal{F}_{pub}$.[22] Table 4 presents the results of this probit estimation.

In the second stage of the estimation, I construct a minimum distance estimator $g(\theta, \cdot)$, which I now describe. Using K simulations, I compute out to T periods in the future the simulation analogue of the firm's value function, given initial state x_j and β_0 and the policy function estimates $\sigma(\bar{\beta}_{kt}, \mathbf{ME}_{kt}, r_{\text{PE},kt}, s_{kt}; x_j)$ from the first stage reduced-form estimation. I choose several different combinations of firm characteristics to span the firm characteristic space while having all of the firms be close to the entry/exit margin for public firms. For each firm j, I compute the expectation of the simulation analogue of that firm's value function over all simulations:

$$W_{jk}(\beta_0, 0; \theta) = \underbrace{\sum_{t=0}^{T} \delta^t v(\bar{\beta}_{kt}, \mathbf{ME}_{kt}, r_{\text{PE},kt}, \sigma(\bar{\beta}_{kt}, \mathbf{ME}_{kt}, r_{\text{PE},kt}, s_{kt}; x_j), s_{kt}; x_j, \theta)}_{\text{Sum of Discounted Period Cash Flow Prices Dependent on } \theta}$$
$$+ \underbrace{\sum_{t=0}^{T} \delta^t \epsilon_{jkt}(\sigma(\bar{\beta}_{kt}, \mathbf{ME}_{kt}, r_{\text{PE},kt}, s_{kt}; x_j))}_{\text{Sum of iid Profit Shocks Not Dependent on } \theta}$$

$$W_j(\beta_0, 0; \theta) = E_k\left[W_{jk}(\theta)\right] \tag{19}$$

Note that while the unconditional expectation of the idiosyncratic profit shocks ϵ_{jkt} is zero, the conditional expectation on the firm choosing the action a is not zero. However, that conditional expectation is crucially not a function of the parameters being estimated, only of $\sigma(\cdot)$, the policy function. Also, because the entire state space of this model is recurrent,

[22]Separately identifying ξ_{entry} and ξ_{exit} is not possible with my data.

it does not matter which starting state I use for the simulation paths, so I choose a starting state β_0 of the mean demand elasticities and a detrended market capitalization of 0, so the market is precisely on trend.

Because I assume that the policy function $\sigma(\bar{\beta}_{kt}, \mathbf{ME}_{kt}, s; x_j)$ estimated in the first stage is optimal, it must rationalize the firm's choice. This implies that for any alternative policy $\tilde{\sigma}_i(\cdot) \neq \sigma(\cdot)$, the following inequality of the firm's value function must hold:

$$V_j(\sigma(\cdot), \hat{\theta}) \geq V_j(\tilde{\sigma}_i(\cdot), \hat{\theta}). \tag{20}$$

Since the simulation analogue $W_j(\theta)$ is an unbiased estimate of the true value function, and the state transition process is weakly stationary and Markov, and thus the entire state space is recurrent, the inequality can be rewritten as[23]

$$W_j(\beta_0, 0; \sigma(\cdot), \hat{\theta}) \geq W_j(\beta_0, 0; \tilde{\sigma}_i(\cdot), \hat{\theta}). \tag{21}$$

This system of inequalities is at the heart of how the BBL estimator works. I draw I alternative policies $\tilde{\sigma}_i(\cdot)$ from a uniform distribution of probit parameters between $\frac{2}{3}$ and $\frac{4}{3}$ of the true probit parameters estimated in the first stage and compute the simulation analogues of the value function for each of those alternative policies:[24]

$$W_{ijk}(\beta_0, 0; \theta) = \sum_{t=0}^{T} \delta^t v(\bar{\beta}_{kt}, \mathbf{ME}_{kt}, \tilde{\sigma}_i(\cdot), s; x_j, \theta) + \sum_{t=0}^{T} \delta^t \epsilon_{ijkt}(\tilde{\sigma}_i(\cdot)) \tag{22}$$

$$W_{ij}(\beta_0, 0; \theta) = E_k \left[W_{ijk}(\theta) \right]. \tag{23}$$

I now have the simulation analogue of the true value function, the simulation analogue of many false value functions, all as functions of θ, the parameters being estimated in the second

[23]For a detailed discussion of the econometric proofs behind this estimation for the case of a dynamic discrete choice model such as this one, please refer to Sections 4.1 and 5.1 of Bajari et al. [2007].

[24]The BBL estimator will be consistent so long as the distribution chosen contains the true policy function $\sigma(\cdot)$. The choice of distribution then only has implications for efficiency, and in my testing, this uniform distribution provided the most efficient second-stage estimates.

stage. Because of simulation error, noise in the observed choice data, and a large number of alternative policy functions, it is not possible to perfectly rationalize the simulation choices, so the BBL estimator uses a minimum squared error estimator to find the best possible set of value function parameters θ to minimize the squared errors in equation (27):

$$g(\theta, \cdot) = \sum_{i=1}^{I} \sum_{j=1}^{5} \mathbf{1}([W_j(\cdot;\theta) - W_{ij}(\cdot;\theta)] < 0) \cdot [W_j(\cdot;\theta) - W_{ij}(\cdot;\theta)]^2 \tag{24}$$

To get the estimates of the value function parameters, I compute the $\hat{\theta}$ that minimizes $g(\cdot)$ using numerical methods:

$$\hat{\theta} = \underset{\theta}{\operatorname{argmin}} \quad g(\theta, \cdot) \tag{25}$$

6 Results

Performing the estimation described in Section 5 on the data from different time periods leads to differing estimates of the value function parameters, which allows me to estimate how much the different channels (cost of capital channel vs. regulatory channel) have contributed to the change in the firm's problem. Traditionally, demand-based asset pricing models conduct a static treatment of investor demand, estimating the elasticity period by period. As I discussed earlier, for US public equities markets where transaction costs are low and rebalancing a portfolio period by period is not costly, this is a reasonable simplification even if you believe that investors make their choices dynamically considering the future. However, to ascertain the firm's vision of how market conditions will be in the future, it is necessary to integrate some dynamics explicitly with the demand behavior. To my knowledge, this is the first time this has been done with characteristics-based demand. To allow for the possibility of demand for one characteristic influencing demand for another, I use a VAR model to estimate the transition behaviors of the characteristic demand elasticity. This is important since it allows me to model demand shocks for different characteristics being

Table 3:
Demand Elasticities State Transition VAR matrix

	β_{me}	β_{bmr}	β_{profit}	β_{Gat}	β_{bmktrf}
β_{me}	0.9510	-0.0079	0.0042	0.0579	-0.0178
β_{bmr}	0.0433	0.6837	-0.0097	-0.0091	-0.0249
β_{profit}	0.1168	-0.6524	0.5187	0.0910	-0.0379
β_{Gat}	0.1728	0.0267	-0.0156	0.6304	0.0223
β_{bmktrf}	0.0033	-0.0155	0.0025	-0.0148	0.7197

Table 3 shows the own-characteristic and cross-characteristic VAR evolution estimates.

possibly correlated. Estimating the VAR model for the demand elasticity state transitions leads to the following matrices for the AR(1) parameters Γ displayed in Table 3.

Notice that most of the cross-interaction terms for the VAR parameters are small, with the exception of the impact of the change in the book to market ratio characteristic demand elasticity on the demand elasticity on profitability. Further, the estimated trend is zero as desired, and the process is stationary. To model the behavior of the aggregate market capitalization, I use a discrete random walk process with a mean of zero (to account for de-trending the aggregate market capitalization) and a yearly standard deviation of returns of 20%.

To estimate the model in a context of regulatory changes, I focus on the enactment of Sarbanes-Oxley (SOX) in 2002. Passed in July of 2002, SOX took effect for firms at the start of 2003. I first estimate the firm policy functions and value function parameters on the dataset from 1980 to 2002 to cover the pre-Sarbanes regime and again in the years 2003-2019 to cover the post-Sarbanes regime. This choice has the benefit of clearly showing the demarcation of regulatory changes affecting the market, but might obscure some trends in the cost of private capital. To remedy this possibility, I will add a variable looking at the overall benchmark cost of private equity capital in North America to the regression and to the value function.

Table 4:
First-Stage Policy Function Estimates

Independent Variable	(1) Entry (Pre-Sarbanes)	(2) Exit (Pre-Sarbanes)	(3) Entry (Post-Sarbanes)	(4) Exit (Post-Sarbanes)
Market Equity x β_{me}	0.4220***	−0.2172***	0.9137***	−0.0927***
	(0.0838)	(0.0347)	(0.0446)	(0.0200)
Book to Market x β_{bmr}	4.7770*	1.3891	1.7525	−1.2268
	(2.4653)	(1.6166)	(3.1703)	(2.0760)
Profitability x β_{profit}	0.0500***	0.0098	0.0066*	0.8391
	(0.0054)	(2.9366)	(0.0034)	(2.4014)
Investment x β_{Gat}	-	2.1307	-	0.2371
		(5.8844)		(1.9974)
Market Beta x β_{bmktrf}	-	−5.6036**	-	0.5709
		(1.9704)		(1.9978)
Aggregate Market	4.2977***	2.0522***	1.2641***	0.5601***
	(0.4641)	(0.1664)	(0.2693)	(0.1321)
PE Cost Benchmark	−0.0040	0.0063	0.0705***	0.0121
	(0.0147)	(0.0061)	(0.0184)	(0.0082)
Constant	−2.8624***	−2.2196***	−9.1174***	−1.8359***
	(0.5072)	(0.2132)	(0.3251)	(0.1674)
Observations	2002	4771	1171	3758
Pseudo R^2	0.6196	0.8106	0.4373	0.5563

Table 4 presents the first stage estimates for the firm policy functions in the pre- and post-Sarbanes regimes for entry to and exit from public markets. The PE Cost benchmark variable is based on the Preqin Venture Capital Pro benchmark of North America PE IRR. The Aggregate Market variable is logged, inflation adjusted, and detrended aggregate market capitalization of the big three US exchanges (NYSE, NASDAQ, ARCA). Investment and Market Beta are not observed for withdrawn IPOs. Standard errors are in parentheses.
*p ≤ 0.1; **p ≤ 0.05; ***p ≤ 0.001.

These policy functions together form the $\sigma(\bar{\beta}_{kt}, \mathbf{ME}_{kt}, s; x_j)$ that are used as inputs in the second-stage estimation of the value function parameters θ in the BBL framework. The estimated policy functions reveal several patterns in firm choices. First, demand elasticity on size (market equity) is by far the most significant input into firms' choices on going public or private. The larger the firm is, the more likely it is to go public and the less likely it is to go private. Price (in the form of book to market ratio) is sometimes significant, especially in the pre-Sarbanes era when public capital was much more important relative to private capital for funding. The other characteristic-elasticity interactions don't have much impact on the firm's choices. Aggregate market capitalization is strongly positive in all periods for both buyout and IPO activity, consistent with the literature on both of those activities being pro-cyclical. Finally, the constant term, where the regulatory burdens have an impact on firms' base reluctance to go public, is significantly different between the pre-and post-Sarbanes era. Importantly, the baseline reluctance doesn't change as much for the going-private choice, consistent with Doidge et al. [2017], who find that the listing gap is driven mostly on the entry side of the firm's choice.

For the second-stage estimation, I choose $K = 500$ simulations going out to $T = 500$ periods (each period is set to be one quarter) for the true policy function and draw $I = 250$ alternative false policy functions which are probit policy functions with weights drawn from a uniform distribution around the weights of the true policy function. For each alternative policy function, I compute 50 simulations in the same manner as I compute the simulations for the true policy function. Then I estimate on the computer the minimum distance estimator in the manner described in Section 5.2. Table 5 presents the results of this estimation for both the pre- and post-Sarbanes regime.

Importantly, only the size parameter is significant here, alongside the fixed and sunk costs. However, this is not too big of a concern as the impact of market equity interacted with demand elasticity for market equity dwarfs the impact of any of the other characteristics. We can also see that the fixed cost estimated is higher in the post-Sarbanes regime, consistent with an increased regulatory burden and decreased propensity for small firms to go public. This is a consistent story with the regulatory burdens hypothesis far more than it is with the costs of capital hypothesis. Note that the differential benefit of scale for firms between public and private markets actually rose in the post-Sarbanes regime over the pre-Sarbanes regime. If the cost of private equity was falling, the cost of public equity was falling even faster.

7 Welfare Analysis

With the estimated model of firm choice and value functions on the supply side, and the estimated demand elasticities for investors from the demand model, I can now conduct counterfactual analysis of the impact of the listing gap for both firm and investor welfare. I

Table 5:
Second-Stage Value Function Parameter Estimates

Parameter	(1) Pre-Sarbanes	(2) Post-Sarbanes
α_{me}	0.0729*	0.0808***
	(0.0385)	(0.0266)
α_1	0.3114	-0.2069
	(0.8755)	(0.5475)
α_2	0.0234	-0.1335
	(1.3355)	(1.2254)
α_0	0.0066	0.1030
	(0.0558)	(0.0965)
α_{PE}	-0.0024	-0.0068
	(0.0056)	(0.0158)
$\mathcal{F}_{pub}$	0.2501	0.6198**
	(0.1896)	(0.2183)
ξ	1.5290***	1.9445***
	(0.1749)	(0.1493)

Table 5 presents the second-stage estimates for the firm value function parameters θ discussed in Section 5. For scale, the impact of α_{me} is 10 to 50 times the magnitude of the impact of the other α parameters and around half the impact of ξ for most firms. To make the estimates more precise I have imposed $\alpha_{\text{bmr}} = \alpha_{\text{bmktrf}} = \alpha_1$ and $\alpha_{\text{profit}} = \alpha_{\text{Gat}} = \alpha_2$. Block bootstrap standard errors are in parentheses.
*$p \leq 0.1$; **$p \leq 0.05$; ***$p \leq 0.001$.

will proceed in two distinct phases in this section. Section 7.1 will consider the simulation analogue of the estimated value function as representing the option value a firm has from being able to switch between being private and being public. This is a logical interpretation because if the firm were unable to ever switch (i.e., if $\xi = \infty$) then the value function would be expectation zero, as there would no longer be an option. In Section 7.2, I will examine the overall combined effect of these forces on the choice set that public investors face in the stock markets and ask whether, under the Koijen-Yogo framework of demand, their average well-being has fallen.

7.1 Firm Option Value

By being able to go public at a finite cost, the firm in my model that is currently private has the economic equivalent of a call option on access to public markets, with a certain strike price that is dependent on the parameters of the value function and the state transition matrix. Similarly, a firm that is currently public has a put option on access to public markets, at a different strike price again dependent on those same parameters. I can compute the NPV of having that option for the firm using the second-stage simulation estimator from the supply model. That NPV is equal to $V_{jt}(\bar{\beta}_t, \mathbf{ME}_t, r_{\mathrm{PE},t}, s_{jt}; x_j, \theta)$ for a firm with characteristics x_j operating in a regime with estimated value function parameters θ. Since the simulation analogue W_j is an unbiased estimator of the value of the true value function at that state, I can compute the numerical value of the simulation analogue for each of the five different firm types I use in the estimation process in Section 5, and then see how that value changes between the pre-Sarbanes estimated regime and the post-Sarbanes estimated regime.

As we can see in Table 6, the impact of the post-Sarbanes regime on the firm's option value is highly heterogeneous based on firm characteristics. The largest firm, firm 3, loses only half of its option value from being public and has an overall option value that is over six times the cost of entry. Meanwhile, the smallest firm, firm 4, loses over 90% of its option value and has a total option value barely above zero in the post-Sarbanes regime. Firm 4 rarely enters in the model simulations and overall stays in for fewer periods on average. This is consistent with the literature that the regulatory changes post-2000 have disproportionately affected the smallest firms entering public markets.

7.2 Investor Welfare

The second part of the welfare analysis is to look at public investors. As described in Section 2.4, I can compute an expected utility of the investor's equilibrium portfolio given his demand elasticities and the choice set he faces within his investment universe. However, I need to

Table 6:
Firm Option Value Change Pre-SOX to Post-SOX

Simulated Firm Characteristics

	Market Equity	Book to Market Ratio	Profitability	Investment	Market Beta
Firm 1	$900M	0.165	0%	0%	-0.5
Firm 2	$450M	0.15	-50%	10%	1
Firm 3	$5000M	0.368	5%	-5%	0.5
Firm 4	$175M	0.135	-20%	50%	2.5
Firm 5	$550M	0.049	1%	-10%	0

Firm Value Function Simulation Analogue t=0 Values

	Pre-Sarbanes Option Value	Post-Sarbanes Option Value	Percentage Change
Firm 1	24.56	3.974	-83.8%
Firm 2	19.98	2.326	-88.4%
Firm 3	33.84	11.68	-65.5%
Firm 4	13.92	0.9296	-93.3%
Firm 5	22.03	2.531	-88.5%

Table 6 presents the estimated simulation analogue $W_j(\cdot;\hat{\theta})$ in both the pre-Sarbanes and post-Sarbanes regimes, for a firm beginning period $t = 0$ as a private firm with the given characteristics. The option values are comparable with each other but are not comparable with a dollar value without assuming the dollar price of certain firm actions such as conducting an IPO.

hold the demand elasticities constant across time to measure the welfare effect of the choice set the investor faces changing over time.

Equations (15) and (16) from Section 2 is the analytical solution for expected utility in a logit environment with a given choice set. To observe whether investors prefer the securities choice set in public markets in later years to the choice set they had in earlier years, I construct the following normalized relative utility measurement for every investor in every time period as described by equation (20), holding demand constant while allowing the choice set to vary over time:

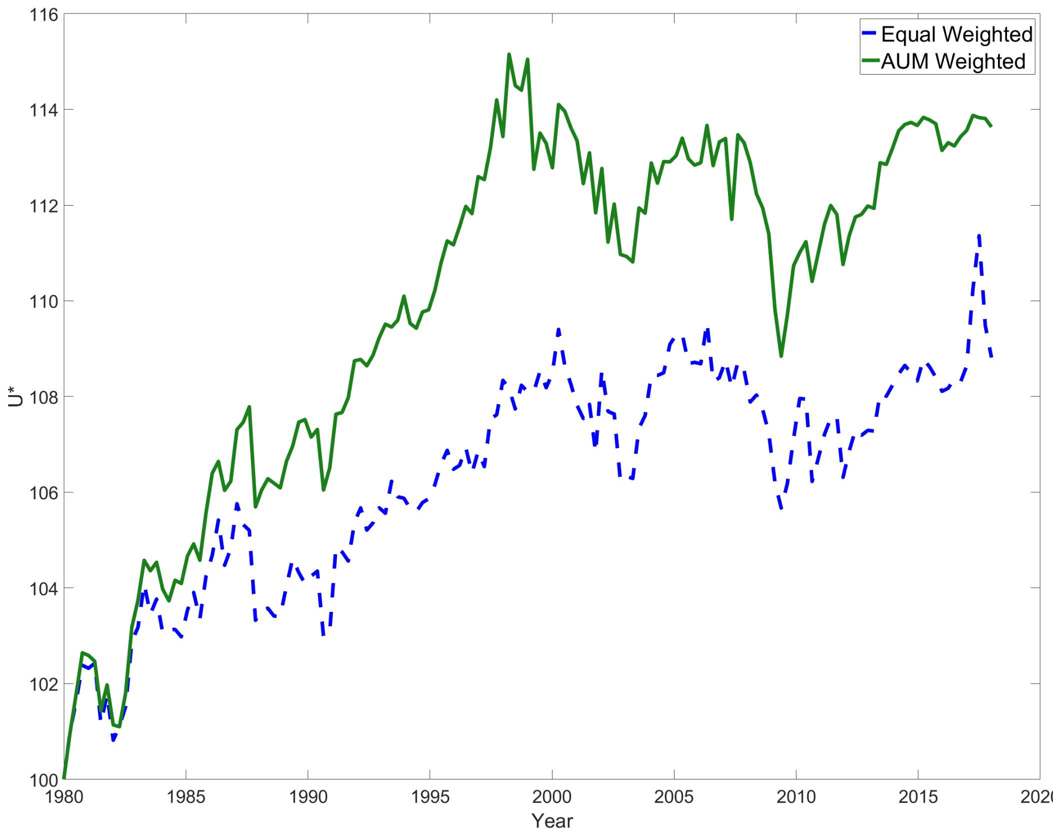

Figure 2: Investor Normalized Expected Utility over Time

$$\hat{U}_{it} = \frac{100 \cdot E_t[U^*_{it}]}{E_t[U^*_{is}]}. \tag{26}$$

This normalizes the utility of every investor i to 100 in the first period they are observed and then measures whether the utility they would get from future choice sets given their current demand elasticities would increase or decrease. This allows me to isolate the relative effect of only the choice set changing as opposed to investor tastes for characteristics changing. Then, I conclude by averaging this expected utility across all investors to get the average investor relative utility over each quarter from 1980 to 2019. Figure 2 shows the results of this analysis;

While this analysis isn't directly comparable to consumer welfare (there is no price/income parameter to adjust to indifference for compensating variation), it does show the trend of public investors to prefer the portfolios available to them in later years to those in earlier years. Compared to the claim advanced in many popular media publications and by some politicians that public investors have been harmed by the emergence and growth of the listing gap, this observation stands in stark contrast. The intuition is that while smaller IPOs may have higher expected returns, they also have higher volatility. In the KY demand model, as well as many other finance models, investors are assumed at the start to have mean-variance preferences that would be consistent with the observation that for smaller stocks to be purchased, their valuations must be more attractive. This trend is true for both equal Pareto weightings as well as weightings by the assets under management of each investor.

7.3 Investor Counterfactuals

Section 7.2 looks at the impact on investor utility from the total effect of all of the channels on the choice set. However, this is an "on-path" analysis, not a counterfactual one and doesn't explain how investors would have felt about having a different investment universe. Having an integrated model of supply and demand, though, allows me to go further and simulate the utility level investors would attain if the choice set were different.

I analyze the choice sets of investors in the final quarter of 2019, which is the last period in my model. I construct the counterfactual choice set by simulating for several different sets of firm characteristics how often they will be public under the estimated policy function in the post-Sarbanes regime and the pre-Sarbanes regime. I then look at the difference in the steady-state time as a public company for these firms and impute a linear function of probability based on the market equity of the firms that they would be public in the pre-Sarbanes regime but not in the post-Sarbanes regime.[25] Then, based on those relative probabilities, I generate additional simulated public firms to add to the choice set for the investors. This allows me to then measure investor utility in both the true regime of 2019 as

[25] I choose only market equity in this analysis because it makes the simulations much quicker to run and because market equity has by far the largest impact on firm choices of any characteristic.

Table 7:
Firm Option Value Change Pre-SOX to Post-SOX

	True Choices	Counterfactual Choices
Number of Available Firms	2327	4690
Investor U^*	13.2586	13.5267
Investor U^* (AUM Weighted)	17.746	17.8297

Table 7 presents the number of available firms for investors in both the true set of public firms in Q4 of 2019 and in the counterfactual choice set I construct. Firms are excluded from the true choice set if there is not enough data on them to impute all of their characteristics.

well as in a counterfactual regime with the pre-Sarbanes incentives affecting firm entry and exit choices. I report in 7 the results of this counterfactual simulation:

The difference in the investors' realized U^* is positive but small in both cases. Remember that $U^* = 0$ would be the case where the investor can only hold the risk-free outside asset, so the observed difference between the investors' portfolio utility is small. This is consistent with the idea that while expanding the choice set is always weakly good, there are severely diminishing returns when the initial choice set already numbers in the thousands, as is the case for public equities markets in the US. Additionally, the relaxation of the Sarbanes constraint means that most of the new entrants are marginal firms which don't affect investors as much by their absence.

To directly get to investor welfare, I need to compute the expected mean and variance of the returns the investor receives. Recall that investors have a standard mean-variance preference structure underlying the characteristics-based demand model. Because the demand model is estimated by regressing the holdings of each investor in each period against firm characteristics, it is not possible to directly back out the $\Gamma_{it}(n)$, the investor's beliefs about the covariance of returns as a function of characteristics, from the model. To solve this issue I use a small factor model considering market equity, the book to market ratio, and investment.[26] Using the investors' estimated characteristic demand elasticities β_{kit} and the characteristics of both the firms in the true choice set for the final quarter of 2019 as well as in the counterfactual choice set, I can estimate the portfolio weights w_{it} each investor has for the true and counterfactual choice sets.

Using the factor model, I bin each security in the portfolio that has characteristics most similar to that security's characteristics. Then I compute the expected returns and variance-covariance matrix of each portfolio in the post-Sarbanes era. This then allows me to estimate the expected return and variance of the return of each investor in the fourth quarter of 2019 for the portfolio weights in both the true and counterfactual choice sets. Figure 3 presents two histograms of the excess portfolio returns in the counterfactual choice set and the change in standard deviation between the true and counterfactual choice set portfolios:

Most investors have a less than 3 basis point change to the expected monthly return of their portfolios. Even the most impacted investors see their expected monthly returns increase by less than 6 basis points or under half a percentage point yearly. At the same time, however, the investors' portfolio volatility is increasing by a meaningful amount. While some investors choose less risky portfolios, almost all investors have more risky portfolios in the counterfactual scenario where firms enter the market as they did before Sarbanes-Oxley.

Figure 4 shows that this leads to most investors actually having a portfolio with a *lower* Sharpe ratio than they had with the true choice set. The explanation is that the portfolio holdings are computed using the estimated demand elasticities for each investor for all 5 firm characteristics, whereas the expected returns and volatility are computed considering only the market equity, book equity, and operating profitability of the firms. Furthermore, the factor model uses the true historical returns of the binned portfolios to compute the expected returns and volatility, whereas investors' demand elasticities reflect their subjective beliefs about the future returns and volatility as a function of firm characteristics. These beliefs could be both different from the past and wrong, leading to investors appearing to buy worse

[26] In Appendix C I also construct a factor model using profitability instead of investment.

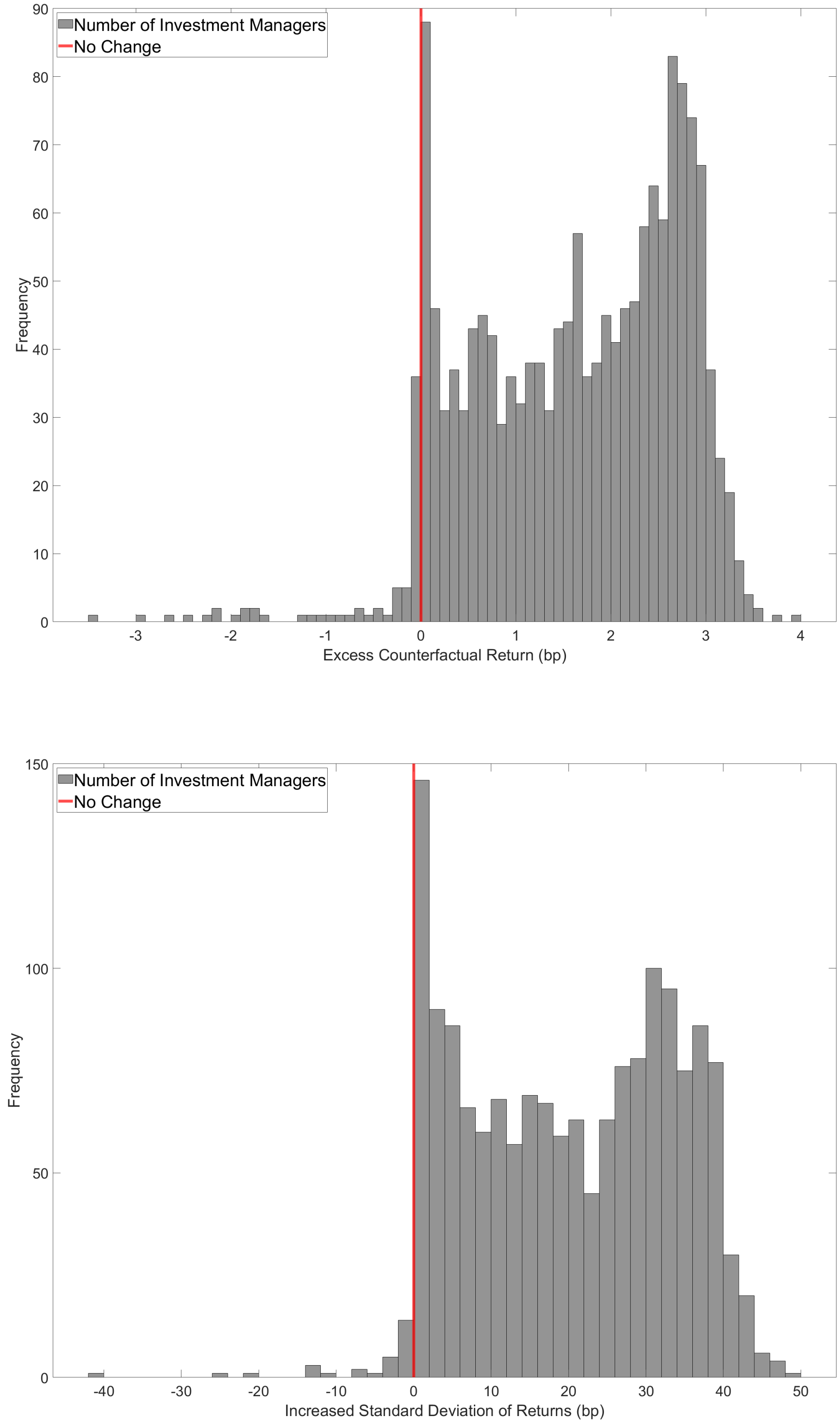

Figure 3: Expected Monthly Excess Returns and Volatility from Counterfactual Investor Choice Set

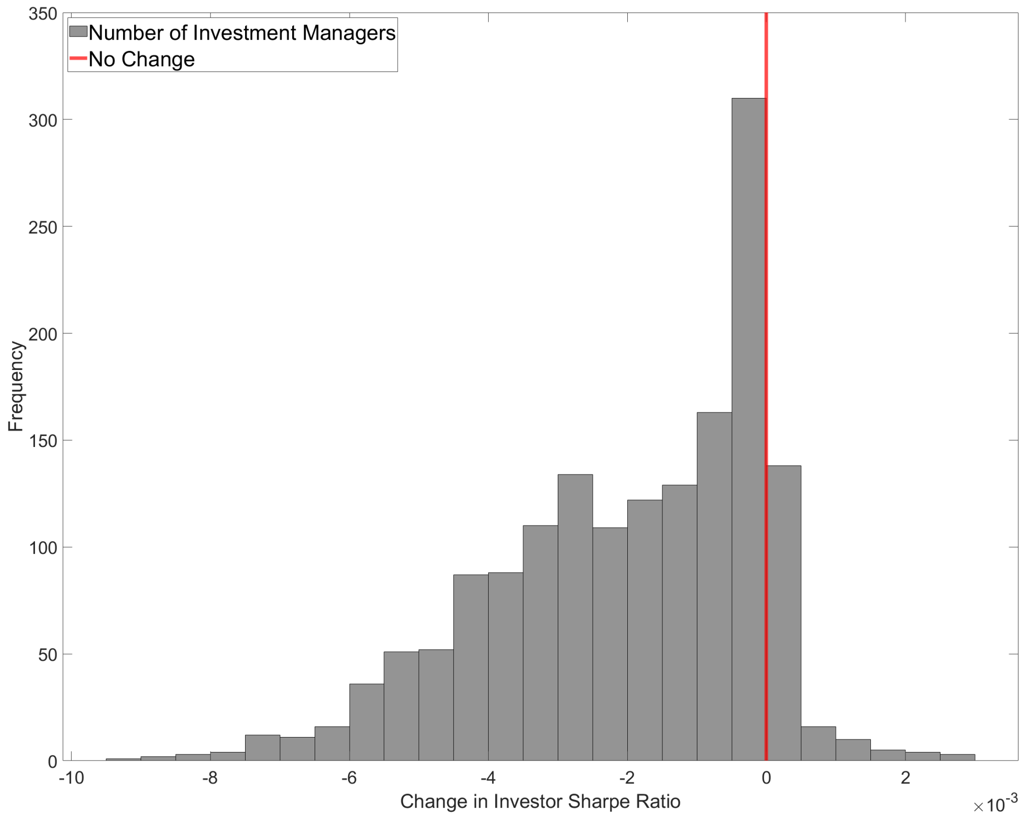

Figure 4: Change in Investor Sharpe Ratio from Counterfactual Portfolio

portfolios when more choices are added.

Regardless, the effect size for almost every investor is very small, with no public investor seeing their Sharpe ratio change by more than 0.01, and very few investors are getting both higher returns and lower volatility in their portfolios. This confirms that investors are not being harmed in any meaningful way by the rise of the listing gap, and depending on how wrong their subjective beliefs are, they may well be actually benefiting from it.

8 Conclusion

This paper examines the welfare impacts on firms and investors of structural changes to the US public equities market in the past few decades. In it, I find that most investors don't see a meaningful change in their portfolios' Sharpe ratio due to the decrease in publicly traded companies available for the to invest in on US stock exchanges, but that small firms have been harmed by the loss of over 90% of their option value of going public. These changes for firms are mostly driven by an increase in the fixed costs of being a public company relative to being a private company in the post-Sarbanes era. While my model is able to look at both supply and demand for securities, it does not look at output changes or other macro impacts. This could affect consumer welfare, if, for instance, regulatory frictions lead to lower-than-optimal investment in a world with inelastic labor supply and thus output falls. That analysis is beyond the scope of this paper, but a macroeconomic model examining some of these trends could potentially quantify these changes, which in any case are not likely to be very large.

An integrated structural model of supply and demand is crucial to answering many asset pricing and corporate finance questions. Looking at the impact of past regulations on firm and investor choices can inform our future choices in regulating public markets. For instance, are SPACs good or bad? For whom? Will reining in private equity investments affect some areas of the economy more than others, and how so?

Furthermore, many questions in the finance literature can be examined more fruitfully using a dynamic approach. While many portfolio choice problems are in reality dynamic, a static model in a world with small transaction costs is a good approximation to the dynamic solution. But many contexts are better served using dynamic programming, For instance, how do investors handle the tax implications of their portfolio choices, and how does this affect the heterogeneity of who owns what? Expanding on these approaches will make it possible to answer many questions at the intersection of corporate finance and asset pricing where dynamic considerations cannot be ignored.

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Appendix A Breakdown of Listed Firms and Changes in Lists Over Time

This table updates the breakdown in Doidge et al. [2017] of listed firms, new lists, and delists by year to the present day. Below is a table containing information about the total number of publicly traded firms, the number of new public firms and public firms that cease to be publicly listed, and a breakdown of the causes of the delists. Note that in this context, merger can be either an acquisition by private equity or similar financial buyers or a strategic merger between two publicly traded corporations so the delist cause of "Merger" can not be taken as a count of the number of LBOs in a year. For Cause refers to firms which cease to meet the financial requirements to be publicly traded on the exchange, often due to imminent bankruptcy. Voluntary delists are mostly firms choosing to list on a different exchange, often overseas.

Table A1: Summary Statistics of Number of Publicly Listed Firms, New Public Firms, and Delisting Firms

Year	Listed Firms	New Listings	Total Delistings	Delisting Causes		
				Merger	For Cause	Voluntary
1975	5341	157	188	97	91	0
1976	5365	233	197	124	71	2
1977	5339	182	272	188	82	2
1978	5307	240	330	246	82	2
1979	5241	256	331	258	72	1
1980	5410	493	342	215	127	0
1981	5779	681	315	203	111	1
1982	6001	520	408	221	185	2
1983	6627	1029	394	212	170	12
1984	6897	666	523	276	231	16
1985	7031	664	670	306	343	21
1986	7464	1064	721	365	344	12
1987	7779	1054	551	316	223	12
1988	7783	587	780	445	318	17
1989	7504	500	678	339	319	20
1990	7323	480	589	234	345	10
1991	7350	626	533	153	367	13
1992	7654	824	648	234	390	24
1993	8167	1168	400	222	168	10
1994	8730	950	546	340	193	13
1995	9113	901	671	420	233	18
1996	9707	1224	716	527	181	8
1997	9954	894	882	604	267	11
1998	9812	693	1159	729	421	9
1999	9481	773	1112	701	402	9
2000	9180	801	1132	788	327	17
2001	8477	327	1040	548	451	41
2002	7778	323	754	327	371	56
2003	7325	297	634	313	276	45
2004	7205	499	492	330	135	27
2005	7258	522	572	396	136	40
2006	7325	568	525	402	113	10
2007	7533	712	668	478	172	18
2008	7004	251	570	319	210	41
2009	6266	201	515	223	232	60
2010	6116	342	457	286	142	29
2011	5974	274	397	267	119	11
2012	5883	280	455	323	122	10
2013	5901	402	393	302	70	21
2014	6073	498	370	295	64	11
2015	6154	382	413	303	96	14
2016	6147	339	509	364	137	8
2017	6087	379	408	304	92	12
2018	6122	390	390	297	85	8
2019	6163	376	401	279	109	13
2020	6371	565	343	193	133	17
2021	7375	1312	429	369	54	6
2022	7531	507	543	286	229	28
2023	7421	398	789	311	450	28

Note: Includes only firms listed on AMEX, NASDAQ, or NYSE.

The total number of listed firms peaks in 1997 before falling by almost half by 2012. After that the number is steady at around 6000 until the COVID-19 pandemic causes a surge in new lists, driven in part by the rise of SPACs during 2020 and 2021.

Appendix B Reduced Form Regressions on Exit

Complementing table 2, table 8 conducts the same reduced form regressions on the firm exit choice. As is the case in table 2, Baseline is a probit regression using only macro variables and firm characteristics, while Baseline (OLS) is the same exercise done as a linear probability model. All controls now includes firm characteristics interacted with characteristics-based demand elasticities.

In contrast to the entry decision probit regression, Aggregate market performance combined with characteristics alone mostly explain the decision to go private. The demand elasticities and characteristic-elasticity interactions are generally not significant, and regulatory changes which burden public firms seem to not drive too many existing public firms to go private after controlling for the cost of private equity. However they do show up strongly negative for the JOBS Act dummy absent the demand controls, suggesting that the demand shift of public firms to go private could have meaningfully affected the cost of private equity in the 2000s. When reducing the regressors to be symmetric with the entry choice the public market cap and some characteristic-elasticity interactions are significant. Furthermore, in the pre-Sarbanes period it was more likely to be smaller firms which would be acquired as seen by the negative sign on the Market Equity characteristic-elasticity interaction, while in the post-Sarbanes period it was actually more likely for larger firms to be bought out. This is consistent with the idea that private equity was the substitute for public markets when larger companies faced increasing regulatory burdens for being public.

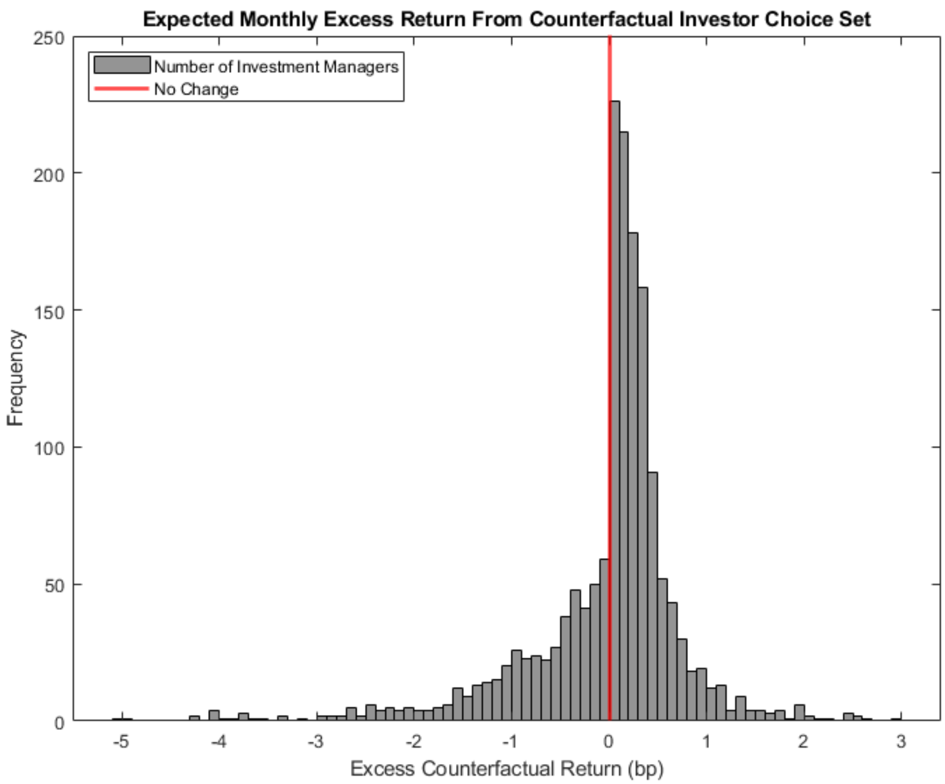
Table 8:
Entry Probit Regressions on Characteristics and Macro Variables

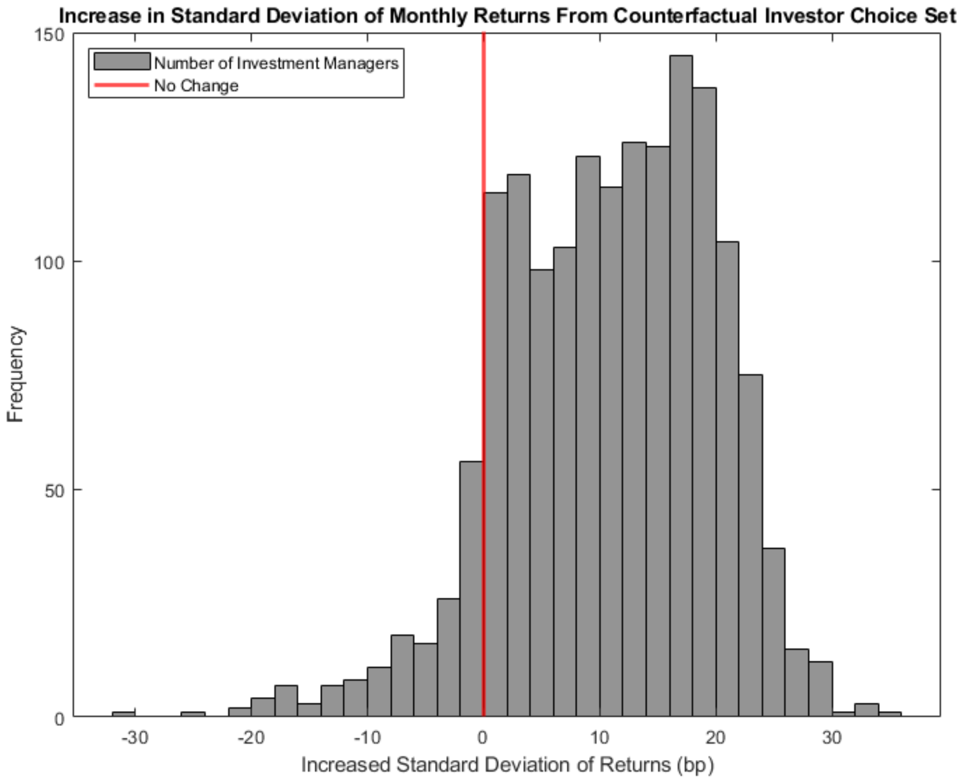
	Baseline	**Baseline (OLS)**	**All Controls**	**All Controls (OLS)**	**Pre SOX**	**Post SOX**
Market Equity	−0.1274***	−0.0139***	−0.7451**	0.0135	-	-
	(0.0158)	(0.0017)	(0.3026)	(0.0206)		
Book to Market	−0.2659***	−0.383***	−0.2210***	−0.0422***	-	-
	(0.0254)	(0.0043)	(0.0400)	(0.0077)		
Profitability	−0.2033***	−0.0767***	−0.2035**	−0.0733***	-	-
	(0.0610)	(0.0157)	(0.0642)	(0.0159)		
Investment	-0.1323	-0.0133	0.0230	0.0079	-	-
	(0.1111)	(0.0183)	(0.1523)	(0.0212)		
Market Beta	−0.2457***	−0.0401***	−0.3541***	−0.0559***	-	-
	(0.0351)	(0.0068)	(0.0521)	(0.0113)		
Market Equity x β_{me}	-	-	0.6763**	−0.0305	−0.2172***	0.0927***
			(0.3298)	(0.0233)	(0.0347)	(0.0200)
Book to Market x β_{bmr}	-	-	2.5282	-0.1698	1.3891	-1.2268
			(1.6882)	(0.3240)	(1.6166)	(2.0760)
Profitability x β_{profit}	-	-	-0.2519	-0.0908	1.0912	0.8391
			(1.5276)	(0.3324)	(2.9366)	(2.2185)
Investment x β_{Gat}	-	-	-3.4956	-0.5432	2.1307	0.2371
			(2.3573)	(0.4366)	(5.8844)	(2.7246)
Market Beta x β_{bmktrf}	-	-	−7.4286**	−1.0657**	−5.6036**	0.5709
			(2.9001)	(0.4388)	(1.9704)	(2.9859)
Aggregate Market Cap	0.6416***	0.0580***	0.6284**	0.0532***	2.0522***	0.5601***
	(0.1009)	(0.0159)	(0.1209)	(0.0158)	(0.1664)	(0.1321)
PE Cost of Capital Benchmark	0.0058	-0.0004	−0.0023	−0.0007	0.0063	0.0121
	(0.0053)	(0.0004)	(0.0065)	(0.0006)	(0.0061)	(0.0082)
SOX Dummy	0.1011	0.0401**	-0.0604	0.0230	-	-
	(0.1068)	(0.0184)	(0.1348)	(0.0174)		
JOBS Act Dummy	−0.5744***	-0.0148	0.5078***	−0.0200	-	-
	(0.0987)	(0.0120)	(0.1082)	(0.0128)		
Demand Controls	N	N	Y	Y	Y	Y
Time Trend	Y	Y	Y	Y	N	N
N	8753	8753	8753	8753	4771	3982
(Pseudo) R^2	0.1511	0.0730	0.1577	0.0750	-	-

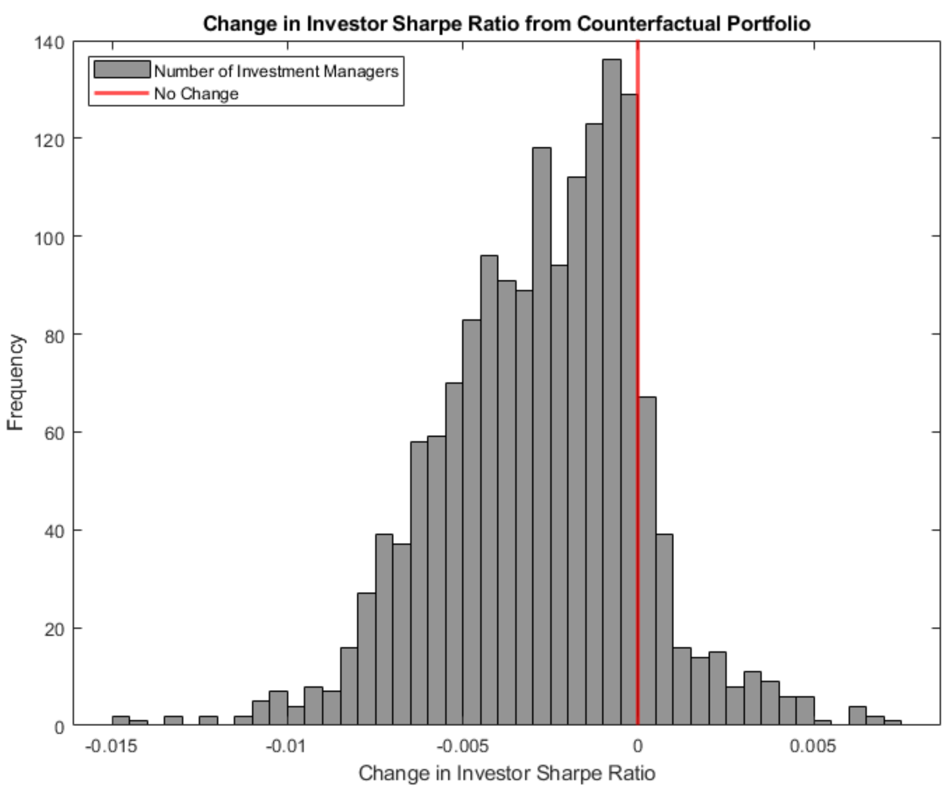
Table 8 presents estimates for the exit decision regressed on various characteristics, market variables, and macro factors. The baseline regression uses only firm characteristics and macro variables to estimate a probit model of entry, with the LBO target firms having a dependent variable of 1 and the publicly-traded firms that remained public having a dependent variable of 0. The baseline (OLS) regression is the same as baseline except estimated as a linear probability model with year fixed effects. All Controls is a probit regression that adds demand elasticities for characteristics and characteristic-elasticity interactions. All Controls (OLS) is the same regression as All Controls but done using OLS. The Pre SOX and Post SOX regressions are the probit policy functions estimated in the first stage of the BBL estimator for the pre- and post-Sarbanes-Oxley regimes respectively. Standard Errors are in parentheses.
*$p \leq 0.1$; **$p \leq 0.05$; ***$p \leq 0.001$.

Appendix C Factor Model Robustness

In section 7 I use a 3-factor Fama-French factor model consisting of investment, book to market ratio, and market equity to model the returns of counterfactual securities that investors could choose. As a robustness exercise I rerun the analysis of section 7.3 using the same counterfactual investor choice set in public markets but modeling security returns using a 3-factor model consisting of market equity, book to market ratio, and profitability instead of investment. The results are largely similar to those for investment and are presented below.




Increase in Standard Deviation of Monthly Returns From Counterfactual Investor Choice Set
Number of Investment Managers
No Change
Frequency
Increased Standard Deviation of Returns (bp)
150
100
50
0
-30
-20
-10
0
10
20
30


Change in Investor Sharpe Ratio from Counterfactual Portfolio
Number of Investment Managers
No Change
Frequency
Change in Investor Sharpe Ratio
140
120
100
80
60
40
20
0
-0.015
-0.01
-0.005
0
0.005

Excess returns are more clustered around zero, while volatility also changes less. The change in Sharpe ratios is similar to when the investment factor model is used, the decrease in many investors being explained by the same issues of subjective beliefs and forward vs backward looking returns discussed in section 7.3.