

Dynamic ownership, private benefits, and stock prices

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Abstract

I quantify largest shareholders' private benefits of control, and their impact on stock prices, by estimating a structural model of optimal shareholding using data on the ownership dynamics of Italian public companies. The results show that controlling shareholders (i) extract private benefits on average around 2% of equity value, and (ii) generally have positive and persistent impact on stock prices. The results imply that large shareholders extract private benefits without cost for the rest of the company shareholders. I also provide evidence of a synergistic effect when the large shareholder is a corporation.

JEL classification: G11, G12, G14, G32

Keywords: Private benefits of control, Large shareholder, Ownership dynamics, Structural estimation, Stock price

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I. Introduction

Controlling shareholders have additional motives to hold shares in the company compared to minority shareholders, as they are able to extract private benefits such as social status, public prestige, or discretionary power to divert cash flows or to pay excessive compensation to blockholders or their relatives.

Private benefits of control, then, can be an important driver in the controlling shareholders' choice about the size of the initial ownership share, and about their subsequent trading decisions. Since the controlling shareholders' trading decisions affect the formation of investors' beliefs and the amount of shares floating on the market, private benefits may have significant impact on stock prices.

In this paper, I present and estimate a dynamic model of optimal shareholding to quantify the private benefits of controlling shareholders and to measure the impact of private benefits of control on shares price.

In the model, a large shareholder and a mass of marginal investors hold shares in a company. The marginal investors are uninformed about the fundamental value of the firm, and they trade on their heterogenous expectations, which they revise over time using two pieces of information: the shocks to the fundamental value of the firm and the trading decision of the large shareholder, who has perfect information over the true value of the firm. However, the large shareholder also extracts private benefits from the stake, so that the information released by his trading is noisy.

The large shareholder trades off stock mispricing and private benefits against risk diversification and price impact of the trade, where the amount of private benefits extracted from the stake depends on the attainment of given thresholds of stake (for instance, 50% for the control of the firm). This assumption is in line with the institutional framework, according to which shareholders' rights and obligations arise as soon as shareholders get hold of a given percentage of the outstanding shares.

In the absence of private benefits, the large shareholder always trades on the mispricing of the marginal investors. However, the mispricing reduces over time as the marginal investors learn from the large shareholder's trades. Thus, it becomes less profitable for the latter to exploit the mispricing. With additional private benefits, instead, the large shareholder may not trade at all. The reason is that the large shareholder sells a block of shares only when the share is largely overvalued, so that the gains offset both the loss in private benefits and shares depreciation, given the negative price impact of the trade. Specular reasoning applies to the purchase of an additional block of shares.

The price impact of private benefits is two-fold. First, private benefits affect the decision of the large shareholder in terms of size of the stake, and so the number of shares tradable on the market. Second, when the controlling shareholder extracts private benefits from the ownership share, his trading decisions are less affected by the fundamental value of the firm, and so they are less informative about the true value of the firm. Therefore, the presence of private benefits makes it more noisy for the rest of the investors to extract information from the large shareholder's trade.

To estimate the model, I use data on Italian public companies for which large shareholders are required to disclose their stakes every six months, thus allowing for data with higher frequency with respect to previous studies on the ownership dynamics (e.g., Donelli, Larrain, and Urzsua (2013)).¹ The data show that large shareholders trade infrequently, despite substantial variation in the economic fundamentals of the firm, stock prices, and trading volumes. Moreover, when they trade, large shareholders buy or sell large blocks of shares, while they trade small stakes very rarely.

The main estimation results are the following. First, I estimate private benefits of control of around 2% of equity value. Moreover, I show that the distribution of private

¹In comparison, US disclosure rules allow to have information only on purchases of blocks above 5% of the outstanding shares (file 13D or 13G), and on the portfolio of big institutional investors with more than 100 millions of dollars of equity assets under management (file 13F).

benefits is highly positively skewed: 50% of the large shareholders extract private benefits of less than 1% of equity value, and the maximum rate is 20%.

Second, I show that private benefits of control generally have positive impact on stock prices. This result implies that large shareholders extract private benefits without cost for the rest of the company shareholders. As for the private benefits, the price impact is very heterogenous across firms. For 15% of firms, in fact, private benefits have a negative impact greater than 1%, and for the same proportion of firms the private benefits have a positive impact larger than 5%. Moreover, I find evidence of a synergistic effect. When the controlling shareholder is a corporation, the positive price impact of the large shareholder's stake is even larger compared to the case of individual large shareholders.

Third, I document that the presence of large shareholders has, overall, a substantial positive impact on stock prices. This positive price impact is large during the European sovereign debt crisis of 2011-2012, so that large shareholders may be particularly beneficial to the rest of the investors during negative economic cycles.

Finally, I estimate the certainty equivalent payoff of the large shareholders' stakes over time, which is unobservable when the large shareholder does not trade. I show that private benefits contribute to compensate large shareholders for holding very undiversified portfolios, thus keeping the stake valuation of the large shareholders always above the market price of the stock.

My paper relates to both theoretical and empirical studies on private benefits of control and controlling shareholders' ownership policy. To the best of my knowledge, this is the first paper to provide a measure of the impact of large shareholders on stock prices over time, only predicted in theory by the dynamic models of Collin-Dufresne and Fos (2015) and DeMarzo and Urosevic (2006), and estimated at the time of the block trade by Albuquerque and Schroth (2010).

Theoretical papers predict that the heterogenous valuation between large and

small shareholders should always trigger trading by the large shareholder (e.g., Collin-Dufresne and Fos (2015), and DeMarzo and Urošević (2006)). The framework closer to the one presented here is the model of DeMarzo and Urošević (2006), where a large shareholder that manages and monitors a firm is prevented to trade to his optimal portfolio allocation from moral hazard, since marginal investors revise the stock price on the base of the large shareholder's stake. As a result, the large shareholder adjusts gradually the stake towards the optimal risk-sharing allocation, where the speed of adjustment is inversely proportional to the reaction of the investors to the large shareholder's trade.

The implication of persistent trading by the large shareholder is contradicted by empirical evidence showing that the frequency of trading by large shareholders is much less than expected from the predictions of current models (e.g., Donelli et al. (2013)). The infrequent trading by the large shareholder, then, emerges as implication of my model with extraction of private benefits.

Since Bradley (1980), the estimation of the private benefits has captured much attention in the academic research. Previous studies focus on the acquisition of the controlling stake to measure private benefits of control (e.g., Barclay and Holderness (1989), Nicodano and Sembenelli (2004), Dyck and Zingales (2004), and Albuquerque and Schroth (2010)). First, they show that controlling shareholders are willing to pay more than the market price to buy the controlling block of shares of a company, where the difference between the block price and the market price of the shares at the day of the block negotiation is defined as block premium. Then, they argue that the premium is justified by the opportunity for the controlling shareholder to extract private benefits from the controlling stake. Barclay and Holderness (1989), Nicodano and Sembenelli (2004), and Dyck and Zingales (2004) use the block premium as an empirical proxy to quantify the private benefits of control, while Albuquerque and Schroth (2010) perform a structural estimation of private benefits by using an under-

lying theoretical model of block pricing.

However, if private benefits may impact on the ownership policy of the controlling shareholder over time, then the ownership policy of the controlling shareholder may contain crucial information to estimate the private benefits. The intuition is that private benefits make the large shareholder's trading less sensitive to changes in the economic conditions of the firm, since the incentive to hold a given stake may be mostly due to the opportunity to extract benefits that are unrelated to the economic fundamentals of the firm. For this reason, I use data on the ownership dynamics of large shareholders to assess the magnitude of private benefits of control and their impact on stock prices.

My estimates of private benefits of control are in line with that of (Albuquerque and Schroth (2010)). Moreover, similarly to Albuquerque and Schroth (2010) and Nicodano and Sembenelli (2004), I show that the distribution of private benefits is highly positively skewed. My results show that 50% of the large shareholders (40% in Albuquerque and Schroth (2010)) extract private benefits less than 1% of equity value, and the maximum rate of private benefits is 20% (15%).

Even though structural estimation relies on a specific theoretical model, I show that the estimated model performs well in replicating empirical facts on the dynamics of large shareholders' stakes that have not been explicitly targeted.

The paper, then, proceeds with the description of the model assumptions and solution in the next section. Section 3 describes the estimation methodology, followed by the estimation results in section 4. Section 5 concludes the paper.

II. The Model

In this section, I describe the model. First, I state the model assumptions, then I derive the optimality conditions for the marginal investors and the large shareholder.

Moreover, I derive the equilibrium stock price and large shareholder's stake. Finally, I summarize the main results.

A. *The Setup*

The economy consists of investors with two investment opportunities: the shares of a company and a riskless asset. The following assumptions describe this economy.

- **Assumption 1. Investment Opportunities**

The firm is in unit supply and generates cumulative free cash flows described by the following diffusion

$$dD_t = \mu_t dt + \sigma_D dZ_t, \quad (1)$$

$$d\mu_t = \sigma dX_t, \quad (2)$$

where μ_t is a time-varying drift, σ and σ_D are constant, and dZ_t and dX_t are two independent standard Brownian motions. The firm pays out all cash flows as dividends. The riskless investment pays a continuously compounded rate of return r , with perfect elastic supply.

I use this assumption to introduce asymmetric information between marginal investors and large shareholder, and the sequential learning of the marginal investors in bayesian fashion, using the observed dividends flow as noisy signal on μ_t (see Assumption 3).

- **Assumption 2. Investors Population**

The economy is populated by a continuum of competitive investors, with measure M . All the investors are risk-averse, with standard CARA utility function, defined on the continuous flow of consumption. The agents have equal risk and intertemporal preferences. The investors live infinitely, and trade continuously

the riskless asset and the company shares, with price P to be determined in equilibrium. Let $\alpha_{i,t}$ denote the number of shares owned at time t by the investor i , with i going from 1 to M . Each investor, then, chooses the amount of consumption and the number of shares to maximise

$$E_t \int_t^\infty e^{-R(s-t)} u(c_s) ds,$$

where $u(c) = -e^{-ac}$, a is the absolute risk-aversion coefficient, and R is the rate of intertemporal preferences, that is equal to r when $a = 0$. The wealth of each investor i is given by the riskless asset and the company shares, that is $W_i = B_i + \alpha_i P$.

Also, there exists a large shareholder, that is risk-averse, with equal risk and intertemporal preferences as the marginal investors, that lives infinitely, and has identical objective function as the marginal investors. However, the large shareholder differs from the rest of the investors in two directions. First, the large shareholder sets the optimal number of shares at discrete dates τ .² Moreover, the large shareholder extracts additional benefits from investing in the firm, that accrue to the total wealth of the shareholder given by $W_L = B_L + \alpha_L P + \Phi(\alpha_L)$. The private benefits from shareholding, $\Phi(\alpha_L)$, generate continuously an instantaneous inflow of additional wealth for the large shareholder, denoted by $\phi(\alpha_L)$, such that $dW_L = d(B_L + \alpha_L P) + \phi(\alpha_L)$, according to a discrete step function:

$$\phi(\alpha_L) = b * \alpha_j,$$

if $\alpha_j \leq \alpha_L < \alpha_{j+1}$, where α_j and α_{j+1} are given thresholds of stakes (for instance, 0.2 and 0.3, respectively), with $j = \{0, 1, 2, \dots, J - 1\}$, $\alpha_0 = 0$, and $\alpha_J = 1$.

I make this assumption for consistency with the actual institutional frame-

²This assumption improves the tractability of the model and follows DeMarzo and Urosevic (2006)

work, where the shareholders' rights and obligations are triggered as soon as the shareholders come into possession of a given percentage of the outstanding shares. It follows that the shareholders acquire additional rights (or have the duty to comply with additional obligations) only if they reach the next higher threshold, and they lose rights (or are free of complying with a given obligation) as soon as they hold one stock less than a given percentage of shares. The private benefits take here the form of monetary incomes, or non-pecuniary amenities that can be converted in additional wealth.

- **Assumption 3. Heterogeneous Information and Beliefs Update**

The time-varying drift of the dividends pay out, denoted by μ_t , is unobservable to the marginal investors, and observable only to the large shareholder. The marginal investors have heterogeneous prior on μ_t , conditioning on the information set at time t , denoted by $\mu_{i,t}$, and they have heterogeneous prior variances, that are different conjectures on σ^2 , denoted by σ_i^2 . The marginal investors receive two types of signal to update their prior on μ_t , in a bayesian fashion.

At each time t , the investors observe the continuous cash flow dD_t , that is a noisy signal on μ_t . The signal is noisy as the investors are not able to disentangle between the pure shock on the dividend payout, given by σdZ_t , and the true dividend drift μ_t . Therefore, each investor updates continuously her prior on μ_t according to the conjecture on σ . In particular, the larger is the investor's prior variance σ_i^2 , the lower is the level of confidence of the investor about her prior, and the larger is the weight assigned to the noisy signal for revising the prior on μ_t . The investor's prior on μ_t , then, evolves according to the following equation

$$d\mu_{i,t} = k_i \eta_{i,t},$$

where, following standard bayesian filtering results,

$$k_i = \frac{\sigma_i^2}{\sigma_D^2 + \sigma_i^2}, \eta_{i,t} = dD_t - E_{i,t}[dD_t],$$

and $E_{i,t}[dD_t] = \mu_{i,t}$.

Therefore, the heterogeneity across investors is fully described by the distribution of the coefficient k_i , that is the weight assigned to the signal for updating the beliefs on the expected dividend payout.³

At the discrete dates τ , the investors observe the ownership share of the large shareholder $\alpha_{L,\tau}$, that is a noisy signal on μ_t , since investors know that the large shareholder has additional motives to invest in the firm, given by the private benefits, that are unobservable to the marginal investors. The update at τ of each marginal investor about μ_t is then described by the following equation:

$$\mu_{i,\tau} = \mu_{i,t < \tau} + g_i(\tau^-)(\alpha_{L,\tau} - \alpha_{L,\tau}(\mu_{i,t < \tau})),$$

where $\mu_{i,t < \tau}$ is the prior of the investor i before observing the choice of the large shareholder, $\alpha_{L,\tau}(\mu_{i,t < \tau})$ is the belief of the investor i about the optimal choice of the large shareholder, and $g_i(\tau^-)$ is the weight assigned to the observation of the large shareholder's choice for updating the prior on μ_t . Therefore, each investor i revises upwards (downwards) the conjecture on the true dividend drift of the firm when the large shareholder sets an ownership share above (below) the expected choice, that is interpreted as a positive (negative) signal on the true state of the firm. Following again standard bayesian filtering results, the weight g_i is equal to

³The reader can refer to a set of investors with different level of confidence or information on the future cash flows generated by a company. An investor with superior level of information, or high degree of confidence, has a low value of k , and relies little on the signals provided by the actual dividend payments. Instead, a poorly informed investor is easily conditioned by the fresher information provided by the new dividend payment, and has a high value of k .

$$g_i(\tau^-) = \frac{\alpha_{L,\tau^-}^\mu \sigma_i^2}{(\alpha_{L,\tau^-}^\mu)^2 \sigma_i^2 + \sigma_\epsilon^2},$$

where $\alpha_{L,\tau}^\mu = \frac{\partial \alpha_{L,\tau}}{\partial \mu_t}$ is the derivative of the optimal choice of the large shareholder with respect to the true dividend drift, and σ_ϵ^2 is the variance of the observation error, as measure of the noise in the observation with respect to the knowledge of μ_t .

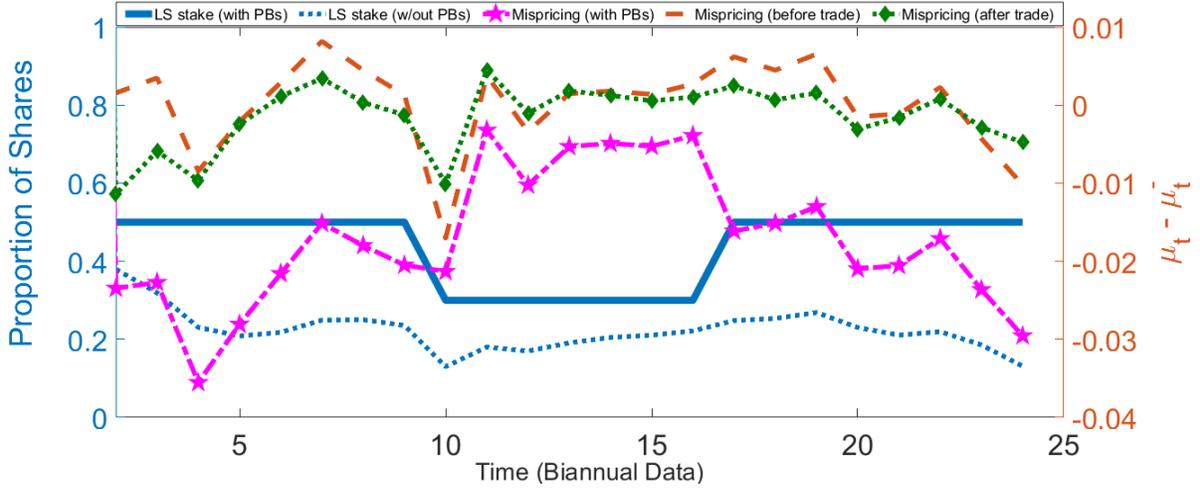
In case of no private benefits, the marginal investors know that the large shareholder sets the demand for shares only on the base of the superior information on the dividend drift, therefore the observation α_{L,τ^-} is clean, that is $\sigma_\epsilon^2 = 0$, so $g_i(\tau^-) = \frac{1}{\alpha_{L,\tau^-}^\mu}$, where α_{L,τ^-}^μ is observable, albeit with one period lag due to asymmetric information. With private benefits, the observation α_{L,τ^-} is not longer clean, that is $\sigma_\epsilon^2 > 0$.

Given assumptions 1,2, and 3, the following sections characterize the model solution. First, I summarize for the reader the main results of the model in figure 1, with a graphical simulation. Details on the simulation study are provided in the Appendix. Then, I describe analytically the investors' optimality and the equilibrium stock price, the large shareholder's optimality, finally deriving the model equilibrium. I leave the proofs for the appendix to save in space and notation.

Without private benefits the large shareholder always trades against the mispricing of the marginal investors, thus gradually converging to the optimal risk-sharing solution. The marginal investors learn from his trade, therefore they revise their valuation after observing the large shareholder's trade.

With private benefits, the large shareholder may not trade at all. Otherwise, the large shareholder sells (buys) a block of shares when the overvaluation (undervaluation) of the marginal investors make the sale (purchase) convenient to the large shareholder, taking into account the loss (gain) in private benefits, and the price im-

Figure 1. Ownership Dynamics, Private Benefits and Mispricing



The figure shows the optimal demand for shares of the large shareholder in presence of private benefits (blue line), and in absence of private benefits (dotted line), against the difference between the true dividends drift (μ_t) and the average belief on the dividends drift ($\bar{\mu}_t$) by the marginal investors before the disclosure of the large shareholder's stake (dashed line), after the disclosure of the large shareholder's stake in absence of private benefits (diamond line), and after the disclosure of the large shareholder's stake in presence of private benefits (stars line). The parameters used for the numerical example are the same as for the simulation study described in the Appendix.

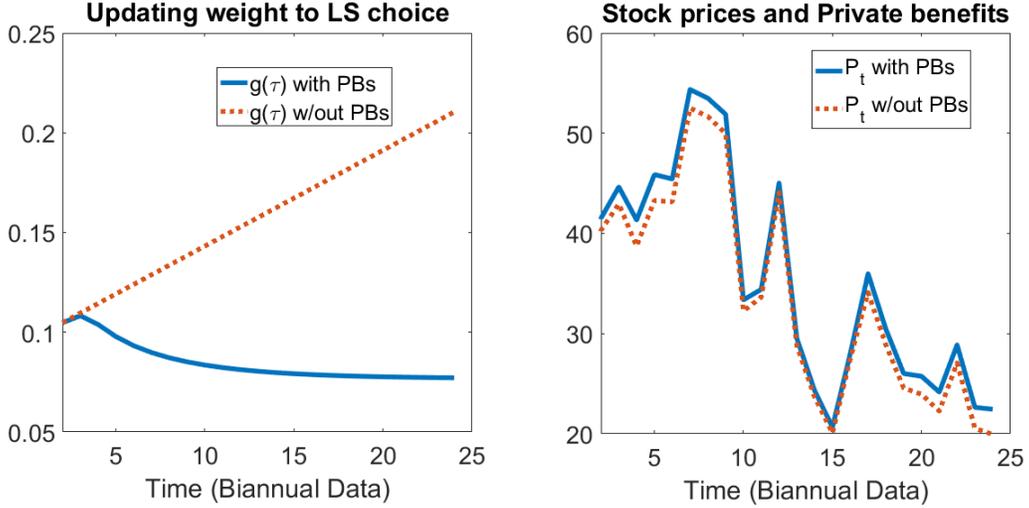
pect of his trade. The signal released by the large shareholder with the demand for shares, then, is noisy, and generates a distortion in the update of the marginal investors about the expected dividend payout of the company, that is also the reason why the weight assigned to the choice of the large shareholder is lower with respect to the case of no private benefits (Figure 2, left panel).

B. *Equilibrium Share Price and Investor's Optimality*

At each time t , the optimal choice in terms of number of shares of the investor i is given by:

$$\alpha_{i,t} = \frac{\mu_{i,t} - \bar{\mu}_t + \rho}{ar\sigma^2}, \quad (3)$$

Figure 2. The impact of LS ownership policy



The left panel shows the average updating weight assigned to the observation of the large shareholder's stake by the marginal investors to update their belief on the dividends drift, with (blue line) and without (red dotted line) private benefits. The right panel shows the equilibrium stock price at the disclosure dates τ with (blue line) and without (red dotted line) private benefits. The parameters used for the numerical example are the same as for the simulation study described in the Appendix.

where $\bar{\mu}_t$ is the average expected dividend by the marginal investors, and the risk premium ρ , determined by market clearing condition, that is $\int_i \alpha_{i,t} di = 1 - \alpha_{L,t}$ for each t , is

$$\rho_t = (1 - \alpha_{L,t}) a^I r \sigma^2,$$

where $\alpha_{L,t}$ is the stake held by the large shareholder at time t , and a^I is the aggregate risk aversion coefficient

$$\frac{1}{a^I} = \int_i \frac{1}{a^i} di$$

□ **Proof.** Appendix A

Equation (3) has a natural interpretation. While the demand for shares decreases with the dividends process variance and the risk aversion coefficient, the demand

increases with the difference between the individual and the average belief about the expected dividend payout of the firm. Equation (3) reminds the familiar optimal risky asset allocation for a mean-variance investor, and it is equivalent to the optimal solution of the small price-taker investor of DeMarzo and Urošević (2006). However, in DeMarzo and Urošević (2006) the risk premium only depends on the large shareholder's trading, as the expected dividend payout is observable.

Then, at each time t , the equilibrium share price is the following.

$$P_t = \int_t^\infty e^{-r(s-t)} (\bar{\mu}_s - \rho_s) ds, \quad (4)$$

□ **Proof.** Appendix A

Hence, the share price is the present value of the expected future dividend payments by the marginal investors, minus the risk premium component. The former evolves continuously according to the following equation

$$d\bar{\mu}_t = \bar{k}_t (dD_t - \bar{\mu}_t), \quad (5)$$

that is the average belief increases (decreases) when the actual dividend payout is greater (lower) than the expected dividend payout by the marginal investors, and the rate of growth is proportional to the average reaction of the marginal investors to the new signal. Then, share prices fluctuate also independently from the economic fundamentals of the company, due to over or under reaction of the investors to news and shocks. Chan (2003) shows that investors react slowly to valid information, while they overreact to price shocks, causing huge trading volume and price volatility.

□ **Proof.** Appendix A

C. Large Shareholder's Optimality

Given the average prior on the expected dividend payout across the marginal investors $\bar{\mu}_t$, reflected in the share price $P_t = P(\bar{\mu}_t)$, the large shareholder chooses at discrete dates τ the optimal number of shares, $\alpha_{L,\tau}$, to maximize the certainty equivalent payoff

$$V(\alpha_{L,\tau}) - (\alpha_{L,\tau} - \alpha_{L,\tau^-})P_\tau,$$

where

$$V(\alpha_{L,\tau}) = \int_\tau^\infty e^{-r(s-\tau)} v(\alpha_{L,s}) ds,$$

and

$$v(\alpha_{L,t}) = \alpha_{L,t}\mu_t - \frac{1}{2}\alpha_{L,t}^2 a^L \sigma_D^2 r + \phi(b, \alpha_{L,t}),$$

is the net benefits flow to the large shareholder at each time t , given by the risk-adjusted instantaneous dividend process accrued to the large shareholder, plus the additional inflow of instantaneous private benefits generated by the stake.

So, the certainty equivalent payoff is given by the present value of the net benefits flow less (plus) the trading costs (gains), where α_{L,t^-} stands for the number of shares at the previous point in time. By taking the first-order derivative with respect to $\alpha_{L,t}$, I obtain the large shareholder's optimality condition:

$$V' = P_\tau + (\alpha_{L,\tau} - \alpha_{L,\tau^-})P', \tag{6}$$

where the prime index stands for the derivative with respect to the control variable. Therefore, the optimal demand for shares of the large shareholder equates the total benefits per share to the total cost of a share. Equation (6), in fact, is the usual

equilibrium condition that equates benefits and costs, where the total benefits per share are given by the risk-adjusted cumulative expected dividends plus the private benefits generated by an additional unit of shares, and the total cost of a share is given by the share price plus the implicit cost of trading, due to the price impact of the large shareholder's stake.

D. Equilibrium

I now characterize the equilibrium stock price and the optimal demand for shares of the large shareholder, taking into account his impact on the stock price. The equilibrium risk premium is derived by the market clearing condition in the static context (sum of investors' demand for shares equal to total number of shares minus the large shareholder's stake), while the average expected dividend payout is derived by the market clearing condition in the dynamic context (sum of shares purchases equal to sum of shares sales).

Proposition 1. At each discrete date τ , the equilibrium share price is given by

$$P_\tau = \int_\tau^\infty e^{-r(s-\tau)} (\bar{\mu}_\tau - \rho_\tau) ds,$$

where the equilibrium risk premium is $\rho_\tau = (1 - \alpha_{L,\tau}) * a^I \sigma_D^2 r$, and

$$\bar{\mu}_\tau = \bar{\mu}_{t<\tau} + \bar{g}(\tau^-) (\alpha_{L,\tau} - \alpha_{L,\tau}(\bar{\mu}_{t<\tau}))$$

is the average posterior belief on the dividend payout of the firm across the marginal investors, after the large shareholder's choice of ownership share, where $\bar{g}(\tau^-)$ is the average reaction across the marginal investors to the large shareholder's choice of ownership share, $\alpha_{L,\tau}(\bar{\mu}_{t<\tau})$ is the average prior across the marginal investors about the optimal choice of the large shareholder, equal to

$$\alpha_{L,\tau}(\bar{\mu}_{t<\tau}) = \frac{(1 + \alpha_{L,\tau^-})a^I\sigma_D^2r}{2a^I\sigma_D^2r + a^L\sigma_D^2r},$$

and $\bar{\mu}_{t<\tau} = \bar{\mu}(dDt)$ is the average expected dividend payout across the marginal investors before the large shareholder's choice of ownership share, which is function of the continuous signals given by the company's cash flows.

□ **Proof.** Appendix A

Proposition 2. Taking into account his price impact, the large shareholder's optimal stake is the following

$$\alpha_{L,\tau} = \frac{\mu_\tau - \bar{\mu}_{t<\tau} + \phi'(b, \alpha_{L,\tau})}{2a^I\sigma_D^2r + a^L\sigma_D^2r + \bar{g}(\tau^-)} + \alpha_{L,\tau}(\bar{\mu}_{t<\tau}),$$

Then, the large shareholder's optimal stake is the sum of three components: the speculation on the investors' mispricing, the expected optimal choice of shares conjectured by the marginal investors, and the gain in the private benefits generated by an additional share, which is positive only when the additional share allows to reach a higher threshold. The next section provides closed-form solution in two benchmark cases, and provides further details on the solution in the general case.

□ **Proof.** Appendix A

E. Main Results

• Perfect Information and No Private Benefits

In case of perfect information and no private benefits, the marginal investors set the weight to assign to the observation of the large shareholder's choice $\alpha_{L,\tau}$ at time τ , then $\bar{g}(\tau)$ is simply equal to $1/(2a^I\sigma_D^2r + a^L\sigma_D^2r)$, so that $\bar{\mu}_t = \mu_t$, since

$$\alpha_{L,\tau} - \alpha_{L,\tau}(\bar{\mu}_{t<\tau}) = \frac{\mu_\tau - \bar{\mu}_{t<\tau}}{2a^I\sigma_D^2r + a^L\sigma_D^2r}$$

When all the investors have the same set of information, at each point in time, then the equilibrium stock price is simply given by the present value of the future dividends payout of the firm, given the true dividends drift μ_t , minus the equilibrium risk premium $\rho = (1 - \alpha_{L,t})a^I r \sigma^2$, where

$$\alpha_{L,t} = \frac{a^I}{a^L + a^I},$$

that is the large shareholder *immediately* trades to the risk-sharing allocation. This result is equivalent to DeMarzo and Urošević (2006) in absence of moral hazard.

- **Asymmetric Information and No Private Benefits**

With asymmetric information and no private benefits, the information released by the large shareholder with his optimal demand for shares is clean with respect to the true drift of the dividends process. However, the marginal investors set the weight to assign to the observation of the large shareholder's choice $\alpha_{L,\tau}$ at time τ^- , so that

$$\bar{g}(\tau) = \frac{1}{\alpha_{L,\tau}^\mu} = \frac{1}{2a^I \sigma_D^2 r + a^L \sigma_D^2 r + \bar{g}(\tau^-)}$$

In turn, at τ , the large shareholder knows and anticipates the response of the investors, thus taking into account the impact of his demand for shares. Given his superior information, the large shareholder can exploit the mispricing of the marginal investors, thus trading on the difference between his valuation of the company shares and the average belief by the marginal investors. Therefore, the large shareholder has always the temptation to trade the company shares in order to gain on the investors' mispricing.

However, as the marginal investors learn from the large shareholder's trade, the stock price increases when the large shareholder buys, and falls when the

large shareholder sells. This mechanism makes convex (concave) the trading costs (profits) for the purchase (sale) of the shares to the large shareholder, and prevents the large shareholder from trading to his first-best solution, that is the trading policy in absence of the investors' learning.

As result, the large shareholder trades *gradually*, yet not monotonically, at the discrete dates τ towards the optimal risk-sharing allocation, while the marginal investors accordingly update their belief on the company expected dividends payout. Indeed, the magnitude of the large shareholder's trade, and so the speed of the adjustment towards the optimal risk-sharing solution, is inversely proportional to the average reaction of the marginal investors ($g(\tau^-)$) to his trade. This result is equivalent to DeMarzo and Urosevic (2006) in the presence of moral hazard.

- **Asymmetric Information and Private Benefits**

With also private benefits, finally, the information released by the large shareholder with his optimal demand for shares is noisy with respect to the true drift of the dividends process, then

$$\bar{g}(\tau) = \frac{\alpha_{L,\tau}^\mu \sigma_i^2}{(\alpha_{L,\tau}^\mu)^2 \sigma_i^2 + \sigma_\epsilon^2},$$

where the actual α_{L,τ^-}^μ is not indeed observable and therefore proxied by $1/(2a^L \sigma_D^2 r + a^L \sigma_D^2 r)$

While in absence of private benefits the large shareholder always trades at the discrete dates τ , with additional private benefits the large shareholder may not trade at all.

The no-trade occurs when the large shareholder's stake is at a given threshold ($\alpha_{L,\tau} = \alpha_j$). The purchase of a share would not produce any additional private benefit while making even more undiversified and suboptimal the investments

portfolio of the large shareholder. On the other side, selling a share produces a loss in private benefits ($\phi(\alpha_{L,\tau} < \alpha_j) = b * \alpha_{j-1}$) which may not be compensated by the gain in risk diversification.

The large shareholder, instead, sells a block of shares when the difference in the valuation, against the marginal investors, is negative (the share is overvalued) and large enough to make convenient the trade, even if this happens at the cost of losing a given amount of private benefits, and the shares depreciate because of the sale, given the price impact of his sale. On the other hand, the large shareholder is willing to buy an additional block of shares, in order to reach the higher stake threshold that generates additional private benefits, only when the difference in the valuation becomes positive (the share is undervalued) and large enough, taking into account the implicit cost of trading due to the share appreciation.

F. Price Impact of Private Benefits

Private benefits affect the equilibrium stock price in two directions. In fact, let remind that the equilibrium stock price depends on both the average expected dividend across the marginal investors following the large shareholder's demand for shares at the discrete dates τ , and on the equilibrium risk premium ρ derived by the market clearing condition

$$P_\tau = P(\bar{\mu}(\alpha_{L,\tau}), \rho(\alpha_{L,\tau}))$$

Then, it is straightforward to note that private benefits increase the equilibrium stock price by reducing the equilibrium risk premium. In fact, private benefits increase the optimal demand for shares of the large shareholder, then reducing the equilibrium risk premium sought by the marginal shareholders to invest in the firm.

In practice, a larger demand for shares of the large shareholder reduces the number of shares tradable on the market, under the assumption of fixed shares supply, thus raising the stock price.

Moreover, private benefits affect the belief of the marginal investors about the true expected dividend payout of the firm, and in particular the update of the belief following the observation of the large shareholder's decision in terms of ownership share at τ . First, since private benefits drive the optimal demand for shares of the large shareholder, then private benefits impact on the distance between the actual and the expected choice, across the marginal investors, of the large shareholder's ownership share:

$$(\alpha_{L,\tau} - \alpha_{L,\tau}(\bar{\mu}_{t < \tau}))$$

Further, private benefits affect the weight assigned to the observation of the large shareholder's choice. As the choice of the large shareholder is driven by additional motives with respect to the dividend payout of the company, then this choice is a noisy signal on the dividend payout of the company, therefore the marginal investors assign a lower weight to that observation for updating their beliefs.

III. Structural Estimation

In this section, I report the actual data used for the estimation, then I state the estimation problem, by describing the quantities to estimate, the parameters that are calibrated and the observable variables involved in the estimation, and I describe the identification process, which links the observable variables to the unobservable quantities of the model. Finally, I report the estimation results, with the relative economic implications.

A. *Data*

The universe of firms consists of the public companies listed in the Italian Stock Exchange, where they are classified by market capitalization. I consider all the non-financial firms listed in the Large, Medium, and Small Capitalization indexes. The source of data for the ownership share of the large shareholders over time is Thomson Reuters Eikon, which combines public and private information on the ownership structure of public companies. However, I double-check manually the data by using the website of the Consob, the Italian security exchange commission, that releases information on the ownership structure of the public companies every six months, on the base of the company disclosure. Hence, I use biannual data on the largest shareholder's stake between March 2004 and September 2016 (24 observations). Thomson Reuters Datastream, on the other hand, provides also data on stock prices and earnings per share.

My final sample is obtained by selecting only the firms reporting the same largest shareholder for at least 75% of the observations, in order to increase the likelihood of identifying correctly the controlling shareholder of the firm, and deleting the firms with missing data over the time series. The final sample, then, consists of 78 firms, 936 firm-year data on the earnings-per-share, 1872 firm-biannual data on shareholdings and stock prices, and 280800 firm-day observations on daily stock prices.

The large shareholder's average and median stake is around 50%, and it is quite stable over the entire time series (Figure 3, left panel). Indeed, the trading activity of the large shareholder is very low over time. I observe a trade in only 18% of the total observations, where I refer to trade as the non-zero difference between two consecutive stake observations, and the average number of trades across firms is slightly above 4 (out of 24 observations for each firm).

Moreover, when they do, they usually trade big blocks of shares: the mean (median) trade is 4.27% (1.17%) of the outstanding shares. Finally, they rarely trade

Table I. Descriptive Statistics

| | Variable | Mean | Median | Std | 10th pct | 90th pct |
|--------------|-------------------|-------|--------|-------|----------|----------|
| Company Data | Total Assets | 1.24 | 0.15 | 3.42 | 0.01 | 2.79 |
| | Debt-To-Equity | 1.72 | 0.87 | 14.77 | 0.11 | 2.45 |
| | Earning-Per-Share | 0.30 | 0.14 | 1.02 | -0.25 | 1.17 |
| | FCF-Per-Share | 0.94 | 0.48 | 1.49 | -0.01 | 2.39 |
| Stock Data | Daily Returns (%) | 1.48 | -0.38 | 20.92 | -19.32 | 22.83 |
| | Daily Turnover | 0.38 | 0.23 | 0.60 | 0.02 | 5.26 |
| LS Data | Stake (%) | 48.63 | 53.29 | 17.53 | 18.88 | 66.96 |
| | Trade (%) | 4.27 | 0.41 | 1.17 | 0.00 | 4.35 |
| | N of Trades | 3.33 | 3 | 2.34 | 1 | 6 |

The table reports the descriptive statistics at company, stock, and largest shareholder levels. The statistics are the mean, the median, the standard deviation, the 10th and the 90th percentiles, computed over the 78 final sample, between March 2004 and September 2016. Company data are on annual basis, and are the total value of assets (in millions of euro), the debt-to-equity ratio, the earnings-per-share, and the free cash flow-per-share. Stock data are on daily basis, and are the returns and the number of shares traded divided by the number of outstanding shares. Largest shareholder data are on biannual basis, and are the percentage of shares held by the largest shareholder, the variation over time of the largest shareholder's stake, and the number of times the stake of the largest shareholder changes.

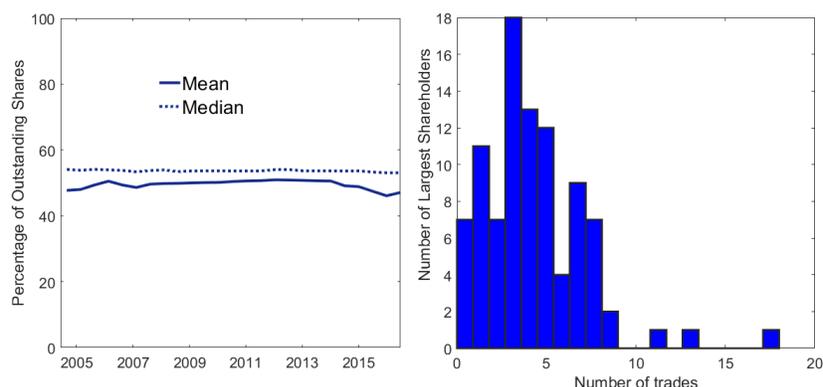
small blocks of shares. I observe a trade that involves less than 1% of the outstanding shares in only 7.79% of total observations.

In summary, the large shareholders show an ownership dynamics quite stable over time, and they trade very infrequently, usually buying or selling large blocks of shares. By contrast, the sample firms are characterised by a huge trading volume over time, and the stock prices fluctuate significantly, thus showing a substantial trading activity of the mass of shareholders and investors operating in the market. On average, 0.38% of the outstanding shares are traded every day.

B. *Parameters Calibration*

The steps of the private benefits function (α_j), and the aggregate risk aversion coefficient (a^I), are calibrated to the Italian data, for consistency with the actual dataset used for the estimation. In particular, I set a^I equal to 2, following Guiso, Sapienza,

Figure 3. Largest Shareholders: Stake and Trading



The left panel shows the mean (blue line) and the median (dotted line) ownership share, as percentage of outstanding shares, across the largest shareholders of the final 78 sample firms, between March 2004 and September 2016, at biannual frequency. The right panel shows the distribution of the number of trades of the largest shareholders of the final 78 sample firms, where a trade is defined as a non-zero difference between two consecutive stake observations.

and Zingales (2008) who measure the aggregate risk aversion on a large set of clients of an Italian bank. The private benefits thresholds follow the Italian law regarding the ownership structure of public listed companies. The thresholds are listed in table II:

The rights (and the obligations) linked to each stake level are triggered *as soon as* the shareholder reaches a given threshold, that motivates the assumption that the stake generates a given amount of private benefits for a given threshold only if the stake is greater or equal than that threshold, while holding a stake even one share lower than a threshold generates private benefits according to the lower threshold (if $\alpha_L = 29.99\%$, then $\phi(\alpha_L) = b * (10\%)$).

The following figure shows the empirical no-trade thresholds observed on the sample firms, where I define no-trade threshold a stake level at which the large shareholder of the company does not trade, that is the large shareholder remains on that ownership share for at least two consecutive observations. Note that the largest number of no-trade thresholds are observed around 30%, and between 50% and 70%.

Table II. Ownership Share Thresholds

| Ownership Share | Right/Commitment |
|-----------------|-------------------------------------|
| 3% | Obligation to stake disclosure |
| 10% | Right to call shareholders meeting |
| 30% | Obligation to launch takeover |
| 50% | Company control |
| 66% | Right to call extraordinary meeting |
| 100% | Full ownership |

The table describes the ownership share thresholds that a shareholder has to attain in order to acquire a given right, or that triggers a given commitment, according to the Italian commercial law. The thresholds are expressed as percentage of the outstanding shares.

C. *Structural parameters and latent variables*

I estimate the model firm-by-firm. For each firm, I estimate the following set of parameters

$$\theta = \{a^L, \sigma_D, \sigma, b, \bar{g}(0), \sigma_\epsilon^2\},$$

that is the large shareholder's absolute risk aversion coefficient, the dividends shocks volatility, the dividends drift shocks volatility, the parameter that quantifies the private benefits extracted by the large shareholder, for a given discrete step function, the initial weight assigned to the large shareholder's choice in terms of ownership share by the marginal investors to update their belief on μ_t , and the noise on μ_t of the information released by the large shareholder's choice due to the private benefits.

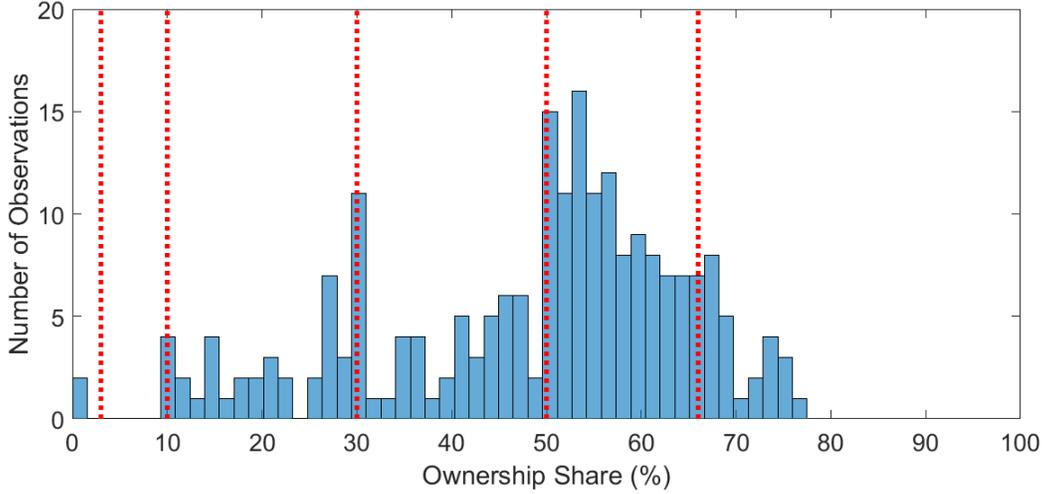
Moreover, for each firm, I infer the dynamics of the following set of latent variables

$$X_t = \{\mu_t, \bar{\mu}_t\}$$

that includes the true dividends drift and the average expected dividends drift across the marginal investors.

I estimate the model by using stock prices, ownership share of the large shareholders, and earnings-per-share.

Figure 4. Empirical No-Trade Thresholds



The figure shows the distribution of the no-trade ownership shares observed on the 78 final sample firms. The no-trade share is defined as the ownership share observed at least for two consecutive observations for a given largest shareholder, that is the ownership share at which the largest shareholder does not trade at least across two periods. The red vertical dotted lines are the stake thresholds described in Table II.

C.1. First Step

In the first step, I estimate $\{\sigma_D, \sigma\}$ by using daily stock prices, that proxy the continuous evolution of the equilibrium share price in the model. To estimate, I discretize the equations (5) and (2), respectively, take the conditional expectation at time t , and derive the following set of diffusion equations that link the two latent variables:

$$E_t[\bar{\mu}_{t+1}] = (1 - \bar{k}_t)\bar{\mu}_t + \bar{k}_t\mu_t, \quad (7)$$

where \bar{k}_t measures the average reaction to the new payout observation across the marginal investors, and

$$E_t[\mu_{t+1}] = \mu_t, \quad (8)$$

as $E_t[dD_t] = \mu_t$, that is the true time-varying drift of the dividends process, and

$E_t[d\mu_t] = 0$. The conditional covariance matrix, then, of the two latent variables is diagonal⁴. The diagonal matrix depends on both σ_D and σ :

$$\Sigma_{t+1|t}(X_t) = \text{Diag}(\sigma^2, \bar{k}_t \sigma_D^2)$$

On the other hand, the stock price is linked to the two state variables according to the equation (4), that can be written as follows

$$P_t = \frac{1}{r} [(\sigma_D^2 a^I (1 - \alpha_{L,t})) + \bar{\mu}_t] \quad (9)$$

Therefore, given a prior on μ_t and $\bar{\mu}_t$, I can compute a predicted stock price at each time t , by using the above equation, then obtaining a prediction error

$$e_t = \tilde{P}_t - \hat{P}_t,$$

where \tilde{P}_t is the actual stock price, and \hat{P}_t is the predicted stock price. Then, the errors are function of the structural parameters and the latent variables, i.e. $e_t = e(a^I, \sigma_D^2, X_t)$, and the covariance matrix of the prediction errors depends on the derivative of the stock price with respect to the state variables and the conditional variance matrix of the state variables.

$$\Sigma(e) = f \left(\frac{\partial P_t}{\partial X_t}, \Sigma_{t+1|t}(X_t) \right),$$

where

⁴In the next formula, k_t is allowed to vary over time to proxy the evolution of the average reaction of the marginal investors to the new signal provided by the firm's payout:

$$k_t = \frac{\nu_t}{\nu_t + \sigma_D^2},$$

where $\nu_t = w_t + \sigma$, and at each time step w_t is updated by using $(1 - k_{t-1})\nu_{t-1}$, and initializing the recursion with a large value of ν_0 . This procedure allows to proxy the prior update on the dividends drift across the marginal investors.

$$\frac{\partial P_t}{\partial X_t} = \left[\frac{1}{r} \bar{k}_t; \frac{1}{r} \right]$$

So, I construct a likelihood function on the prediction errors, under the assumption of normality, that I maximize with respect to σ :

$$\hat{\sigma} = \operatorname{argmax}_{\sigma} \ln \ell(e_t; \sigma) = -\frac{1}{2} \sum_{t=0}^T \ln |\Sigma(e)| - \frac{1}{2} \sum_{t=0}^T e_t' \Sigma(e)^{-1} e_t,$$

under the restriction that

$$\hat{\sigma}_D = \operatorname{argmin}_{\sigma_D} \left[\sigma_D - \sqrt{\frac{\operatorname{var}(\delta(D_t)) - \hat{\sigma}^2}{2}} \right]^2,$$

where $\delta(D_t)$ stands for the innovations in the earnings-per-share, and the above condition is derived from equation (1), noting that

$$\operatorname{var}(\delta(dD_t)) = \operatorname{var}(\delta(d\mu_t)) + 2\operatorname{var}(dD_t - \mu_t) = \sigma^2 + 2\sigma_D^2,$$

The maximization of the likelihood function, combined with the condition on the variance of the innovations in the earning-per-share, allows to simultaneously estimate σ_D and σ , and infer the dynamics of the two state variables. The second result is achieved by iterating the updating and the predicting equations of the linear Kalman filter.⁵ In particular, for each time t , the prior estimate on X_t is updated on the base of the prediction error, thus obtaining a posterior estimate in a bayesian fashion of X_t , that is used as prior estimate for the next point in time.

C.2. Second Step

In the second step, I estimate $\{a_L, \bar{g}(0), \sigma_e^2\}$ by using biannual stock prices and contemporaneous ownership share of large shareholders. By using the model equilibrium

⁵Details on the Kalman filter implementation, and details on the identification of k_t are provided in the appendix

conditions, I arrive at one equation that describes the stock price at the discrete dates τ , when the large shareholder discloses his choice in terms of demand for shares, as function only of the exogenous variables and the demand for shares of the large shareholder, by eliminating all the remaining endogenous quantities determined in the model.

Given $\bar{\mu}_{t<\tau}$ that I have estimated in the previous step with daily stock prices, the evolution of the biannual stock prices is endogenously determined using $\alpha_{L,\tau}$, $\bar{g}(\tau)$, and $\alpha_{L,\tau}(\bar{\mu}_{t<\tau})$, where $\bar{g}(\tau)$ is function of the exogenous parameters and $\bar{g}(\tau^-)$, and $\alpha_{L,\tau}(\bar{\mu}_{t<\tau})$ is function of the exogenous parameters and α_{L,τ^-} .

Hence, using again the equation (9), and similar approach to the previous step, I can compute a predicted stock price at each date τ , where I use $\bar{\mu}_\tau$, as determined in the model, to form my prediction on the stock price, thus obtaining again a prediction error at each date τ . Once more, the errors are function of the structural parameters and the latent variable $\bar{\mu}_\tau$. The conditional variance of the state variable is now simply $\bar{k}_t\sigma_D^2$, while the variance of the prediction errors depends again on the derivative of the stock price with respect to the state variable, now simply given by $1/r$, and the conditional variance of the state variable. Then, I construct a likelihood function on the prediction errors, under the assumption of normality, that I maximize with respect to $\{a_L, \bar{g}(0), \sigma_\epsilon^2\}$.

D. Identifying Private Benefits

Now, I describe the identification process of the private benefits parameter b . In particular, I derive upper and lower bounds for b , for each firm-large shareholder. First, let $J_\tau^L = J(\alpha_{L,\tau}, b)$ denote the maximal certainty equivalent payoff for the large shareholder at each time τ , given the optimal demand for shares $\alpha_{L,\tau}$

$$J_\tau^L = \int_\tau^\infty e^{-r(s-\tau)} v_s^*(\alpha_{L,\tau}) ds - (\alpha_{L,\tau} - \alpha_{L,\tau^-}) P(\alpha_{L,\tau}),$$

where $v^*(\alpha_{L,\tau})$ is the maximal net benefits flow to the large shareholder, given the optimal demand for shares $\alpha_{L,\tau}$.

J_τ^L can be written as $J_\tau^L = J_\tau^C + J_\tau^B$, where

$$J_\tau^C = J(\alpha_{L,\tau}, 0)$$

$$J_\tau^B = \int_\tau^\infty e^{-r(s-\tau)} \phi(b, \alpha_{L,s}) ds$$

Hence, J_τ^C is the present value of the risk-adjusted instantaneous dividend process accrued to the large shareholder less (plus) the trading costs (gains), and J_τ^B is the present value of the private benefits flow. Let define J_τ^C as the marginal utility of the large shareholder. Then, note that without private benefits the actual choice $\alpha_{L,\tau}$ is not optimal, that is

$$J_\tau^C < J(\alpha_{m,\tau}, 0)$$

where $\alpha_{m,\tau}$ denotes the number of shares that the large shareholder would choose as optimal solution in absence of private benefits, thus behaving as a marginal investor with perfect information. $\alpha_{m,\tau}$ solves the utility maximization problem of the large shareholder when $b=0$, for a given dynamics of μ_t and $\bar{\mu}_t$, risk aversion coefficient a^L , dividends shock volatility σ_D , initial updating weight $\bar{g}(0)$, and using the fact that in absence of private benefits $\sigma_\epsilon^2 = 0$. Hence, it is possible to compute both J_τ^C and $J(\alpha_{m,\tau}, 0)$, by using the implied dynamics of μ_t , and the parameters estimates.

Then, the gain in terms of private benefits must be at least equal to the loss in terms of marginal utility, choosing $\alpha_{L,\tau}$ rather than $\alpha_{m,\tau}$:

$$\phi(\alpha(L, t)) - \phi(\alpha(m, t)) > J(\alpha_{m,t}, 0) - J_\tau^C,$$

from which I derive the lower bound for b , where $\phi(\alpha(L, t)) = b * \alpha_j(L, t)$ and $\phi(\alpha(m, t)) =$

$b * \alpha_j(m, t)$, and $\alpha_j(L, t)$ and $\alpha_j(m, t)$ are the thresholds associated to $\alpha_{L,t}$ and $\alpha_{m,t}$, respectively. So,

$$b > \frac{J(\alpha_{m,t}, 0) - J_\tau^C}{(\alpha_j(L, t) - \alpha_j(m, t))} = b^l$$

On the other hand, the private benefits that the large shareholder can extract from the stake are not large enough to make convenient for the large shareholder to increase his stake up to a higher threshold. In other words, jumping to a higher threshold would produce gains in terms of private benefits not sufficient to cover the loss in terms of marginal utility:

$$\phi(\alpha_{j+1}(L, t)) - \phi(\alpha_j(L, t)) < J(\alpha_{j+1,t}, 0) - J_\tau^C,$$

from which I derive the upper bound for b , where $\alpha_{j+1}(L, t)$ is the threshold above the one associated to $\alpha_{L,t}$ (e.g., if $\alpha_{L,t}$ is 53%, then $\alpha_j(L, t)$ is 50% and $\alpha_{j+1}(L, t)$ is 66%). So,

$$b < \frac{J(\alpha_{j+1,t}, 0) - J_\tau^C}{(\alpha_{j+1}(L, t) - \alpha_j(L, t))} = b^u$$

E. Estimating the price impact

The estimation of the price impact of the private benefits involves a simple counterfactual analysis. First, note that the observed stock price is the stock price that reflects the private benefits. In fact, the observed stock price, at the discrete dates at which the large shareholder discloses the stake, depends on the large shareholder's stake.

Then, in the counterfactual analysis, I compare the observed stock price, at the discrete disclosure dates, with two unobservable stock prices: the stock price in absence of private benefits, that is the equilibrium stock price when there is one large

shareholder that is fully informed about the true expected payout of the firm, and the stock price in absence of a large shareholder, that is the equilibrium stock price when the marginal investors do not receive any additional signal at the discrete disclosure dates to update their beliefs. Let P^m denote the equilibrium stock price in absence of private benefits, and P^n the equilibrium stock price in absence of a large shareholder, then

$$P_\tau^m = P(\bar{\mu}(\alpha_{m,\tau}), \rho(\alpha_{m,\tau})),$$

$$P_\tau^n = P(\bar{\mu}_\tau = \bar{\mu}_{t<\tau}, \rho(0)),$$

and

$$\psi^m = \frac{\tilde{P}_\tau - P_\tau^m}{P_\tau^m},$$

$$\psi^n = \frac{\tilde{P}_\tau - P_\tau^n}{P_\tau^n},$$

where ψ^m and ψ^n denote the (percentage) price impact in the two different cases, respectively.

I estimate the price impact at the disclosure discrete dates τ , that is at biannual frequency. I compute both P^m and P^n by using the equation (9). As for P_τ^m , I first determine the optimal stake of the large shareholder in absence of private benefits, $\alpha_{m,\tau}$, for a given dynamics of μ_t and $\bar{\mu}_t$, risk aversion coefficient a^L , dividends shock volatility σ_D , initial updating weight $\bar{g}(0)$, and using the fact that in absence of private benefits $\sigma_\epsilon^2 = 0$. Then I derive the equilibrium risk premium and the updated belief about the dividends drift across the marginal investors ($\bar{\mu}_\tau$), thus obtaining the equilibrium stock price. Computing P_τ^n , instead, requires only the dynamics of $\bar{\mu}_t$, and the equilibrium risk premium is simply given by $a^L \sigma_D^2 r$.

Table III. Parameters Estimates and Goodness of Fit

| | Mean | Median | Std | 10th pct | 90th pct |
|------------------------|--------|--------|--------|----------|----------|
| σ | 0.024 | 0.016 | 0.028 | 0.002 | 0.051 |
| σ_D | 0.279 | 0.210 | 0.294 | 0.038 | 0.639 |
| a_L | 2.664 | 2.137 | 1.452 | 1.131 | 4.999 |
| b | 0.001 | 0.000 | 0.008 | -0.003 | 0.009 |
| $\bar{g}(0)$ | 0.137 | 0.041 | 0.172 | 0.000 | 0.493 |
| σ_ϵ^2 | 0.584 | 0.764 | 0.405 | 0.000 | 0.998 |
| | Mean | | Median | | |
| | Actual | Fitted | Actual | Fitted | |
| Stock Price volatility | 1.98 | 2.05 | 1.22 | 1.19 | |
| LS Trading volatility | 0.029 | 0.031 | 0.016 | 0.014 | |
| Trade (% of shares) | 7.73 | 11.73 | 3.64 | 5.46 | |
| | Actual | Fitted | | | |
| N of Trades $\geq 1\%$ | 10.76% | 6.63% | | | |

The table reports statistics on the parameters estimates for the final sample of 78 firms. The parameters are estimated firm-by-firm, by using maximum likelihood. σ and σ_D are estimated with daily stock prices and annual earnings-per-share, a^L , $\bar{g}(0)$ and σ_ϵ^2 are estimated with biannual stock prices and ownership shares, b is the average between the lower bound b^l and the upper bound b^u . The goodness of fit shows the comparison between actual empirical moments on stock price, large shareholder's stake and trading (averaged across firms), and estimation-implied moments on stock price, large shareholder's stake and trading. Moreover, the bottom line compares the observed number of trades with the estimated-implied number of trades, above 1% of the outstanding shares, as percentage of the total number of observations.

IV. Results

A. Model Fit

Table III reports parameter estimates (top panel), and goodness of fit in terms of empirical moments on stock prices and large shareholders' stake and trading (bottom panel).

The volatility of the exogenous shocks to the dividends process of the firm (σ_D) is widely larger than the volatility of the shocks (σ) in the dynamics of the fundamental value of the firm, proxied by the true time-varying drift of the dividends process. We can interpret in the real data the continuous dynamics of the dividends process of the

model as the daily arrival of news and information about the state of the firm.

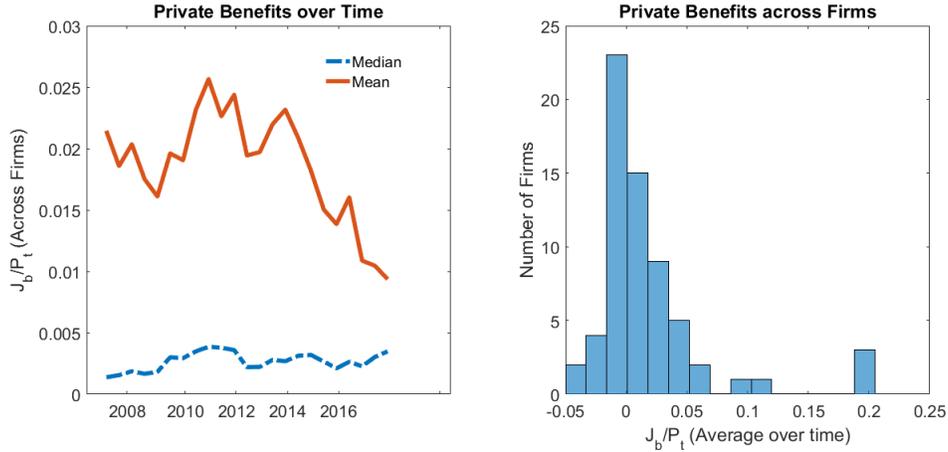
The estimate of the large shareholder's risk aversion coefficient is close to the value calibrated for the aggregate risk aversion. Further, estimates on $\bar{g}(0)$ document heterogeneity across firms in terms of initial weight assigned to the large shareholder's stake by the marginal investors, and also in terms of noise of the information released by the large shareholders with their demand for shares.

The bottom panel compares the model in-sample predictions on the dynamics of stock prices and large shareholders' stake to their corresponding actual values in the data. The estimated model performs well in replicating these features of the data, even though the stylized facts on the dynamics of large shareholders' stake have not been explicitly targeted by the estimation model. Mean and median across firms of the large shareholders' trading volatility are almost equal between real data (1.98%, and 1.22%, respectively) and model-implied estimates (2.05%, and 1.19%), and close in terms of size of trade (7.73%, and 3.64% in real data, and 11.73% and 5.46% in the model). The differences between real data and model predictions, in terms of size of trade, and also in terms of number of trades (10.76% and 6.63%, respectively), are likely due to the exogenous thresholds imposed in model, so that the model tends to predict larger blocks trades than the actual trades, but with a lower frequency.

B. Private Benefits

I use the estimated parameter b , and the actual stake of the large shareholder, to compute the present value per share of the private benefits flow, defined in the model as J_b , for each firm, and each disclosure date τ . I report results on J_b in terms of stock price, then $J_{b,\tau}/P_\tau$ is the measure of the present value of the private benefits flow extracted by large shareholders with their stake, in terms of equity value of the firm. The left panel of figure 5 reports the time series of mean and median across firms at each biannual date, and the right panel of figure 5 reports the distribution of

Figure 5. Private Benefits over Stock Price



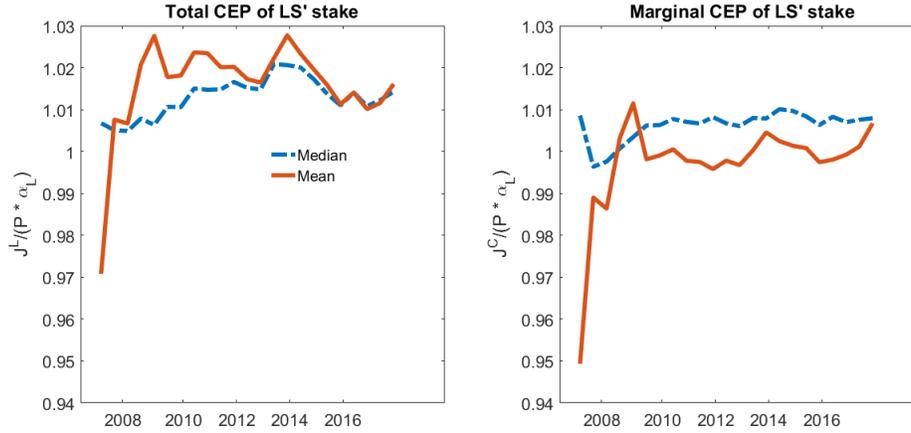
The left panel shows the mean (red line) and the median (blue dotted line) across firms, for each biannual date between March 2004 and September 2016, of the present value of the private benefits flow (J_b), divided by the stock price at the same date. The right panel shows the distribution of the present value of the private benefits flow divided by the stock price over the 78 sample firms, where for each firm I compute the average ratio over time.

the average over time for each sample firm. Statistics on the distribution are shown in table IV.

Private benefits count, on average across firms, for around 2% of the total equity value over time. This number is slightly lower than the estimate of Albuquerque and Schroth (2010). Similarly to Albuquerque and Schroth (2010), I also document a pronounced positive skewness in the distribution across firms, where the mean is much higher than the median, and does not provide an accurate picture of the results. Half of the large shareholders (40% in Albuquerque and Schroth (2010)) extract private benefits less than 1% of the total equity value, and the maximum rate of private benefits is 20% (15%).

Then, I report the overall certainty equivalent payoff of the large shareholders' stakes, defined in the model as J^L , that is the sum of the present value of the private benefits flow plus the marginal utility, that is the present value of the risk adjusted dividends flow plus (minus) the trading costs (gains). Remind that the certainty equi-

Figure 6. Certainty Equivalent of Large Shareholders

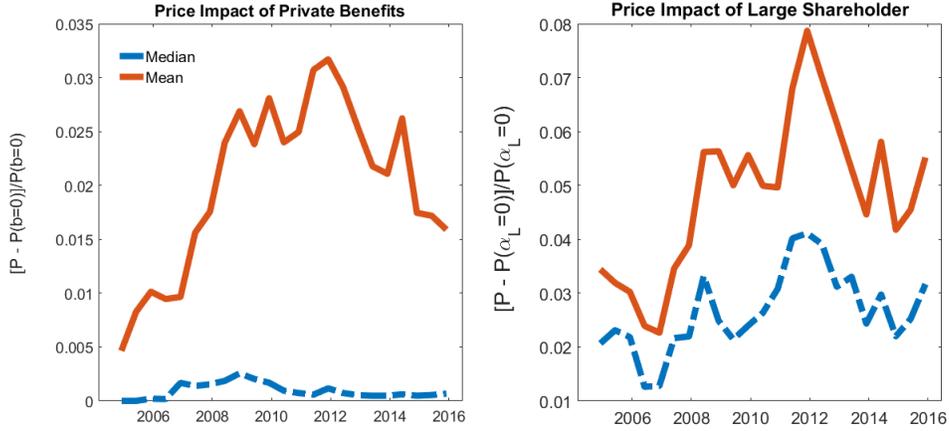


The left panel shows the mean (red line) and the median (blue dotted line) across firms, for each biannual date between March 2004 and September 2016, of the certainty equivalent payoff of the largest shareholder (J^L), divided by the stock price at the same date, and the largest shareholder's stake. The right panel shows the mean (red line) and the median (blue dotted line) across firms, for each biannual date between March 2004 and September 2016, of the marginal component of the certainty equivalent payoff of the largest shareholder (J^C), divided by the stock price at the same date, and the largest shareholder's stake.

valent payoff is simply the valuation of the stake by an investor, so the maximum price at which the investor is willing to buy that block of shares. I report results in terms of stock price, dividing by the large shareholders' stake, so that $J^L/(P_\tau * \alpha_{L,\tau})$ is equal to 1 when the large shareholder values one share exactly as the market does. The left panel of figure 6 reports the time series of mean and median across firms at each biannual date for $J^L/(P_\tau * \alpha_{L,\tau})$, and the right panel of figure 6 reports the time series of mean and median across firms at each biannual date for $J^C/(P_\tau * \alpha_{L,\tau})$, that is the marginal component of the certainty equivalent payoff of large shareholders' stakes. Statistics on the distributions of the average over time for each firm are shown in table IV.

Intuitively, the large shareholders value their stakes more than the market price. With risk aversion, an investor is willing to buy a stock only if the certainty equivalent is above the market price of the stock. The difference between the total

Figure 7. Price impact over time. All Firms



The left panel shows the mean (red line) and the median (blue dotted line) across firms, for each biannual date between March 2004 and September 2016, of the price impact of the private benefits extracted by the largest shareholder (ψ^n). The right panel shows the mean (red line) and the median (blue dotted line) across firms, for each biannual date between March 2004 and September 2016, of the price impact of the overall large shareholder's stake (ψ^m).

and the marginal large shareholders' certainty equivalent is due to the private benefits. So, private benefits contribute to compensate large shareholders for holding very undiversified portfolios, thus keeping the stake valuation of the large shareholders always above the market price of the stock.

C. Price Impact

Finally, I use the model estimates to compute the (percentage) price impact of the private benefits of control, and of the overall large shareholder's stake, defined as ψ^m and ψ^n , respectively. Figure 7 reports the time series of mean and median across all sample firms at each biannual date, and Figure 8 reports the time series of the average across two different types of large shareholders at each biannual date: corporations, and individuals. Statistics on the distributions of the average over time for each firm are shown in table IV.

Overall, private benefits of control have positive impact on stock prices, so they

Table IV. Private Benefits and Stock Price

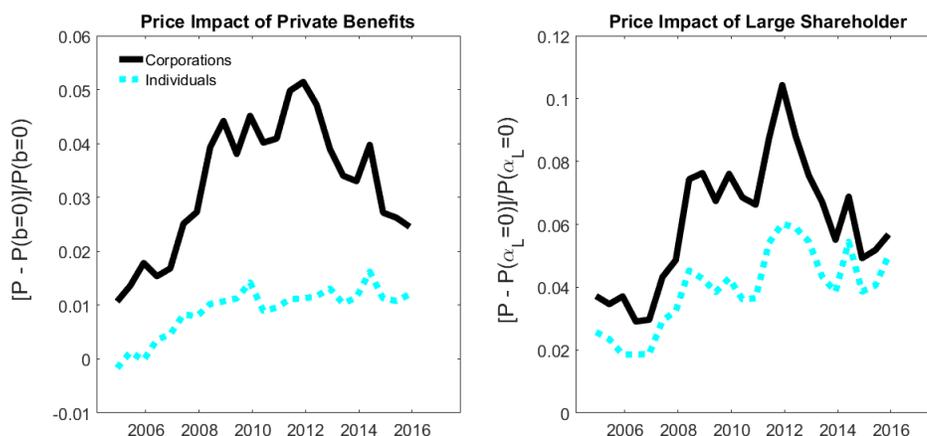
| Panel A: All Sample | | | | |
|-----------------------|-------|--------|----------|----------|
| | Mean | Median | 10th pct | 90th pct |
| J^L/P | 1.015 | 1.014 | 0.984 | 1.053 |
| J_b/P | 0.018 | 0.003 | -0.015 | 0.054 |
| J_C/P | 0.997 | 1.006 | 0.945 | 1.054 |
| ψ^m | 0.020 | 0.002 | -0.021 | 0.096 |
| ψ^n | 0.048 | 0.028 | -0.001 | 0.128 |
| Panel B: Corporations | | | | |
| | Mean | Median | 10th pct | 90th pct |
| J^L/P | 1.018 | 1.022 | 0.982 | 1.063 |
| J_b/P | 0.029 | 0.009 | -0.016 | 0.105 |
| J_C/P | 0.989 | 1.002 | 0.865 | 1.052 |
| ψ^m | 0.032 | 0.003 | -0.018 | 0.127 |
| ψ^n | 0.060 | 0.046 | 0.001 | 0.149 |
| Panel C: Individuals | | | | |
| | Mean | Median | 10th pct | 90th pct |
| J^L/P | 1.013 | 1.014 | 1.001 | 1.023 |
| J_b/P | 0.011 | 0.001 | -0.010 | 0.011 |
| J_C/P | 1.002 | 1.007 | 0.967 | 1.059 |
| ψ^m | 0.009 | 0.002 | -0.026 | 0.029 |
| ψ^n | 0.039 | 0.021 | -0.002 | 0.132 |

The table reports statistics on the total certainty equivalent payoff of the large shareholder, the marginal certainty equivalent payoff of the large shareholder, and the present value of the private benefits flow, in terms of stock price, and on the price impact of private benefits and presence of large shareholder. First, I compute the average over time for each firm for these quantities, then I report in this table mean, median, and 80% confidence interval across firms, for all sample firms, and by type of large shareholder.

are generally not extracted with cost for the rest of the company shareholders. The average price impact over time fluctuates between 1% and 3%, and the mean is always significantly larger than the median, signalling again highly positive skewness. The price impact of private benefits, in fact, is quite heterogenous across firms. For 15% of the firms, in fact, private benefits have a negative impact greater than 1%, and for the same proportion of firms private benefits have a positive impact larger than 5%.

The impact of the overall large shareholder's stake is even more beneficial to the rest of the investors. For 15% of the firms, in fact, the presence of the large share-

Figure 8. Price impact over time. Types of shareholders



The left panel shows the mean, across the firms where the largest shareholder is a corporation (black line) and the firms where the largest shareholder is an individual (sky-blue line), for each biannual date between March 2004 and September 2016, of the price impact of the private benefits extracted by the largest shareholder (ψ^n). The right panel shows the mean, across the firms where the largest shareholder is a corporation (black line) and the firms where the largest shareholder is an individual (dotted line), for each biannual date between March 2004 and September 2016, of the price impact of the overall large shareholder's stake (ψ^m).

holder increases the stock price by more than 10%, and for only 6% of the firms the negative impact is greater than 1%. In general, the positive price impact of both private benefits and large shareholder's stake is substantially greater during the crisis of 2011-2012. This suggests that large shareholders support stock prices and are significantly beneficial to the rest of the investors over negative economic cycles. In untabulated results, I find that the average price impact of private benefits across firms is 3.17% at the beginning of 2012 (at the boom of the European sovereign debt crisis) and only 0.96% at the beginning of 2007, before the start of the great financial crisis. Moreover, the overall average price impact of large shareholders across firms is 7.87% at the beginning of 2012, and only 2.27% at the beginning of 2007.

Table IV shows that corporate large shareholders exert more beneficial effect to the stock price than individuals, both in terms of private benefits and presence of large shareholder, and both over time and across firms. The combination between positive

price impact of corporate large shareholders, and positive estimate of private benefits extracted by corporate large shareholders, offers the evidence of a synergistic effect between owner and owned firm. In this case, in fact, I document a reciprocal beneficial effect so that private benefits are not extracted at cost for the rest of shareholders, and they can be properly defined as synergies.

V. Conclusion

The paper estimates private benefits of control using the restrictions provided by a dynamic model of optimal shareholding, with asymmetric information and heterogeneous shareholders. The model equilibrium conditions allows to quantify the price impact of large shareholders and private benefits of control over time. The estimation results provide evidence that large shareholders have positive impact on stock prices that does not vanish over time, so that they extract private benefits without cost for the rest of the company shareholders. On the other side, private benefits contribute to compensate large shareholders for holding very undiversified portfolios. When the large shareholder is a corporation, for instance, this reciprocal beneficial effect sheds light on a synergy between owned and owner firm.

While this paper proposes the first structural approach to quantify the price impact of large shareholders over time, both the theoretical and the empirical analysis is far from being exhausted. The main challenge is to disentangle the two drivers of the heterogeneity between large shareholder and marginal investors, namely the opportunity to extract private benefits and the superior information. Larger set of observable and informative data, further than a more elegant theoretical model, may potentially produce substantial improvement in the fit of the data, thus also providing evidence of a larger impact of large shareholders on stock prices.

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Appendix A. Proofs

Appendix A.1. Investors' Optimality Conditions

To derive the optimality conditions of the marginal investor, I follow the same approach of DeMarzo and Urosevic (2006). First, I formulate the investor's conjecture about the price process, and I conjecture a value function for the investor in the customary form as in DeMarzo and Urosevic (2006). Then, I derive the Bellman equation, to be maximized with respect to the control variables α and c . Finally, I derive the equilibrium risk premium, and the equilibrium share price in Proposition 1.

In a CARA-utility framework, with normality assumption on the dividend payout, the conjecture of the price process is the following

$$dP_t = (rP_t + \rho_t - \bar{\mu}_t)dt,$$

that is the share price grows at the riskless rate, plus a risk premium component ρ to compensate the investor's risk aversion, and to be determined in equilibrium, minus the biased expected dividend payout.

Then, for a given price process, the investor's optimality conditions are the followings:

$$u_c = J_W,$$

where u_c denotes the marginal utility from consumption, and J_W is the partial derivative of the value function of the investor, that is his expected payoff on each point in time, with respect to the state variable wealth, and

$$\alpha_{i,t} = \frac{\mu_{i,t} - \bar{\mu}_t + \rho}{ar\sigma^2},$$

where $\bar{\mu}_t$ is the average expected dividend across the marginal investors, and the

risk premium ρ compensates the investor's risk aversion. By market clearing, that is $\int_i \alpha_{i,t} di = 1 - \alpha_{L,t}$ for each t , the equilibrium risk premium is given by

$$\rho_t = (1 - \alpha_{L,t})a^I r \sigma^2,$$

where $\alpha_{L,t}$ is the stake held by the large shareholder at time t , and a^I is the aggregate risk aversion coefficient

$$\frac{1}{a^I} = \int_i \frac{1}{a^i} di$$

In fact, let the riskless holdings of the investor to evolve as follows, for given consumption level c_t , shareholding α_t , and share price P_t

$$dB_t = (rB_t - c_t)dt + \alpha_t dD_t - P_t d\alpha_t,$$

The wealth of the investor is defined as $W = \alpha P + B$. Then, the expected value of the wealth accumulation over time, $dW_t = dB_t + \alpha_t dP_t + P_t d\alpha_t$, is

$$\frac{1}{dt} E_t[dW] = rW_t + \alpha_t(\mu_{i,t} + \rho_t - \bar{\mu}_t) - c_t = rW_t + \alpha_t(\rho_t + e_{i,t} - \bar{e}_t) - c_t$$

Consider the value function

$$J(W, t) = \frac{1}{r} u \left(r[W + y_t] + \frac{(R - r)}{ar} \right),$$

where y_t is the certainty equivalent of the investor at time t

$$y_t = \int_t^\infty e^{-r(s-t)} \left(\frac{1}{2} \alpha_t^2 r \sigma^2 a \right) ds$$

The value function $J(W, t)$ satisfies the following HJB equation

$$\max_{\alpha, c} J_t + J_W dW + \frac{1}{2} J_{WW} dW^2 + u(c) = RJ,$$

Substituting dW , taking the expectation at t , and maximizing over c and α , I obtain the equations of optimality in the desired form, where $J_W = arJ$, and $J_{WW} = -aJ_W$.⁶□

Appendix A.2. Equilibrium Stock Price

Consider the i -th investor's certainty equivalent at time t for the stake $\alpha_{i,t}$,

$$\int_t^\infty e^{-r(s-t)} \left(\alpha_{i,t} \mu_{i,t} - \frac{1}{2} \alpha_{i,t}^2 a^i \sigma_D^2 r \right) ds,$$

that, with constant interest rate r , can be written as

$$\frac{\alpha_{i,t} \mu_{i,t} - \frac{1}{2} \alpha_{i,t}^2 a^i \sigma_D^2 r}{r},$$

that in equilibrium must be equal to the cost of the stake, that is

$$\frac{\alpha_{i,t} \mu_{i,t} - \frac{1}{2} \alpha_{i,t}^2 a^i \sigma_D^2 r}{r} = \alpha_{i,t} P_t$$

Then, take the derivative of both sides with respect to α , and solve for α

$$\alpha_{i,t} = \frac{\mu_{i,t} - r P_t}{a r \sigma^2}.$$

Then, impose the market clearing condition, so that $\int_i \alpha_{i,t} = 1(1 - \alpha_{L,t})$, substitute $\alpha_{i,t}$ and solve for P_t ,

$$P_t = \frac{\bar{\mu}_t - (1 - \alpha_{L,t}) * a^I \sigma_D^2 r}{r},$$

where $\bar{\mu}_t = \int_i \mu_{i,t} di$, and $a^I = \int_i (1/a^i) di$. So, P_t can be written as

⁶For the proof that the Bellman equation holds, and the conditions to avoid doubling strategies and Ponzi scheme, the reader can refer to DeMarzo and Urosevic (2006).

$$P_t = \int_t^\infty e^{-r(s-t)} (\bar{\mu}_s - \rho_s) ds$$

where $\rho_s = (1 - \alpha_{L,t}) * a^I \sigma_D^2 r$

Appendix A.3. Evolution of average expected dividend

First, I derive the evolution over time of the demand for shares of the investors, by setting $\alpha_{i,t}$ as function of $\mu_{i,t}$ and $\bar{\mu}_t$, then using Ito's lemma. The investor, then, buys (sells) company shares when the change in her expectation about the future dividend is greater (lower) than the change in the average expectation about the future dividend. In fact, setting $\alpha_{i,t} = f(\mu_{i,t}, \bar{\mu}_t)$, then

$$d\alpha_{i,t} = \frac{1}{ar\sigma^2} (d\mu_{i,t} - d\bar{\mu}_t),$$

where $d\mu_{i,t} = k_i(dDt - E_{i,t}(dD_t))$.

Note then that the market clearing condition holds also in a dynamic fashion: $\int_i d\alpha_{i,t} = 0$, so that

$$\int_i d\mu_{i,t} di = M d\mu_t$$

where M is the measure of the marginal investors. It follows that

$$d\mu_t = \frac{1}{M} \int_i (k_i(dDt - E_{i,t}(dD_t))) = \bar{k}(dD_t - \mu_t),$$

since k_i and $E_{i,t}(dD_t)$ are independent.

Appendix A.4. Proposition 1

The proof of the proposition 1 is simply the combination between the two previous proofs, at the disclosure dates τ . When the large shareholder discloses his stake, then

each investor i revises the prior on μ_t , and so the optimal demand for shares, so that, applying again Ito's lemma,

$$d\alpha_{i,\tau} = \frac{1}{ar\sigma^2}(d\mu_{i,\tau} - d\bar{\mu}_\tau),$$

where $d\mu_{i,\tau} = g_i(\tau^-)(\alpha_{L,\tau} - E_{t<\tau}(\alpha_{L,\tau}))$, with $E_{t<\tau}(\alpha_{L,\tau})$ equal across the investors as it is common knowledge at τ , and

$$d\bar{\mu}_\tau = \bar{\mu}_\tau - \bar{\mu}_{t<\tau}$$

Again, the market clearing condition holds in a dynamic fashion: $\int_i d\alpha_{i,\tau} = 0$, so that

$$\int_i d\mu_{i,\tau} di = Md\bar{\mu}_\tau$$

It follows that

$$d\bar{\mu}_\tau = \frac{1}{M} \int_i (g_i(\alpha_{L,\tau} - E_{t<\tau}(\alpha_{L,\tau}))) di = \bar{g}(\tau^-)(\alpha_{L,\tau} - E_{t<\tau}(\alpha_{L,\tau}))$$

Then, consider the i -th investor's certainty equivalent at time τ for the stake $\alpha_{i,\tau}$,

$$\frac{\alpha_{i,\tau}\mu_{i,\tau} - \frac{1}{2}\alpha_{i,\tau}^2 a^i \sigma_D^2 r}{r},$$

that in equilibrium must be equal to the cost of the stake, that is

$$\frac{\alpha_{i,\tau}\mu_{i,\tau} - \frac{1}{2}\alpha_{i,\tau}^2 a^i \sigma_D^2 r}{r} = \alpha_{i,\tau} P_\tau$$

Then, take the derivative of both sides with respect to α , and solve for α

$$\alpha_{i,\tau} = \frac{\mu_{i,\tau} - rP_\tau}{ar\sigma^2}.$$

Then, impose the market clearing condition, so that $\int_i \alpha_{i,\tau} = (1 - \alpha_{L,\tau})$, substitute $\alpha_{i,\tau}$ and solve for P_τ ,

$$P_\tau = \frac{\bar{\mu}_\tau - (1 - \alpha_{L,\tau}) * a^I \sigma_D^2 r}{r},$$

where $\bar{\mu}_\tau = \int_i \mu_{i,\tau} di$, and $a^I = \int_i (1/a^i) di$. So, P_τ can be written as

$$P_\tau = \int_\tau^\infty e^{-r(s-\tau)} (\bar{\mu}_s - \rho_s) ds$$

where the equilibrium risk premium is $\rho_\tau = (1 - \alpha_{L,\tau}) * a^I \sigma_D^2 r$

Appendix A.5. Proposition 2

Next, consider the large shareholder's certainty equivalent payoff,

$$V(\alpha_{L,\tau}) - (\alpha_{L,\tau} - \alpha_{L,\tau^-}) P_\tau,$$

write P_τ and V_τ in the explicit form, take the derivative with respect to α , and solve explicitly for $\alpha_{L,\tau}$,

$$\alpha_{L,\tau} = \frac{\mu_t - \bar{\mu}_\tau + (1 + \alpha_{L,\tau^-}) a^I \sigma_D^2 r + \phi(\alpha_{L,\tau})}{\Delta},$$

where $\Delta = 2a^I \sigma_D^2 r + a^L \sigma_D^2 r$.

Now, let define

$$\alpha_{L,\tau}(\bar{\mu}_{t<\tau}) = \frac{(1 + \alpha_{L,\tau^-}) a^I \sigma_D^2 r}{\Delta},$$

then

$$\alpha_{L,\tau} = \frac{\mu_t - \bar{\mu}_\tau + \phi(\alpha_{L,\tau})}{\Delta} + \alpha_{L,\tau}(\bar{\mu}_{t<\tau})$$

then substitute $\bar{\mu}_\tau = \bar{\mu}_{t<\tau} + \bar{g}(\tau^-)(\alpha_{L,\tau} - \alpha_{L,\tau}(\bar{\mu}_{t<\tau}))$, collect common terms over $\alpha_{L,\tau}$

and $\alpha_{L,\tau}(\bar{\mu}_{t<\tau})$, and solve again explicitly for $\alpha_{L,\tau}$, thus obtaining the desired form.

Appendix B. Kalman Filter

The Kalman filter allows to reconstruct the dynamics of a latent variable, by using observable variables, and a given known relationship between latent and observable variables. The relationship between observed and unobserved variables forms the *measurement equation*, while the evolution over time of the latent variable is called *transition equation*.

In few words, the filter starts from a prior on the latent variable, and forms a prediction of the next step value of the latent following the diffusion described in the transition equation. Then, the filter makes a forecast of the observable variable based on the prediction of the latent, by using the relationship described in the measurement equation. At each time step, the filter generates an error, given by the distance between the actual value of the observable and the forecast. The error is then used to update the prior on the latent, for a given weight assigned to the error, which is called *Kalman Gain*. Moreover, the errors depend on the model parameters, so under the assumption of normality the errors are used to construct a likelihood function that is maximized with respect to the model parameters.

In my set up, the transition equations describe the evolution of the average expected dividend across the marginal investors, and the true time-varying dividends drift, that are defined in the equation (7) and (8), respectively. The parameter \bar{k} in equation (7) is allowed to vary over time

$$k_t = \frac{\nu_t}{\nu_t + \sigma_D^2},$$

where $\nu_t = w_t + \sigma$, and at each time step w_t is updated by using $(1 - k_{t-1})\nu_{t-1}$, and initializing the recursion with a large value of ν_0 . This procedure allows to proxy the

prior update on the dividends drift across the marginal investors. Moreover, the state prediction on $\bar{\mu}_t$ has variance equal to $\omega_t + k_t^2 \sigma_D^2$, where the second term is the variance of the state, conditional at time t , derived by the market clearing equation. The state prediction on μ_t has variance equal to $\omega_t + \sigma^2$, ω_t is updated at each time step according to the Kalman Gain, and the recursion is initialized with a large value of ω_0 .

The measurement processes, instead, come from the pricing equation defined in (9), and I assume that the actual prices are observed with noise, for instance due to microstructure issues, so that

$$\tilde{P}_t = P_t + \epsilon_{1,t},$$

where the noises are gaussian, with zero mean and variance σ_P^2 .

Hence, starting from an initial guess $\{\mu_0, \bar{\mu}_0\}$, I define the prediction for $\{\mu_1, \bar{\mu}_1\}$ by using the transition equations. Then, given the prediction on the state, I compute the forecast for the share price P_1 , thus obtaining a prediction error, by using the actual observations \tilde{P}_1 . Combining the errors with the Kalman Gain, I update the prior for the state, and iterate recursively the filter up to the end of the time series. The Kalman Gain is the optimal weight to assign to prediction error in order to revise the prior on the state variable. It is derived by minimizing the conditional variance (covariance matrix) of the state variable(s).

Appendix C. Simulation Study

To test the accuracy of the estimation methodology, I perform a numerical analysis over 1000 simulations. I simulate the dynamics of the dividends time varying drift, and the dividends process of the firm, according to the equations (1) and (2), with daily frequency ($\delta t = 1/250$), for a set of arbitrary values of σ and σ_D . I also simulate a mass of marginal CARA-maximizer investors, who observe dD_t and update their prior on μ_t

Table V. Parameters Estimates: Simulation Study

| | True | Mean | Median | 10th pct | 90th pct |
|---------------------|------|-------|--------|----------|----------|
| σ | 0.1 | 0.093 | 0.093 | 0.087 | 0.099 |
| σ_D | 0.2 | 0.202 | 0.199 | 0.132 | 0.274 |
| a_L | 8 | 8.71 | 7.97 | 7.10 | 10.36 |
| b | 0.02 | 0.019 | 0.021 | 0.007 | 0.027 |
| $\bar{g}(0)$ | 0.1 | 0.097 | 0.099 | 0.082 | 0.105 |
| σ_ϵ^2 | 0.2 | 0.189 | 0.188 | 0.138 | 0.245 |

according to their heterogenous prior variances, thus obtaining an average expected dividend across the marginal investors, $\bar{\mu}_t$, for each t .

Next, for given parameter b and thresholds of the private benefits function, aggregate risk aversion coefficient a^I , large shareholder's risk aversion coefficient a^L , initial average weight $\bar{g}(0)$ and noise σ_ϵ assigned to the large shareholder's choice by the marginal investors for updating their beliefs at the discrete disclosure dates, I obtain the time series of the large shareholder's stake and the equilibrium stock price with biannual frequency ($\delta\tau = 0.5$).

Then, using daily stock prices, I estimate σ and σ_D , and I infer the dynamics of μ_t and $\bar{\mu}_t$, which I use in the second step to estimate the remaining parameters by using biannual stock prices and large shareholder's stakes. Finally, I identify the parameter b following the identification approach described above. Table V reports mean, median, and 80% confidence interval, over 1000 simulations, for the six parameters against the true arbitrary value of the parameters.