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Essays in Corporate Finance

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ABSTRACT

This dissertation consists of three chapters in corporate finance and private equity. Chapter 1, “Incentives of Private Equity General Partners from Future Fundraising”, co-authored with Ji-Woong Chung, Berk Sensoy and Michael Weisbach, studies the incentives of private equity general partners (GPs). Lifetime incomes of GPs are affected by their current funds’ performance not only directly, through carried interest profit-sharing provisions, but also indirectly by the effect of the current fund’s performance on GP’s abilities to raise capital for future funds. In the context of a rational learning model, which we show better matches the empirical relations between future fundraising and current performance than behavioral alternatives, we estimate that indirect pay for performance from future fundraising is of the same order of magnitude as direct pay for performance from carried interest. Consistent with the learning framework, indirect pay for performance is stronger when managerial abilities are more scalable and weaker when current performance is less informative about ability. Specifically, it is stronger for buyout funds than for venture capital funds, and declines in the sequence of a partnership’s funds. Total pay for performance in private equity is both considerably larger and much more heterogeneous than implied by the carried interest alone. Our framework can be adapted to estimate indirect pay for performance in other asset management settings.

Uncertainty is ubiquitous in financial markets, and market participants form expectations and learn about parameters, which may be the ability of general partners or the quality of a firm’s governance structure. Assessing the quality of a firm's governance is valuable, which might explain the recent growth of the governance industry. Yet, governance indices have been criticized by researchers and practitioners alike, mainly on the grounds of overlooking firms'

heterogeneity and their specific governance needs. Chapter 2, "D&O Insurance and IPO Performance: what can we learn from insurers?", co-authored with Martin Boyer, provides new insights into the ability of directors' and officers' (D&O) insurers to price risk, and in particular risk related to governance characteristics. Therefore, learning by investors about governance quality could be facilitated by providing investors with a market-based assessment of governance as reflected in the D&O insurance premium. We investigate whether a firm's D&O liability insurance contract at the time of the IPO is related to insured firms' first year post-IPO performance. We find that insurers charge a higher premium per dollar of coverage to protect the directors and officers of firms that will subsequently have poor first year post-IPO stock performance. A higher price of coverage is also associated with a higher post-IPO volatility and lower Sharpe ratio. Our results are robust to various econometric specifications and suggest that even when the high level of information asymmetry inherent to the IPO context prevails, insurers have information about the firms' prospects that should be valuable to outside investors.

In Chapter 3, "A Learning-Based Approach to Evaluating Boards of Directors", I develop a general framework based on a theoretical model of learning to assess how investors react to the appointment of new directors. Using predictions from a learning model, this chapter exploits the cross-sectional variation in the learning-induced decline in stock return volatility over director tenure to infer the marginal value of different kinds of directors. This new framework confirms prior empirical findings and documents new results. For example, directors joining better compensated boards have higher marginal value while the marginal value of a director joining an entrenched board is muted. Furthermore, the estimates imply that governance related uncertainty associated with the arrival of a new director accounts for 7% of return volatility, shedding light on the extent to which governance matters.

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Chapter 1. Incentives of Private Equity General Partners from Future Fundraising

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Compensation agreements in private equity (PE) partnerships typically give general partners (GPs) a fixed management fee that is a percentage (usually 1.5% to 2.5%) of the amount of capital committed to the fund, as well as a variable "carried interest" equal to a percentage of the profits (almost always 20%). Many observers credit pay for performance from carried interest as an important driver of the success of private equity firms (e.g., Jensen 1989; Kaplan and Strömberg 2009). Others, especially in the popular press, argue that pay for performance from carried interest is not strong enough to provide adequate incentives to GPs, especially because fixed management fees alone are often a source of considerable income.[1]

Missing from these arguments is the fact that explicit compensation formulas provide only part of the total pay for performance in private equity. GPs' lifetime incomes depend on their ability to raise capital in the future, which in turn depends on the performance of their current funds. Consequently, GPs' total pay for performance is also impacted by the indirect, market-based pay for performance caused by the relation between today's performance and future fundraising.

[1] See for example, "It's the Fees, Not the Profits," Wall Street Journal, Sept. 13, 2007.

Indirect pay for performance is not specific to private equity; it is a potentially important source of incentives in many settings.[2] Yet, despite the widespread theoretical interest in indirect incentives and their importance to real-world organizations, little is known about their actual magnitude or the nature of the economic forces that give rise to them. This gap in our knowledge is important because understanding the magnitude of indirect pay for performance, and how it varies over time and across firms, is essential to drawing inferences about managers' motives.

This article seeks to understand the economic forces that lead to a relation between performance and future fundraising in private equity, and to estimate the magnitude of the resulting indirect pay for performance. We first present a rational learning model in which the ability of a GP to earn profits is uncertain and rationally inferred by market participants. We develop testable predictions from this model about the way a fund's current performance affects the partnership's ability to raise subsequent funds. Using a database of fund sizes and returns, we estimate the relations between fund performance and future fundraising, and evaluate the predictions of our learning model relative to those of behavioral alternatives. We next provide an approach that transforms the empirical relations between fund performance and future fundraising into estimates of indirect pay for performance in private equity. We present estimates of the magnitude of indirect pay for performance and the way in which it varies across types of partnerships and over a given partnership's life cycle. We present our estimates in both absolute magnitude and, to gauge their relative importance, relative to the much-discussed direct (explicit)

[2] Examples include promotion or elimination tournaments inside corporations (e.g., Lazear and Rosen 1981; Rosen 1986; Han et al. 2009), the possibility that a CEO will be fired for poor performance (e.g., Jensen and Murphy 1990; Hermalin and Weisbach 1998), and the possibility that the careers of securities analysts depend on the accuracy of their forecasts (Hong and Kubik 2000; Hong et al. 2003). Market-based indirect pay for performance in other asset management settings can also arise from a relation between current performance and future fund flows.

pay for performance from carried interest.[3] Finally, we construct estimates of the total pay for performance facing private equity GPs and show that these incentives are both much larger than commonly believed, and also vary substantially across types of partnerships and over time within a given partnership.

We begin by presenting a rational learning model in the spirit of Berk and Green (2004) to formalize the logic by which good performance in the current fund could lead to higher future incomes for GPs through an effect on expected future fundraising. In the model, a private equity partnership potentially has an ability to earn (abnormal) returns for its investors, but this ability is unknown. Given a performance signal, investors update their assessment of the GP's ability and, in turn, decide whether the GP is able to raise another fund and, if so, how much capital to allocate to it (in the presence of diminishing returns to scale).

The rational learning framework predicts that both the likelihood of raising a follow-on fund and the size of the follow-on if it is raised depend on current performance, and offers intuitive cross-sectional predictions that have not been tested in the literature. First, when abilities are more "scalable," investors are willing to commit more capital for a given assessment of managerial ability. Second, the more informative the fund's performance (signal) about GPs' abilities, the more sensitive future fundraising is to today's performance. Third, holding performance fixed, follow-on fundraising is more likely when the prior assessment of ability is greater.

These predictions suggest that the future fundraising of buyout funds should be more sensitive to performance than that of venture capital funds, both because buyout funds are more

[3] It is sometimes argued in the literature that GPs' indirect incentives are strong enough to motivate their behavior (e.g., Gompers 1996; Gompers and Lerner 1999). Our work is the first to estimate the strength of these incentives.

scalable (Metrick and Yasuda 2010), and because the variance of buyout returns is lower (informativeness is higher) than that of venture capital returns. In addition, because ability is known with more precision as a partnership ages, the performance of later funds should have less impact on the assessment of ability and hence be less strongly related to future inflows of capital than the performance of earlier funds. Thus the learning model predicts that the sensitivity of future fundraising to performance should decline in the sequence of a partnership's funds. Finally, for a given performance, later sequence funds should be more likely to raise a follow-on fund because the average assessment of ability will be higher in later sequence funds than in earlier ones, for the simple reason of their survival.

Our estimates from a sample of buyout, venture capital, and real estate private equity funds from 1969 to 2009 are consistent with these predictions, and favor the rational learning model over behavioral alternatives of "naive reinvestment" or "return chasing." For all types of funds, we find that both the probability of raising a follow-on fund and the size of the follow-on if one is raised are significantly positively related to the final performance of the current fund.[4] These results suggest that even though final performance is generally not known with certainty at the time of fundraising, there is more to whether a GP can raise another fund than simple naive reinvestment. At least some limited partners (LPs) appear to have and use information about what final fund performance is likely to be.[5] These results complement Lerner, Schoar, and

[4] While Kaplan and Schoar (2005) and subsequently others find a positive relation between follow-on size and performance in tobit specifications with left-censoring at zero, such specifications do not allow for separate identification of the effect of performance on the likelihood of raising a follow-on fund. Consistent with our results, Hochberg, Ljungqvist, and Vissing-Jorgensen (2010) find that intermediate fund performance is positively related to the likelihood of raising a follow-on fund in a sample of venture capital funds.

[5] In our tests, we use a fund's ex post realized final performance (IRR) as our empirical proxy for investors' expectation at the time of subsequent fundraising about what final performance will

Wongsunwai's (2007) findings that at the level of individual LPs, there is considerable heterogeneity in the extent to which performance is taken into account in reinvestment decisions.

We also find that the relation between future fundraising and current performance is strongest for buyout funds, which relative to venture capital funds are both more scalable and likely have more informative returns. This relation is stronger for younger partnerships than for older, so the sensitivity of future fundraising to current performance declines in the sequence of a partnership's funds. Controlling for performance, older partnerships are more likely to raise a follow-on fund. All of these results match the predictions of the learning model.

In contrast, our findings are inconsistent with behavioral "return chasing" or "dumb money" explanations for private equity fund flows, in which investors chase returns without regard to their informativeness or disproportionately react to the performance of older, more famous partnerships. These explanations predict, contrary to our results, either a flat or an increasing sensitivity of future fundraising to current performance in the sequence of a partnership's funds.[6]

We next turn to estimating the magnitude of total pay for performance in private equity, and evaluate the relative magnitudes of its direct (from contractual carried interest) and indirect (from future fundraising) components. Our theoretical framework provides an explicit formula for the sensitivity of GPs' lifetime incomes to the return of the current fund. Our calculations use this formula, our estimates of the sensitivity of future fundraising to current performance,

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turn out to be. This is analogous to the common practice in asset pricing studies of using ex post realized returns to proxy for ex ante expected returns. We discuss performance measurement issues in detail in Section 3.3.

[6] A declining sensitivity of fund size to performance as a partnership ages could be consistent with return chasing if GPs are shutting out willing investors in order to avoid growing too large. However, this alternative does not explain our finding that the likelihood that a follow-on fund is raised at all also loses sensitivity to performance as the partnership ages.

parameters reflecting the characteristics of our sample of private equity funds, and estimates of expected GP 5 revenue as a fraction of fund size from Metrick and Yasuda (2010).

For an average-sized first-time buyout fund in our sample ($417.5 million), we estimate that for an extra percentage point of internal rate of return (IRR) to limited partners in the current fund, general partners receive on average an extra $3.32 million[7] in direct carried interest, assuming a carried interest of 20%.[8] For the same incremental percentage point of IRR in this current fund, our estimates of the present value of expected incremental revenue from future funds range from $4.27 million to $7.81 million, depending on whether we assume the GP potentially runs up to three or up to five more funds, resulting in estimated ratios of present values of indirect to direct pay for performance of 1.29 to 2.35. These estimates suggest that indirect pay for performance from future fundraising is at least as large as direct pay for performance from carried interest for first-time buyout funds.

We also perform the same calculations for venture capital and real estate funds. Expected compensation from future fundraising is less sensitive to current performance for these types of funds than for buyout funds, with venture capital funds displaying the least sensitivity. For an average-sized first-time venture capital fund, our estimates of the ratio of indirect to direct pay

[7] All dollar amounts and ratios are present values using annual discount rates of 9% for buyout and real estate funds, and 15% for venture capital funds. Though the exact estimates of pay for performance do vary with the chosen discount rate, our key cross-sectional conclusions are robust to reasonable alternatives.

[8] Carried interest rarely differs from 20%, especially during the post-1990 time period that covers the bulk of our sample. In Gompers and Lerner's (1999) sample of 419 venture capital funds raised before 1992, 81% have carry between 20% and 21%. In Metrick and Yasuda's (2010) sample of 238 funds from 1993 to 2006, 95% of venture capital funds and 100% of buyout funds have carry equal to 20%. In Robinson and Sensoy's (2011b) sample of 837 funds from 1984 to 2010, carry is equal to 20% for 89% and 97% of venture capital and buyout funds, respectively, and the average carry is 20.44% and 19.96%, respectively.

for performance range from 0.39 to 0.44, and for an average first-time real estate fund they range from 1.37 to 1.96.

Consistent with the learning framework, the ratio declines in the sequence of funds for all types of funds. The decline is fairly weak for buyout funds, sharper for real estate funds, and sharpest for venture capital funds. Assuming the GP potentially runs up to five more future funds, our estimates of the present values of the ratios of indirect to direct pay for performance for buyout funds are 2.35 if the current fund is the first in a buyout partnership's sequence, 2.10 if it is the second fund in a buyout partnership's sequence, and 1.75 if it is the third. For real estate funds, the corresponding ratios are 1.96, 1.39, and 1.12, while for venture capital funds, they are 0.44, 0.35, and 0.18. Figure 1-1 depicts these patterns graphically, and Figures 1-2 to 1-4 show that our cross-sectional conclusions are robust to reasonable alternative discount rates used to compute present values.

Overall, our results are consistent with indirect pay for performance from future fundraising in private equity being driven by rational learning about ability. They suggest that indirect pay for performance is of the same order of magnitude as the often-discussed direct, explicit pay for performance coming from carried interest. For the typical first-time private equity fund, the estimates indicate that GP lifetime income increases by about $0.50 for every $1 increase in LP income in the current fund, double the $0.25 implied by a 20% in-the-money carry alone. In short, total pay for performance in private equity is much stronger, by a factor of about two, than implied by the carried interest alone. Consequently, discussions of the incentives of private equity GPs that focus on carried interest alone are substantially incomplete.

Our estimates also imply that total pay for performance in private equity exhibits substantially more heterogeneity than suggested by the carried interest alone. Given that carried interest typically does not change much over time, the results imply that total pay for performance in private equity declines as funds mature.[9] Why does the carry remain relatively flat over time despite the declining indirect pay for performance, instead of increasing to compensate for career concerns over time, as models such as Gibbons and Murphy (1992) predict? One possibility is that because of learning, low-ability agents are forced out of the profession over time. The remaining high-ability agents could require lower total incentives, possibly because learning-by-doing decreases the marginal cost of effort, or because effort and ability are substitutes in generating profits from private equity investments. Another possibility is that the carried interest reflects rent-splitting between GPs and LPs rather than agency problems. In this case, the observed pay-performance relations are a consequence of this rent-splitting together with learning about ability, rather than the solution to an agency problem. An important topic for future research is to understand whether the pattern of explicit compensation over a partnership's life cycle is efficient, given the declining indirect pay for performance that we find.

Our work is related to the large literature, surveyed by Frydman and Jenter (2010), studying the magnitude of the pay-performance incentives of CEOs. Important contributions to this literature are Jensen and Murphy (1990) and Hall and Liebman (1998) for public company CEOs, and Leslie and Oyer (2009) for CEOs of private equity portfolio companies. We are the first to estimate the magnitude of the total pay-for-performance incentives of private equity general partners.

[9] Gompers and Lerner (1999) argue that the dynamics of GP compensation are also consistent with learning, and are the first to show that the largest and most successful venture capital funds do sometimes raise their carried interest above 20%. The average effect is, however, much too small to compensate for the declining indirect pay for performance we document. They find that the average carry among first-time venture capital funds is 20.5%, and 21.4% among partnerships older than eight years.

Closely related to our work is a large literature, beginning with Ippolito (1992), investigating mutual fund inflows and their strongly positive relation to historical performance. Chevalier and Ellison (1997) find that the sensitivity of mutual fund flows to performance is greater for younger funds, consistent with our results. Berk and Green (2004) rationalize many of these findings with a learning model of investor behavior similar to our approach. However, there is also considerable evidence that mutual fund investors chase returns in a manner difficult to reconcile with rational theories (e.g., Frazzini and Lamont 2008 and Sensoy 2009). Our work is also closely related to Chevalier and Ellison (1999), who find that younger mutual fund managers are more likely to be terminated for poor performance than older ones, consistent with our results. No prior work has attempted to quantify the total pay-for-performance relations facing managers in other asset management settings in light of the flow- and termination-performance relations in those industries. An additional contribution of this article is to provide an approach and framework that can be readily adapted for use for these interesting topics for future research.

The remainder of this article proceeds as follows. Section 1 lays out the theoretical learning framework. Section 2 describes the data. Section 3 presents estimates of the effect of current performance on future fundraising, and contrasts the predictions of the learning model with those of behavioral alternatives. Section 4 transforms these estimates into pay-for-performance sensitivities, using the formula derived in Section 1 as a basis for the calculations. Section 5 discusses the implications of this work and concludes.

1. Theoretical Framework

In this section we present a theoretical framework based on rational learning in which investors assign cash flows to private equity partnerships based on their perceptions of GPs' abilities to earn profits. This framework provides intuitive cross-sectional predictions that contrast with behavioral alternatives and guide our empirical tests. This framework also enables us to derive a formula expressing GP total pay for performance (direct from carried interest plus indirect from future fundraising) in terms of quantities we can estimate from the data. We assume that investors observe signals about the performance of a partnership, and based on their posterior estimate of GP ability decide whether the GP is able to raise another fund, and if so, how much to invest in it. This capital allocation process leads to a strong relation between performance in a current fund and GPs' future compensation.

1.1 Setup

We assume that a particular GP currently manages a fund and could potentially manage up to *N* more funds in the future (e.g., the GP will retire after managing N more funds). The GP has ability to earn returns through private equity investing equal to θ.[10] Ability θ is unobservable and there is symmetric information, so all agents, including the GP, have the same estimate of its value.[11] We assume that θ is constant over time for a particular partnership, which abstracts

[10] It is possible that GPs could be rewarded through future fundraising for either absolute or relative (abnormal) returns. Our empirical analysis examines both possibilities.

[11] The assumption that there is symmetric information about managers' abilities dates to Holmstrom (1999), and has been used in similar learning models by Gibbons and Murphy (1992), Hermalin and Weisbach (1998, forthcoming), Berk and Green (2004), and others. Implicitly, the idea is that anyone who can become a GP is smart, hard-working, well-educated, and so on, but the key factor determining who can earn returns is an unobservable match between the individual and the tasks associated with earning profits as a general partner.

away from issues of changing partnership composition, investment environments, or changing ability over time due to health or other considerations. Before any returns are observed, the commonly held prior assessment of θ is $\theta_0 \sim N\left(\theta, \frac{1}{\tau}\right)$.[12]

The parameter θ can be thought of as the ability to generate returns in absence of decreasing returns to scale. With decreasing returns to scale, greater fund size erodes the ability to translate θ into returns. To capture this idea, let the net return to LPs of the i^{th} fund managed by the GP be given by $r_i = \theta - c(q_i) + e_i$, where q_i is the size (committed capital) of fund *i*, $c(.)$ is an increasing, convex, and differentiable function (representing the return cost of each unit of capital) and is common knowledge, and $e_i \sim N\left(0, \frac{1}{s}\right)$. for all *i*, where *s* is the precision of the distribution.

1.1.1 Updating beliefs

Under these assumptions, after observing the returns on *i* funds, the market's updated assessment of θ, θ_i, is given by:

$$\theta_i = \frac{\tau\theta_0 + s\sum_i [r_i + c(q_i)]}{\tau + is} \qquad (1)$$

for all *i* (DeGroot (1970) provides a derivation of this Bayesian updating formula). In other words, θ_i is the expectation (posterior mean) of θ conditional on observing the returns on *i* funds.

[12] The assessment θ_0 represents the expected skill of a particular GP conditional on all observable characteristics prior to any returns being observed. Different GPs will have different values of θ_0 and consequently raise initial funds of different sizes.

Note that because q_i and c (.) are known to all, observing r_i is equivalent to observing $r_i + c(q_i)$.[13]

1.1.2 Follow-on fund size, conditional on raising a follow-on

Given that it is raised, the conditional expected return on fund *i+1* is given by $Er_{i+1} = \theta_i - c(q_{i+1})$. The equilibrium q_{i+1}, denoted q^*_{i+1}, is obtained by imposing the equilibrium condition that investors allocate capital so that the expected return on fund $i + 1$ is equal to their cost of capital, which for simplicity we normalize to zero. In equilibrium, then, $Er_{i+1} = 0$, and consequently q^*_{i+1} is given implicitly by $c(q^*_{i+1}) = \theta_i$. For our purpose, it is more convenient to invert this function. Define $f(.) = c^{-1}(.)$, so that $q^*_{i+1} = f(\theta_i)$.

1.1.3 Probability of raising a follow-on

We further assume that there is a minimum viable fund size, so funds smaller than this size are not raised. This minimum size could occur as a result of, for example, a minimum investment scale in the industry or a fixed cost of running a fund. Since the factors that determine a fund's minimum size change over time, a fund's minimum viable size varies through time following exogenous shocks to these parameters. That is, at the time a follow-on to fund *i*, fund $i + 1$, is potentially raised, we assume there exists a $\bar{q}_{i+1}$ such that the follow-on is not raised if θ_i is such that $f(\theta_i) < \bar{q}_{i+1}$. Because the shocks are not observed until the time fund $i + 1$ is to be

[13] While we speak of investors observing returns for convenience of exposition, in practice the final performance of a private equity fund is generally not known with certainty at the time a follow-on fund is raised. A more flexible interpretation of our model is that the "return" r_i that investors observe is actually a signal about what eventual performance will be. In our empirical analysis, we use a fund's actual final performance, known only ex post, as an empirical proxy for the information about performance that investors have at time of fundraising. We discuss this measurement issue in detail in Section 3.

(potentially) raised, the GP does not know ex ante (at the time fund *i* is raised) whether a given return r_i will suffice to pass the hurdle for raising fund $i+1$.[14] Denote by $p(\theta_i)$ the ex ante probability that fund $i+1$ will be raised if, ex post, the assessment of ability turns out to be θ_i.

1.2 Cross-sectional implications

This learning formulation characterizes the way in which fund returns affect future fundraising and, consequently, the future expected compensation for the funds' partners. Conditional on the sequence of returns earned in the first *i* funds, the expected size of the next fund is given by $Eq_{i+1} = p(\theta_i)f(\theta_i)$ for $i \leq N$, and zero for $i > N$.

1.2.1 Sensitivity of future fundraising to current performance across partnership types

The sensitivity of future fundraising to current performance is governed by the derivatives of $p(\theta_i)$and $f(\theta_i)$with respect to r_i, which are equal to $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$, respectively. Intuitively, a more steeply sloped $f(.)$ function means that for a small increase in the assessment of ability, the market is relatively more willing to allocate capital to a fund. More formally, by the definition of $f(.)$, we have $f'(.) = 1/c'(.)$, where $c'(.)$ represents the degree of diminution of returns for a given increase in fund size. In other words, greater $c'(.)$ represents lower "scalability" of the investment technology, so greater $f'(.)$, represents greater scalability. Holding *i* fixed, a larger weighting term $\frac{s}{\tau+is}$ reflects a greater relative infomativeness of the return to the market's perception of the GP's ability.

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[14] If the minimum viable fund size were known ex ante, raising a follow-on would be a deterministic function of r_i.

We expect buyout funds to be more scalable, and hence have a larger $f'(.)$, than other types of funds, particularly venture funds. If a GP of a buyout partnership is shown to be talented at increasing value by buying out companies, he can potentially employ the same skills to buy out larger companies and increase their value, and hence make effective use of a larger pool of capital. In contrast, if a venture capitalist has demonstrated that she is talented at investing in startup companies, she is not able to increase fund size as much because the size of startup investments is not scalable (and because, given the time-consuming value-added nature of the private equity investing process, it is not feasible simply to increase the number of investments). Metrick and Yasuda (2010) present evidence consistent with greater scalability of buyout compared to venture capital. Further consistent is the observation that the largest buyout investments in portfolio companies are on the order of tens of billions of dollars, whereas the largest venture capital investments rarely exceed a few tens of millions of dollars. Moreover, the most successful buyout funds, such as KKR and Blackstone, have steadily increased the size of their funds to the point where the largest funds are between $15 and $20 billion in committed capital, while the most successful Silicon Valley venture capitalists, such as Kleiner Perkins and Sequoia, have remained at or under $1 billion in committed capital in a given fund.

We also expect that the informativeness of returns about ability is likely to be greater for buyout funds than for venture capital funds. If a venture fund performs particularly well, this performance likely comes from the success of a small number of investments in the fund's portfolio. As a result, there is likely to be a greater variance of returns to specific investments in venture capital than in buyouts, implying a lower precision of the estimate of the fund-level return. In addition, the cross-sectional standard deviation of fund returns (IRR) is much lower in buyout (20.7% in our data) than in venture capital (52.5%), which also suggests greater informativeness of buyout returns relative to venture capital returns.

It is less clear how $p'(.)$ should vary across types of funds. Nonetheless, it seems likely that $p'(.)$ would be higher for buyout funds than for venture capital funds for similar scalability reasons. In the buyout industry, marginal underperformers are potentially more likely to be shut out of future fundraising completely because the more successful buyout partnerships can scale up to absorb the demand of investors to a greater extent than is possible in the venture capital industry. For all of these reasons, we expect the sensitivity of future fundraising to current performance to be greater for buyout funds than venture capital funds.

1.2.2 Sensitivity of future fundraising to current performance in the sequence of funds within a partnership

Holding θ_i fixed, both $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$ are decreasing in *i* because of the weighting term $\frac{s}{\tau+is}$. Intuitively, as partnerships progress through time, the partnership's θ becomes known more precisely. The optimal updating rule therefore implies that subsequent θs do not change as much as earlier θs for a given return. Consequently, in the data we expect to observe the sensitivity of future fundraising to current performance to decline as a given partnership manages subsequent funds.

1.2.3 Sensitivity of future fundraising to the sequence of funds within a partnership

Holding performance r_i fixed, the updated assessment of ability θ_i will be greater when the just-prior assessment of ability θ_{i-1} is higher. Because the probability of raising funds throughout a partnership's life depends on the market's assessment of its ability, later sequence funds will on average have higher prior assessments of ability θ_{i-1} than earlier sequence funds. Consequently, in the data we expect to observe that holding performance fixed, later sequence funds are more likely to raise a follow-on fund, so the probability of raising a follow-on fund should increase with the sequence number of the current fund.

1.3 Lifetime compensation of GPs

Let $k(r_i)$ be the fraction of the size of fund *i* that accrues as revenue to the GP with performance of r_i, including management fees, carried interest, and other income earned by the fund, such as additional fees earned by funds for managing portfolio companies.[15]

The total expected revenue earned by the GP over his lifetime is then given by:

$$TR = k(r_1)f(\theta_0) + k(r_2)p(\theta_1)f(\theta_1) + k(r_3)p(\theta_1)p(\theta_2)f(\theta_2) + \cdots + k(r_{N+1})\prod_{i=1}^{N} p(\theta_i)f(\theta_N) \qquad (2)$$

As stated above, this formulation assumes that the GP can run a maximum of N future funds. If the GP ever fails to raise a follow-on fund, he is unable to raise any funds subsequently and earns no subsequent income from managing private equity investments. For example, a third fund cannot be raised unless a second fund is raised. Hence the expected revenue from the third fund depends on the probability that the third fund is raised conditional on the assessment of ability following the second fund ($p(\theta_2)$), multiplied by the probability that the second fund is

[15] We refer to revenue and compensation synonymously throughout the article. While private equity partnerships do have some costs that create a wedge between revenue and partner compensation, many of these costs are more or less fixed and do not affect marginal compensation. We discuss potential omitted marginal costs in Section 4.4.

raised $(p(\theta_1))$. We are interested in calculating the magnitude of the total pay-performance relation facing general partners. This pay-for-performance relation is made up of a direct component, from carried interest in the current fund, and an indirect component, from the greater probability of raising future funds and greater future fund size conditional on raising future funds. The total pay-performance relation is the sensitivity of total lifetime revenue to r_1:

$$\frac{\partial TR}{\partial r_1} = \tag{3}$$

$$k'(r_1)f(\theta_0) \quad +$$

$$k(r_2)[p'(\theta_1)f(\theta_1) + p(\theta_1)f'(\theta_1)\tfrac{s}{\tau+s} \quad +$$

$$k(r_3)[p'(\theta_1)p(\theta_2)f(\theta_2)\tfrac{s}{\tau+s} + p(\theta_1)p'(\theta_2)f(\theta_2)\tfrac{s}{\tau+s} + p(\theta_1)p(\theta_2)f'(\theta_2)\tfrac{s}{\tau+2s} +$$

$$\cdots +$$

$$k(r_{N+1})\left[f(\theta_N)\sum_{i=1}^{N}\left(p'(\theta_i)\frac{s}{\tau+is}\prod_{j=1,i\neq j}^{N}p(\theta_j)\right) + \prod_{i=1}^{N}p(\theta_i)f'(\theta_N)\frac{s}{\tau+Ns}\right]$$

The terms above have natural interpretations. The first line represents the direct effect from carried interest in the current fund. The subsequent lines together make up the indirect component. The second line is the incremental expected revenue from the next fund. Intuitively, improving performance has two effects on incremental revenue from the next fund. The first term in brackets represents the increase in the probability that a follow-on fund will be raised multiplied by the size of the follow-on fund conditional on one being raised. The second term in brackets represents the probability of raising a follow-on multiplied by the increase in fund size conditional on one being raised. Similarly, the third line is the incremental expected revenue from the third fund. The three components in brackets represent, respectively, the increments to expected fund size from the increase in probability of raising the second fund, the increase in probability of raising the third fund, and the increase in size of the third fund. The weighting terms, of the form $\frac{s}{\tau+is}$, represent the extent to which an incremental change in *r* affects the update of θ. The $k(.)$ terms represent the expected fraction of future fund sizes that accrues to the GPs as revenue.

1.4 Empirical Implementation

We test the predictions of our learning model against those of behavioral alternatives using regressions that estimate the sensitivities to current performance of both the probability of raising a follow-on fund, and the size of the follow-on fund conditional on raising one. These equations also yield estimates of the $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$ terms in Equation (3). We estimate other terms in Equation (3) as follows: Incremental expected revenue to the GPs from the current fund, $k'(r_1)$, is based on the standard 20% carried interest, which, as Gompers and Lerner (1999), Metrick and Yasuda (2010), and Robinson and Sensoy (2011b) document, involves only a slight approximation. For the $k(.)$ terms for future funds, we use the estimates provided by Metrick and Yasuda (2010), who estimate the expected revenue to GPs as a fraction of a fund's size using simulations. For the $p(.)$ and $f(.)$ terms, we use the respective fund type- and sequence-specific averages in our data: the fraction of funds that raise a follow-on, and the average size of follow-on funds conditional on raising one.[16] Finally, we discount future compensation using a range of fund type-specific discount rates.

2. Data

Our analysis uses fund-level data provided by Preqin for the three major types of private equity funds: buyout, venture capital, and real estate. There are a total of 9,523 funds in Preqin as of June 2009, which, according to Preqin's documentation, represent about 70% of all capital ever raised in the private equity industry. In addition, in private communication Preqin informs us that about 85% of their data is collected via Freedom of Information Act (FOIA) requests made to limited partners subject to the act and thereby is not subject to self-reporting biases.[17] In all of our analysis, we exclude funds without vintage year data (64), without fund size data (1,137), and which are still being raised (78), and we construct our sample from the remaining 8,244 funds. We begin by constructing a sample of "preceding," or current, funds. To obtain

[16] Equation (3) involves product terms of the form $p'f$ and $f'p$. Our approach is to estimate each term separately and multiply them together. This approach is an appropriate estimate of the expectation of the product if the estimation errors of the two terms are uncorrelated—i.e., if the sampling error in p and f is uncorrelated with the regression errors associated with the estimates of p' and f', respectively. A sufficient (but not necessary) condition under which this will be true is if our sample is representative of the population of private equity funds. In that case, sampling error is uncorrelated with all other characteristics of the funds.

[17] Harris, Jenkinson, and Stucke (2010) demonstrate than Preqin has better coverage than other commercially available private equity databases, particularly of buyout funds, and perform a comprehensive comparison of performance statistics across different data sources. Despite the broad coverage, Preqin could be subject to a bias if the types of LPs subject to FOIA, the most notable type of which is public pension funds, invest in private equity funds that systematically differ from the population of funds. Lerner, Schoar, and Wongsunwai (2007) provide reassuring evidence that public pension funds have middle-of-the-road (i.e., representative) performance, and report that Preqin has also been successful in obtaining performance information from a number of successful, established partnerships. In addition, any bias from self-reporting by non-FOIA sources would likely oversample funds with good performance that do raise a follow-on fund. This effect would lead to downward-biased estimates of the fundraising/performance relation. In the limit, if every fund in the sample raises a follow-on, then performance is unrelated to the likelihood 38 of raising a follow-on.

estimates of the sensitivity of future fundraising to current performance, we require a sample of funds for which performance (IRR) data are available. From this sample of funds, we follow Kaplan and Schoar (2005) and drop funds with less than $5 million (in 1990 dollars) in committed capital (nine funds), to reduce the influence of potentially extreme growth rates of small funds on our results. In addition, to allow for sufficient time to ascertain whether a fund raises a follow-on, we drop funds raised after 2005. Finally, when a private equity firm raises multiple funds in a given year, we aggregate funds in that year and compute the fund-size-weighted IRR. There are two exceptions to this rule. The first is a few cases in which the same partnership manages, for example, both buyout and real estate funds. In these cases, we treat the partnership for econometric purposes as two separate partnerships, one each for buyout and real estate funds. The second (rare) exception is when the same partnership manages funds of the same type but different geographical focus, such as a fund focusing on European buyouts and another focusing on U.S. buyouts. In this case, we treat the European buyout funds and U.S. buyout funds as two separate partnerships. This process leaves us with a sample of 1,745 preceding funds, consisting of 645 (37%) buyout funds, 851 (49%) venture capital funds, and 249 (14%) real estate funds. The preceding funds range from 1969 to 2005, with 91% in the 1990–2005 period. For each of these preceding funds, we determine whether there is a follow-on fund in the full sample of 8,244 funds. We define a follow-on fund as the next fund raised by the same partnership for which we have information on fund size (we do not require information on the performance of the follow-on fund). If we do not observe a follow-on fund by the end of our sample period (June 2009), or if the data indicate a follow-on fund but do not provide size information, we treat this as if the partnership did not raise a follow-on fund. The working assumption we use throughout the article is that the absence of a follow-on fund with size information in the data means the partnership was unable to raise one.[18] Of the 1,745 preceding funds, 1,469 (84.2%) raise a follow-on fund. Table 1-1 presents descriptive statistics for this sample of preceding and follow-on funds. Panel A reports that the sample represents 843 distinct partnerships: 314 buyout, 412 venture capital, and 117 real estate. The distribution of number of preceding funds per partnership is clearly skewed, with many partnerships having just one or two preceding funds and a few substantially more (the maximum in the sample is twelve preceding funds). Note that these are the numbers of preceding funds used in our analysis, not the actual number of funds per partnership.

Panel B of Table 1-1 reports additional descriptive statistics. The mean (median) preceding fund size is $497.9 ($210.0) million for all funds taken together, $866.4 ($380.0) million for buyout funds, $217.7 ($125.0) million for venture capital funds, and $501.0 ($314.9) million for real estate funds. These statistics show that buyout funds are typically larger than venture capital funds, and that the distribution of private equity fund size is highly skewed. The mean (median) preceding fund performance (IRR) is 15.1% (10.6%) for all funds taken together, 16.5% (14.3%) for buyout funds, 14.1% (5.8%) for venture capital funds, and 14.6% (14.1%) for real estate funds. The mean (median) growth in fund size from preceding to follow-on fund, conditional on raising a follow-on, is 92.4% (53.8%) for all funds taken together, 110.9% (70.0%) for buyout funds, 78.6% (42.9%) for venture capital funds, and 89.7% (48.9%) for real estate funds. The time between successive fundraisings averages 3.3 years for the entire sample, 3.8 years for buyout funds, 3.3 years for venture capital funds, and 2.4 years for real estate funds.

[18] This assumption has the effect of downward-biasing our estimates of the relation between current performance and future fundraising. Undoubtedly some partnerships do raise follow-on funds that are missing from the data because the data are incomplete. Additionally, in practice, partnerships sometimes dissolve even though the market would have been willing to provide capital for a follow-on fund had the partnership desired one.

Table 1-2 reports the same fund characteristics broken out by the focal fund's position in the partnership's sequence of funds in the full Preqin database. Table 1-2 shows that higher sequence number funds are substantially larger than lower sequence number funds, both because they represent successful partnerships and also because they tend to be located later in time when funds were larger. The growth rate in fund size from preceding to follow-on funds tends to decrease in the sequence of funds. The time between successive fundraisings generally decreases in the sequence of funds, suggesting that older partnerships are more able to raise new funds on the basis of their past track records and rely less on performance in the current fund. The percentage of preceding funds that raise a follow-on is generally increasing in the sequence of funds. All of these patterns are consistent with the learning framework developed in Section 1.

3. The Empirical Relations between Current Performance and Future Fundraising

In this section, we estimate the sensitivities of the probability of raising a follow-on fund, and the size of the follow-on if one is raised, to current performance. All of our estimates in this section use a fund's realized final performance (IRR) as our measure of performance. We are therefore using the realized final IRR as a proxy for investors' expectation at the time of subsequent fundraising about what final performance of the current fund will turn out to be, even though final IRR is not generally known with certainty at that time. In other words, we use ex post realized returns to proxy for ex ante expected returns, in keeping with common practice in asset pricing studies. We discuss the measurement issues implicit in this proxy in more detail in Section 3.3, and present results using the interim IRR available at the time of fundraising for robustness in the Appendix.

3.1 Estimates without sequence effects

Table 1-3 reports estimates of the relation between future fundraising and current performance that do not allow for the possibility that the sensitivities can vary in the sequence of funds. In Table 1-3, columns labeled "(1)" use the IRR of the "current" (preceding) fund as the sole regressor, and columns labeled "(2)" contain vintage year (of the preceding fund) fixed effects to control for any market-wide, time-varying factors that potentially affect the ability to raise a follow-on fund, and to control for systematic differences in fund performance across different vintage years. These factors are likely to be important in light of the well-documented cyclicality of the private equity market (e.g., Gompers and Lerner 1998). In all specifications, we cluster standard errors at the partnership level, following Kaplan and Schoar (2005).[19]

Panel A of Table 1-3 presents marginal effects, evaluated at the mean of all independent variables, from probit specifications predicting the probability of raising a follow-on fund as a function of current (preceding) fund performance (IRR). The relation between current performance and the likelihood of raising a follow-on is statistically significantly positive for all fund types. The point estimates from the specifications with vintage year fixed effects are slightly larger than those from the specifications without. The marginal effects for the "All Funds" regressions imply that a one percentage point improvement in IRR relative to the sample mean is associated with a 0.316–0.324 percentage point increase in the probability of raising a follow-on fund. Consistent with the learning framework, the estimated marginal effects are larger

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[19] In addition, we estimate but to conserve space do not report specifications using as the independent variable the preceding fund IRR minus the preceding fund's benchmark IRR provided by Preqin. Preqin defines the benchmark IRR as the average IRR of all funds of the same type, vintage year, and geographic focus. Our results using this "risk-adjusted" measure of IRR are virtually identical to those reported below.

for buyout funds (0.467–0.588 percentage points) than for venture capital funds (0.288–0.297 percentage points), and the differences in the probit coefficients between buyout funds and venture capital funds are statistically significant (p-value 0.057), as are the differences between real estate and venture capital funds (p-value 0.086).[20] The differences between buyout and real estate are not statistically significant (p-value 0.633). In unreported analysis, we obtain statistically and economically similar results using linear probability (OLS) models instead of probit. These findings reject the "naive reinvestment" hypothesis that limited partners on average do not have or are too unsophisticated to use information about what final fund performance is likely to be when deciding whether to allow a GP to raise a subsequent fund, and complement Lerner, Schoar, and Wongsunwai's (2007) findings of considerable heterogeneity at the LP level in the extent to which performance is taken into account in reinvestment decisions. These findings are consistent with Kaplan and Schoar (2005) and subsequently others who find a positive relation between follow-on size and performance in tobit specifications with left-censoring at zero. However, these prior specifications do not allow for separate identification of the effect of performance on the likelihood of raising a follow-on fund, which is key to the "naive reinvestment" hypothesis. Panel B of Table 1-3 presents OLS estimates of equations predicting the growth in fund size from preceding to follow-on fund as a function of IRR, for the subsample of preceding funds that raise a follow-on fund. Growth in fund size is defined as follow-on fund size divided by preceding fund size minus one. The estimates indicate that current performance is strongly positively related to follow-on fund size, consistent with Kaplan

[20] Here and in all similar tests, we assess statistical significance by pooling the observations of different fund types into a single regression, and including an interaction of IRR with a dummy variable indicating fund type (either). A significant coefficient on the interaction term indicates a significant difference across fund types. We report p-values based on the specifications with vintage year fixed effects, which are estimated more precisely.

and Schoar (2005).The coefficients are all positive and are all statistically significant except those for venture capital funds. The magnitudes of the coefficients in the “All Funds” regressions imply that a one percentage point increase in IRR is associated with a 0.623–0.663 percentage point increase in fund growth. As in Panel A, the estimated effects for buyout funds (2.152–2.314 percentage points) are considerably larger than those for venture capital funds (0.426–0.492 percentage points), with real estate in between (1.723–1.955 percentage points). The differences between buyout and venture capital, and between real estate and venture capital, are statistically significant (p-values 0.016 and 0.062, respectively), while the differences between buyout and real estate are not (p-value 0.635). Panel C of Table 1-3 reports estimates of similar equations in which the dependent variable is the natural logarithm of follow-on fund size divided by preceding fund size plus one. (We add one to avoid taking the logarithm of a number close to zero.) Because the distribution of growth rates in the data is skewed, a logarithmic specification is likely to fit the data better, which is confirmed by the fact that the R^2 values in Panel C are generally considerably higher than those in Panel B. The estimates again indicate that current performance is strongly positively related to follow-on fund size.[21] The coefficients are all positive and statistically significantly different from zero. Similar to the results reported above, the estimates are significantly larger for buyout than for venture capital, and for real estate than for venture capital (p-values 0.004 and 0.024, respectively), while the difference between buyout and real estate is statistically insignificant (p-value 0.858). Overall, the estimates in Table 1-3 confirm two of the main predictions from the learning framework. First, both the likelihood of raising a follow-on fund and the size of that fund if one is raised are strongly positively related to

[21] In unreported analysis, we test whether future fundraising is nonlinear in performance. We find a statistically significantly negative coefficient on the square of IRR, indicating concavity, but the effects are economically tiny.

performance in the current fund. Second, the sensitivity of future fundraising to current performance is larger for buyout funds than for venture capital funds.

3.2 Sequence-specific estimates

The estimates presented in Table 1-3 do not consider a key prediction of the learning framework, that the sensitivity of future fundraising to current performance is declining in the sequence of funds managed by a given partnership. To test this prediction, in Table 1-4 we re-estimate the equations from Table 1-3, including variables for the preceding fund's sequence number as well as the sequence number interacted with IRR.[22] Panel A of Table 1-4 presents estimates of equations predicting the probability of raising a follow-on fund. In Panel A, we focus on linear probability models because of the difficulty of interpreting marginal effects of interaction terms in probit specifications (and the potential bias in coefficient estimates resulting from including fixed effects in probit specifications).[23] As in Panel A of Table 1-3, we find that current performance is positively related to the probability of raising a follow-on fund when all fund types are pooled, for buyout funds separately, and for venture capital funds separately. The coefficients are of similar magnitude to those in Table 1-3, and once again the difference between the coefficients for buyout and for venture capital funds is statistically significant (p-value 0.001). The coefficient on IRR for real estate funds is similar to the one reported in Table

[22] As in Table 1-3, results are similar if we use the preceding fund's benchmark-adjusted IRR. The results are also unaffected by controlling for the time between successive fundraisings in the fund growth specifications, which addresses the concern that the declining sensitivity in the sequence may be confounded by the fact that older partnerships raise follow-on funds faster on average (Table 1-2 Panel E).

[23] See Ai and Norton (2003) and Greene (2000).

1-3 but is estimated less precisely, is not statistically significant, and is significantly different from the coefficient for buyout funds but not from that for venture capital funds (p-values 0.006 and 0.708, respectively). For all funds taken together, and for buyout and venture capital funds individually, the coefficients on sequence number in Panel A of Table 1-4 are positive and statistically significant. The coefficients on the interaction of sequence number with IRR are negative and statistically significant. This pattern of coefficients matches the predictions of the learning framework of Section 1.

Higher sequence numbers are associated with funds that have done well historically and hence have high current assessments of ability, so they are more likely to raise a follow-on regardless of current performance. In addition, ability is estimated more precisely over time, so the incremental effect of current performance on a fund's ability to raise a follow-on fund grows smaller over time. Panel B of Table 1-4 presents OLS regressions predicting growth in fund size conditional on raising a follow-on fund, similar to those of Panel B of Table 1-3. The coefficients on IRR are positive, statistically significant (with one exception), and generally larger in magnitude than those in Panel B of Table 1-3. The coefficients on sequence number are all positive but not statistically significant. With the exception of buyout funds, the coefficients on the interaction of sequence number with IRR are negative and statistically significant. Panel C of Table 1-4 presents estimates of similar equations in which the dependent variable is the natural logarithm of growth in fund size plus two. As in Table 1-3, the R^2 values indicate that these specifications fit the data better than those of Panel B. The coefficients on IRR are all positive, statistically significant, and larger in magnitude than those in Panel C of Table 1-3. The coefficients on the interaction of sequence number with IRR are all negative and, with the exception of buyout funds, statistically significant. In both Panels B and C, the coefficients indicate that the sensitivity of fund growth to performance is greater (but not significantly so) for first-time buyout funds than for first-time venture capital funds, and that the gap between them grows quickly in the sequence of funds. For all fund types, Table 1-4 shows that the sensitivity of future fundraising to current performance is significantly decreasing in the sequence number of the current fund. For all funds taken together, and for venture capital funds individually, the effects are statistically significant for both the probability of raising a follow-on fund and the growth in fund size if a follow-on is raised. For buyout funds, the effect is significant only through the probability of raising a follow-on, and for real estate, only through the growth in follow-on fund size. All of our results continue to hold when controlling for vintage year fixed effects, and all match the predictions of the learning model. In contrast, our findings are inconsistent with a behavioral "return chasing" or "dumb money" explanation for private equity fund flows, by which investors chase returns without regard to their informativeness or disproportionately react to the performance of older, more famous partnerships. These explanations predict, contrary to our results, either a flat or an increasing sensitivity of future fundraising to current performance in the sequence of a partnership's funds. Prior work, beginning with Kaplan and Schoar (2005), finds as we do that follow-on fund size is positively related to current performance, but this result alone cannot distinguish behavioral return chasing from rational learning. Overall, the evidence in Tables 1-3 and 1-4 suggests that the rational learning framework better describes the empirical relations between fundraising and performance than behavioral "naive reinvestment" or "return chasing" explanations. Investors appear to utilize information about what final fund performance is likely to be when deciding on whether a GP can raise a subsequent fund, and the size of that fund conditional on raising it. Later sequence funds are more likely to raise a follow-on fund controlling for performance, the sensitivity of future fundraising to current performance is greater for buyout funds than for venture capital funds, and this sensitivity declines in the sequence of a partnership's funds. All of these findings match the predictions of the learning framework.

3.3 Measurement issues

In all of the estimates presented above, we use the fund's final IRR as the measure of the fund's performance. A concern with doing so is that a fund's ultimate performance is not known with certainty at the time the next fund is raised. The summary statistics presented in Table 1-1 show that the typical fund that raises a follow-on fund does so after three years of life, while final fund performance is not known until the end of the fund's life. An important question is whether the fund's final IRR is a reasonable proxy for the information about performance that a fund's investors use at time of subsequent fundraising in deciding whether and how much capital to allocate to a partnership's next fund. There are several reasons to believe that the answer is "yes." First, Hochberg, Ljungqvist, and Vissing-Jorgensen (2010) present a model in which a fund's current investors have soft information about the likely profitability of a fund's investments (obtained, for example, from close communication with the GPs), and use it when deciding whether to allocate capital to the partnership's next fund. This soft information about performance is not reflected in the hard information about performance, "interim IRR," available at that time, and is not observable to the econometrician. Soft information becomes observable to the econometrician only ex post, as it is reflected in the fund's final IRR. Hochberg, Ljungqvist, and Vissing-Jorgensen (2010) find evidence supporting this idea: The performance of the follow-on fund (if one is raised) is strongly correlated with the first fund's final IRR, but uncorrelated with the interim IRR that was available at the time the follow-on was raised. Given this result, it seems likely that a fund's final IRR is a better proxy than its interim IRR for the information about performance investors use in deciding whether to allocate capital to the partnership's next fund. Second, even if the interim IRR were the more desirable measure, in the Appendix we show that interim IRR (at time of fundraising) and final IRR are highly correlated, with a correlation coefficient of about 0.6. Similarly, Kaplan and Schoar (2005) find correlation coefficients of about 0.8–0.9 between interim IRR at five years and final IRR, consistent with the first few exits (or, in the case of venture capital, follow-on investments in portfolio companies) being strongly indicative of a fund's ultimate performance. Moreover, to the extent that interim IRR is the preferable measure and is imperfectly correlated with final IRR, the standard errors-in-variables effect implies that we will understate, not overstate, the sensitivity of future fundraising to performance. Notwithstanding these arguments, in the Appendix we present estimates of sensitivities of fundraising to performance in which we use the interim IRR at time of fundraising as our measure of fund performance. While we have interim IRR data for only somewhat less than half of our sample funds, we nonetheless obtain results similar to those presented in this section.

4. Estimating Direct and Indirect Pay for Performance

In this section, we use the theoretical framework discussed in Section 1, together with the regression estimates presented in Section 3, to estimate the magnitude of the total pay for performance relation facing private equity GPs. We compare the magnitudes of its direct component, from carried interest in the current fund, and its indirect component, from future fundraising. We consider two measures of pay for performance: the incremental revenue to GPs for an incremental dollar returned to LPs, and the incremental revenue to GPs for an incremental percentage point improvement in IRR.

4.1 Discounting future GP compensation

Our estimates require a discount rate for future GP compensation. Unfortunately, the literature has yet to converge on a set of widely agreed-upon estimates of the cost of capital for different types of private equity funds, making it difficult to know what discount rate to use. The main problem in estimating discount rates is the lack of objective market values at sufficient frequency with which to compute a covariance of returns with public markets. At the same time, in the literature, estimates of buyout betas tend to be close to one, and estimates of venture capital betas tend to be in the range of two to three (Korteweg and Sorensen 2010, Driessen, Lin, and Phalippou forthcoming). Metrick and Yasuda (2011) estimate that the beta of venture capital is about two, leading to a cost of capital of about 15%, assuming a risk-free rate of 3% and a market risk premium of 6%. A buyout beta of one then leads to a cost of capital of about 9%. We use a discount rate of 9% for real estate as well. For calculations involving all funds taken together, we use a weighted average of these costs of capital (weighted by the number of funds in our sample), which works out to 12%. The results reported below in Tables 1-5 and 1-6 and Figure 1-1 use these discount rates.[24] Our main conclusions are robust to alternative choices of discount rates based on the range of estimates reported in the literature, as discussed in Section 4.3 below and presented in Figures 1-2 to 1-4. Collectively, we believe Figures 1-1 to 1-4 do a good job in spanning the range of beta estimates in the literature. In addition, by following the

[24] We thank Andrew Metrick for suggesting these choices of discount rates.

approach described below, calculations analogous to the ones we present can be performed using any potential discount rate.

4.2 Direct (explicit) pay for performance

In this subsection we estimate direct pay for performance in the current fund, which is represented by the first term in equation (3) in Section 1. Our calculations assume that the fund has the standard 20% carry, and we use the relevant means in our sample (by fund type and sequence) as the baseline levels of performance and fund size. It is straightforward to perform analagous calculations for different breakpoints of fund size and performance using the sample distributions given in Table 1-2. Panel A of Table 1-5 shows that for first-time funds of all fund types, the sample mean IRR is positive and greater than a potential hurdle rate of 8%, so the carry is in the money. A 20% carry implies that GPs earn $0.25 (undiscounted) for an incremental $1 earned for LPs.[25] To calculate the incremental revenue to GPs for a percentage point improvement in IRR, it is necessary to make further assumptions. We assume that the fund's capital is called in equal annual installments, and the distribution corresponding to each capital call occurs *T* years later. The resulting IRR is algebraically equal to the IRR obtained by assuming that there is a single capital call and a single distribution spaced *T* years apart, which we take to be three years.

[25] Our use of the standard 20% carry is motivated by evidence in the literature that carried interest rarely differs from 20%, especially in recent times matching the bulk of our sample. In Gompers and Lerner's (1999) sample of 419 venture capital funds raised before 1992, 81% have carry between 20% and 21%. In Metrick and Yasuda's (2010) sample of 238 funds from 1993 to 2006, 95% of venture capital funds and 100% of buyout funds have carry equal to 20%. In Robinson and Sensoy's (2011b) sample of 837 funds from 1984 to 2010, carry is equal to 20% for 89% and 97% of venture capital and buyout funds, respectively, and the average carry is 20.44% and 19.96%, respectively.

Under these assumptions, the net-of-fee total dollar return to limited partners in the first fund, D, is given by $D = [(1+r_1)^T - 1]$, where r_1 is the IRR (which is a net-of-fee measure) of the first fund and I_1 is the size of the fund. Let R be the revenue earned by the GP. By the chain rule, $\frac{\partial R}{\partial D} = \frac{\partial R}{\partial r_1}\frac{\partial r_1}{\partial D}$. Inverting D and differentiating yields:

$$\frac{\partial R}{\partial D} = \left[\frac{1}{TI_1}(1+r_1)^{1-T}\right]\frac{\partial R}{\partial r_1} \qquad (4)$$

We use this formula to convert incremental revenue per extra dollar returned to LPs to incremental revenue per incremental percentage point of IRR, and vice versa. Panel A of Table 1-5 displays the direct pay for performance calculated using this formula with $\frac{\partial R}{\partial D}$ = 0.25, corresponding to 20% carry, and the displayed sample parameters. For the average first time fund in our sample (size $262.3 million), improving IRR from a baseline of 15.75% to 16.75% results in $2.636 million in incremental revenue to the GP, or $1.876 million in present value. For buyout funds the present value is larger, $3.323 million, reflecting both the larger average size of buyout funds and the higher baseline level of performance. The present value for venture capital funds is the smallest ($0.795 million), and real estate funds fall in the middle ($2.290 million).

4.3 Indirect pay for performance from future fundraising

We now turn to estimating indirect pay for performance arising from the effect of current performance on future fundraising. This effect corresponds to the second and following lines in equation (3) of Section 1. We require estimates of the $k(.)$ terms, the $p(.)$ and $f(.)$ terms, and the $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$ terms in equation (3). The $k(.)$ terms represent the expected fraction of a fund's size that accrues to GPs as compensation, through a combination of management fees and carried interest. The appropriate values for $k(.)$ are not obvious, and depend on the fee structure as well as the entire distribution of returns. We rely on Metrick and Yasuda (2010), who perform Monte Carlo simulations to estimate the distribution of $k(.)$ using details of the compensation terms of a recent sample of venture capital and buyout partnerships. We use similar values for real estate funds (not covered by Metrick and Yasuda 2010) and the overall sample of funds.

For the $p(.)$ and $f(.)$ terms, we use the type- and sequence-specific averages in our sample. For example, suppose the fund of interest (current fund) is a first-time buyout fund. Then $p(\theta_1)$ and $f(\theta_1)$ are the fraction of preceding buyout funds of sequence number 1 that raise a follow-on fund in our sample, and the average size of the follow-on, conditional on raising one. Panels F and C of Table 1-2 report that these values equal 76.5% and $685.7 million, respectively. In this way, all of the p (.) and f (.) terms used in our calculations are provided in Table 1-2.

It remains to obtain estimates of the $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$ terms from the regression coefficients in Tables 1-3 and 1-4. In all of our calculations, we use the coefficients from the specifications without rather than with vintage year fixed effects, which lead to smaller estimates of indirect pay for performance. We begin with the coefficients from Table 1-3. The marginal effects from the probit regressions in Panel A are estimates of the change in probability of raising a follow-on fund for an incremental change in current performance, and so are direct estimates of $p'(\theta_i)\frac{s}{\tau+is}$ under the constraint that the estimate is the same for all *i*—i.e., sequence effects are ignored.

We use the coefficients from the logarithmic specifications in Panel C to obtain estimates of the $f'(\theta_i)\frac{s}{\tau+is}$ terms.[26] In Panel C, the dependent variable is the natural logarithm of follow-on fund size divided by preceding fund size plus one—i.e., $ln\left(\frac{f(\theta_i)}{f(\theta_{i-1})}+1\right)$. The estimated regression coefficient, β, is an estimate of the derivative of this quantity with respect to r_i, the IRR of the preceding fund: $\beta = \frac{1}{\frac{f(\theta_i)}{f(\theta_{i-1})}+1} f'(\theta_i)\frac{s}{\tau+is}$. Rearranging, we have

$$f'(\theta_i)\frac{s}{\tau+is} = \beta(f(\theta_{i-1}) + f(\theta_i)).$$

Continuing the example of the first-time buyout fund, the expected incremental compensation from the next fund is given in equation (3) as $k(r_2)[p'(\theta_1)f(\theta_1) + p(\theta_1)f'(\theta_1)\frac{s}{\tau+s}$. Metrick and Yasuda (2010) estimate an average $k(.)$ for buyout funds of 17.72%. The marginal effect in Panel A of Table 1-3 for a one percentage point increment in IRR is equal to 0.00467, and the coefficient from Panel C of Table 1-3 is equal to 0.00524 (after, in both cases, converting decimal IRR to percentage). As described above, $p(\theta_1)$ = 76.5% and $f(\theta_1)$= \$685.7 million. Panel A of Table 1-2 reports that the average size of preceding buyout funds of sequence number 1 in our sample is $f(\theta_0)$= \$417.5 million. Putting it all together, the incremental expected compensation from the next (second) fund for a one percentage point improvement in IRR in the current fund is equal to

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[26] A comparison of Panels B and C of Table 1-3 indicates that a logarithmic specification for follow-on fund size fits the data better. Our estimates are higher, generally by about 10%, if we use the coefficients from the raw growth specifications in Panel B instead.

0.1772 * [0.00467 * 685.7 + 0.765 * 0.00524 * (685.7 + 417.5)], or $1.351 million. This figure is a present value as of the beginning of the life of the second fund (this is how Metrick and Yasuda compute *k*), so we further discount for the average time between fundraisings (approximately three years in our data) to convert to present value as of the beginning of the current fund. In this way, we calculate the expected incremental compensation from the second, third, etc. follow-on funds following equation (3) of Section 1, discounting each appropriately using the fund type–specific discount rates discussed above, and assuming a three-year gap between successive fundraisings. We then add the discounted expected incremental compensation from each future fund to arrive at the total estimated indirect pay for performance.

4.3.1 Estimates ignoring sequence effects

Panel B of Table 1-5 displays estimates of indirect pay for performance using the coefficients from Table 1-3 and the methodology described in Section 4.3, focusing on first-time funds. We present results for the quartile breakpoints of *k* reported by Metrick and Yasuda (2010), which are 15.75%, 17.72%, and 19.60% for buyout funds and 20.24%, 22.84%, and 26.11% for venture capital funds. For all funds taken together and for real estate funds, we use 15%, 20%, and 25%. As shown in equation (3), all of the estimates are proportional to *k*. We also present results for different values of *N*, the maximum number of future funds the GP could potentially run (e.g., before retirement). As discussed in Section 1, the estimates incorporate the realistic feature that failure to raise a follow-on is a once and for all event, so dropping out is permanent.

In the columns labeled $\delta TR/\delta IRR$, we present estimates of the present value of the expected incremental revenue from future funds resulting from a one percentage point improvement in current fund IRR, and in the columns labeled $\delta TR/\delta D$ we use equation (4) to convert these estimates into those resulting from an extra dollar returned to LPs. To gauge the relative magnitudes of the present values of indirect and direct pay for performance, we present their ratios in the rightmost columns of Panel B of Table 1-5. The ratios do not depend on whether the performance measure is IRR or dollars because the term in brackets in equation (4) drops out when taking the ratio. It is evident from Panel B of Table 1-5 that indirect pay for performance from future fundraising is important in the private equity industry, and of the same order of magnitude as direct pay for performance. The ratios range from a low of 0.42 for venture capital funds with $N = 3$ and $k = 20.24\%$ to a high of 3.09 for buyout funds with $N = 5$ and $k = 19.60\%$. The estimates of indirect pay for performance are largest for buyout funds and smallest for venture capital funds, consistent with the patterns in Table 1-3.

4.3.2 Estimates accounting for sequence effects

The estimates presented in Table 1-4 suggest that the indirect incentives calculated in Table 1-5 are likely to be strongly affected by the declining sensitivity of future fundraising to current performance in the sequence of a partnership's funds. The learning framework predicts two channels through which sequence effects are likely to be important. First, holding the sequence number of the "current" fund fixed, there is relatively less value from each potential subsequent fund, and hence relatively less value from increasing *N*. Second, as a partnership ages (the current fund becomes more advanced in the sequence of the partnership's funds), indirect pay for performance will decline. The indirect pay for performance estimates presented in Table 1-6 strongly support these ideas. We obtain these estimates by applying the methods described in Section 4.2., taking sequence effects into account. Wherever we previously used a coefficient from Table 1-3, we instead use the corresponding level effect coefficient plus the product of the coefficient on the sequence interaction and the sequence number of the preceding fund, all from Table 1-4. For example, when calculating the incremental compensation from the second follow-on fund for buyout funds, the estimate of $p'(\theta_2)\frac{s}{\tau+2s}$ is given by (from Panel A of Table 1-4) 0.698 -0.091 * 2 = 0.516. In Panel A of Table 1-6, we calculate the (discounted) direct effect or explicit pay for performance for different sequence number current funds. The effects per incremental dollar returned to LPs are the same as in Table 1-5, but the effect per incremental percentage point of IRR grows with fund sequence reflecting the growth in fund size with sequence. In Panel B of Table 1-6, we estimate indirect pay for performance, holding *k* fixed at its median values from Table 1-5. Two patterns are evident. The estimates are smaller than their counterparts in Table 1-5, though still large, and decline with the sequence number of the current fund. The decline is very strong for venture capital funds and fairly weak for buyout funds, for which indirect pay for performance remains important well into a partnership's sequence of funds.

Figure 1-1 depicts the patterns in Table 1-6 graphically, and shows that for all funds taken together and for venture capital funds, indirect pay for performance declines to virtually zero by the time the partnership is managing its fourth fund, leaving only the direct component. Overall, the estimates indicate that indirect pay for performance is a substantial component of the total pay for performance relation facing private equity GPs, especially for funds early in a partnership's life. Figures 1-2 to 1-4 show that our key cross-sectional conclusions are robust to alternative choices of discount rates. First, because GPs hold what is essentially an option on the equity returns of their portfolio, the cost of capital may underestimate the riskiness of the GP claim. For this reason, Figure 1-2 reports results using discount rates five percentage points higher than our base cost of capital estimates. Second, based on the range of beta estimates in the literature it is possible (but unlikely) that venture capital funds have in fact a lower cost of capital than buyout funds. To assess the sensitivity of our conclusions to this possibility, Figure 1-3 reports results assuming the most extreme low venture capital beta estimate (0.86; Woodward and Hall 2003) and high buyout beta estimate (1.3; Phallipou and Zollo 2005). Even with a lower discount rate for venture capital than for buyout, indirect pay for performance is still larger for buyout funds. Finally, Figure 1-4 uses high-end beta estimates of 3 for venture capital and 1.3 for buyout. Figures 1-2 to 1-4 continue to show that indirect pay for performance is higher for buyout funds compared to venture capital, and declines in the sequence of a partnership's funds. We believe that collectively Figures 1-1 to 1-4 do a good job spanning estimates of discount rates in the literature. The figures show that while the magnitude of indirect pay for performance declines with increased discount rates, the estimates remain considerable in magnitude. Importantly, the figures show that our key cross-sectional conclusions are robust to alternative choices of discount rates.

4.4 Factors Omitted from the Estimates

There are several factors that could affect the magnitude of our estimates that are not explicitly modeled in the learning framework and which we do not have the data to estimate.[27] First, we ignore costs. Fixed costs do not affect general partners' pay for performance incentives. However, costs do change as private equity funds grow and raise additional capital. In particular, as future funds grow in size, partnerships may hire new partners who receive some share of the

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[27] One potential such effect we can test comes from the notion that good performance leads to faster future fundraising. If so, GPs would get revenue from future funds earlier and potentially manage more funds over a career. However, in the data there is no significant relation between a fund's performance and the time between fundraisings

revenue. Omitting this growth in the number of partners causes us to overestimate indirect pay for performance. To estimate the magnitude of this effect would require data we do not have: information on the number of partners, as well as the revenue-sharing arrangements between partners as partnerships progress through time. To the extent that new partners added on to future funds are likely to receive much lower shares of revenue than the original partners who were responsible for good performance in the prior fund, the bias will be small.[28]

Another possibility is that a partnership's carried interest percentage may respond to its prior performance. Hochberg, Ljungqvist, and Vissing-Jorgensen (2010) provide evidence that this adjustment sometimes happens when venture capital firms have extremely good performance. However, the sensitivity of these adjustments to performance is small. Hochberg et al.'s estimates (in their Table 1-6) imply that carried interest grows by about eight basis points for an incremental one percentage point improvement in IRR. An eight basis point change is 0.4% of a base carry of 20%, so this effect causes our estimates to understate actual indirect pay for performance very slightly, by about 0.4%.

The impact of good performance on the partners' outside options could also influence estimates of indirect pay for performance. Good performance in a fund likely positively affects a partner's human capital, which she could use to form a new partnership or to leave the private

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[28] Metrick and Yasuda (2011, p.27) report suggestive compensation numbers based on surveys of venture capitalists. Their numbers indicate that, consistent with our intuition, more senior partners (who presumably have been with the partnership since its earlier funds) earn considerably more total compensation than junior partners, and five to 39 eight times as great a share of the carried interest. We also note that while experienced general partners occasionally leave one firm to join another existing firm, Alter (2009) finds that none of the experienced venture capitalists in his sample do so. His evidence suggests that venture capital firms at least only rarely hire experienced partners with whom they would have to share a large portion of the revenue.

equity industry altogether and pursue other options. Since the value of these other options is likely to be positively related to the fund's performance, this effect leads our estimates to be understated.[29]

Kaplan and Schoar (2005) find evidence of performance persistence, as do Chung (2010), Hochberg et al. (2010), Phalippou (2010), and Robinson and Sensoy (2011a). Persistence would result in somewhat higher carry dollars in the subsequent fund, suggesting that it may be appropriate to use the upper range of the *k* estimates given by Metrick and Yasuda (2010) when calculating indirect pay for performance. Our Figures 1-1 to 1-4 use the median *k* to be conservative. Conversion to other values is straightforward as all estimates are linear in *k*.

Finally, in all of our calculations, we assume that the direct, explicit pay for performance driven by the carried interest is "in the money," so that GPs receive the full 20% of profits as carried interest. While our calculations are appropriate for the average fund in our sample, whose carry is in the money, this nonetheless represents an upper bound in the cross-section of funds, since many funds' performance is such that they earn no carried interest. This effect implies that our estimates of direct pay for performance are an upper bound, and that for some funds the ratio of indirect to direct pay for performance is much larger than for the average fund.

Overall, while costs that rise with fund size cause our estimates of the ratio of indirect to explicit pay for performance to be overstated, all other omitted factors discussed above cause them to be understated. Consequently, our conclusion that the indirect component of pay for

[29] Alter (2009) reports that it is rare for the young California venture capitalists in his sample to defect to raise their own funds, with a cumulative rate of 7% over every four-year block of time in his data, less than 2% per year. If the rate for buyout partners is even lower than this, which seems unlikely, our estimates of the difference between buyout and venture capital pay-performance sensitivities would be slightly overstated.

performance in private equity is important and substantial in magnitude is likely to be robust to refinements of our estimates. Moreover, such refinements are unlikely to overturn the support in the data for the key cross-sectional differences implied by the learning model: that venture capital funds have lower indirect pay for performance than buyout funds, and that pay for performance declines in the sequence of a partnership's funds.

5. Conclusion

In the private equity industry, the possibility of future fundraising provides substantial indirect pay for performance incentives to general partners above and beyond the much-discussed incentives from the explicit compensation system. Achieving high returns early on allows a partnership to establish a reputation for being able to generate returns, which is valuable as it allows partners to earn fees on larger funds in the future. We present a learning framework that characterizes this process, and show that its predictions better match the fundraising dynamics in the data than behavioral alternatives based on "naive reinvestment" or "return chasing." In particular, both the likelihood of raising a follow-on fund and the size of that fund if one is raised are strongly positively related to current performance, the relations betwen future fundraising and performance are stronger for buyout funds than for venture capital funds, and these relations decline in the sequence of a partnership's funds.

From the learning framework we derive an explicit formula that we use to transform our estimates of the sensitivity of future fundraising to current performance into estimates of the size of indirect pay for performance in private equity. Our estimates suggest that the indirect component of pay for performance is of the same order of magnitude as the direct component from carried interest. Indirect pay for performance is particularly important for buyout partnerships compared to venture capital and for newer partnerships that have yet to establish a reputation. Our results are all consistent with the learning framework, and suggest that learning about ability is a key driver of indirect pay for performance in private equity.

This article contributes to the debate about the incentives of private equity general partners and their effect on value creation. Despite the central importance of general partner incentives to understanding the activities of private equity firms, we are the first to estimate how large their total incentives (direct plus indirect) actually are. Our results suggest that total performance-based compensation in private equity partnerships is larger, by a factor of about two, than commonly discussed, because most discussions focus on the carried interest alone. Total pay for performance in private equity is much larger and exhibits much more variation, both across partnership types and in the sequence of funds, than suggested by the carried interest alone.

While the indirect pay for performance that we find is consistent with our learning framework, our results do not speak directly to whether the resulting total compensation system, including the dynamics of carried interest, is efficient. Understanding whether the total pay-performance relations in private equity, in particular the fact that the direct carried interest typically does not increase much in the face of diminishing indirect pay for performance over time, are efficient and reflect optimal contracting is an important topic for future research.

The analysis in this article could be applied to other forms of organization. Perhaps the most straightforward application would be to other asset management settings, such as hedge funds, mutual funds, and pension funds, because their explicit fee structures would allow for similar calculation of the returns to managing a larger quantity of funds. Calculating the indirect pay for performance implied by the flow-performance (and termination-performance) relations in these settings would be an important addition to our understanding of these industries.

Most generally, our analysis provides empirical evidence consistent with the idea started by Fama (1980) and Holmstrom (1999) that indirect pay for performance can be an important source of incentives inside firms. An advantage of studying private equity is that it is possible to quantify these incentives. Private equity is also an industry where incentives, both direct and indirect, are particularly important. The extent to which indirect, market-based incentives are important in other industries, both in absolute terms and relative to direct incentives, is likely to be an important topic of future research.

Figure 1-1 Ratio of indirect to direct pay for performance using discount rates: All Funds 12%, Buyout 9%,Venture Capital 15%, Real Estate 9%

This figure presents estimates of the ratio of the indirect to direct effect of an incremental improvement in performance in the current fund on GP revenue. The indirect effect is the estimated effect on expected revenue from future funds, while the direct effect comes from carried interest in the current fund. The figure presents estimates computed using the formulas provided in Section 4, sample parameters from Table 1-2, and regression coefficients from Table 1-4. Estimates are computed for all funds taken together, buyout funds, venture capital funds, and real estate funds, for different assumptions about the current fund's placement in the partnership's sequence of funds. All estimates assume N, the number of potential future funds, is equal to five. Discount rates of 12%, 9%, 15%, and 9% are used for all funds taken together, buyout funds, venture capital funds, and real estate funds, respectively. These discount rates correspond to betas of 1 for buyout funds, 2 for venture capital funds, and 1 for real estate funds. The discount rate for all funds is a sample-size weighted average of the type-specific discount rates.

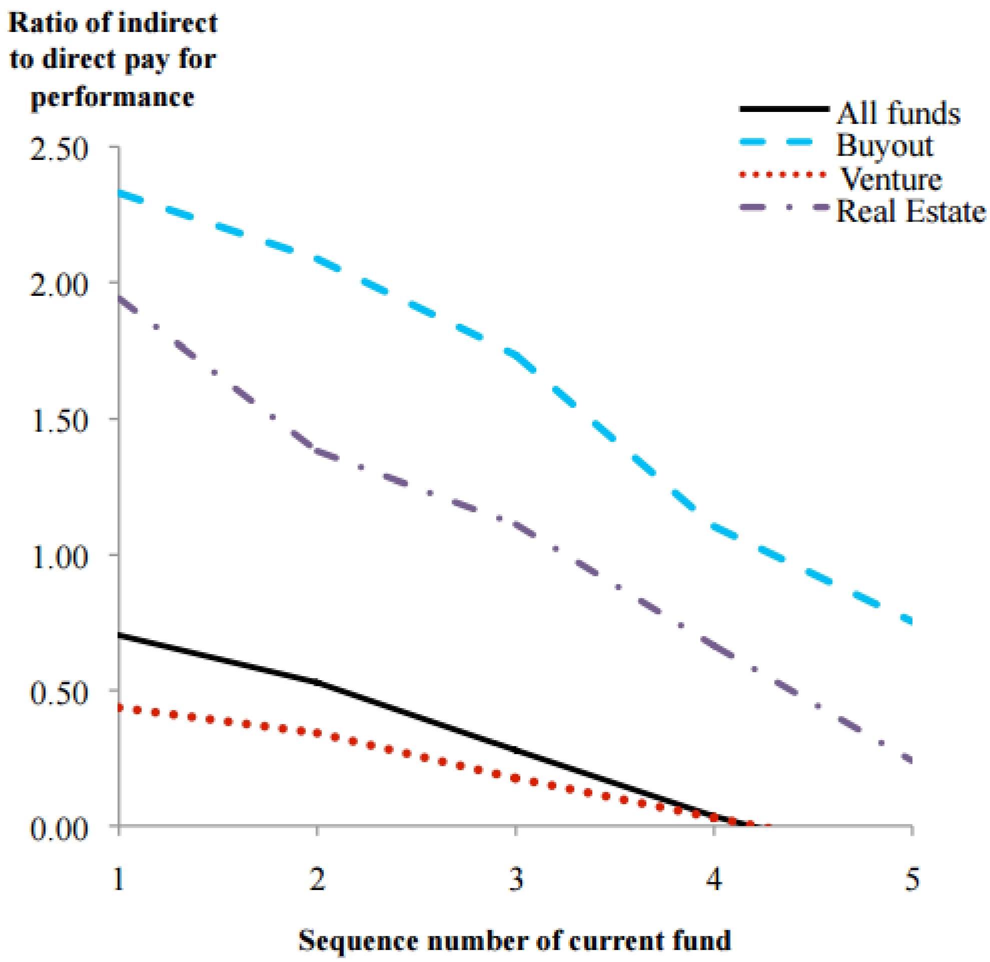

Figure 1-2 Ratio of indirect to direct pay for performance using discount rates: All Funds 17%, Buyout 14%,Venture Capital 20%, Real Estate 14%

This figure presents estimates of the ratio of the indirect to direct effect of an incremental improvement in performance in the current fund on GP revenue. The figure is identical to Figure 1-1 except that it uses different discount rates. Discount rates of 17%, 14%, 20%, and 14% are used for all funds taken together, buyout funds, venture capital funds, and real estate funds, respectively. These discount rates are five percentage point increments from those used in Figure 1-1.

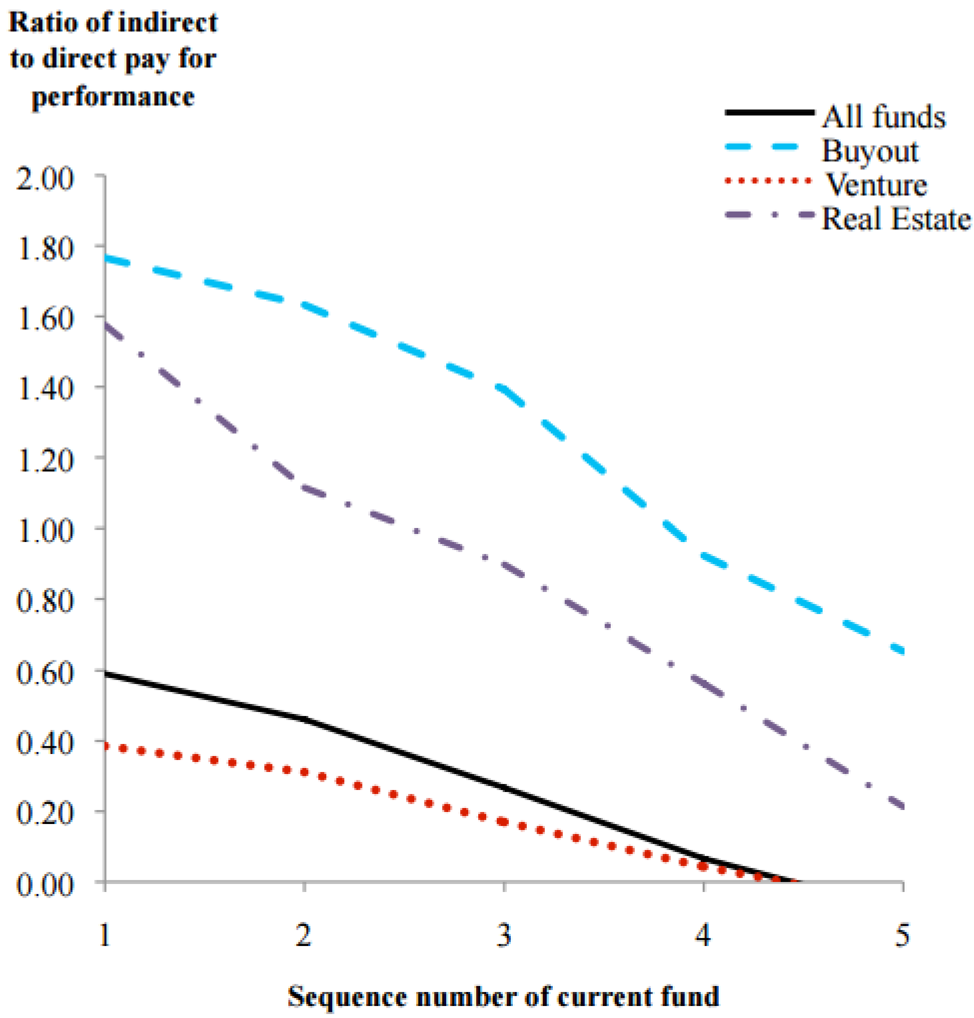

Figure 1-3 Ratio of indirect to direct pay for performance using discount rates: All Funds 10%, Buyout 11%,Venture Capital 8%, Real Estate 11%

This figure presents estimates of the ratio of the indirect to direct effect of an incremental improvement in performance in the current fund on GP revenue. The figure is identical to Figure 1-1 except that it uses different discount rates. Discount rates of 10%, 11%, 8%, and 11% are used for all funds taken together, buyout funds, venture capital funds, and real estate funds, respectively. These discount rates correspond to betas of 1.3 for buyout funds, 0.86 for venture capital funds, and 1.3 for real estate funds.

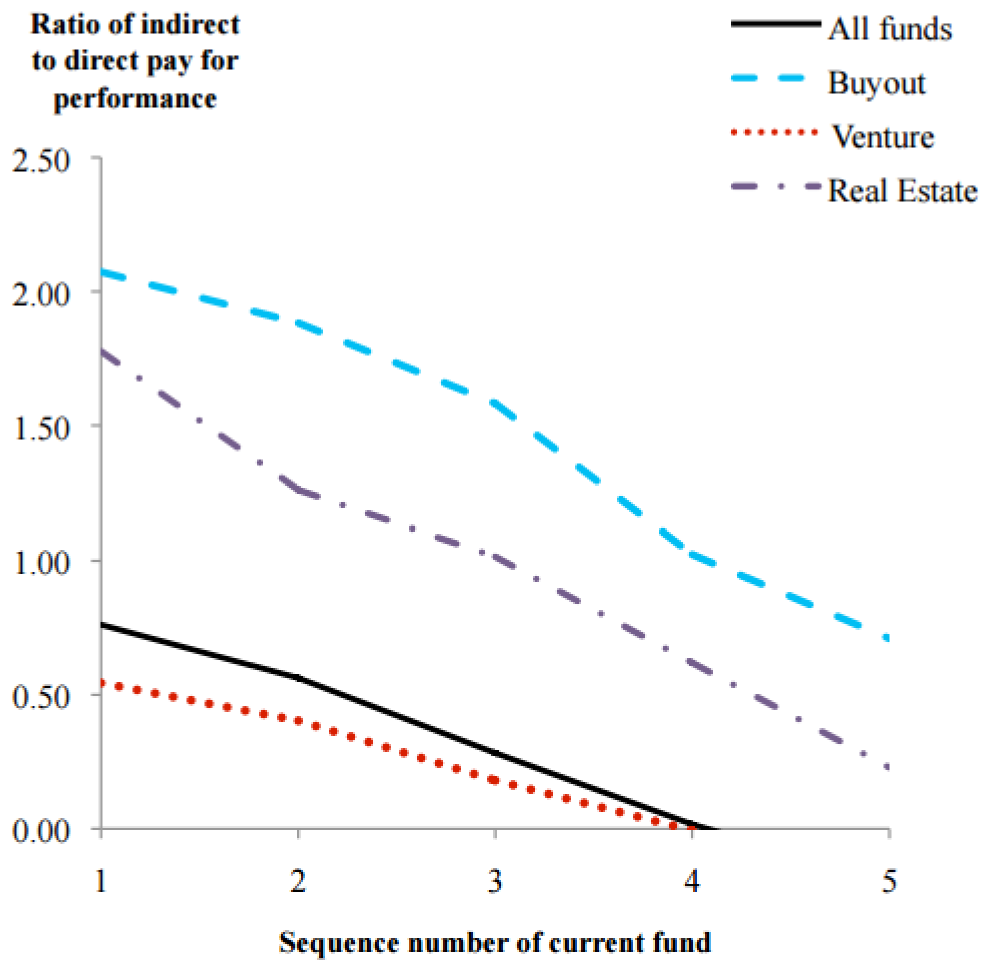

Figure 1-4 Ratio of indirect to direct pay for performance using discount rates: All Funds 16%, Buyout 11%, Venture Capital 21%, Real Estate 11%

This figure presents estimates of the ratio of the indirect to direct effect of an incremental improvement in performance in the current fund on GP revenue. The figure is identical to Figure 1-1 except that it uses different discount rates. Discount rates of 16%, 11%, 21%, and 11% are used for all funds taken together, buyout funds, venture capital funds, and real estate funds, respectively. These discount rates correspond to betas of 1.3 for buyout funds, 3 for venture capital funds, and 1.3 for real estate funds.

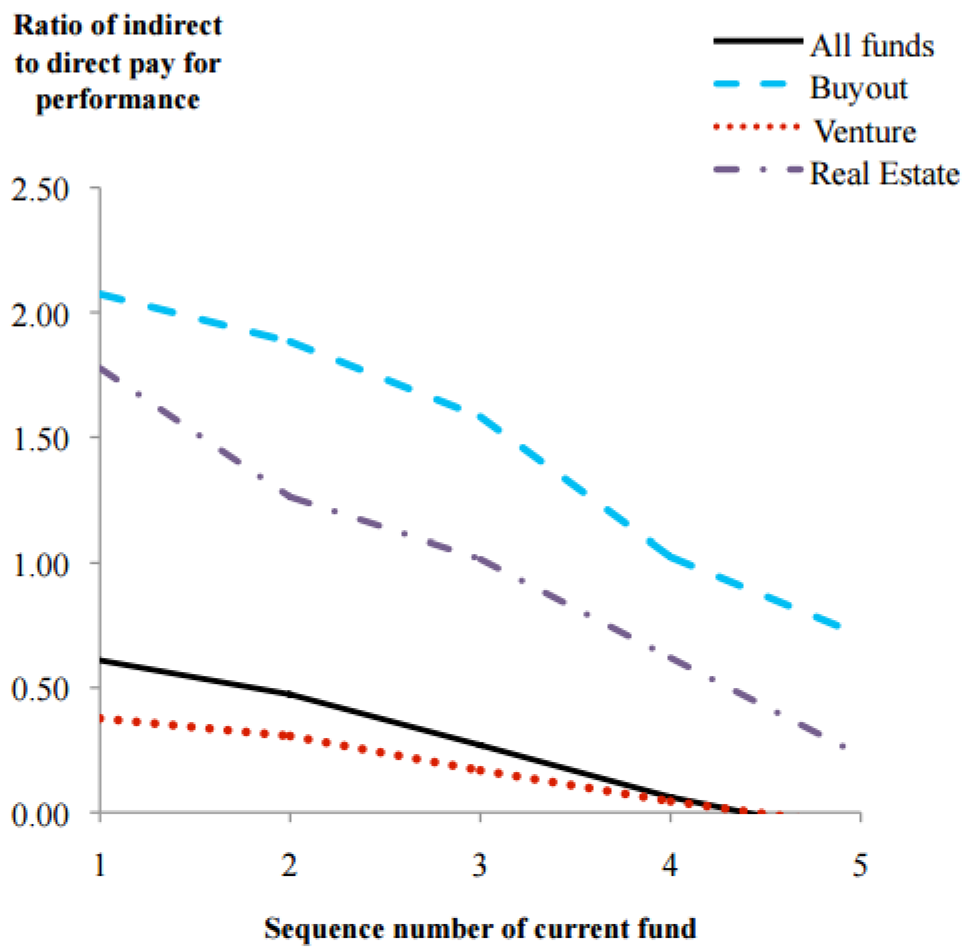

Table 1-1 Descriptive Statistics

Descriptive statistics for the sample funds. Panel A reports the distribution of the number of preceding funds per partnership. Panel B reports the distributions of preceding fund size and performance, follow-on fund size conditional on raising a follow-on, growth in fund size conditional on raising a follow-on (percentage difference between preceding and follow-on size), the time between successive funds (the time elapsed before raising a follow-on), and the percentage of preceding funds that raise a follow-on. Preceding funds meet the following criteria: fund size and performance (IRR) information is available, fund size is at least $5M in 1990 dollars, and the fund is raised before 2006. The follow-on fund for each preceding fund (if one is raised) is the next fund raised by the same private equity partnership.

Panel A: Descriptive statistics for the number of preceding funds per partnership

Fund Type	Number of partnerships	Number of preceding funds per partnership						
		Mean	Median	Std Dev	Min.	Q1	Q3	Max.
All	843	2.07	1	1.65	1	1	3	12
Buyout	314	2.05	1.00	1.56	1.00	1.00	3.00	11.00
Venture Capital	412	2.07	1.00	1.75	1.00	1.00	2.00	12.00
Real Estate	117	2.13	2.00	1.47	1.00	1.00	3.00	9.00

Panel B: Descriptive statistics for fund size, performance, and fundraising

	All Funds				
	Obs	Mean	Median	Q1	Q3
Preceding fund size ($M)	1745	497.9	210.0	82.4	500.0
Preceding fund performance (IRR)	1745	15.1%	10.6%	0.5%	22.3%
Follow-on fund size conditional on raising one ($M)	1469	792.2	314.0	136.0	728.4
Growth in fund size conditional on raising a follow-on (%)	1469	92.4%	53.8%	0.0%	123.1%
Time between successive funds (years)	1469	3.3	3.0	2.0	4.0
Percentage of preceding funds that raise a follow-on		84.2%			

	Buyout				
	Obs	Mean	Median	Q1	Q3
Preceding fund size ($M)	645	866.4	380.0	169.2	900.0
Preceding fund performance (IRR)	645	16.5%	14.3%	5.9%	25.4%
Follow-on fund size conditional on raising one ($M)	549	1465.3	632.6	289.3	1500.0
Growth in fund size conditional on raising a follow-on (%)	549	110.9%	70.0%	21.7%	140.3%
Time between successive funds (years)	549	3.8	3.0	2.0	5.0
Percentage of preceding funds that raise a follow-on		85.1%			

	Venture Capital				
	Obs	Mean	Median	Q1	Q3
Preceding fund size ($M)	851	217.7	125.0	56.0	254.0
Preceding fund performance (IRR)	851	14.1%	5.8%	-5.0%	17.6%

	Obs	Mean	Median	Q1	Q3
Follow-on fund size conditional on raising one ($M)	681	283.9	181.0	80.0	368.0
Growth in fund size conditional on raising a follow-on (%)	681	78.6%	42.9%	-8.3%	113.6%
Time between successive funds (years)	681	3.3	3.0	2.0	4.0
Percentage of preceding funds that raise a follow-on		80.0%			

	Real Estate				
	Obs	Mean	Median	Q1	Q3
Preceding fund size ($M)	249	501.0	314.9	106.0	622.8
Preceding fund performance (IRR)	249	14.6%	14.1%	7.9%	21.9%
Follow-on fund size conditional on raising one ($M)	239	694.2	425.0	145.0	817.3
Growth in fund size conditional on raising a follow-on (%)	239	89.7%	48.9%	-3.6%	100.6%
Time between successive funds (years)	239	2.4	2.0	1.0	3.0
Percentage of preceding funds that raise a follow-on		96.0%			

Table 1-2 Descriptive Statistics by Fund Sequence

Descriptive statistics by preceding and follow-on fund sequence number. Panel A presents statistics for preceding fund size. Panel B presents statistics for preceding fund performance (IRR). Panel C presents statistics for follow-on size conditional on raising a follow-on. Panel D reports statistics for growth in fund size conditional on raising a follow on (in percent). Panel E reports statistics for the number of years elapsed between successive fundraisings, conditional on raising a follow-on. Panel F reports the percentage of preceding funds that raise a follow-on.

Panel A: Descriptive statistics for preceding fund size ($M)

	All Funds					Buyout				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1	612	262.3	112.0	50.0	271.0	247	417.5	220.0	100.0	500.0
2	392	362.9	187.5	75.0	417.0	147	587.8	357.0	165.0	700.0
3	271	488.2	250.0	109.7	518.0	101	812.5	469.0	220.0	900.0
4	186	723.2	355.0	151.0	825.0	65	1397.5	825.0	400.0	1902.0
5	109	861.4	312.5	148.0	750.0	35	1807.4	750.0	331.5	2100.0
6	68	897.2	481.0	202.0	829.0	17	1978.0	1000.0	604.2	3496.9
7	41	921.7	444.0	238.0	917.0	11	2041.7	1425.7	470.0	3200.0
8	24	1265.3	787.5	345.5	1868.5	10	2354.4	1950.0	1324.8	3000.0
9	18	2184.3	900.0	305.0	3781.0	7	4483.4	5000.0	3085.0	5300.0
>=10	24	1536.3	848.9	400.5	1558.0	5	4427.9	5426.1	3272.0	5941.5
Total	1745	497.9	210.0	82.4	500.0	645	866.4	380.0	169.2	900.0

(continued)

	Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1	290	124.0	75.0	38.7	150.0	75	286.4	202.0	50.0	386.0
2	192	169.9	106.0	54.9	218.5	53	438.0	273.9	126.0	600.0
3	127	216.3	140.0	65.6	279.0	43	530.0	387.1	119.1	831.0
4	87	264.6	176.0	100.0	300.0	34	607.7	518.9	225.0	830.0
5	52	258.7	169.0	101.5	295.0	22	781.0	509.5	290.0	950.0
6	38	350.3	247.0	170.0	505.0	13	1082.3	567.0	475.0	1000.0
7	23	439.8	300.0	225.0	450.0	7	744.8	570.0	168.0	917.0
8	13	518.5	500.0	311.0	750.0	1	82.0	82.0	82.0	82.0
9	10	787.0	583.0	159.6	1000.0	1	63.0	63.0	63.0	63.0
>=10	19	775.3	526.8	290.0	1100.0					
Total	851	217.7	125.0	56.0	254.0	249	501.0	314.9	106.0	622.8

Panel B: Descriptive statistics for preceding fund performance (IRR)

	All Funds					Buyout				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1	612	15.8%	12.2%	3.0%	22.4%	247	17.2%	16.5%	7.2%	26.5%
2	392	13.5%	9.6%	-0.4%	22.1%	147	16.8%	13.9%	4.6%	24.6%
3	271	12.4%	10.3%	0.1%	22.3%	101	15.6%	12.9%	4.2%	25.3%
4	186	19.1%	10.5%	-0.6%	21.1%	65	13.3%	11.9%	4.5%	21.1%
5	109	15.3%	10.0%	-2.2%	26.0%	35	17.5%	12.4%	4.1%	33.2%
6	68	19.6%	9.7%	-2.5%	25.5%	17	16.8%	14.7%	8.9%	23.4%
7	41	16.6%	10.3%	-2.5%	17.9%	11	20.6%	17.9%	10.3%	35.3%
8	24	17.7%	12.2%	-2.5%	40.8%	10	24.6%	21.0%	11.7%	48.8%
9	18	9.9%	6.4%	1.5%	22.8%	7	10.1%	8.8%	1.5%	22.8%
>=10	24	7.2%	1.1%	-4.9%	20.4%	5	0.7%	-2.1%	-7.9%	13.4%
Total	1745	15.1%	10.6%	0.5%	22.3%	645	16.5%	14.3%	5.9%	25.4%

(continued)

	Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1	290	14.0%	8.0%	-1.6%	17.4%	75	17.5%	15.8%	10.9%	24.8%
2	192	10.6%	5.0%	-4.9%	16.5%	53	14.6%	14.1%	8.2%	23.0%
3	127	10.1%	4.0%	-6.9%	19.9%	43	11.6%	12.0%	6.9%	18.3%
4	87	26.1%	2.9%	-7.2%	20.6%	34	12.2%	13.6%	6.3%	21.0%
5	52	14.2%	5.6%	-8.6%	21.0%	22	14.6%	13.0%	7.7%	17.7%
6	38	22.5%	2.6%	-5.2%	29.9%	13	15.0%	12.3%	5.6%	25.4%
7	23	16.8%	1.6%	-6.9%	10.4%	7	9.6%	11.6%	5.8%	16.0%
8	13	12.1%	1.1%	-8.5%	16.5%	1	21.5%	21.5%	21.5%	21.5%
9	10	7.2%	2.2%	-1.0%	13.4%	1	35.0%	35.0%	35.0%	35.0%
>=10	19	8.9%	1.2%	-2.7%	25.1%					
Total	851	14.1%	5.8%	-5.0%	17.6%	249	14.6%	14.1%	7.9%	21.9%

Panel C: Descriptive statistics for follow-on fund size conditional on raising a follow-on ($M)

	All Funds					Buyout				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
2	462	422.7	215.9	90.0	472.0	189	685.7	390.4	180.0	767.0
3	347	557.6	279.0	116.0	600.0	130	978.8	540.3	252.0	1000.0
4	231	772.2	404.0	165.0	855.7	89	1380.6	850.0	405.0	1550.0
5	163	1039.7	380.0	154.3	900.0	58	2070.4	855.0	392.0	2996.9
6	100	1543.2	474.1	223.5	950.0	34	3505.4	1326.0	473.3	5125.0
7	66	1030.3	464.2	252.9	917.0	17	1777.6	682.6	500.0	3100.0
8	38	1658.0	735.0	315.0	1500.0	11	3763.4	1900.0	1170.0	3000.0
9	23	1846.6	800.0	400.0	3085.0	10	3599.6	3433.0	1300.0	5150.3
10	16	1800.3	760.5	237.1	3386.0	6	3985.6	3600.0	3272.0	5941.5
>=11	23	3064.8	1100.0	290.0	2560.0	5	10789.5	12179.5	5426.1	15000.0
Total	1469	792.2	314.0	136.0	728.4	549	1465.3	632.6	289.3	1500.0

(continued)

	Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
2	201	175.3	114.2	57.2	225.0	72	422.6	304.6	100.0	675.1
3	167	232.3	154.0	73.0	318.0	50	549.2	326.4	150.0	772.2
4	101	273.4	191.0	116.1	375.0	41	680.2	537.9	145.0	846.0
5	72	295.4	199.5	104.0	412.0	33	852.0	530.0	290.0	950.0
6	44	360.9	247.0	172.5	527.5	22	875.2	506.5	340.0	900.0
7	36	442.4	315.0	234.0	469.2	13	1681.2	707.5	498.0	1325.0
8	21	517.0	400.0	300.0	750.0	6	1791.7	1065.0	594.0	1994.0
9	12	534.3	480.0	232.3	703.0	1	63.0	63.0	63.0	63.0
10	9	533.0	470.7	226.4	650.0	1	95.0	95.0	95.0	95.0
>=11	18	919.1	691.3	102.5	1450.0					
Total	681	283.9	181.0	80.0	368.0	239	694.2	425.0	145.0	817.3

Panel D: Descriptive statistics for growth in fund size conditional on raising a follow-on

	All Funds					Buyout				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1~2	462	112.6%	71.1%	19.0%	143.9%	189	119.7%	84.1%	38.5%	151.8%
2~3	347	83.3%	56.3%	0.0%	125.0%	130	99.9%	77.0%	17.4%	155.5%
3~4	231	92.4%	51.1%	-0.2%	128.6%	89	122.7%	70.0%	30.8%	170.3%
4~5	163	40.7%	31.6%	-32.8%	76.8%	58	52.5%	40.7%	-10.5%	88.8%
5~6	100	125.7%	50.1%	12.0%	99.8%	34	146.8%	66.1%	45.7%	133.1%
6~7	66	62.6%	34.6%	-35.8%	80.6%	17	39.8%	31.7%	-37.5%	82.4%
7~8	38	150.0%	65.8%	-14.8%	157.8%	11	277.5%	110.4%	-8.2%	300.0%
8~9	23	53.3%	26.0%	-48.7%	100.0%	10	102.5%	42.3%	-48.7%	254.2%
9~10	16	22.9%	11.3%	-60.1%	58.6%	6	51.2%	1.0%	-55.2%	94.5%
>=11	23	125.4%	-1.0%	-55.8%	164.1%	5	246.7%	105.0%	13.1%	225.1%
Total	1469	92.4%	53.8%	0.0%	123.1%	549	110.9%	70.0%	21.7%	140.3%

(continued)

	Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1~2	201	97.9%	62.7%	7.4%	140.6%	72	135.1%	60.8%	5.6%	127.6%
2~3	167	73.8%	39.6%	-2.0%	113.6%	50	71.7%	51.8%	-8.6%	88.7%
3~4	101	71.9%	33.3%	-11.9%	115.1%	41	77.6%	50.0%	-0.2%	100.0%
4~5	72	34.1%	25.4%	-35.4%	62.5%	33	34.3%	26.2%	-16.3%	87.5%
5~6	44	135.8%	48.9%	0.0%	90.4%	22	72.9%	29.9%	-20.0%	72.2%
6~7	36	79.2%	37.6%	-32.2%	79.4%	13	46.1%	25.0%	-3.6%	65.6%
7~8	21	51.3%	35.2%	-20.8%	100.0%	6	262.1%	109.9%	4.2%	181.8%
8~9	12	18.8%	12.7%	-35.0%	80.9%	1	-23.2%	-23.2%	-23.2%	-23.2%
9~10	9	0.9%	7.3%	-65.0%	55.5%	1	50.8%	50.8%	50.8%	50.8%
>=11	18	91.7%	-11.1%	-74.8%	127.3%					
Total	681	78.6%	42.9%	-8.3%	113.6%	239	89.7%	48.9%	-3.6%	100.6%

Panel E. Number of years elapsed between successive funds, conditional on raising a follow-on

	All Funds					Buyout				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1~2	462	3.93	4.00	2.00	5.00	189	4.43	4.00	3.00	6.00
2~3	347	3.42	3.00	2.00	4.00	130	3.73	4.00	3.00	5.00
3~4	231	3.23	3.00	2.00	4.00	89	3.48	3.00	2.00	5.00
4~5	163	2.89	3.00	2.00	4.00	58	3.36	3.00	2.00	4.00
5~6	100	2.78	3.00	1.00	4.00	34	3.06	3.00	2.00	4.00
6~7	66	2.62	2.00	1.00	4.00	17	3.00	3.00	2.00	4.00
7~8	38	2.32	2.00	1.00	3.00	11	2.36	3.00	1.00	3.00
8~9	23	2.52	2.00	2.00	3.00	10	2.60	2.00	2.00	3.00
9~10	16	2.19	2.00	1.00	3.50	6	2.67	2.50	1.00	4.00
>=11	23	1.91	2.00	1.00	3.00	5	2.20	2.00	1.00	3.00
Total	1469	3.33	3.00	2.00	4.00	549	3.75	3.00	2.00	5.00

(continued)

	Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1~2	201	3.95	4.00	2.00	5.00	72	2.60	2.00	1.00	3.00
2~3	167	3.45	3.00	2.00	4.00	50	2.54	2.00	1.00	3.00
3~4	101	3.39	3.00	2.00	4.00	41	2.32	2.00	2.00	3.00
4~5	72	2.88	3.00	2.00	4.00	33	2.09	2.00	1.00	3.00
5~6	44	2.86	3.00	2.00	4.00	22	2.18	2.00	1.00	3.00
6~7	36	2.78	3.00	2.00	4.00	13	1.69	1.00	1.00	2.00
7~8	21	2.43	2.00	1.00	3.00	6	1.83	1.00	1.00	3.00
8~9	12	2.50	2.00	1.00	3.50	1	2.00	2.00	2.00	2.00
9~10	9	2.00	2.00	1.00	2.00	1	1.00	1.00	1.00	1.00
>=11	18	1.83	2.00	1.00	2.00					
Total	681	3.34	3.00	2.00	4.00	239	2.35	2.00	1.00	3.00

Panel F: Percentage of preceding funds that raise a follow-on

Sequence	All	BO	VC	RE
1	75.5%	76.5%	69.3%	96.0%
2	88.5%	88.4%	87.0%	94.3%
3	85.2%	88.1%	79.5%	95.3%
4	87.6%	89.2%	82.8%	97.1%
5	91.7%	97.1%	84.6%	100.0%
6	97.1%	100.0%	94.7%	100.0%
7	92.7%	100.0%	91.3%	85.7%
8	95.8%	100.0%	92.3%	100.0%
9	88.9%	85.7%	90.0%	100.0%
>=10	95.8%	100.0%	94.7%	
Total	84.2%	85.1%	80.0%	96.0%

Table 1-3 Follow-on Fundraising Regressions

Preceding fund-level regressions to explain follow-on fundraising. Panel A presents probit regressions in which the dependent variable is 1 if a follow-on is raised and 0 otherwise. Marginal effects are reported and z-scores are given in parentheses. Panels B and C present OLS regressions for preceding funds that raise a follow-on fund. In Panel B, the dependent variable is fund growth, defined as follow-on fund size divided by preceding fund size minus one. In Panel C, the dependent variable is the natural logarithm of fund growth plus one. In all Panels,"All Funds" regressions include fund type fixed effects and model (2) includes vintage year fixed effects. Heteroskedasticity-robust standard errors are clustered at the PE firm level. In Panels B and C, t-statistics are given in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Probit regressions for the probability of raising a follow-on fund

	All Funds		Buyout	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.316***	0.324***	0.467***	0.588***
	(4.788)	(4.563)	(4.814)	(4.742)
Number of observations	1,745	1,622	645	560
Pseudo R2	0.084	0.146	0.087	0.140

(continued)

	Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.297***	0.288***	0.187***	0.393**
	(3.337)	(3.032)	(2.671)	(2.487)
Number of observations	851	786	249	115
Pseudo R2	0.043	0.128	0.073	0.166

Panel B: OLS regressions for growth in fund size conditional on raising a follow-on fund

	All Funds		Buyout	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.663**	0.623**	2.314***	2.152***
	(2.088)	(2.045)	(4.119)	(3.316)
Constant	0.984***	1.590***	0.675***	2.034
	(11.545)	(2.770)	(7.390)	(1.569)
Number of observations	1,469	1,469	549	549
Adjusted R2	0.026	0.038	0.058	0.075

(continued)

	Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.492	0.426	1.955***	1.723***
	(1.634)	(1.413)	(3.029)	(2.724)
Constant	0.699***	0.887***	0.602***	-0.107***
	(9.902)	(4.489)	(4.810)	(-2.691)
Number of observations	681	681	239	239
Adjusted R2	0.021	0.027	0.014	0.036

Panel C: OLS regressions for log(fund growth + 1) conditional on raising a follow-on fund

	All Funds		Buyout	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.177***	0.161***	0.524***	0.466***
	(2.813)	(2.798)	(5.065)	(3.967)
Constant	0.991***	1.126***	0.926***	1.114***
	(52.650)	(12.882)	(45.103)	(6.450)
Number of observations	1,469	1,469	549	549
Adjusted R2	0.039	0.070	0.050	0.081

(continued)

	Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.139**	0.101**	0.572***	0.503***
	(2.553)	(2.120)	(3.280)	(2.901)
Constant	0.886***	1.003***	0.853***	0.662***
	(59.797)	(13.045)	(23.575)	(60.784)
Number of observations	681	681	239	239
Adjusted R2	0.033	0.088	0.024	0.073

Table 1-4 Follow-on Fundraising Regressions: Sequence Interactions

Preceding fund-level regressions to explain follow-on fundraising, with sequence interactions. Panel A presents linear probability regressions in which the dependent variable is 1 if a follow-on is raised and 0 otherwise. Panels B and C present OLS regressions for preceding funds that raise a follow-on fund. In Panel B, the dependent variable is fund growth, defined as follow-on fund size divided by preceding fund size minus one. In Panel C, the dependent variable is the natural logarithm of fund growth plus one. In all Panels,"All Funds" regressions include fund type fixed effects and model (2) includes vintage year fixed effects. Heteroskedasticity-robust standard errors are clustered at the PE firm level. T-statistics are given in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Linear probability model for the probability of raising a follow-on fund

	All Funds		Buyout	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.305***	0.287***	0.698***	0.683***
	(4.082)	(4.141)	(5.447)	(4.925)
Preceding fund sequence number	0.033***	0.035***	0.048***	0.048***
	(7.425)	(7.470)	(5.724)	(5.035)
Preceding fund IRR*Preceding fund sequence #	-0.051***	-0.051***	-0.091***	-0.075**
	(-2.686)	(-2.957)	(-3.500)	(-2.494)
Constant	0.738***	0.927***	0.650***	0.802***
	(32.868)	(39.113)	(18.709)	(21.140)
Number of observations	1,745	1,745	645	645
Adjusted R2	0.072	0.124	0.110	0.135

(continued)

	Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.214***	0.199***	0.227	0.144
	(3.159)	(3.427)	(1.578)	(1.055)
Preceding fund sequence number	0.030***	0.035***	0.004	-0.004
	(5.849)	(5.780)	(0.287)	(-0.338)
Preceding fund IRR*Preceding fund sequence #	-0.034**	-0.039***	0.004	0.041
	(-2.019)	(-2.777)	(0.087)	(0.888)
Constant	0.696***	0.902***	0.915***	0.993***
	(28.294)	(43.013)	(21.005)	(58.993)
Number of observations	851	851	249	249
Adjusted R2	0.043	0.137	0.015	0.068

Panel B: OLS regressions for growth in fund size conditional on raising a follow-on fund

	All Funds		Buyout	
	(1)	(2)	(1)	(2)
Preceding fund IRR	1.950***	1.911***	1.977**	1.537
	(3.142)	(3.079)	(2.093)	(1.640)
Preceding fund sequence number	0.040	0.050	0.016	0.011
	(1.246)	(1.565)	(0.301)	(0.247)
Preceding fund IRR*Preceding fund sequence #	-0.376**	-0.375**	0.127	0.215
	(-2.468)	(-2.501)	(0.355)	(0.610)
Constant	0.813***	1.333**	0.636***	2.092*
	(6.011)	(2.322)	(3.768)	(1.657)

Number of observations	1,469	1,469	549	549
Adjusted R2	0.043	0.055	0.056	0.076

(continued)

	Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)
Preceding fund IRR	1.964***	1.936***	3.899***	3.369***
	(2.695)	(2.619)	(2.886)	(2.611)
Preceding fund sequence number	0.034	0.056	0.036	0.011
	(0.888)	(1.539)	(0.433)	(0.131)
Preceding fund IRR*Preceding fund sequence #	-0.423**	-0.433**	-0.708**	-0.603*
	(-2.464)	(-2.536)	(-2.103)	(-1.704)
Constant	0.562***	0.607***	0.496	-0.183
	(4.221)	(2.588)	(1.604)	(-1.618)
Number of observations	681	681	239	239
Adjusted R2	0.060	0.067	0.018	0.039

Panel C: OLS regressions for log(fund growth + 1) conditional on raising a follow-on fund

	All Funds		Buyout	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.400***	0.388***	0.580***	0.466**
	(5.390)	(5.282)	(2.761)	(2.197)
Preceding fund sequence number	-0.010**	-0.007	-0.004	-0.006
	(-2.037)	(-1.534)	(-0.333)	(-0.696)
Preceding fund IRR*Preceding fund sequence #	-0.066***	-0.066***	-0.021	-0.001
	(-3.062)	(-3.237)	(-0.305)	(-0.014)
Constant	1.006***	1.104***	0.935***	1.123***
	(45.394)	(13.539)	(23.543)	(6.858)
Number of observations	1,469	1,469	549	549
Adjusted R2	0.056	0.085	0.047	0.078

(continued)

	Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)
Preceding fund IRR	0.358***	0.334***	1.179***	1.039***
	(4.288)	(3.800)	(3.598)	(3.219)
Preceding fund sequence number	-0.014**	-0.008	0.011	0.005
	(-2.512)	(-1.440)	(0.506)	(0.223)
Preceding fund IRR*Preceding fund sequence #	-0.063***	-0.066***	-0.221**	-0.196**
	(-2.831)	(-3.057)	(-2.477)	(-2.064)

Constant	0.925***	0.991***	0.821***	0.636***
	(39.443)	(14.805)	(10.612)	(19.044)
Number of observations	681	681	239	239
Adjusted R2	0.063	0.113	0.037	0.085

Table 1-5 Sensitivity of GP Lifetime Revenue to Current Performance

This table presents estimates of the sensitivity of GP lifetime revenue to current performance, assuming the current fund is the first in the partnership's sequence of funds. Panel A presents estimates of the direct effect of a one percentage point improvement in net return to LPs (IRR) in the current fund, relative to the sample average return, on GP revenue from the current fund. Sample means are taken from Table 1-2. We approximate the cash flow distribution that gives rise to the IRR as a single cash in and a single cash out, spaced 3 years apart. The GP revenue share of 25% is based on the standard carry of 20% (for each $1 returned to LPs, GPs receive $0.25). At the baseline level of performance, the carry is in the money. We discount the incremental GP revenue at 5% for 3 years because the cashflow out is 3 years in the future. The discounted direct effect per extra undiscounted dollar of return to LPs is therefore $0.216.
Panel B presents estimates of the indirect effect of a one percentage point or one dollar improvement in net return to LPs in the current fund on expected GP revenue from future funds. Estimates are computed using the formulas provided in Section 4, using sample parameters from Table 1-2 and regression coefficients and marginal effects from Table 1-3. N is the maximum number of future funds the GP could potentially run. k is the expected fraction of future fund sizes that the GP receives as compensation. δTR/δIRR and δTR/δD are the incremental indirect effect from an extra percentage point and extra dollar of return, respectively.

Panel A: Direct effect of incremental performance on GP revenue from current fund

	All funds	Buyout	Venture	Real Estate
Current fund is first in sequence				
Mean current fund size ($M)	262.3	417.5	124.0	286.4
Mean current fund IRR	15.75%	17.23%	14.04%	17.50%
Years between cash in/out	3	3	3	3
Revenue share	25%	25%	25%	25%
Incremental GP revenue ($M)	2.636	4.340	1.209	2.290
Discount rate	12%	9%	15%	9%
Present value of GP revenue ($M)	1.88%	3.32%	0.80%	2.29%
Present value of GP revenue/dollar	0.178	0.193	0.164	0.193

Panel B: Indirect effect of incremental performance on GP expected revenue from future funds

Indirect effect ($M)	Ratio of indirect to direct

							effect	
All Funds						All Funds		
	N=3		N=5					
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD		k	N=3	N=5
15%	0.884	0.084	1.657	0.157		15%	0.471	0.883
20%	1.179	0.112	2.210	0.210		20%	0.628	1.178
25%	1.474	0.140	2.762	0.262		25%	0.785	1.472
Buyout						Buyout		
	N=3		N=5					
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD		k	N=3	N=5
15.75%	3.650	0.212	8.259	0.480		15.75%	1.098	2.486
17.72%	4.107	0.239	9.293	0.540		17.72%	1.236	2.796
19.60%	4.542	0.264	10.278	0.597		19.60%	1.367	3.093
Venture						Venture		
	N=3		N=5					
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD		k	N=3	N=5
20.24%	0.337	0.070	0.478	0.099		20.24%	0.423	0.601
22.84%	0.380	0.078	0.539	0.111		22.84%	0.478	0.678
26.11%	0.434	0.090	0.616	0.127		26.11%	0.546	0.775
Real Estate						Real Estate		
	N=3		N=5					
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD		k	N=3	N=5
15%	1.827	0.154	3.117	0.263		15%	0.798	1.361
20%	2.435	0.205	4.156	0.350		20%	1.064	1.815
25%	3.044	0.257	5.195	0.438		25%	1.329	2.269

Table 1-6 Sensitivity of GP Lifetime Revenue to Current Performance: Sequence Interactions

This table presents estimates of the sensitivity of GP lifetime revenue to current performance, for different assumptions about the placement of the current fund in the partnership's sequence of funds. Panel A presents estimates of the direct effect of a one percentage point improvement in net return to LPs (IRR) in the current fund, relative to the sample average return, on GP revenue from the current fund. Sample means are taken from Table 1-2. We approximate the cash flow distribution that gives rise to the IRR as a single cash in and a single cash out, spaced 3 years apart. The GP revenue share of 25% is based on the standard carry of 20% (for each $1 returned to LPs, GPs receive $0.25). At the baseline level of performance, the carry is in the money. We discount the incremental GP revenue at 5% for 3 years because the cashflow out is 3 years in the future. The discounted direct effect per extra undiscounted dollar of return to LPs is therefore $0.216.

Panel B presents estimates of the indirect effect of an improvement in net return to LPs in the current fund on expected GP revenue from future funds. Estimates are computed using the formulas provided in Section 4, using sample parameters from Table 1-2 and regression coefficients and marginal effects from Table 1-4 which take sequence interactions into account. N is the maximum number of future funds the GP could potentially run. k is the expected fraction of future fund sizes that the GP receives as compensation. δTR/δIRR and δTR/δD are the incremental indirect effect from an extra percentage point and extra dollar of return, respectively.

Panel A: Direct effect of incremental performance on GP revenue from current fund

	All funds	Buyout	Venture	Real Estate
Current fund is first in sequence				
Mean current fund size ($M)	262.3	417.5	124.0	286.4
Mean current fund IRR	15.75%	17.23%	14.04%	17.50%
Incremental GP revenue ($M)	2.636	4.303	1.209	2.965
Discounted	1.876	3.323	0.795	2.290
Current fund is second in sequence				
Mean current fund size ($M)	362.9	587.8	169.9	438.0
Mean current fund IRR	13.45%	16.83%	10.56%	14.56%
Incremental GP revenue ($M)	3.503	6.018	1.558	4.311
Discounted	2.493	4.647	1.024	3.329
Current fund is third in sequence				
Mean current fund size ($M)	488.2	812.5	216.3	530.0
Mean current fund IRR	12.41%	15.62%	10.14%	11.59%
Incremental GP revenue ($M)	4.627	8.145	1.967	4.950
Discounted	3.293	6.290	1.294	3.822

Panel B: Indirect effect of incremental performance on GP expected revenue from future funds

Indirect effect ($M) — All Funds

k=20%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	1.034	0.098	1.331	0.126
2	1.164	0.083	1.330	0.095
3	1.063	0.057	0.927	0.050

Ratio of indirect to direct effect — All Funds

Current fund sequence	N=3	N=5
1	0.551	0.709
2	0.467	0.533
3	0.323	0.282

Indirect effect ($M) — Buyout

k=17.72%	N=3		N=5	
Current fund	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD

Ratio of indirect to direct effect — Buyout

Current fund sequence	N=3	N=5

sequence						sequence		
1	4.271	0.248	7.807	0.454		1	1.285	2.349
2	6.048	0.251	9.779	0.406		2	1.301	2.104
3	8.223	0.252	11.007	0.338		3	1.307	1.750

	Venture			
k=22.84%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	0.309	0.064	0.350	0.072
2	0.332	0.053	0.354	0.057
3	0.250	0.032	0.229	0.029

Venture		
Current fund sequence	N=3	N=5
1	0.389	0.440
2	0.324	0.346
3	0.193	0.177

	Real Estate			
k=20%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	3.139	0.265	4.482	0.378
2	3.163	0.183	4.639	0.269
3	2.790	0.141	4.291	0.217

Real Estate		
Current fund sequence	N=3	N=5
1	1.371	1.957
2	0.950	1.394
3	0.730	1.123

Chapter 2. D&O Insurance and IPO Performance: what can we learn from insurers?

This is a pre-copyedited, author-produced PDF of an article accepted for publication in the *Journal of Financial Intermediation* following peer review. The version of record Boyer, M.M. and L. H. Stern (2014), D&O Insurance and IPO Performance: What Can we Learn from Insurers? *Journal of Financial Intermediation* 23: 504-540.is available online at: http://doi.org/10.1016/j.jfi.2014.05.001

1. Introduction

When a firm goes public, investors typically know very little about the cash flow prospects of a firm. A high level of information asymmetry prevails during the initial public offering of a firm. Investors are cognizant of governance risk, yet as of today, there is no easy and reliable way to assess this particular type of risk. As representatives of the corporation, directors and officers are personally liable[30] for damages caused by the corporation's actions, or absence thereof. Having their personal wealth exposed to such an important liability risk induces managers to request protection in the event a lawsuit is brought against them as representatives of the corporation. This insurance, known as directors' and officers' liability insurance (D&O insurance hereinafter), is extremely common in public corporations.[31]

The goal of this paper is to assess whether the information that insurers acquire in their underwriting process is valuable for capital markets. To achieve this goal we use a sample of

[30] A corporate director's duty goes beyond a simple firm value maximizing paradigm to include a fiduciary duty, a duty of loyalty and a duty of care.

[31] According to different Towers-Watson surveys (that were in the past published by Tillinghast Towers-Perrin, and before that by Watson-Wyatt), approximately 95% of public corporations in the United States and 75% of public corporations in Canada provide such insurance to their managers.

Canadian firms that have become public through an initial public offering and that had the opportunity to purchase D&O insurance before the IPO to cover their directors and officers in the event of a costly lawsuit. Our results show that the higher a firm's D&O insurance premium per dollar of coverage (which is known as the *rate-on-line* in the insurance industry), the higher the firm's stock market volatility and idiosyncratic risk in the first year after the IPO, and the lower its return. In other words, firms that insurers deem riskier at the time of the IPO have a lower (higher) stock market return (risk or volatility) in the first year post-IPO. Our results suggest that D&O insurers possess information that could be valuable to stock market participants. The results are robust to many econometric specifications (simultaneous equations, treatment effects) and robustness checks. Although further research is needed to formally test it, the results in this paper imply that the price of D&O liability insurance may be used as an assessment of a firm's governance risk; such information could prove to be valuable to market participants.

Our results provide new insights into the insurers' ability to price risk. Baker and Griffith (2007a) find that corporate governance is key in the insurance underwriting process and the main focus of insurers' risk evaluation. Insurers are interested in a firm's "deep governance" features, i.e. the *culture* within the firm as well as its executives' *character*. Provided that insurers use the correct technology to transform a firm's characteristics into a D&O liability insurance premium, the insurance contract should provide information on the firm's prospects, the quality of its management team and its "deep governance" features. Furthermore, insurers have the appropriate incentives to correctly measure the expected cost of litigation so that the structure of a D&O insurance contract could prove to be an unbiased measure of a firm's governance risk. As suggested by Griffith (2006), disclosing D&O insurance information to capital markets could be used as an antidote for the failure of boards to properly monitor managerial behavior. A *"managerial character score"* such as this one would be similar to credit ratings that are default probability indicators.

The results in this paper have several financial economics implications. First, the positive correlation between insurance pricing and stock market volatility reconciles economic theory with empirical evidence by providing literature's missing link: insurers charge a higher price *ex ante* to firms that are riskier *ex post*. Second, our findings are of interest for the asset pricing literature inasmuch as one believes that D&O insurance providers have a technology that allows them to assess one type of risk. This means that the rate-on-line should be priced in the cross-section of returns in such a way that a factor constructed to capture the excess return of firms with a low rate-on-line over firms with a high rate-on-line should have a significant coefficient. Because of the low number of observations, we are currently unable to perform such an empirical asset pricing test.

Third, our results provide a potential evaluation tool for investors in firms in which information asymmetry is important. This tool should be especially valuable when investors are looking for a way to assess the management quality and the risk associated with governance issues. A growing body of research suggests that a one-size-fits-all governance structure is ineffective in improving firm performance (see Larcker and Tayan, 2013). It seems instead that what matters are individual managerial characteristics and qualities. And as D&O insurance prices reflect an insurer's assessment of a firm's "deep governance", a firm's rate-on-line should therefore be related to its personal and personnel characteristics. Although our results point in this direction, further research is needed to formally evaluate the extent to which D&O insurance information may substitute commercial governance indices.

The volatility and return results complement each other and are two sides of the same coin. If one was to interpret post-IPO volatility as a proxy for information asymmetry (or risk unknown to the market at the time of the IPO), then it would follow that, as investors become aware of additional risks after the IPO, realized returns drop. Both results suggest that insurers have information that investors don't have and that they value. Our results speak to the risk perceived by the insurance companies, provide a missing link in the literature, and complement the results stemming from the managerial incentives in Chalmers *et al.* (2002), the study closest to ours. Indeed, whereas Chalmers *et al.* (2002) find that insurers penalize abnormal insurance coverage purchased at the time of the IPO, they cannot find a significant relationship between post-IPO returns and the premium paid by firms. Moreover, they find a negative relationship between post-IPO volatility and the price of coverage, which they find puzzling.

The remainder of the paper is organized as follows. Section 2 presents a short primer on directors' and officers' insurance contracts. We develop the hypotheses and describe the data in Section 3, and present the main results of the paper in Section 4. Section 5 is devoted to robustness checks. Section 6 concludes with a discussion.

2. Directors' and officers' insurance: a primer

Directors' and officers' liability insurance contracts cover corporate directors and officers against lawsuits brought against them as representatives of the corporation. Diverging interests mixed with asymmetric information between managers (including both directors and officers) and shareholders is the main source of conflict, and potentially the costliest. The insurance company will reimburse the corporation and/or its managers for the costs of settling and defending the lawsuit up to the policy limit, provided the firm's directors and officers have acted honestly and in good faith. In theory, should managers and their company have acted in a fraudulent manner, the insurance company could decide not to honor the policy (see Weisdom *et al.*, 2006, for more details on the three distinct types of coverage that are included in D&O insurance policies). Baker and Griffith (2008) argue that shareholders are the most likely firm stakeholders to sue directors and officers, and that security class actions on the basis of misrepresentation are the most costly type of lawsuits (also see the different Towers-Watson[32] surveys). The threat of a class action lawsuit is so important that it prompts firms to significantly invest in decreasing the potential cost of agency problems (see McTier and Wald, 2011).

2.1 Timing of D&O insurance information release

An important feature is the timing of information release in the Canadian investment context since the release of D&O insurance information generally occurs much later after its purchase. The figure in Appendix 2-A provides a typical timeline of the purchase and release of D&O insurance information for the firms that are becoming public through an IPO. See Appendix 2-B for examples of information that can be found in management proxies related to the D&O insurance contract and that illustrate the timing of the purchase of D&O insurance and information release.

2.2 The pricing of D&O insurance coverage

Insurance companies must accurately assess the potential cost of each policyholder since they ultimately bear the full cost of any mistake. As a result, D&O insurance underwriters have developed specific risk assessment tools that allow them to properly select clients and their litigation risk. Underwriters use three sources of information: The written application that contains a full array of documentation, the public financial and accounting data analysis, and

[32] According to many of these surveys, 20% of U.S. firms had at least one lawsuit brought against their directors in the previous ten years, of which half, and the most costly, came from shareholders.

interviews with the prospective insured's senior management team.[33] The information gathered by the insurer about a potentially insured firm's internal processes and structure is not divulged to other market participants.[34]

As in the pricing of any insurance contract, insurers must assess the probability that a claim will be paid as well as the severity of such a claim. Since the most costly D&O lawsuits originate from the firms' shareholders, they are then likely linked to stock market performance. Using the *Culture & Character* approach of Baker and Griffith (2007a), we measure a firm's potential cost of litigation based on its financial information, the industry's perspective and its governance risk factors. Of particular interest is the fact that insurers appear to place the analysis of governance characteristics into two categories: *Culture*, which refers to the stringency of the firm's formal and informal internal controls (how the information is disseminated in the firm), and *Character*, which refers to the directors' and officers' attitude toward risk. In essence, *Culture* seeks to identify the source of potential D&O litigation whereas *Character* aims at uncovering the managers' sense of ethics.

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[33] Baker and Griffith (2007a) provide a valuable in-depth account of the pricing approach used by D&O underwriters using detailed interviews of 41 D&O insurance professionals (underwriters, actuaries, brokers, risk managers, lawyers and claim process specialists). They also report that, in the United States, the average settlement was $13.3 million for the period 1996-2001, $22.3 million for the period 2002-2005 and $33 million in 2006-2007.

[34] See Knepper and Bailey (1998) and Baker and Griffith (2007a) for more details on the underwriting and auditing process of insurers. In the case of D&O insurance, the moral hazard hypothesis that is often linked to having insurance was shown to be inconsequential by Bhagat *et al.* (1987) who find that the decision to purchase D&O insurance does not decrease shareholder wealth.

3. Hypotheses development, data and variables description

3.1 Hypotheses and data

The main hypothesis we develop in this paper is that firms that are riskier in the eyes of D&O insurance providers have a post-IPO stock return that is lower and more volatile. Underpinning this question is the assertion that providers of D&O insurance use a plethora of publicly unavailable information from which a premium emerges, much like a credit score. The question we seek to answer is whether such information is valuable to investors.

As highlighted in Baker and Griffith (2007a), the risk assessment conducted by D&O insurers is partly based on private information regarding the inner working and the governance quality of the firms as well as on the D&O insurers' risk underwriting technology that is insurer-specific and not publicly known. Because they are usually absent from the offering prospectus, information about D&O insurance coverage and premiums is not publicly known at the time of the IPO, even though such information is revealed later in the life of the firm (see Appendix 2-A). When such information reaches the market, it should be embedded immediately in the prices. The null hypothesis is therefore that D&O insurance contract parameters have no power in explaining future risk and returns. The alternative hypothesis is that D&O insurance contract parameters have some ability to forecast a firm's stock market risk and returns in the first year of public life post-IPO.

$H1_0$: A firm's D&O insurance rate-on-line at the time of the IPO has no power in explaining the firm's first year stock market risk and return.

$H1_A$: A firm's D&O insurance rate-on-line at the time of the IPO is linked to higher stock market volatility and lower return in the first year of trading.

The measure we use to assess an insurer's perception of a firm's D&O liability risk is the "rate-on-line". The rate-on-line is calculated as the ratio of the total premium paid to the maximum possible coverage (or the policy limit); it is essentially the price per unit of coverage. Since firms that pay a higher rate-on-line are more susceptible to file a claim, their stock market return in the first year post-IPO should be lower and more volatile.[35] If a D&O insurance contract's rate-on-line conveys information, then a corollary to hypothesis **H1$_A$** should be that the firm's stock market performance after the information is revealed should be uncorrelated to such information. The information gathered by insurers to form an opinion regarding the IPO firm's liability risk before the IPO date becomes known to market participants after the first year post-IPO. This information should then be incorporated in the stock prices so that D&O insurance information should not have any long-term predictive power.[36]

Our results show strong support for rejecting hypothesis **H1$_0$** in favor of hypothesis **H1$_A$,** Consequently, we conclude that basic D&O insurance contract parameters have some power to predict stock market returns and risk in the first year post-IPO.

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[35] Boyer and Tennyson (2008) and Boyer (2003, 2013) argue that similar to any insurance contract, D&O insurance premiums depend on the frequency as well as on the severity of claims, as well as the cost of risk and other expenses. Assuming that premiums are the product of frequency (f), severity (s) and a proportional loading factor (m), and that severity can be measured by the policy limit, we believe that the rate-on-line (the ratio of premium to policy limit) is a good proxy for the frequency of lawsuits. To see why, let P=f*s*m so that P/S=f*m. If the loading factor is the same for all firms, then it will be picked-up in the regression constant when we use the log of the rate-on-line as an independent variable. Given that the different Towers-Watson surveys report that lawsuits are more likely to occur (and with more severity) following a decrease in the stock price, the result is that the D&O insurance market is efficient if the premium-to-coverage ratio is a function of the likelihood that the stock price will decline.

[36] In a previous iteration of the paper, we tested whether the first year's D&O insurance information had any impact in explaining the second year's return. In line with the efficient market hypothesis, we found that it had no impact. These results are available from the authors upon request.

The use of Canadian data is dictated by data availability challenges. For instance, basic D&O insurance contract characteristics are not publicly available for most U.S. firms (see Griffith, 2006). That is why Chalmers et al. (2002) and Kalchev (2004) have relied on a broker's private book of business. A second strategy (see Linck et al., 2009) is to use the 27 firms incorporated in the state of New York and the 12 S&P firms that voluntarily disclose enough information to examine the determinants of D&O premiums paid by each company. Unfortunately, these companies do not reveal how much coverage they purchased, thus limiting the quality of the signal associated with the premium paid. A third alternative is to use excerpts from the Towers-Watson surveys, as in Cao and Narayanamoothy (2011) and Fier et al. (2010) who use only two survey years (2001 and 2002). A fourth approach is to use Canadian data as in Core (1997, 2000), Boyer (2003), Park Wynn (2008), Gillan and Panasian (2009), Li et al. (2011), Rees et al. (2011) and Boyer and Stern (2012) since Canadian firms typically disclose their D&O insurance coverage and premium. Unlike most studies on D&O insurance that examine large and well established firms (the notable exceptions being Chalmers et al., 2002, and Boyer and Stern, 2012), we focus on firms that just went public through an initial public offering (IPO).

Chalmers *et al.* (2002) find that firms with more coverage at the time of the IPO are more likely to be sued for mispricing. However, the dataset used in Chalmers *et al.* (2002) does not include only D&O liability insurance protection contracts. Their dataset includes IPO liability insurance contracts (known also as *Public Offering of Securities Insurance* or POSI) that cover the firm's managers as well as the investment bankers, the venture capitalists and the angel investors who are seeking an exit. IPO liability insurance contracts are accordingly more expensive.[37] Also, in contrast to Chalmers *et al.* (2002) and Kaltchev (2006), our sample includes firms that opted for no insurance, thus reducing the potential bias involved in using only firms that purchased insurance from one particular insurance broker.

To gather data to test our hypothesis, we used the same approach as in Huson and Pazzaglia (2007). Starting with the 2000-odd new securities issued in Canada over the period 1995-2010, we are left with 340 firms that correspond to the classic definition of an IPO (see Huson and Pazzaglia, 2007, for more details). Financial data is collected from Compustat and from SEDAR, the Canadian equivalent of EDGAR. As many firms' first proxy circular or annual reports are not available on SEDAR, and because there is much missing information in annual reports and management proxies, the number of usable observations drops to 241. We then removed the firms for which the first day of the D&O insurance contract is after the IPO completion date (11 observations), and the firms that report the D&O insurance premium and policy limit in the IPO prospectus (21 observations). The final dataset contains 209 observations. The first column of Table 2-1 displays the number of initiated IPOs per year, whereas the second column displays the number of completed IPOs per year.

[INSERT TABLE 1 ABOUT HERE]

Financial variables are collected as of the end of the first fiscal year post-IPO. The governance and insurance information is collected in the first available management proxy. All numbers are in Canadian dollars and a conversion to Canadian dollars as of the end of the firm's fiscal year was applied when needed.

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[37] For instance in the case of the Addax corporation (IPO completed on February 16th 2006), the management proxy states that "The total 2006 premium payable is $374,500 for the D&O twelve month cover and $505,000 for the POSI 72 month cover".

3.2 Description of variables

3.2.1 Dependent variables

The dependent variables we use reflect the firm's observed stock market risk and return following the date of the IPO. Starting with our risk measurements, the *Volatility* variable is calculated as the standard deviation of annualized daily returns. We expect firms that are deemed riskier by insurers, as reflected by a higher rate-on-line, to have higher stock market volatility. We also calculated the firm's idiosyncratic risk of returns (*Idiosyncratic*) as in Ang *et al.* (2006) and used the standard deviation of the residual of a daily three-factor Canadian Fama-French model (see Francoeur *et al.*, 2008, for the source of these factors).[38]

To evaluate the stock performance of firms we use the *First year excess return* as well as the firm's *First year total return*. If D&O insurance providers have private information regarding the operations and governance of insured firms, firms that have a higher risk assessment measure should have a lower return. *First year excess return* is equal to the *First year total return* of the firm post-IPO minus the return on the S&P/TSX, Canada's main stock market index, over the same period. If D&O insurers are able to charge a higher premium to firms that will perform poorly because of their revealed poor governance and opaque operations, then the relationship between the first year excess return and our measure of D&O insurance risk will be negative.

We also combine the risk and return variables by calculating three quasi-Sharpe ratios: *Total Sharpe ratio*, *Excess Sharpe ratio*, and *Idiosyncratic Sharpe ratio*. The first measure is computed by dividing *First year total return* by *Volatility;* the second, by dividing *First year excess return* by *Volatility*; and the third, by dividing *First year total return* by *Idiosyncratic*. If

[38] Canadian factors are only available until 2009.

the rate-on-line is associated with higher volatility and lower returns, it should also be associated with lower quasi-Sharpe ratios.

IPO issue prices were collected using the firms' prospectus available on SEDAR. Values were verified using the FPInfomart database. Subsequent stock market price information comes from Bloomberg.

3.2.2 Main independent variables

The main variable of interest in this paper is the ratio of the total premium paid to the maximum possible coverage (or the policy limit). This information is released in the first management proxy after the firm becomes public[39]. As D&O insurance is considered by the board of directors to be a part of the managerial compensation package, the information that is released indicates the previous year's protection (just as salary information relates to the previous year's compensation). In the paper, this rate-on-line measure is modified in two ways, to make it more tractable. First, we use the natural logarithm of the ratio of the D&O premium to $1,000 dollars of coverage (*Ln_ROL*) to reduce the impact of very large rate-on-lines on the results. Second, we use the D&O premium divided by $1,000 dollars of coverage (*Rate-on-line*). In both cases, a firm that pays a higher rate-on-line is hypothesized to be perceived by the insurer as riskier since it is paying more per unit of coverage. We therefore test whether the rate-on-line is related to stock market volatility and returns (as well as the quasi-Sharpe ratios) in the first year of operations post-IPO.

The decision to purchase or not to purchase insurance is used in the first step regression equation of the Heckman two-step procedure (see the Robustness section), to account for the

[39] In some rare instances, the D&O insurance information is released in the prospectus. We thank a referee for pointing out this issue; we therefore deleted from our final sample all firms that divulged their D&O insurance information in their prospectus.

possible selection bias where the rate-on-line was not random for the sample of firms we observed. In other words, we need to account for the fact that we do not observe the rate-on-line for firms that choose to remain uninsured. *Insurance* is thus an indicator variable equal to one if the firm reported that it carried D&O insurance in its first management proxy following its first annual report post-IPO, and it should be zero otherwise.[40]

Appendix 2-C provides a detailed description of all control variables.

3.3 Sample Statistics

Table 2-2 presents the main sample statistics, starting with the dependent variables, the variables related to the D&O insurance contract and finishing with the different control variables and the variables used in the treatment equation related to the decision to purchase D&O insurance. Dichotomous variables in Table 2-2 are those for which the entire sample statistic is not provided.

[INSERT TABLE 2-2 ABOUT HERE]

It is interesting to note that the average return in the first year is 11.5%, giving an average excess return in the first year of 4.4%, whereas the median return is only 7.8% with a median excess return of -2.9%. Eight companies did not reach the end of the first year of operations.

Our sample consists of 148 firms that reported having D&O insurance in the first year post-IPO and 61 not reporting having insurance, which give us a take up of 71%, a percentage very similar to the average D&O insurance penetration in the Canadian market according to the different Tillinghast-Towers reports. In terms of the main variables of interest, information about

[40] As in Core (1997), Park Wynn (2008), Lin *et al.* (2011) and Boyer and Stern (2012), we assume that the lack of D&O insurance information disclosure in a firm's proxy circular means that the firm is uninsured.

the *Rate-on-line* is available for 96 firms out of the original 209. Of the 113 firms for which no rate-on-line is available, 61 did not purchase D&O insurance whereas the other 52 purchased D&O insurance but did not give enough details to calculate the rate-on-line. These 52 firms must be kept in the dataset regressions because the mere fact that they purchased insurance tells us something about their behavior toward insurance.

4. Analysis of results

The theoretical econometric model has the following structure.

1- Firms decide to go public through an initial public offering;

2- Firms decide to purchase D&O insurance or not;

3- Insurers give firms that purchase D&O insurance a price per unit of coverage (rate-on-line);

4- The stock market reacts to the flow of information during the year.

The variables that determine whether a firm goes public (step 1) are not measurable since we do not have access to information for non-public firms. After deciding to go public, a firm purchases a D&O insurance contract (or not) in step 2, an information that is available. Regarding step 3, we observe a firm's rate-on-line only if it purchased insurance. To control for the potential selection bias in steps 2 and 3, we will conduct a classic Heckman two-step procedure as a robustness check.

4.1 Preliminary results

Table 2-3 separates the observations presented in Table 2-2 between firms that have D&O insurance and firms that do not, and offers some descriptive statistics. Of the 71% of IPO firms that reveal they purchased D&O insurance before their IPO date, the average premium is approximately $145,658 for an average coverage of $22 million. There is a very wide distribution for the rate-on-line variable, which is reported as the premium paid per $1,000 of coverage. The 95th percentile rate-on-line is more than 7 times larger than the 5th percentile rate-on-line, with an average of $7.19 per $1,000 of coverage and a median of $5.27 per $1,000 of coverage. This provides some justification for using a log-transformation of the rate-on-line.

[INSERT TABLE 2-3 ABOUT HERE]

When examining the decision to purchase insurance (the *Insurance* variable is equal to one if the firm revealed carrying D&O insurance, and zero otherwise), the hypothesis is that this decision should be influenced by financial and governance measures as well as other control variables. It is interesting to see that none of the return variables differ in distribution as a function of whether insurance is purchased or not. This provides a possible indication that the mere fact of purchasing insurance or not conveys no information to the market.

In the second part of Table 2-3, we see that firms that take up insurance are in some respect significantly different from firms that do not. For instance, firms that are larger (in terms of market capitalization at the time of their IPO) are more likely to have D&O insurance. Firms that have operations in the U.S. are also more likely to carry D&O insurance. As the U.S. relies more on litigation to keep firms in line, it seems logical that the more important the presence in the U.S., the more likely a lawsuit could occur so that carrying insurance becomes more likely. The only other dimension over which insured and non-insured firms differ in means and median is in terms of their corporate structure. It seems that income trusts are more likely to have no insurance than common equity firms. Table 2-4 shows the results of a simple probit model regarding the decision to purchase D&O insurance for different model specifications.

[INSERT TABLE 2-4 ABOUT HERE]

The results are consistent across model specifications, with four variables remaining generally significant throughout: *Duality*, *US_Presence*, *ITCE* and *Hard*. It therefore seems that firms that are more likely to purchase D&O insurance are those that have a chairman of the board who is not the CEO, that have activities in the U.S. and that are incorporated as common equity firms. Firm size, as measured by the natural logarithm of the firm's market value of equity (*lnMVE_IPO*), seems to have only a marginal impact on the decision to purchase D&O insurance when controlling for other factors. These results are in line with most studies that examine the demand for D&O insurance (see Rees *et al.*, 2011, Core, 1997 and Boyer, 2003). Specification 2 will be the model used later as the Heckman's selection regression (first stage) model since it is the one that has the best goodness of fit.

4.2 The Predictive Power of D&O Insurance Rate-on-Line

Table 2-5 reports the results from OLS regressions where we examine the relationship between the main independent variables (the log of the rate-on-line or the premium per $1,000 of coverage) and the first year excess return (Panel A) and the total return (Panel B) post IPO. In Panel A, the first regression model presents the results when we do not include the rate-on-line variables in the regression. We see that only two variables have the power to explain the returns in the first year post-IPO: return on assets and the type of incorporation. No other variable has any explanatory power at the 5% level or better.

Model specifications 2 and 3 are very parsimonious and control only for basic financial and governance variables in addition to either rate-on-line measures: Specification 2 uses the natural log of the rate-on-line whereas Specification 3 uses the rate-on-line as the main independent variable of interest. In the next set of two regressions, we add more financial and governance control variables as well as variables related to the IPO (the fee ratio and the float).

Specifications 6 and 7 are similar to Specifications 4 and 5 with the difference that they control whether the firm went public during a "hard market year" in the D&O insurance industry (i.e., when premium levels were high). Across all model specifications, the price per unit of D&O insurance coverage (whether it is the log of the rate-on-line or simply the premium-to-coverage ratio) is negatively and significantly related to the firm's excess stock market return in the first year after the IPO. Panel B shows regressions that predict first year total returns while controlling for systematic risks using three Canadian Fama-French measures. Results are the same in Panel B and in Panel A: the rate-on-line is negatively and significantly related to the firm's stock market return in the first year post IPO.

All results in both panels of Table 2-5 are consistent with the hypothesis that D&O liability insurers have information at the time of the IPO that should be valuable to stock market participants. Our results are economically significant. Using any model specification that uses the natural logarithm of the rate-on-line in Panel B of Table 2-5, we can conclude that a 50% increase in the rate-online (resp. a 10% increase) leads to an approximate 7.3% to 9.4% (resp. 1.7% to 2.2%) decrease in the one-year excess return post IPO.

[INSERT TABLE 2-5 ABOUT HERE]

We then turn to examine whether the rate-on-line is related to other stock performance measures in the first year post-IPO: risk, and return per unit of risk. We use two measures of risk in our OLS regressions. *Volatility* is the standard deviation of annualized daily returns, whereas *Idiosyncratic* is the standard deviation of the residual of a daily three-factor Canadian Fama-French model. We use the idiosyncratic risk to verify that our results on volatility are not contaminated by market volatility. With respect to the return per unit of risk, we shall use different quasi-Sharpe ratio measures by dividing a return measure by a risk measure.

Table 2-6 and Table 2-7 present the regression results for the two risk measurements. In both tables, the first specification presents the regression results when no rate-on-line variable is included. Specifications 2 & 3 control for financial variables and variables related to the firm's governance. The second set of two regressions controls for the same variables, but a dummy variable to control for a hard insurance market is added. Finally, model specifications 6 & 7 show how our results hold with a more parsimonious model specification.

[INSERT TABLE 2-6 ABOUT HERE]

[INSERT TABLE 2-7 ABOUT HERE]

In all specifications, results show that the price of coverage is statistically and positively related to the one-year ahead total return volatility and idiosyncratic risk. In addition, the results are economically significant. Using Specification 4 in Table 2-7, the estimated coefficient for the natural logarithm of the rate-on-line shows that if the rate-on-line of the average firm in our sample was to increase by 50% (resp. 10%), the one-year post IPO volatility would increase by 2.8% (resp. 0.7%). Apart from the rate-on-line variables, only firm size (as measured by *lnMVE_IPO*) and *Float* are significant at the 5% level or better in all model specifications in both tables.

Results in Tables 2-6 and 2-7 are remarkably similar. Insurers appear to be able to charge a higher price to IPO firms that will have more volatile stock returns in the first year following their IPO. These results are in line with economic theory, in contrast with the results in Chalmers et al. (2002). Although we cannot assert that insurers are better at anticipating volatility than investors, we nevertheless believe that the metric provided by the rate-on-line could be very useful to market participants.

Our final set of results combines the first year excess return and volatility to analyze whether the excess Sharpe ratio (i.e. the ratio of the one-year excess return to volatility), the total Sharpe ratio (i.e. the ratio of the one-year total return to volatility), or the idiosyncratic Sharpe ratio (i.e. the ratio of the one-year total return to idiosyncratic risk) of our sample firms is negatively related to the D&O insurance rate-on-line. Results are presented in Table 2-8. No control variable seems to be consistently and significantly related to the excess Sharpe ratio of our sample firms. The only variable that is significant in explaining the return per unit of risk is the rate-on-line.

[INSERT TABLE 2-8 ABOUT HERE]

Again, our results strongly support the idea that the technology used by D&O insurers to transform the firms' liability risk characteristics into an insurance premium has some power in explaining the firms' first year basic stock market return characteristics. The data therefore supports the hypothesis that insurers are able to anticipate the performance of firms in their first year as a public company, even in a context where high information asymmetry prevails.

The results presented in Table 2-5 through Table 2-8 use information that one could argue has already been incorporated by the investment banker in the offer price at the time of the IPO, or that it has been quickly and immediately incorporated in the stock price at the end of the first day. As a consequence, we could expect not to observe any link between known firm specific characteristics and the stock return in the first year. This offers an explanation for the low level of significance of most control variables in the regressions of Table 2-5 through 2-8.

In Table 2-9, we therefore present regression results that only use the information that is unknown to investors at the time of the IPO: the rate-on-line, the return of market portfolio and the first day return. We also include a dummy variable to control for a hard insurance market, meaning that insurance policies are less affordable and that they come with more stringent constraints. Panel A uses the first day return as an explanatory variable. In Panel B, the first day return is included in the dependent variable. In Specifications 1 through 6, we use as our dependent variable the first year total return net of the first day, while controlling for market return. In Specifications 7 and 8, we use the excess return in the first year net of the first day as our dependent variable.

[INSERT TABLE 2-9 ABOUT HERE]

In Panel A of Table 2-9, we see that the paper's main hypothesis, that the rate-on-line conveys valuable information, is supported since returns and returns per unit of risk are negatively affected by both measures of the rate-on-line. The positive relationship between the rate-on-line and risk is not as significant though.[41] When we focus solely on the first year return after the first day, as in Panel B of Table 2-9, then both measures of the rate-on-line remain negatively and significantly related to the total return and to the excess return. The magnitude of the coefficients of *Ln_ROL* and *Rate-on-line* in Panel B are similar to what we had in the previous tables.

5. Robustness checks

This section reports the results of a series of robustness tests to see how sensitive our empirical results are to various econometric specifications.[42] First, we examine the possibility that the decision to purchase D&O insurance conveys information to the market that is not

[41] If we concentrate only on the firms that have a high enough idiosyncratic risk (for instance more than 2%), then the main results of the paper hold with a significance of better than 1% on our variables of interest.

[42] For brevity purposes, we mainly focus from this point forward on results related to return and to return per unit of risk.

captured when we use an OLS regression. Indeed, given that we do not observe the rate-on-line of firms which do not purchase insurance, the distribution of insured and non-insured firms is not random and could therefore bias the results. We use a Heckman (1979) two step approach to reduce the potential bias. The first step consists in a probit regression that measures a firm's propensity to purchase D&O insurance before its IPO. Similar to the regression results in Table 2-4, the dependent variable in this regression is *Insurance*. We model the firms' decision to purchase insurance using Specification 2 in Table 2-4. The second step in the Heckman two-step procedure involves an OLS regression to determine the impact of the rate-on-line on the different post-IPO dependent variables.

The second robustness analysis we conduct examines the consequences of a situation where the stock market risk and return are jointly determined and where each feedbacks into the other. We therefore modify the econometric models to simultaneously estimate the stock market returns and risk in the first year post-IPO. The econometric technique used is either a two-stage least square or three-stage least square regression to make sure that the results are not due to a misspecification of the econometric model.

5.1 Likelihood of carrying D&O insurance and two-step regression

The first robustness check is to verify whether the choice of being insured or not creates a significant selection bias in the sense that firms who choose to purchase insurance are fundamentally different from those that do not. We control for the potential selection bias by using a classic Heckman two-step approach in Table 2-10 (we only report the results from the second stage regressions), in order to explain the first year excess return, the first year total return, as well as the market excess quasi-Sharpe ratio (the selection regression model is omitted, but available from the authors). The basic results of the paper hold: there is a negative and significant relationship between the two measures of the rate-on-line and the firms' total return, excess return, and excess return per unit of risk in the first year post IPO.

[INSERT TABLE 2-10 ABOUT HERE]

As we see in Table 2-10, the two main variables of interest are significantly negatively associated with the return of firms that went public through an initial public offering. Not only do the selection bias regression results confirm the results presented in Table 2-5, the coefficients' value are extremely similar. This should tell us that the impact of the selection bias is small. Even when we use market-adjusted quasi-Sharpe ratios as our dependent variable, the results are similar to the results presented in Table 2-8. This again suggests that the selection bias, if it exists, is relatively small and economically inconsequential (which is confirmed by the Wald test). In unreported results, we find that the volatility results are also unchanged when controlling for the selection bias, and the inclusion of the full set of control variables.

In Panel B of Table 2-10, we also report regression results where we explicitly control for systematic differences which may exist between firms that purchase insurance and disclose the policy limit and premium and those that purchase insurance but do not provide this information. The econometric model therefore has three steps: the decision to purchase, the decision to reveal all information, and the return in the first year. Using the inverse Mills ratio from probit model 2 from Table 2-4, we run a Heckman selection model where the first dependent variable takes the value one for firms that disclose their policy limit and premium, and zero otherwise. The second stage is an OLS regression with our return and risk measures as dependent variables, and where the computed inverse Mills ratio variable is included as a control. Our results remain unchanged, which suggests that the impact of the disclosure selection bias is small or even inexistent.

5.2 Simultaneous (feedback) effects of risk and return

The results of Table 2-11 take into account the potential simultaneous determination of risk and return in the model since feedback effects could exist between risk (however measured) and return. We test our main hypothesis using a two-stage least square (Panel A) as well as a three-stage least square (Panel B) approach.

[INSERT TABLE 2-11 ABOUT HERE]

Correcting for the simultaneity of risk and return measures reduces the significance of the coefficients of interest but does not alter the overall results. In both panels we corrected for the selection bias and the feedback effect by including the inverse-Mills ratio in all of the regressions. Overall results show that the price-to-coverage ratio is positively associated with risk and negatively associated with returns. The main message of the paper is therefore supported using many different econometric models.

We can therefore be confident that the paper's main results presented in Tables 2-5 through 2-8 are robust, which means that the firms' first year returns are significantly related to their D&O insurance contracts' rate-on-line. This suggests that insurers who offer D&O insurance protection are able to process information at the time of the IPO that investors should find valuable.

6. Discussion and conclusion

The primary objective of this paper is to examine whether insurers that provide firms and their managers with protection against the event of costly litigation are able to effectively process information that could be valuable to investors at the time of the firms' initial public offering. More precisely, firms that seek to protect their managers against costly liability lawsuits may purchase protection from insurers that examine each firm's governance structure, organizational processes and its "character and culture" to arrive at a premium that reflects the firm's risk of lawsuits. Even though this audit is performed prior to the IPO date, investors only learn this information much later, in the proxy statement, which is typically released a few months after the end of the first fiscal year.

Whenever insurers decide to provide coverage to any policyholder, they assess the probability and severity of claims they could potentially be asked to cover. D&O insurance claims are generally related to lawsuits brought against the firm's managers by shareholders or other stakeholders. Lawsuits are more frequent when the stock has performed poorly, and a lawsuit's severity is greater when volatility is higher. Consequently, insurers that sell D&O insurance must use an audit technology (known as risk underwriting in the insurance industry) that yields a higher price of insurance when the expected loss is greater, whether this is due to a higher frequency of losses (i.e. lower stock returns) or a higher severity of lawsuits (higher stock volatility). The main results of this paper confirm this view of the D&O insurance world. We find that firms that pay a high price for their directors' and officers' liability insurance coverage tend to underperform in their first year since they are more likely to have a lower stock return and a higher volatility. Our results connect the premium paid before the IPO with the volatility post IPO, and thus provide a missing link in the literature. Our findings reconcile economic theory with empirical evidence as insurers charge more *ex ante* to firms that are risker *ex post.* Chalmers et al. (2002) found the opposite result, which was surprising.

Our results lend support to the hypothesis that D&O liability insurers have material information about the internal structure of soon-to-be public firms that other investors do not have.[43] Given that the main determinant of the premium is the assessment of deep corporate governance (Baker and Griffith, 2007a), our study provides support for the idea that D&O insurance information could be a potential substitute to commercial governance indices. Further research to formally test this hypothesis is on our research agenda. For American investors, the information related to the purchase of D&O insurance is usually not available in the United States (see Griffith, 2006). Even in cases where some information is available, as in the state of New York (see Linck *et al.*, 2009), only the premium information is provided, which is insufficient to draw any reasonable conclusion on the firm's risk.

The use of D&O insurance information as a tool to assess stock return and volatility falls within the recent push to find a way to properly account for a firm's governance structure (see Rose, 2007, Bebchuk and Hamdani, 2009, Bebchuk and Weisbach, 2010, Adams *et al.*, 2010, and Larcker and Tayan, 2013, *inter alia*). As many governance factors are not properly specified or are completely unavailable to the general investor (see Baker and Griffith, 2007a), one has to wonder how much of the internal structure of the firm remains unknown to market participants. That is why Holderness (1990), O'Sullivan (1997), Core (2000) and Boyer and Stern (2012) argue that D&O insurance providers are more likely to be good firm monitors since they have a monetary incentive to price the contract properly.

The results herein can be seen as a laboratory test that adds weight to calls for disclosure of D&O insurance information (see Griffith, 2006). Mandating the revelation of basic D&O insurance information (premium and coverage) could potentially be valuable to investors since it

[43] In unreported results, we find that the predictive power of D&O insurance disappears after the first year. The likely reason is that market participants slowly incorporate in stock prices the information that was only available to insurers at the time of the IPO so that the information advantage of D&O insurers is dissipated.

would provide them with an unbiased signal about a firm's risk of litigation against its directors and officers, perhaps because of some managerial mishaps or accidental incompetence. Since the vast majority of Canadian and American corporations purchase liability insurance on behalf of their directors and officers, it would seem efficient to have access to this risk measure.

Further research is necessary in order to specifically assess the welfare implications of mandating such disclosure. Particular attention should be paid to the fact that the interests of existing and new shareholders do not necessarily converge with respect to the disclosure of D&O insurance information. Furthermore, the generalization to large U.S. listed firms is uncertain since our results relate to the case of new Canadian firms that became public through an IPO. These caveats notwithstanding, the questions we raise in this paper are relevant and timely given the time and energy that investors and regulators devote to governance issues.

Table 2-1 Number of Canadian IPOs per year in sample: Year of IPO initiation and year of IPO completion

For the firms in our sample, we present the number of IPOs initiated between 1995 and 2010, and completed between 1995 and 2011.

Year	IPO initiated	IPO completed
1995	4	2
1996	11	12
1997	16	15
1998	5	6
1999	9	8
2000	10	12
2001	9	7
2002	25	27
2003	14	13
2004	26	26
2005	26	22
2006	20	23
2007	12	8
2008	2	8
2009	3	2
2010	15	10
2011	-	6
missing	2	2
Total	209	209

Table 2-2 Summary statistics of the sample data set

We present for each variable mentioned in the paper the number of available data points, the mean, standard deviation and the value of the non-dummy variables for different distribution points. The table separates the different variables with respect to the categories in which they were presented in the paper.

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*5%*	*25%*	*Median*	*75%*	*95%*	*Max*
Dependent variables										
First year total return	199	0.115	0.562	-0.939	-0.673	-0.180	0.078	0.306	1.200	2.928
First year excess return	199	0.044	0.544	-1.027	-0.762	-0.262	-0.029	0.246	1.032	2.830
Volatility	202	0.436	0.352	0.128	0.148	0.226	0.315	0.511	1.100	2.600

Idiosyncratic	186	0.0276	0.0224	0.0080	0.0092	0.0141	0.0198	0.0319	0.0685	0.1645
SharpeExcess	197	0.265	1.331	-2.265	-1.352	-0.652	-0.050	0.978	2.631	5.085
Main independent variables										
Rate-on-line (per $1000)	96	7.191	5.273	1.000	2.088	3.775	5.675	9.354	15.500	37.500
ln_ROL (per $1000)	96	1.762	0.654	0.000	0.736	1.328	1.736	2.236	2.741	3.624
Insurance	209	0.708	0.456							
Financial variables										
FirstDayReturn	193	0.040	0.111	-0.152	-0.061	-0.010	0.011	0.074	0.235	0.867
MarketRet	207	0.077	0.190	-0.409	-0.281	-0.069	0.127	0.213	0.307	0.563
RiskFree	186	0.024	0.007	0.008	0.016	0.018	0.022	0.029	0.035	0.038
SMB	186	0.158	0.185	-0.173	-0.066	0.023	0.124	0.265	0.513	0.783
HML	186	0.051	0.273	-0.443	-0.248	-0.093	0.002	0.114	0.731	1.301
lnMVE_IPO	206	18.819	1.209	13.638	16.743	18.201	18.853	19.488	20.577	22.504
Growth	190	1.313	1.814	0.003	0.308	0.697	0.927	1.232	3.149	17.767
ROA	207	-0.004	0.199	-1.453	-0.277	-0.008	0.025	0.062	0.114	0.937
Debt_Ratio	207	0.374	0.240	0.003	0.011	0.175	0.350	0.535	0.828	0.995
Governance variables										
Duality	209	0.273	0.446							
Blockholder	209	0.722	0.449							
Independence	209	0.708	0.164	0.182	0.429	0.600	0.714	0.818	1.000	1.000
ITCE	209	0.464	0.500							
Other variables										
Board_size	205	6.878	2.091	3	4	5	7	8	11	15
Risky_Industry	209	0.335	0.473							
Age	205	25.97	29.92	0.000	0.323	5.000	14.000	38.40	97.17	130.00
IPOfeerat	188	0.0584	0.0215	0.0065	0.0438	0.0550	0.0600	0.0600	0.0675	0.3240
Float	204	0.546	0.320	0.048	0.140	0.243	0.495	0.887	1.000	1.023
Big5	185	0.686	0.465							
US_Presence	209	0.536	0.500							
US_Sales	198	0.208	0.310	0.000	0.000	0.000	0.000	0.403	0.860	1.000

Table 2-3 Separation and test between firms that have D&O insurance or not

We test for differences in means and median between the sample of firms that purchased D&O insurance (148 firms) and firms that did not purchase D&O insurance (61 firms). A selection of independent control variables are presented.

	No D&O insurance (61)				**D&O insurance (148)**				*Tests* of differences in*	
Return Variables	*Obs*	*Mean*	*Std. Dev.*	*Median*	*Obs*	*Mean*	*Std. Dev.*	*Median*	*Mean*	*Median*
First year return	57	0.076	0.582	0.070	142	0.131	0.556	0.081	ns	ns
First year excess return	57	0.015	0.538	-0.037	142	0.056	0.547	-0.015	ns	ns
First day return	54	0.032	0.083	0.014	139	0.043	0.120	0.010	ns	ns
First day return (imputed)	61	0.029	0.079	0.001	148	0.041	0.117	0.004	ns	ns
Volatility	59	0.426	0.394	0.274	143	0.440	0.334	0.325	ns	ns
Idiosyncratic	49	0.028	0.027	0.015	137	0.028	0.207	0.020	ns	ns
Sharpexs (Excess return/volatility)	56	0.158	1.314	-0.182	141	0.308	1.341	-0.019	ns	ns
Other independent variables										
Ln (MVE at IPO)	60	18.502	1.392	18.483	146	18.950	1.104	18.923	1.45%	1.73%
Debt_Ratio (%)	60	0.351	0.256	0.318	147	0.383	0.233	0.354	ns	ns
ROA	60	-0.028	0.296	0.032	147	0.006	0.142	0.024	ns	ns
Growth	48	1.133	1.385	0.829	142	1.373	1.938	0.951	ns	ns
IPO fees / MVE at IPO	54	0.056	0.009	0.060	134	0.059	0.025	0.060	ns	ns
IPO fees / MVE at IPO (imputed)	61	0.057	0.009	0.060	148	0.059	0.024	0.060	ns	ns
Risky industry	61	0.266	0.444	0	148	0.365	0.483	0.000	7.86%	ns
US Presence	61	0.377	0.489	0	148	0.601	0.491	1.000	0.16%	0.32%
US sales	59	0.109	0.257	0	139	0.250	0.322	0.010	0.07%	0.10%
Age	58	24.618	31.658	9.339	147	26.505	29.295	14.302	ns	ns
Float	59	0.609	0.330	0.636	145	0.520	0.311	0.427	3.91%	ns
Income trust	61	0.590	0.496	1	148	0.412	0.494	0	0.99%	1.93%
Independence	61	0.725	0.184	0.750	148	0.701	0.156	0.707	ns	ns
Duality	61	0.311	0.467	0	148	0.257	0.438	0	ns	ns
Blockholder	61	0.639	0.484	1.000	148	0.757	0.430	1	5.15%	8.56%

* A t-stat was used to test the equality of the two sample means (with equal variance), whereas we used a Wilcoxon rank-sum test for the test of equality of medians. Only differences significant at the 10% level or better are highlighted.

Table 2-4 Marginal impact on the decision to purchase D&O insurance.

We evaluate the marginal impact of control variables on a firm's likelihood to purchase D&O insurance. The dependent variable is Insurance, an indicator variable equal to one if the firm purchased D&O insurance in the first year post IPO. Onle the marginal effects are reported for ease of interpretation of the estimated coefficients.
lnMVE_IPO is the log of the market value of equity at the time of the IPO. Debt_ratio is the ratio of total debt to market value of equity at the time of the IPO. Growth is the market value of equity plus the book value of liability, divided by the book value of assets. ROA is the firm's return on assets. Duality takes on the value one if the CEO of the company is also the chairman of the board. Blockholder is an indicator variable equal to one if a shareholder owns 10% or more of the firm’s voting shares. Independance is the proportion of directors deamed independent in Canada. Risky_Industry is an indicator variable equal to one if the company operates in one of the industries classified as risky in Bajaj et al. (2000). US_Presence is an indicator variable equal to 1 if the firm has activities in the United States and zero otherwise. IPOfeerat is equal to the fees paid to the investment banker divided by the firm's market value of equity at the time of the IPO. Float is the ratio of the number of shares available at the IPO to the total number of shares outstanding. ITCE is a dummy variable equal to 1 if the firm is an income trust and 0 otherwise. Age is the age of the operating firm at the time of the IPO. Hard is equal to one if the D&O insurance market is characterized by higher than normal premiums.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Insurance	Insurance	Insurance	Insurance	Insurance	Insurance
lnMVE_IPO	0.045	0.028	0.035	0.030	0.026	0.051*
	(0.028)	(0.029)	(0.029)	(0.027)	(0.028)	(0.028)
Debt_Ratio	0.063	0.055	0.068	0.093	0.065	
	(0.141)	(0.140)	(0.139)	(0.137)	(0.140)	
Growth	0.008	0.006	0.001	0.018	0.002	
	(0.018)	(0.020)	(0.019)	(0.022)	(0.021)	
ROA		0.123	0.091	0.088	0.109	
		(0.181)	(0.186)	(0.184)	(0.193)	
Duality	-0.172**	-0.165*		-0.137*		-0.092
	(0.084)	(0.084)		(0.082)		(0.082)
Blockholder	-0.008	-0.011		0.092	0.032	0.056
	(0.074)	(0.072)		(0.077)	-0.073	(0.076)
Independence	-0.146	-0.184		-0.178	-0.037	-0.140
	(0.218)	(0.214)		(0.213)	(0.211)	(0.210)
Risky industry	0.043	0.071	0.072		0.053	0.072
	(0.070)	(0.069)	(0.068)		(0.070)	(0.070)
US Presence	0.193***	0.195***	0.193***		0.188***	0.151**
	(0.069)	(0.069)	(0.068)		(0.068)	(0.068)
IPOfeerat0	2.393	2.527	2.213			
	(3.178)	(3.572)	(3.391)			

Float	0.121	0.108	0.111			
	(0.155)	(0.153)	(0.153)			
ITCE	-0.157	-0.290**	-0.280**		-0.208**	-0.269***
	(0.101)	(0.117)	(0.116)		(0.094)	(0.083)
Age	0.001	0.001	0.001			
	(0.001)	(0.002)	(0.002)			
Hard		0.230**	0.243**	0.0450	0.244**	0.291***
		(0.108)	(0.108)	(0.0700)	(0.102)	(0.084)
Constant						
PseudoR2	0.123	0.154	0.132	0.044	0.108	0.138
LL	-88.485	-85.410	-87.653	-101.11	-94.306	-107.18
Observations	183	183	183	188	188	206

In all cases, the standard deviation is in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.
Model specification 2 is used as our first stage regression in our Heckman two-stage regression

Table 2-5A OLS regression that measures the firms' first year excess return – Panel A

We evaluate the impact of price per unit of coverage on the firms' market-adjusted stock return in the first year following the IPO. The dependent variable is the first year total return minus the return of the market over the same year (FirstYearReturn - Mkt1Year). The two main variables of interest are Rate-on-line, calculated as the premium per thousand dollars of maximum coverage, and ln_ROL, the log of the Rate-on-line. We hypothesize that these two measures should be negatively related to the firm's first year excess return.
FirstDayReturn is our control variable for underpricing and is computed as the first day return on the close of the first trading day. LnMVE_IPO is the log of the firm's market value of equity at the time of the IPO (issue price multiplied by number of outstanding shares). Growth is the market value of equity plus the book value of liability, divided by the book value of assets. DebtRatio is the ratio of total debt to assets. ROA is the firm's return on assets. IPOfeerat is the ratio of the IPO fees paid per million dollars of market value of equity. Float is computed as the ratio of the number of shares issued over the total number of shares outstanding. ITCE is a dummy variable equal to 1 if the firm is an income trust. US_Sales is the percentage of sales carried out in the US. Independence is the proportion of board members that are classified as independent. Duality is equal to 1 if the CEO is also the Chairman of the board and zero otherwise. Blockholder is equal to 1 if there is a major shareholder that holds more than 10% of the shares after the IPO and 0 otherwise. Age is the age of the operation entity before the IPO. Hard is a dummy variable equal to 1 to account for the period of time when D&O insurance premium were abnormally high.

VARIABLES	(1) First year excess return	(2) First year excess return	(3) First year excess return	(4) First year excess return	(5) First year excess return	(6) First year excess return	(7) First year excess return

ln_ROL		-0.124**		-0.122*		-0.129**	
		(0.059)		(0.063)		(0.060)	
Rate-on-line			-0.0167***		-0.0177***		-0.0183***
			(0.006)		(0.006)		(0.006)
FirstDayReturn	0.596			0.220	0.297	0.249	0.325
	(0.429)			(0.395)	(0.396)	(0.400)	(0.398)
lnMVE_IPO	0.033	0.028	0.022	0.031	0.022	0.025	0.016
	(0.040)	(0.042)	(0.043)	(0.045)	(0.047)	(0.049)	(0.051)
Growth	-0.011			0.008	0.008	0.004	0.004
	(0.034)			(0.049)	(0.048)	(0.045)	(0.044)
DebtRatio	0.205			0.323	0.316	0.326	0.318
	(0.164)			(0.230)	(0.232)	(0.231)	(0.232)
ROA	0.892***	0.927**	0.967***	0.800**	0.836**	0.768*	0.810*
	(0.191)	(0.362)	(0.362)	(0.391)	(0.386)	(0.422)	(0.416)
IPOfeerat	-1.245			-0.530	-0.518	-0.746	-0.697
	(1.605)			(2.065)	(2.066)	(2.141)	(2.134)
Float	-0.063			-0.0841	-0.110	-0.104	-0.129
	(0.149)			(0.257)	(0.248)	(0.272)	(0.265)
ITCE	-0.259**			-0.236	-0.231	-0.279*	-0.268*
	(0.108)			(0.145)	(0.143)	(0.160)	(0.156)
US_sales	-0.134			-0.160	-0.169	-0.146	-0.157
	(0.115)			(0.183)	(0.183)	(0.180)	(0.181)
Independence	-0.211	-0.164	-0.188	-0.086	-0.113	-0.088	-0.117
	(0.242)	(0.295)	(0.284)	(0.358)	(0.346)	(0.368)	(0.359)
Duality	-0.132			-0.195	-0.213	-0.181	-0.201
	(0.106)			(0.174)	(0.176)	(0.165)	(0.167)
Blockholder	-0.127*	-0.016	-0.029	-0.040	-0.057	-0.04	-0.061
	(-0.071)	(0.095)	(0.094)	(0.113)	(0.112)	(0.110)	(0.108)
Age	0.002			0.003	0.003	0.003	0.003
	(-0.001)			(-0.003)	(-0.003)	(-0.003)	(-0.003)
Hard	-0.006					0.082	0.071
	(-0.132)					(-0.196)	(-0.197)
Constant	-0.170	-0.146	-0.100	-0.208	-0.074	-0.081	0.037
	(0.852)	(0.836)	(0.847)	(0.958)	(0.997)	(1.049)	(1.086)
Observations	167	93	93	87	87	87	87
R-squared	0.235	0.128	0.131	0.209	0.214	0.211	0.216

Coefficients are reported with their robust standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 2-5B OLS regression that measures the firms' first year total return – Panel B

We evaluate the impact of price per unit of coverage on the firms' total stock return in the first year following the IPO. The dependent variable is the first year total return (FirstYearReturn). The two main variables of interest are Rate-on-line, calculated as the premium per thousand dollars of maximum coverage, and ln_ROL, the log of the Rate-on-line. We hypothesize that these two measures should be negatively related to the firm's first year total return. FirstDayReturn is our control variable for underpricing and is computed as the first day return on the close of the first trading day. MarketRet, RiskFree, SMB and HML are the one year total returns of the Canadian market portfolio, the risk free rate and the two Fama-French size and growth portfolios respectively. LnMVE_IPO is the log of the firm's market value of equity at the time of the IPO (issue price multiplied by number of outstanding shares). Growth is the market value of equity plus the book value of liability, divided by the book value of assets. DebtRatio is the ratio of total debt to assets. ROA is the firm's return on assets. IPOfeerat is the ratio of the IPO fees paid per million dollars of market value of equity. Float is computed as the ratio of the number of shares issued over the total number of shares outstanding. ITCE is a dummy variable equal to 1 if the firm is an income trust. US_Sales is the percentage of sales carried out in the US. Independence is the proportion of board members that are classified as independent. Duality is equal to 1 if the CEO is also the Chairman of the board and zero otherwise. Blockholder is equal to 1 if there is a major shareholder that holds more than 10% of the shares after the IPO and 0 otherwise. Age is the age of the operation entity before the IPO. Big5 is a dummy variable equal to 1 when one of the top-5 Canadian Banks was the lead underwriter. Hard is a dummy variable equal to 1 to account for the period of time when D&O insurance premium were abnormally high.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	First year total return	First year total return	First year total return	First year total return	First year total return	First year total return	First year total return
ln_ROL		-0.180**		-0.226***		-0.232***	
		(0.084)		(0.079)		(0.077)	
Rate-on-line			-0.0251**		-0.0300***		-0.0297***
			(0.010)		(0.009)		(0.009)
FirstDayReturn				0.140	0.319	0.310	0.477
				(0.469)	(0.462)	(0.513)	(0.522)
MarketRet	0.480**	0.564*	0.527*	-0.008	-0.068	-0.270	-0.311
	(0.207)	(0.299)	(0.293)	(0.286)	(0.287)	(0.364)	(0.362)
RiskFree	0.139	-6.457	-8.250	-1.467	-4.984	7.857	3.943
	(5.697)	(6.743)	(6.960)	(10.64)	(10.40)	(15.84)	(15.85)
SMB	0.0783	-0.400	-0.416	-0.307	-0.287	-0.203	-0.189
	(0.217)	(0.336)	(0.340)	(0.327)	(0.328)	(0.290)	(0.291)
HML	-0.148	-0.177	-0.181	-0.513	-0.512	-0.577*	-0.568*
	(0.133)	(0.203)	(0.205)	(0.316)	(0.317)	(0.331)	(0.330)
lnMVE_IPO	0.114**	0.073	0.068	0.101*	0.089	0.072	0.061
	(0.044)	(0.062)	(0.062)	(0.056)	(0.058)	(0.055)	(0.056)
Growth				0.021	0.018	0.010	0.008
				(0.061)	(0.060)	(0.053)	(0.053)

DebtRatio				0.398	0.400	0.394	0.398
				(0.245)	(0.250)	(0.263)	(0.266)
ROA	0.747***	0.792*	0.854**	0.584	0.649	0.515	0.589
	(0.160)	(0.432)	(0.423)	(0.444)	(0.434)	(0.459)	(0.450)
IPOfeerat				-1.316	-1.269	-2.135	-2.001
				(1.831)	(1.845)	(1.814)	(1.832)
Float				0.0432	-0.0630	-0.0257	-0.129
				(0.245)	(0.237)	(0.237)	(0.236)
ITCE				-0.086	-0.083	-0.232	-0.218
				(0.189)	(0.185)	(0.198)	(0.195)
US_sales				-0.276	-0.270	-0.239	-0.235
				(0.192)	(0.197)	(0.181)	(0.187)
Independence	-0.045	0.031	-0.022	0.064	0.038	0.044	0.013
	(0.194)	(0.315)	(0.297)	(0.418)	(0.407)	(0.452)	(0.442)
Duality				-0.239	-0.252	-0.235	-0.247
				(0.206)	(0.205)	(0.210)	(0.207)
Blockholder	-0.038	0.078	0.058	0.189	0.144	0.189	0.143
	(0.078)	(0.082)	(0.077)	(0.148)	(0.141)	(0.144)	(0.139)
Age				0.004	0.004	0.004	0.004
				(0.003)	(0.003)	(0.003)	(0.003)
Big5	-0.117	-0.273	-0.297	-0.252	-0.263	-0.223	-0.232
	(0.112)	(0.192)	(0.199)	(0.157)	(0.161)	(0.155)	(0.161)
Hard						0.363	0.338
						(0.300)	(0.301)
Constant	-1.962**	-0.637	-0.557	-1.346	-1.106	-1.097	-0.885
	(0.821)	(1.124)	(1.152)	(1.251)	(1.309)	(1.179)	(1.236)
Observations	160	82	82	78	78	78	78
R-squared	0.205	0.191	0.203	0.302	0.314	0.330	0.339

Coefficients are reported with their robust standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 2-6 OLS regression that measures the firms' idiosyncratic risk in the first year post-IPO

We evaluate the impact of price per unit of coverage on the firms' idiosyncratic risk calculated as the variance of the error term of a Canadian three-factor Fama-French market model in the first year following the IPO. The two main variables of interest are Rate-on-line, calculated as the premium per thousand dollars of maximum coverage, and ln_ROL, the log of the Rate-on-line. We hypothesize that these two measures should be positively related to the firm's idiosyncratic risk.
LnMVE_IPO is the log of the firm's market value of equity at the time of the IPO (issue price multiplied by number of outstanding shares). Growth is the market value of equity plus the book value of liability, divided by the book value of assets. DebtRatio is the ratio of total debt to assets. IPOfeerat is the ratio of the IPO fees paid per million dollars of market value of equity. Float is computed as the ratio of the number of shares issued over the total number of shares outstanding. ITCE is a dummy variable equal to 1 if the firm is an income trust. US_Sales is the percentage of sales carried out in the US. RiskyIndustry is equal to 1 if the firm is a member of a risky

industry as defined by Bajaj et al. Blockholder is equal to 1 if there is a major shareholder that holds more than 10% of the shares after the IPO and 0 otherwise. Age is the age of the operation entity before the IPO. Big5 is a dummy variable equal to 1 when one of the top-5 Canadian Banks was the lead underwriter. Hard is a dummy variable equal to 1 to account for the period of time when D&O insurance premium were abnormally high.

VARIABLES	(1) Idiosyncratic Risk	(2) Idiosyncratic Risk	(3) Idiosyncratic Risk	(4) Idiosyncratic Risk
ln_ROL		0.00533*		0.00607**
		(0.00272)		(0.00274)
Rate-on-line			0.000714**	
			(0.000286)	
lnMVE_IPO	-0.00330	-0.00758**	-0.00734**	-0.00712**
	(0.00234)	(0.00326)	(0.00331)	(0.00322)
Growth	0.00166**	0.000819	0.000856	0.00129*
	(0.000743)	(0.000759)	(0.000769)	(0.000741)
DebtRatio	-0.00667	-0.00367	-0.00300	-0.00371
	(0.00629)	(0.00882)	(0.00874)	(0.00909)
IPOfeerat	0.00491	-0.0600	-0.0624	-0.0333
	(0.0482)	(0.0471)	(0.0474)	(0.0464)
Float	-0.0137**	-0.0262***	-0.0250***	-0.0237***
	(0.00631)	(0.00687)	(0.00635)	(0.00652)
ITCE	-0.00517	-0.00644	-0.00646	-0.00257
	(0.00352)	(0.00464)	(0.00449)	(0.00515)
US_sales	0.00578	0.0106	0.0108	0.00909
	(0.00459)	(0.00707)	(0.00706)	(0.00739)
RiskyIndustry	0.00694**	0.00875**	0.00961**	0.00780**
	(0.00313)	(0.00399)	(0.00391)	(0.00391)
Blockholder	0.00178	-0.00470	-0.00423	-0.00418
	(0.00268)	(0.00354)	(0.00336)	(0.00341)
Age	-2.50e-05	-3.48e-05	-3.25e-05	-3.94e-05
	(3.04e-05)	(3.83e-05)	(3.68e-05)	(3.61e-05)
Big5	-0.00531	-0.00376	-0.00370	-0.00305
	(0.00327)	(0.00464)	(0.00456)	(0.00434)
Hard				-0.00782
				(0.00509)
Constant	0.0957**	0.181***	0.179***	0.171***
	(0.0465)	(0.0651)	(0.0659)	(0.0643)
Observations	158	83	83	83
R-squared	0.367	0.587	0.594	0.600

VARIABLES	(5) Idiosyncratic Risk	(6) Idiosyncratic Risk	(7) Idiosyncratic Risk
ln_ROL		0.00636**	
		(0.00242)	
Rate-on-line	0.000764**		0.000785***
	(0.000295)		(0.000265)
lnMVE_IPO	-0.00689**	-0.00729**	-0.00703**
	(0.00328)	(0.00281)	(0.00284)
Growth	0.00127*	0.00142**	0.00141*
	(0.000749)	(0.000699)	(0.000727)
DebtRatio	-0.00310		
	(0.00901)		
IPOfeerat	-0.0388		
	(0.0461)		
Float	-0.0224***	-0.0183***	-0.0166***
	(0.00615)	(0.00527)	(0.00490)
ITCE	-0.00289	-0.00453	-0.00476
	(0.00497)	(0.00528)	(0.00500)
US_sales	0.00937		
	(0.00735)		
RiskyIndustry	0.00880**	0.00889**	0.00984***
	(0.00387)	(0.00336)	(0.00333)
Blockholder	-0.00364	-0.00328	-0.00262
	(0.00328)	(0.00309)	(0.00299)
Age	-3.68e-05		
	(3.54e-05)		
Big5	-0.00315	-0.00208	-0.00216
	(0.00427)	(0.00429)	(0.00428)
Hard	-0.00719	-0.0101**	-0.00965**
	(0.00490)	(0.00478)	(0.00467)
Constant	0.170**	0.169***	0.168***
	(0.0652)	(0.0539)	(0.0547)
Observations	83	84	84
R-squared	0.606	0.581	0.586

Coefficients are reported with their robust standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 2-7 OLS regression that measures the firms' stock volatility in the first year post-IPO

We evaluate the impact of price per unit of coverage on the firms' stock market volatility in the first year following the IPO. Volatility is calculated as the annualize standard deviation of daily returns. The two main variables of interest are Rate-on-line, calculated as the premium per thousand dollars of maximum coverage, and ln_ROL, the log of the Rate-on-line. We hypothesize that these two measures should be positively related to the firm's stock volatility. LnMVE_IPO is the log of the firm's market value of equity at the time of the IPO (issue price multiplied by number of outstanding shares). Growth is the market value of equity plus the book value of liability, divided by the book value of assets. DebtRatio is the ratio of total debt to assets. IPOfeerat is the ratio of the IPO fees paid per million dollars of market value of equity. Float is computed as the ratio of the number of shares issued over the total number of shares outstanding. ITCE is a dummy variable equal to 1 if the firm is an income trust. US_Sales is the percentage of sales carried out in the US. RiskyIndustry is equal to 1 if the firm is a member of a risky industry as defined by Bajaj et al. Blockholder is equal to 1 if there is a major shareholder that holds more than 10% of the shares after the IPO and 0 otherwise. Big5 is a dummy variable equal to 1 when one of the top-5 Canadian Banks was the lead underwriter. Age is the age of the operation entity before the IPO. Hard is a dummy variable equal to 1 to account for the period of time when D&O insurance premium were abnormally high.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Volatility	Volatility	Volatility	Volatility	Volatility	Volatility	Volatility
ln_ROL		0.0556*		0.0702**		0.0823***	
		(0.0302)		(0.0308)		(0.0309)	
Rate-on-line			0.00807**		0.00910**		0.0104***
			(0.00361)		(0.00386)		(0.00362)
lnMVE_IPO	-0.0857***	-0.109**	-0.107*	-0.100*	-0.0976*	-0.101**	-0.0977**
	(0.0226)	(0.0541)	(0.0548)	(0.0533)	(0.0542)	(0.0476)	(0.0484)
Growth	0.0327***	0.00549	0.00615	0.0147	0.0147	0.0199*	0.0198*
	(0.0109)	(0.0108)	(0.0111)	(0.0109)	(0.0112)	(0.0103)	(0.0108)
DebtRatio		-0.174	-0.165	-0.175	-0.167		
		(0.130)	(0.129)	(0.132)	(0.131)		
IPOfeerat		-1.113	-1.128	-0.585	-0.643		
		(0.708)	(0.718)	(0.733)	(0.735)		
Float	-0.215***	-0.348***	-0.339***	-0.299***	-0.286***	-0.234***	-0.213***
	(0.0742)	(0.102)	(0.0972)	(0.0870)	(0.0849)	(0.0771)	(0.0740)
ITCE	-0.112*	-0.159**	-0.159**	-0.0825	-0.0860	-0.123	-0.126*
	(0.0595)	(0.0697)	(0.0681)	(0.0831)	(0.0806)	(0.0774)	(0.0731)
US_sales		0.132	0.134	0.102	0.105		
		(0.112)	(0.112)	(0.115)	(0.114)		
RiskyIndustry	0.0594	0.0990*	0.109*	0.0802	0.0920*	0.0978**	0.110**
	(0.0388)	(0.0579)	(0.0555)	(0.0546)	(0.0521)	(0.0465)	(0.0447)
Blockholder	0.00727	-0.0663	-0.0621	-0.0559	-0.0500	-0.0556	-0.0473
	(0.0437)	(0.0451)	(0.0436)	(0.0411)	(0.0406)	(0.0405)	(0.0395)
Age		-0.000673	-0.000646	-0.000765	-0.000733		
		(0.000479)	(0.000454)	(0.000475)	(0.000460)		
Big5		-0.0984	-0.0960	-0.0843	-0.0847	-0.0712	-0.0715
		(0.0764)	(0.0770)	(0.0696)	(0.0705)	(0.0716)	(0.0729)
Hard	-0.153**			-0.155*	-0.148*	-0.187**	-0.181**
	(0.0662)			(0.0808)	(0.0769)	(0.0760)	(0.0732)

Constant	2.247***	2.856***	2.830***	2.653**	2.641**	2.532***	2.514***
	(0.449)	(1.050)	(1.063)	(1.039)	(1.054)	(0.902)	(0.915)
Observations	180	83	83	83	83	84	84
R-squared	0.453	0.612	0.617	0.633	0.637	0.609	0.613

Coefficients are reported with their robust standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 2-8 OLS regression that measures the firms' return-to-risk ratio in the first year post-IPO

We evaluate the impact of price per unit of coverage on different measures of the firms' return-to-risk ratio (quasi-Sharpe ratios) in the first year following the IPO. The dependent variable are one of the following: Excess Sharpe (First year excess return divided by Volatility), Total Sharpe (First year total return divided by Volatility) and Idiosyncratic Sharpe (First year total return divided by Idiosyncratic Risk). The two main variables of interest are Rate-on-line, calculated as the premium per thousand dollars of maximum coverage, and ln_ROL, the log of the Rate-on-line. We hypothesize that these two measures should be negatively related to the firm's return-to-risk ratio.
FirstDayReturn is our control variable for underpricing and is computed as the first day return on the close of the first trading day. MarketRet, RiskFree, SMB and HML are the one year total returns of the Canadian market portfolio, the risk free rate and the two Fama-French size and growth portfolios respectively. LnMVE_IPO is the log of the firm's market value of equity at the time of the IPO (issue price multiplied by number of outstanding shares). Growth is the market value of equity plus the book value of liability, divided by the book value of assets. DebtRatio is the ratio of total debt to assets. ROA is the firm's return on assets. IPOfeerat is the ratio of the IPO fees paid per million dollars of market value of equity. Float is computed as the ratio of the number of shares issued over the total number of shares outstanding. ITCE is a dummy variable equal to 1 if the firm is an income trust. US_Sales is the percentage of sales carried out in the US. Independence is the proportion of board members that are classified as independent. RiskyIndustry is equal to 1 if the firm is a member of a risky industry as defined by Bajaj et al. Blockholder is equal to 1 if there is a major shareholder that holds more than 10% of the shares after the IPO and 0 otherwise. Age is the age of the operation entity before the IPO. Big5 is a dummy variable equal to 1 when one of the top-5 Canadian Banks was the lead underwriter. Hard is a dummy variable equal to 1 to account for the period of time when D&O insurance premium were abnormally high.

VARIABLES	(1) Total Sharpe Ratio	(2) Excess Sharpe Ratio	(3) Excess Sharpe Ratio	(4) Total Sharpe Ratio	(5) Total Sharpe Ratio	(6) Idiosyncratic Sharpe Ratio	(7) Idiosyncratic Sharpe Ratio
ln_ROL		-0.481**		-0.472**		-7.681**	
		(0.203)		(0.225)		(3.646)	
Rate-on-line			-0.0579**		-0.0696**		-1.144***
			(0.0247)		(0.0263)		(0.427)
FirstDayReturn	0.883	0.763	1.128	0.364	0.848	5.683	13.62

	(1.025)	(1.345)	(1.343)	(1.027)	(0.982)	(16.59)	(15.79)
MarketRet	-0.119			-0.551	-0.635	-9.775	-11.17
	(0.595)			(0.782)	(0.765)	(13.02)	(12.74)
RiskFree	5.508			-24.39	-35.84	-353.5	-543.3
	(24.29)			(28.47)	(27.77)	(476.8)	(461.8)
SMB	0.647			-0.213	-0.223	-4.169	-4.348
	(0.553)			(0.726)	(0.729)	(11.84)	(11.89)
HML	-0.599			-0.994	-0.988	-17.19	-17.11*
	(0.374)			(0.611)	(0.597)	(10.31)	(10.09)
lnMVE_IPO	0.225**	0.133	0.109	0.171	0.153	2.781	2.492
	(0.0952)	(0.117)	(0.113)	(0.118)	(0.117)	(1.884)	(1.858)
Growth	0.0391	0.0193	0.0237	0.0600	0.0553	1.104	1.023
	(0.0694)	(0.0885)	(0.0835)	(0.0957)	(0.0922)	(1.658)	(1.598)
DebtRatio	0.801*	0.968	0.951	1.045	1.027	16.69	16.37
	(0.482)	(0.658)	(0.662)	(0.628)	(0.629)	(10.08)	(10.10)
ROA	1.952***	1.886	1.956	1.482	1.492	20.94	21.08
	(0.441)	(1.228)	(1.197)	(1.115)	(1.083)	(19.05)	(18.52)
IPOfeerat	-1.867	-3.205	-2.681	-4.467	-4.137	-70.46	-65.30
	(3.795)	(4.764)	(4.707)	(4.126)	(4.136)	(66.43)	(66.56)
Float	-0.280	-0.191	-0.352	-0.633	-0.815	-9.800	-12.75
	(0.439)	(0.810)	(0.788)	(0.652)	(0.632)	(10.47)	(10.15)
ITCE	-0.362	-0.607	-0.564	-0.0610	-0.0631	-1.415	-1.463
	(0.354)	(0.533)	(0.531)	(0.480)	(0.467)	(7.686)	(7.476)
US_sales	-0.481*	-0.437	-0.417	-0.686*	-0.670*	-11.29*	-11.02*
	(0.269)	(0.540)	(0.540)	(0.373)	(0.373)	(6.024)	(6.005)
Independence	0.127	-0.288	-0.387	0.470	0.483	6.914	7.186
	(0.618)	(0.962)	(0.954)	(1.013)	(0.984)	(16.72)	(16.23)
Duality	-0.419*	-0.555	-0.622	-0.706	-0.774*	-12.34*	-13.48*
	(0.246)	(0.454)	(0.455)	(0.428)	(0.425)	(7.201)	(7.162)
Blockholder	-0.0220	-0.162	-0.235	0.639*	0.593	10.76*	10.02
	(0.219)	(0.401)	(0.407)	(0.374)	(0.361)	(6.369)	(6.165)
Age	0.00646*	0.00613	0.00556	0.00661	0.00632	0.116	0.112
	(0.00355)	(0.00673)	(0.00674)	(0.00594)	(0.00579)	(0.101)	(0.0981)
RiskyIndustry	-0.276	-0.334	-0.411	-0.532	-0.650	-9.396	-11.35
	(0.236)	(0.476)	(0.483)	(0.426)	(0.438)	(7.096)	(7.294)
Big5	-0.378	-0.526	-0.515	-0.681**	-0.727**	-10.93**	-11.71**
	(0.263)	(0.402)	(0.401)	(0.340)	(0.343)	(5.451)	(5.514)
Hard	0.247	0.0274	-0.0259	0.000379	-0.0927	0.492	-1.036
	(0.400)	(0.446)	(0.449)	(0.557)	(0.556)	(9.045)	(8.995)
Constant	(1.854)	-0.412	-0.157	-0.991	-0.442	-17.09	-8.007
	(1.828)	(2.244)	(2.244)	(2.149)	(2.181)	(34.53)	(34.91)
Observations	144	82	82	78	78	78	78
R-squared	0.296	0.282	0.283	0.422	0.443	0.418	0.439

Coefficients are reported with their robust standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 2-9A OLS regression that measures the firms' first year return and risk assuming all the information is incorporated in the price on the first day.

We evaluate the impact of price per unit of coverage on the firms' excess return, idiosyncratic risk, volatility and quasi-Sharpe ratio in the first year following the IPO. The two main variables of interest are Rate-on-line, calculated as the premium paid for one thousand dollar of maximum possible coverage, and ln_ROL, the log of the Rate-on-line. We hypothesize that these two measures should be negatively related to the excess return and the Sharpe ratio, and positively related to the idiosyncratic risk and the volatility. FirstDayReturn is the firm's stock return on the first day post IPO. Hard is a dummy variable equal to 1 when the D&O insurance market is expensive for the firms seeking insurance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARS	First year excess return	First year excess return	First year total return	First year total return	Idiosyncratic Risk	Idiosyncratic Risk	Excess Sharpe Ratio	Excess Sharpe Ratio
ln_ROL	-0.156***		-0.138**		0.00169		-0.452**	
	(0.0586)		(0.0604)		(0.00309)		(0.182)	
Rate-on-line		- 0.0205***		-0.0184***		0.000360		-0.0525**
		(0.00615)		(0.00593)		(0.000508)		(0.0221)
FirstDayRet.	0.434	0.479	0.305	0.340	0.0246	0.0244	0.838	0.981
	(0.301)	(0.316)	(0.333)	(0.356)	(0.0225)	(0.0228)	(0.858)	(0.901)
MarketRet			0.734***	0.717***				
			(0.275)	(0.271)				
RiskFree			1.642	0.557				
			(8.736)	(8.597)				
SMB			-0.336	-0.352				
			(0.291)	(0.293)				
HML			-0.0478	-0.0495				
			(0.189)	(0.190)				
Constant	0.323**	0.192**	0.302	0.218	0.0227***	0.0231***	1.016***	0.587**
	(0.133)	(0.0939)	(0.212)	(0.190)	(0.00582)	(0.00435)	(0.376)	(0.236)
Observations	94	94	89	89	96	96	93	93
R-squared	0.041	0.043	0.101	0.104	0.022	0.027	0.052	0.044

Table 2-9B OLS regression that measures the firms' first year return assuming all the information is incorporated in the price on the first day, net of the first day.

We evaluate the impact of price per unit of coverage on the firms' stock market return net of the return on the first day. In all Models we control for the market return in the first year post IPO, but we only control for the risk free rate and the two Fama-French size and growth portfolios in Models 1 through 4. In Models 7 & 8, the market return is deducted from the dependent variable. The two main variables of interest are Rate-on-line, calculated as the premium paid for one thousand dollar of maximum possible coverage, and ln_ROL, the log of the Rate-on-line. We

hypothesize that these two measures should be negatively related to the return net of the first day.
MarketRet, RiskFree, SMB and HML are the one year total returns of the Canadian market portfolio, the risk free rate and the two Fama-French size and growth portfolios respectively. Hard is a dummy variable equal to 1 when the D&O insurance market is expensive for the firms seeking insurance.

VARIABLES	(1) Return net of 1st day	(2) Return net of 1st day	(3) Return net of 1st day	(4) Return net of 1st day	(5) Return net of 1st day	(6) Return net of 1st day	(7) Excess return net of 1st day	(8) Excess return net of 1st day
ln_ROL	-0.122**		-0.106*		-0.139**		-0.134**	
	(0.0561)		(0.0580)		(0.0584)		(0.0577)	
Rate-on-line		-0.0156**		-0.0156**		-0.0203***		-0.0188***
		(0.00592)		(0.00635)		(0.00563)		(0.00602)
MarketRet	0.155	0.150	0.672**	0.653**	0.531**	0.503*		
	(0.359)	(0.356)	(0.295)	(0.292)	(0.256)	(0.256)		
RiskFree	23.27	21.75	3.022	1.910				
	(15.22)	(15.22)	(8.887)	(8.760)				
SMB	-0.171	-0.182	-0.167	-0.179				
	(0.279)	(0.280)	(0.290)	(0.291)				
HML	-0.238	-0.235	-0.00931	-0.0178				
	(0.208)	(0.211)	(0.195)	(0.197)				
Hard	0.467**	0.452*			0.149	0.151		
	(0.229)	(0.229)			(0.151)	(0.149)		
Constant	-0.578	-0.634	0.134	0.0887	0.188	0.0878	0.240*	0.137
	(0.463)	(0.453)	(0.219)	(0.199)	(0.152)	(0.130)	(0.127)	(0.0894)
Observations	86	86	86	86	91	91	91	91
R-squared	0.158	0.158	0.079	0.084	0.085	0.093	0.022	0.027

Coefficients are reported with their robust standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 2-10A Two-step regression that measures the first year's stock return and return-to-risk ratio by controlling for the purchase of insurance

We evaluate the impact of price per unit of coverage on the firms' stock market return in the first year following the IPO controlling for the information imbedded in the purchase of insurance or not (model 2 in Table 4). The dependent variable is the return in excess of the market in Models 1 and 2, the total return in Models 3 through 6, and the total return net of the market return divided by the one year volatility in Models 7 and 8. The two main variables of interest are Rate-on-line, calculated as the premium-to-coverage ratio, and ln_ROL, the log of the Rate-on-line. We hypothesize that these two measures should be negatively related to the first year return. FirstDayReturn is our control variable for underpricing and is computed as the first day return on the close of the first trading day. MarketRet, RiskFree, SMB and HML are the one year total returns of the Canadian market portfolio, the risk free rate and the two Fama-French size and growth portfolios respectively. LnMVE_IPO is the log of the firm's market value of equity at the time of the IPO (issue price multiplied by number of outstanding shares).

VARIABLES	(1A) First year excess return	(2A) First year excess return	(3A) First year total return	(4A) First year total return	(5A) First year total return	(6A) First year total return	(7A) Return-to-Risk ratio	(8A) Return-to-Risk ratio
ln_ROL	-0.165***		-0.136**		-0.131**		-0.504**	
	(0.0634)		(0.0608)		(0.0621)		(0.199)	
Rate-on-line		-0.0274**		-0.0205*		-0.0202		-0.0840**
		(0.0126)		(0.0122)		(0.0135)		(0.0339)
FirstDayReturn	0.762	0.831	0.790	0.868	0.877	0.949*	1.834	2.043
	(0.496)	(0.532)	(0.539)	(0.547)	(0.556)	(0.565)	(1.339)	(1.404)
MarketRet			0.385	0.401	0.441	0.454		
			(0.321)	(0.337)	(0.346)	(0.382)		
RiskFree			-0.264	-0.267	-0.247	-0.250		
			(0.278)	(0.282)	(0.276)	(0.281)		
SMB			-0.273	-0.259	-0.184	-0.175		
			(0.233)	(0.257)	(0.268)	(0.314)		
HML			1.482	0.532	2.006	1.058		
			(10.07)	(9.679)	(10.21)	(9.820)		
lnMVE_IPO	0.0678	0.0662	0.0795	0.0781			0.159	0.154
	(0.0515)	(0.0538)	(0.0487)	(0.0495)			(0.108)	(0.109)
Constant	-0.857	-0.909	-1.083	-1.121	0.402	0.345	-1.698	-1.856
	(1.113)	(1.227)	(1.003)	(1.046)	(0.287)	(0.381)	(2.237)	(2.316)
Observations	128	128	128	128	128	128	129	129

Coefficients are reported with their robust standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The first stage regression (i.e., the decision to puchase insurance or not) is given by Model 2 in Table 4. In none of the regression models presented in this Table can we reject the hypothesis that the two equation are independent.

Table 2-10B Two-step regression that measures the first year's stock return by controlling for the decision to reveal the D&O insurance premium and policy limit

We evaluate the impact of price per unit of coverage on the firms' stock market return in the first year following the IPO controlling for the information imbedded in the purchase of insurance or not (model 2 in Table 4) and the decision to reveal the premium paid and the coverage chosen. The dependent variable is the return in excess of the market in Models 1 and 2, and the total return in Models 3 and 4. The two main variables of interest are Rate-on-line, calculated as the premium-to-coverage ratio, and ln_ROL, the log of the Rate-on-line. We hypothesize that these two measures should be negatively related to the first year return.
FirstDayReturn is our control variable for underpricing and is computed as the first day return on the close of the first trading day. MarketRet, RiskFree, SMB and HML are the one year total

returns of the Canadian market portfolio, the risk free rate and the two Fama-French size and growth portfolios respectively. IMR is the inverse-Mills ratio calculated from the insurance purchase decision regression of Model 2 in Table 4.

	(5A)	(6A)	(7A)	(8A)
VARIABLES	First year excess return	First year excess return	First year total return	First year total return
ln_ROL	-0.160**		-0.114*	
	(0.0636)		(0.0584)	
Rate-on-line		-0.0245**		-0.0155*
		(0.0108)		(0.00885)
FirstDayReturn	0.534	0.608	0.562	0.635
	(0.579)	(0.572)	(0.597)	(0.596)
MarketRet			0.240	0.242
			(0.321)	(0.322)
RiskFree			-0.264	-0.260
			(0.252)	(0.253)
SMB			-0.382*	-0.365
			(0.230)	(0.230)
HML			0.588	0.0708
			(9.638)	(9.450)
lnMVE_IPO	0.0481	0.0461	0.0586	0.0569
	(0.0640)	(0.0643)	(0.0557)	(0.0563)
IMR	-0.245	-0.256	-0.0724	-0.0834
	(0.286)	(0.299)	(0.291)	(0.299)
Constant	-0.282	-0.346	-0.509	-0.554
	(1.438)	(1.458)	(1.183)	(1.215)
Observations	126	126	122	122

Coefficients are reported with their robust standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The first stage regression (i.e., the decision to reveal the D&O insurance premium and coverage is given by InsDetails= Growth + ROA + Blockholder + Debtratio + Float + Riskyindustry + us + Age + Big5. In none of the regression models presented in this Table can we reject the hypothesis that the two equations are independent.

Table 2-11A Two-stage least square simultaneous regressions for the first year total return and risk

We evaluate simultaneously the impact of price per unit of coverage on the firms' stock market return and risk in the first year following the IPO. The dependent variables are the first year total return and the first year idiosyncratic risk in Models 1 and 2, and volatility in Model 3 and 4. The two main variables of interest are Rate-on-line, calculated as the premium-to-coverage ratio, and ln_ROL, the log of the Rate-on-line. We hypothesize that both measures should be negatively related to the first year return and positively to the first year risk.

FirstDayReturn is our control variable for underpricing and is computed as the first day return on the close of the first trading day. MarketRet, RiskFree, SMB and HML are the one year total returns of the Canadian market portfolio, the risk free rate and the two Fama-French size and growth portfolios respectively. LnMVE_IPO is the log of the firm's market value of equity at the time of the IPO (issue price multiplied by number of outstanding shares). IPOfeerat is the ratio of the IPO fees paid per million dollar of market value of equity. Float is computed as the ratio of the number of shares issued over the total number of shares outstanding. ITCE is a dummy variable equal to 1 if the firm is an income trust. US_Sales is the percentage of sales carried out in the US. Independence is the proportion of board members that are classified as independent. Duality is equal to 1 if the CEO is also the Chairman of the board and zero otherwise. Growth is the market value of equity plus the book value of liability, divided by the book value of assets. DebtRatio is the ratio of total liabilities to the market value of equity at the time of the IPO. Risky_Industry is an indicator variable equal to one if the company operated in one of the industries classified as risky in Bajaj et al. (2000). Age is the number of years separating inception from the announcement of the IPO. Blockholder is a dummy variable equal to one if a shareholder holds 10% or more of the firm's stock. Big5 is a dummy variable equal to 1 when one of the top-5 Canadian Banks was the lead underwriter. Hard is a dummy variable equal to one in the years where the D&O insurance market is expensive. IME is the inverse-Mills ratio of the probit regression explaining the purchase of insurance (Model 2 of Table 4).

VARIABLES	(1) Two-stage least square First year total return	(2) Idiosyncratic	(3) Two-stage least square First year total return	(4) Idiosyncratic
ln_ROL	-0.265**	0.00436		
	(0.115)	(0.00268)		
Rate-on-line			-0.0372***	0.000549*
			(0.0136)	(0.000312)
FirstDayReturn	0.532		0.791	
	(0.744)		(0.736)	
MarketRet	-0.198		-0.253	
	(0.428)		(0.421)	
RiskFree	7.455		1.914	
	(14.66)		(14.80)	
SMB	-0.238		-0.230	
	(0.369)		(0.362)	
HML	-0.541*		-0.538*	
	(0.280)		(0.274)	
lnMVE_IPO	0.0827	-0.00783***	0.0754	-0.00759***
	(0.0753)	(0.00169)	(0.0736)	(0.00169)
Growth	0.00912	0.00123	0.00760	0.00121
	(0.0315)	(0.000753)	(0.0309)	(0.000744)
RiskyIndustry	-0.249	0.00350	-0.300	0.00420
	(0.190)	(0.00393)	(0.189)	(0.00393)
ROA	0.283		0.305	
	(0.481)		(0.470)	
IPOfeerat	-1.140	-0.0579	-0.851	-0.0615
	(2.316)	(0.0551)	(2.248)	(0.0544)
Float	0.100	-0.0187**	0.0116	-0.0174*
	(0.397)	(0.00905)	(0.388)	(0.00891)
ITCE	-0.303	-0.00380	-0.329	-0.00406
	(0.347)	(0.00736)	(0.341)	(0.00731)
US_sales	-0.167		-0.142	
	(0.270)		(0.265)	
Independence	0.0612		0.0405	
	(0.492)		(0.479)	
Duality	-0.320		-0.367*	
	(0.215)		(0.212)	
Blockholder	0.306*	-0.00360	0.278	-0.00305
	(0.183)	(0.00412)	(0.178)	(0.00409)
Age	0.00349	-9.49e-05	0.00352	-8.94e-05
	(0.00306)	(6.75e-05)	(0.00300)	(6.74e-05)
Big5	-0.211	-0.00369	-0.230	-0.00382
	(0.171)	(0.00404)	(0.168)	(0.00398)
Hard	0.323	-0.0123**	0.292	-0.0119**
	(0.307)	(0.00549)	(0.302)	(0.00543)
IMR	0.162	-0.0105	0.226	-0.0105
	(0.622)	(0.0106)	(0.611)	(0.0106)

Constant	-0.446	0.178***	-0.241	0.175***
	(1.157)	(0.0315)	(1.149)	(0.0313)
Observations	86	86	86	86
R-squared	0.297	0.581	0.317	0.589

	(5)	(6)	(7)	(8)
	Two-stage least square		Two-stage least square	
VARIABLES	First year total return	Volatility	First year total return	Volatility
ln_ROL	-0.265**	0.0786*		
	(0.115)	(0.0456)		
Rate-on-line			-0.0372***	0.00948*
			(0.0136)	(0.00531)
FirstDayReturn	0.532		0.791	
	(0.744)		(0.736)	
MarketRet	-0.198		-0.253	
	(0.428)		(0.421)	
RiskFree	7.455		1.914	
	(14.66)		(14.80)	
SMB	-0.238		-0.230	
	(0.369)		(0.362)	
HML	-0.541*		-0.538*	
	(0.280)		(0.274)	
lnMVE_IPO	0.0827	-0.111***	0.0754	-0.107***
	(0.0753)	(0.0287)	(0.0736)	(0.0287)
Growth	0.00912	0.0189	0.00760	0.0183
	(0.0315)	(0.0128)	(0.0309)	(0.0127)
RiskyIndustry	-0.249	0.0628	-0.300	0.0750
	(0.190)	(0.0669)	(0.189)	(0.0669)
ROA	0.283		0.305	
	(0.481)		(0.470)	
IPOfeerat	-1.140	-0.764	-0.851	-0.840
	(2.316)	(0.936)	(2.248)	(0.926)
Float	0.100	-0.293*	0.0116	-0.268*
	(0.397)	(0.154)	(0.388)	(0.152)
ITCE	-0.303	-0.0621	-0.329	-0.0676
	(0.347)	(0.125)	(0.341)	(0.125)
US_sales	-0.167		-0.142	
	(0.270)		(0.265)	
Independence	0.0612		0.0405	
	(0.492)		(0.479)	
Duality	-0.320		-0.367*	
	(0.215)		(0.212)	
Blockholder	0.306*	-0.0657	0.278	-0.0557
	(0.183)	(0.0700)	(0.178)	(0.0696)

Age	0.00349	-0.00144	0.00352	-0.00134
	(0.00306)	(0.00115)	(0.00300)	(0.00115)
Big5	-0.211	-0.0683	-0.230	-0.0722
	(0.171)	(0.0687)	(0.168)	(0.0678)
Hard	0.323	-0.210**	0.292	-0.202**
	(0.307)	(0.0933)	(0.302)	(0.0924)
IMR	0.162	-0.147	0.226	-0.147
	(0.622)	(0.181)	(0.611)	(0.180)
Constant	-0.529	0.178***	-0.333	0.175***
	(1.034)	(0.0294)	(1.027)	(0.0293)
Observations	86	86	86	86
R-squared	0.294	0.581	0.314	0.589

Coefficients are reported with their standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The first stage regression from which the inverse-Mills ratio is calculated is drawn from Model 2 in Table 4. In none of the regression models presented in this Table can we reject the hypothesis that the equations are independent.

Table 2-11B Three-stage least square simultaneous regressions for the first year total return and risk

We evaluate simultaneously the impact of price per unit of coverage on the firms' stock market return in the first year following the IPO. The dependent variables are the first year total return and the first year idiosyncratic risk. The two main variables of interest are Rate-on-line, calculated as the premium-to-coverage ratio, and ln_ROL, the log of the Rate-on-line. We hypothesize that both measures should be negatively related to the first year return and positively to idiosyncratic risk.

FirstDayReturn is our control variable for underpricing and is computed as the first day return on the close of the first trading day. Mkt1Year is the market return during the first year of the IPO. LnMVE_IPO is the log of the firm's market value of equity at the time of the IPO (issue price multiplied by number of outstanding shares). IPOfeerat is the ratio of the IPO fees paid per million dollar of market value of equity. Float is computed as the ratio of the number of shares issued over the total number of shares outstanding. ITCE is a dummy variable equal to 1 if the firm is an income trust. US_Sales is the percentage of sales carried out in the US. Independence is the proportion of board members that are classified as independent. Duality is equal to 1 if the CEO is also the Chairman of the board and zero otherwise. Growth is the market value of equity plus the book value of liability, divided by the book value of assets. DebtRatio is the ratio of total liabilities to the market value of equity at the time of the IPO. Risky_Industry is an indicator variable equal to one if the company operated in one of the industries classified as risky in Bajaj et al. (2000). Age is the number of years separating inception from the announcement of the IPO. Blockholder is a dummy variable equal to one if a shareholder holds 10% or more of the firm's stock. Hard is a dummy variable equal to one in the years where the D&O insurance market is expensive. InvMills is the inverse Mills' ratio obtained from Specification 2 in the Probit regression table.

	(1)	(2)	(3)	(4)
	Three-stage least square		Three-stage least square	
VARIABLES	First year total return	Idiosyncratic	First year total return	Idiosyncratic
ln_ROL	-0.280***	0.00436*		
	(0.0962)	(0.00245)		
Rate-on-line			-0.0381***	0.000549*
			(0.0113)	(0.000285)
FirstDayReturn	0.505		0.724	
	(0.587)		(0.583)	
MarketRet	-0.0971		-0.147	
	(0.337)		(0.334)	
RiskFree	3.631		-0.767	
	(11.56)		(11.73)	
SMB	-0.398		-0.384	
	(0.291)		(0.287)	
HML	-0.437**		-0.438**	
	(0.221)		(0.217)	
lnMVE_IPO	0.0832	-0.00783***	0.0739	-0.00759***
	(0.0628)	(0.00154)	(0.0615)	(0.00154)
Growth	0.00734	0.00123*	0.00658	0.00121*
	(0.0265)	(0.000688)	(0.0260)	(0.000679)
RiskyIndustry	-0.326**	0.00350	-0.374**	0.00420
	(0.157)	(0.00359)	(0.156)	(0.00359)
ROA	-0.000589		0.0326	
	(0.380)		(0.373)	
IPOfeerat	-1.126	-0.0579	-0.830	-0.0615
	(1.945)	(0.0503)	(1.889)	(0.0496)
Float	0.0921	-0.0187**	0.000393	-0.0174**
	(0.332)	(0.00826)	(0.325)	(0.00814)
ITCE	-0.265	-0.00380	-0.285	-0.00406
	(0.288)	(0.00671)	(0.283)	(0.00668)
US_sales	-0.159		-0.137	
	(0.213)		(0.210)	
Independence	0.167		0.143	
	(0.388)		(0.380)	
Duality	-0.294*		-0.334**	
	(0.169)		(0.168)	
Blockholder	0.339**	-0.00360	0.306**	-0.00305
	(0.153)	(0.00376)	(0.148)	(0.00373)
Age	0.00339	-9.49e-05	0.00334	-8.94e-05
	(0.00255)	(6.17e-05)	(0.00251)	(6.15e-05)
Big5	-0.214	-0.00369	-0.226	-0.00382
	(0.143)	(0.00369)	(0.141)	(0.00363)
Hard	0.248	-0.0123**	0.221	-0.0119**
	(0.251)	(0.00501)	(0.247)	(0.00495)
IMR	0.0507	-0.0105	0.110	-0.0105

	(0.507)	(0.00970)	(0.500)	(0.00966)
Constant	-1.068	0.199***	-0.902	0.197***
	(1.367)	(0.0325)	(1.348)	(0.0325)
Observations	78	78	78	78
R-squared	0.332	0.649	0.355	0.651

	(5)	(6)	(7)	(8)
	Three-stage least square		Three-stage least square	
VARIABLES	First year total return	Volatility	First year total return	Volatility
ln_ROL	-0.274***	0.0786*		
	(0.0964)	(0.0416)		
Rate-on-line			-0.0375***	0.00948*
			(0.0114)	(0.00485)
FirstDayReturn	0.442		0.663	
	(0.594)		(0.590)	
MarketRet	-0.112		-0.162	
	(0.341)		(0.338)	
RiskFree	4.565		0.103	
	(11.70)		(11.86)	
SMB	-0.398		-0.384	
	(0.294)		(0.290)	
HML	-0.421*		-0.425*	
	(0.223)		(0.219)	
lnMVE_IPO	0.0801	-0.111***	0.0713	-0.107***
	(0.0629)	(0.0262)	(0.0617)	(0.0262)
Growth	0.00647	0.0189	0.00578	0.0183
	(0.0265)	(0.0117)	(0.0260)	(0.0116)
RiskyIndustry	-0.313**	0.0628	-0.361**	0.0750
	(0.158)	(0.0610)	(0.157)	(0.0610)
ROA	0.0621		0.0919	
	(0.384)		(0.377)	
IPOfeerat	-1.204	-0.764	-0.908	-0.840
	(1.948)	(0.855)	(1.891)	(0.845)
Float	0.0795	-0.293**	-0.0103	-0.268*
	(0.333)	(0.140)	(0.325)	(0.139)
ITCE	-0.259	-0.0621	-0.279	-0.0676
	(0.289)	(0.114)	(0.284)	(0.114)
US_sales	-0.148		-0.128	
	(0.215)		(0.212)	
Independence	0.170		0.147	
	(0.392)		(0.384)	
Duality	-0.279		-0.320*	
	(0.171)		(0.170)	

Blockholder	0.331**	-0.0657	0.300**	-0.0557
	(0.153)	(0.0639)	(0.149)	(0.0636)
Age	0.00336	-0.00144	0.00333	-0.00134
	(0.00255)	(0.00105)	(0.00251)	(0.00105)
Big5	-0.214	-0.0683	-0.227	-0.0722
	(0.144)	(0.0627)	(0.141)	(0.0619)
Hard	0.263	-0.210**	0.236	-0.202**
	(0.253)	(0.0851)	(0.249)	(0.0843)
IMR	0.0556	-0.147	0.114	-0.147
	(0.510)	(0.165)	(0.503)	(0.165)
Constant	-1.047	2.908***	-0.886	2.879***
	(1.371)	(0.553)	(1.351)	(0.554)
Observations	78	78	78	78
R-squared	0.332	0.619	0.356	0.620

Coefficients are reported with their standard deviation in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The first stage regression from which the inverse-Mills ratio is calculated is drawn from Model 2 in Table 4. In none of the regression models presented in this Table can we reject the hypothesis that the equations are independent.

Chapter 3. A Learning-Based Approach to Evaluating Boards of Directors

Using predictions from a learning model, this paper exploits the cross-sectional variation in the learning-induced decline in stock return volatility over director tenure to infer the marginal value of different kinds of directors. This new framework confirms prior empirical findings and documents new results. For example, directors joining better compensated boards have higher marginal value while the marginal value of a director joining an entrenched board is muted. Furthermore, the estimates imply that governance related uncertainty associated with the arrival of a new director accounts for 7% of return volatility, shedding light on the extent to which governance matters.

1. Introduction

Boards of directors are critical pillars in corporate governance. They are legally responsible for governing the firm and protecting the interests of shareholders. Yet, inasmuch as corporate directors are not perfect agents, providers of capital may find it beneficial to assess them.. There has been a debate going back to Smith (1776) and Berle and Means (1932) about whether boards of directors are monitors of, or are tools of management.[44] How does one measure whether boards of directors make a difference in the fortunes of a typical corporation? If they do make a difference, how can we quantify the extent to which boards affect value? Are there systematic patterns in effectiveness between certain kinds of boards?

[44] Smith (1776) wrote: "The Directors of [joint stock] companies, however, being the managers of other people's money rather than their own, it cannot be expected that they should watch over it with the same anxious vigilance [as owners]… Negligence and profusion, therefore, must always prevail, more or less, in the management of the affairs of such a company." ([1937] p.700). One hundred fifty-six year later, Berle and Means (1932) argued: "…control will tend to be in the hands of those who select the proxy committee and by whom, the election of directors for the ensuing period will be made. Since the proxy committee is appointed by existing management, the latter can virtually dictate their successors." (p. 87).

These questions have been front and center in the governance debate for over a decade and have been addressed to some extent. The literature however often yields conflicting evidence and it is difficult to draw conclusions due to methodological issues.[45] Understanding the importance of boards and what the constituents of a well performing board are is still an open question.

This paper attempts to shed some light on this issue by proposing a novel approach based on a theoretical model of learning, which yields a general method to assess how the market reacts to the appointments of directors. The model relies on the idea that the arrival of new directors creates uncertainty and through their actions, newly appointed directors provide information to investors who update their assessment of their ability to contribute to the generation of cash flows. As investors become more acquainted with their new board, they update their assessment of the board's quality to a lesser extent. The resolution of governance-related uncertainty leads to a decline in stock return volatility.

The formal model of this process is borrowed from Pan, Wang and Weisbach (2015) who study learning about management and derive their stylized model based on the work of Pastor and Veronesi (2003). The model as applied to boards yields intuitive testable predictions about the relationship between stock return volatility and director tenure which motivate the empirical analysis. First, if directors do not purely engage in window-dressing but do in fact affect firm value, investors should react to their appointment and stock return volatility should subsequently decline over their tenure. Furthermore, stock return volatility should decline faster at the beginning of their tenure when uncertainty is highest. Second, the model predicts that volatility should decline by different amounts for different kinds of directors. In other words, the

[45] See Hermalin and Weisbach (2003) and Adams, Hermalin and Weisbach (2010).

magnitude of the decline in volatility over a director's tenure is related to her marginal return to ability. Support for these predictions is found in the data.

The focus on the second moment of stock returns stems from the observation that whereas the first moment provides the market's assessment of the anticipated effect of a director upon her arrival, this is a very uncertain valuation at time zero. To wit, having a low expected value does not necessarily imply that a particular director is irrelevant. Hence, the mean does not provide a complete picture of the extent to which directors matter. Studying the second moment of returns provides a new and complementary lens through which to examine the importance of boards.

The increase in return volatility upon the arrival of directors is driven by the conjunction of two effects: that director ability is relevant and that it is uncertain. Importantly, how much uncertainty there is about a director decreases at a predetermined rate due to Bayes' rule. This rate is faster for higher *ex-ante* levels of uncertainty. The model therefore provides a theoretical framework to assess which directors matter more: after controlling for the *ex-ante* uncertainty about the ability of a new director, the cross-sectional variation in the magnitude of the learning-induced decline in return volatility provides an estimate of the marginal return to ability of different kinds of directors. For example, the results suggest that if the current board is entrenched, investors expect an incoming director's ability to sway the fortunes of the firm to be muted.

In addition, the model is useful to quantify the fraction of return volatility imputable to the uncertainty about the firm's board and to compare it to the uncertainty about management.

The empirical analysis uses a sample of 18,579 directors on the boards of 2,228 firms, taken from the intersection of S&P 1,500 firms in BoardEx, CRSP and Compustat during the

2000-2014 period. The estimates indicate that when a director joins a board, stock return volatility jumps by 13% on average and subsequently declines over the next few years. This implies that learning about directors lowers volatility, presumably by reducing governance-related uncertainty. Interpreted in light of the learning model, the decline in return volatility over the course of director tenure provides empirical support for the assumption that investors expect board members to be relevant in their valuation of the firm.

An important concern with this interpretation is the potential endogeneity of director appointments. To wit, firms could reshuffle their boards in times of crisis, when volatility tends to be especially high. In particular, we might expect periods of turmoil to be accompanied by a transition in leadership. Therefore, all estimates exclude directors appointed within a year around a CEO turnover. For this subsample of director appointments, which is the one used in the regressions, the median (mean) ratio of the average return volatility over the three month period prior to the arrival of a new director to the average return volatility over the two year period preceding the director appointment is 0.94 (1.00). This suggests that for this sample, return volatility does *not* appear to be especially high in the period leading to the appointment.

To alleviate the endogeneity concern further, the documented patterns still hold when restricting the sample to exogenous director appointments. First, results hold for a sample of appointments specifically designed to satisfy the new board independence-listing requirement set by the stock exchanges in the early 2000s. Many firms had to initiate board changes to comply with these new requirements and these appointments are unlikely to coincide systematically with a time when the firm's fundamental volatility is high. Second, results hold for directors appointed to replace a board member who either passed away or retired. A board member is defined as retiring if she is over 70 and/or was sitting on multiple boards and left all her boards within two years. Restricting the sample to directors appointed to replace a director who passed away or who retired yields a sample of board turnovers that are likely exogenous to firm conditions.

The concern of potentially endogenous turnover is most valid when the firm is going through turmoil. Therefore, a further restriction that is imposed is that these appointments occur when the firm has had good stock return performance and low return volatility over the past year.

A similarity score is used to compare the individual profiles of the departing directors who left due to deaths or retirements to the profile of the directors replacing them. Requiring that the departing and incoming directors share a similar profile helps further ensure that the firm did not appoint a particular director due to a major shift in strategy[46].

A series of additional tests are designed to rule out the possibility that the documented volatility patterns are a byproduct of potentially endogenous director appointments. These tests also help to disentangle the investor learning hypothesis put forth in this paper from potential alternative explanations.

First, stock return volatility patterns for young boards are compared to those of mature boards. There is presumably more governance related uncertainty for younger boards than there is for more seasoned boards. If the decline in stock return volatility reflects the resolution of governance related uncertainty, we should observe a stronger decline for these younger boards. Consistent with this idea, stock return volatility declines sharply over the average board tenure for relatively young boards while it does not for mature boards (controlling for firm age and board size). In contrast, if the documented volatility patterns were due to the endogenous nature

[46] Note that the firms' exposure to systematic risk does not appear to change over the learning period: plots of the firms' market, SMB and HML betas over director tenure do not show any specific pattern.

of director appointments there would be no reason to expect different patterns based on the average tenure of board members.

A potential alternative explanation for the decline in return volatility rests on the assumption that directors come on the board having little idea how to do their job thus creating a lot of noise around their decisions. As directors get better at their job over time, they develop skills which allow them to produce better decisions in the interest of the firm, which may drive the decline in return volatility. The findings contrasting young and mature boards is difficult to reconcile with this director learning alternative hypothesis though. If anything, it should be easier for new directors to learn to do their job if the board is more mature and can more effectively coach a newly appointed director. The director learning alternative explanation is addressed directly in additional tests below.

Second, if the documented volatility pattern reflects investors learning about incoming directors, we should observe an attenuated decline in volatility for directors who are well-known to market participants. The data shows that this is the case: the decline in return volatility is sharply muted for well-known directors.

The alternative director learning explanation is grounded in the idea that as directors get better over time, they develop skills to produce better decisions in the interest of the company which reduces return volatility. This paper exploits the fact that some directors are better equipped than others to produce better decisions when joining new boards: directors with board experience in the same industry who have held multiple previous directorships will arguably be quicker to adjust to the production function of a particular firm, thereby predicting a smaller decline in return volatility over their tenure. The investor learning hypothesis predicts the opposite: directors with industry expertise who have a rich history of directorships should be a wealth of resources for the board and therefore be more relevant for firm value. The data supports the investor learning hypothesis: controlling for how much the market knows about them, “professional” directors are associated with larger declines in stock return volatility over their tenure.

Third, the analysis is run using all firm-months instead of using the first years of director tenure to test the volatility-tenure relationship. This exercise is designed to ensure that the results are not inflated by zooming in on a narrow window. The results indicate that volatility declines significantly over the first three years following the arrival of new directors, but does not outside this window.

Finally, a matched sample confirms that the drop in volatility exceeds what is observed for firms that do not experience the arrival of a director. These findings are consistent with the notion that the spike and subsequent decline in stock return volatility following director appointments reflect the uncertainty about how much a new director will sway the fortunes of their firm.

The model has implications about the fraction of overall volatility attributable to the uncertainty about the board. Borrowing the methodology developed in Pan et al. (2015), the estimates imply that the uncertainty about a new director’s ability accounts for about 7% of overall stock return volatility on average. These estimates indicate that the arrival of corporate directors generates substantial uncertainty.

Next, the learning slope is computed for each director-firm pair, by estimating the average decline in volatility over the course of their tenure, over and above the variation in volatility predicted by firm level covariates and macroeconomic factors. Performance (as measured by the firm’s return on assets and abnormal stock returns three years post appointment) clearly improves following the appointment of high learning slope directors, (i.e. directors with learning slopes in the top decile), while it tends to stagnate for directors with learning slopes in the bottom decile. The diverging performance paths for top and bottom learning slope deciles provides suggestive evidence that the decline in return volatility reflects not only the extent to which a director can make a difference but also the extent to which they participate in value creation.

This learning-based framework can be used to revisit the literature on boards and test new hypotheses on the importance of different governance attributes. The last section of the paper studies how some director, board or firm characteristics affect the volatility-tenure relationship, thereby testing which governance characteristics are important and under which circumstances.

The results suggest that chairmen and chairs of the compensation and audit committees are expected to be more important contributors than the average director. This is not the case for any of the other committee chairs. These findings shed new light on the channels through which board members impact firm value. There is no evidence that independent directors have a stronger effect on average. However, consistent with evidence in Masulis et al. (2012) and Faleye et al. (2012), independent directors with industry expertise do. In addition, investors expect independent directors joining firms with high monitoring needs to make a difference.

Female directors do not contribute to firm value as much as their male counterparts on average. There is however evidence that as in the case of independent directors, female directors make a difference when the firm's monitoring needs are acute, which is consistent with evidence in Adams et al. (2009) and Adams et al. (2012). Busy directors, directors with more board experience and those with work experience in the industry have higher marginal value.

Boards dominated by a powerful CEO (i.e. CEOs with at least five years of tenure who cumulate the titles of CEO, President and Chairman of the board) are *de facto* potentially more entrenched. The results based on the learning-induced changes in return volatility indicate that the ability to make a difference for entrenched boards is muted, consistent with Coles, Daniel and Naveen (2014), who find that co-opted boards are less effective monitors. Among other proxies, Coles, Daniel and Naveen (2015) use the percentage of directors with long tenures as a proxy for groupthink. The authors find that groupthink is detrimental for firm value in dynamic industries. Consistent with their finding, groupthink mutes directors' marginal value. This result supports growing voices in the market for the need of board refreshment.[47] In addition, directors joining small boards are more important and boards with a high Board Pay Slice, i.e. boards that compensate their directors generously relative to their CEO, play a larger role.

Finally, the results indicate that directors matter more in small firms, in firms that have had poor performance and in firms that operate in more complex industries. This last finding corroborates the evidence in Coles, Daniel and Naveen (2015) who show that groupthink is particularly detrimental in dynamic industries.

This paper contributes to the literature by providing evidence that providers of capital expect corporate directors to play a role in the fortunes of their firm. Not all directors are equal though and this paper proposes a new framework to estimate the importance of various governance attributes. In addition, the estimates allow for a direct comparison of the extent to which governance related uncertainty affects stock return volatility relative to management uncertainty. More broadly, this paper also relates to the literature on learning in financial market.

[47] In a speech from April 2015, Patrick S. McGurn, executive vice president and special counsel at ISS stressed the importance of board refreshment in governance assessments.

2. Background and related literature

Part of the literature on boards of directors is summarized in Table 3-5. Early empirical work focused on how board characteristics affect firm profitability. One of the questions most often raised addresses the composition of the board and in particular whether more independent directors increases firm performance or value (e.g. Hermalin and Weisbach, 1991; Bhagat and Black, 2000). Much of the literature on boards examines the relationship between board characteristics and board actions. For example, researchers extensively studied how the composition of the board or its size impacts CEO turnover (Weisbach, 1988; Yermack, 1996; Wu, 2000), takeover probabilities (Shivdasani, 1993), or CEO compensation (Core et al., 1999). More recently, the literature has evolved to focus on the role of director networks and ties (Barnea and Guedj, 2007; Kuhnen, 2009; Fracassi and Tate, 2012). Empirical studies have also looked at the dynamics of board composition (Shivdasani and Yermack, 1999; Baker and Gompers, 2000). Theoretical work includes Hermalin and Weisbach (1998) who use a model of bargaining power between the board and the CEO, in which the structure of the board and its actions are derived endogenously. Harris and Raviv (2008) present a model that determines the optimal control of corporate boards as a function of the importance of insiders' and outsiders' information and the extent of agency problems.

Given the potentially endogenous nature of board turnovers, researchers have looked at plausibly exogenous director appointments or departures (see among others Nguyen and Nielsen, 2010, Falato, Kadyrzhanova and Lel, 2014 and Ahern and Dittmar, 2012). A substantial part of the literature, reviewed in Yermack (2006), studies abnormal returns around director appointments. Recent articles using this methodology include Adams et al. (2012) who examine market reactions to female directors' appointments. They find that gender is value-relevant as on average, the market reacts positively to the appointment of female directors, particularly for firms that need more monitoring. Masulis et al. (2012) show that appointments of independent directors with industry expertise are associated with a significant positive abnormal return, while appointments of independent director without industry expertise are not. Fich and Shivdasani (2006) find that the market reacts positively to the departure of busy directors.

Richardson et al. (2003) use a sample of directors with multiple directorships and find evidence that supports the idea that directors are important in explaining firms' governance, financial, disclosure and strategic policy choices. Larcker et al. (2013) investigate the role of directors by studying the effects of social networks. They show that boards are important in shaping firm performance whereas Fernau (2013) finds that the variation in firm performance is partially attributable to director fixed effects. The study conducted by Schwartz-Ziv and Weisbach (2013) provides an opportunity to understand the workings of boards and shows that they do play an active management role when necessary.

In a recent paper, Denis, Denis and Walker (2015) build on the intuition in Hermalin and Weisbach (2014) and show that in addition to the monitoring and advising roles put forth in the literature, corporate boards also have an assessment responsibility: they have to learn about the quality of the CEO and his match with the firm. Using spinoff transactions to explore the formation of boards, the authors find that board composition depends on the need for CEO assessment. Their results provide empirical evidence that learning about managerial competence is an important determinant of the structure of corporate boards.

In this paper, the assessment is performed not by the board but by investors, who learn about new directors. Using a Bayesian learning model, this paper provides estimates of the value of directors and studies the value relevance of director attributes and board characteristics. The theoretical framework derived in this paper draws on the work by Harris and Holmström (1982), Murphy (1986), Gibbons and Murphy (1992), and Holmström (1999) in the context of learning about managerial ability. Using a sample of CEO turnovers, Pan et al. (2015) implement the logic set up by Pastor and Veronesi (2003) to study learning about CEO ability. These two papers together lay the groundwork for the examination of the dynamics of stock return volatility following a change in the composition of the board.

3. A learning model of board quality: theoretical framework and empirical implementation

3.1 Bayesian learning

Appendix 3-B develops the theoretical framework of rational learning that motivates the empirical hypotheses in this paper. It is based on Pan et al. (2015) who study learning about management. It features market participants who update their beliefs about the ability of newly appointed directors. The model serves the purpose of characterizing the relationship between uncertainty surrounding the appointment of new directors and stock price volatility.

The model generates the following predictions:

1) Volatility decreases in a convex manner over director tenure.
2) Return volatility increases with uncertainty about ability.
3) Return volatility increases with the marginal return to ability of directors.

By testing these predictions, the goal of this article is to uncover what drives learning about director ability, thereby shedding light on the importance of corporate boards.

3.2 Empirical design

3.2.1 Regression model

The predictions from the learning model are tested using regression models that estimate the relation between the tenure of a newly appointed director and stock return volatility. The regression model is characterized by the following equation:

$$Vol_{i,t} = \beta_{1,k,i} + \beta_2 f\left(tenure_{i,j}\right) + \beta_3 X_{i,t} + \lambda_t + \varepsilon_{i,t} \tag{1}$$

where $\beta_{1,k,i}$ is a board fixed effect for board k of firm *i*,

$f\left(tenure_{i,j}\right)$ is a function of director *j*'s tenure, allowing for a decreasing and convex relationship between volatility and tenure as predicted by the model,

$X_{i,t}$ is a set of firm level control variables,

λ_t is the calendar-month fixed effect.

The null hypothesis is that tenure and volatility are not related (H_0: β_2 is insignificant). The alternative hypothesis is that the governance-related component of stock return volatility decreases as the market learns about the ability of a director (H_1: β_2 is significantly negative).

Regressions include board fixed effects to account for unobservable board and director characteristics. For example, directors with higher ability may self-select to serve on larger firms and the dynamics of information sharing and groupthink may vary across different board compositions. Board fixed effects control for such time-invariant board and director characteristics. Regressions with board fixed effects thus estimate learning about director ability from the time-series variation in volatility within a particular composition of the board. In addition, all regressions include a month fixed effect to account for macroeconomic factors that affect the volatility of all firms. Standard errors are clustered at the firm level.

3.2.2 Data sources and descriptive statistics

The sample consists of 2,228 firms from the intersection of S&P 1,500 firms in BoardEx, CRSP and Compustat from 2000 to 2014. It comprises 18,579 directors and 13,074 new director appointments.

The relationship between director tenure and stock return volatility is estimated in monthly regressions following director appointments using two measures of volatility. *Realized volatility* is the standard deviation of daily returns within a month. *Idiosyncratic volatility* is the standard deviation of the residuals of a Fama-French three-factor model as in Ang et al. (2006). Appendix 3-A reports the definition of all variables.

Table 3-1 presents summary statistics. Panel A reports director and board summary statistics at the firm-year level. The average board consists of 9.4 directors, 12% of whom are women. On average, 19% of board members have experience as CEO of a public company and 10% have previously had a directorship in the same industry. The average director is 61 years old and has been a director for 6.5 years. There is a new director on average every two years. The average director stays for over eleven years. On average, 79% of board members are independent. A board is "entrenched" if the CEO combines the titles of Chairman and President and has been in office for at least five years. Using this definition, 35% of boards are considered entrenched. Coles et al. (2015) use the percentage of directors with tenure greater than nine years as a proxy for groupthink. In this sample, 43% of board members are prone to groupthink. On average, 15% of board members sit on three or more boards. *Board Pay Slice* is defined as the sum of independent directors' compensation over CEO total compensation, and averages 25%.[48]

Statistics for the two volatility measures and betas are reported at the firm-month level in Panel B of Table 3-1. Average monthly realized (idiosyncratic) volatility is 11.7% (8.6%). Firm level financial statistics are reported at the firm-year level in Panel C.

[Insert Table 3-1]

4. Empirical relationship between volatility and director tenure

4.1 Full sample

The model implies that as the market learns about directors, its update of its assessment of their quality is reduced, and hence stock return volatility declines. This decline occurs as governance-related uncertainty dissipates as investors become more acquainted with their board. Figure 3-1 graphs the relationship between monthly average idiosyncratic volatility and director tenure for three samples of newly appointed directors. Panel A shows the volatility pattern for all newly appointed directors. In Panel B, only directors appointed solo are included (i.e. no other director are appointed over the six months period around their appointment). In Panel C, there are no other director appointments at least two years before and two years after the new director joins. For the three samples, volatility sharply increases at time zero, i.e. the arrival of new directors.

If directors are relevant for firm value, their arrival adds a random variable to the firm's value and as investors discover what that random variable is, return volatility declines. The spike

[48] This is consistent with figures for the average S&P500 firm which spent $2.2 million in 2012 in basic board compensation and $10.7 million on average to compensate its CEO. Source: http://www.bloomberg.com/news/2013-05-30/board-director-pay-hits-record-251-000-for-250-hours.html

in volatility suggests that the arrival of a new director may be viewed as a positive shock to the uncertainty about future profitability. The higher uncertainty pushes up volatility through a mechanism described in Pastor and Veronesi (2003). The idea is that when there is a new director, the effect of any news is amplified as the market updates both the effect of the news and their assessment of the director's quality, and consequently their expectation of future events and their effect on firm value. This upswing is followed by a decline in volatility, as the uncertainty progressively resolves and investors no longer update their valuation of the firm according to their assessment of the new director's ability.

[Insert Figure 3-1]

Three functional forms of director tenure are specified to determine whether the empirical relation between volatility and director tenure is consistent with the theoretical framework: a quadratic regression model, a logarithmic specification and a reciprocal specification. The convexity of the volatility-tenure relationship can be verified with all three specifications. Two restrictions are imposed in all specifications: appointments must not overlap with a CEO turnover within a year and directors must remain on the board for at least five years to ensure that the decline in volatility is not driven by the high volatility in firms with high director turnover. Panel A of Table 3-2 presents regression results for the three functional forms and for the two volatility measures. All new director appointments satisfying the above two restrictions are included. All regressions estimate the volatility-tenure relation over the first five years of tenure. In Panel B, the tenure variables are interacted with an indicator variable equal to one when directors are appointed solo, i.e. no other directors are appointed during the six months period around their appointment. In Panel C, the tenure variables are interacted with an indicator variable equal to one when there is no other directors appointed during the two year period preceding the appointment as well as during the two year period following the appointment.

All regressions control for firm level factors that affect the firm's return volatility. The coefficient estimates for the control variables are significant in the expected direction. In addition, when the dependent variable is realized volatility, the regressions include the market beta, SMB beta and HML beta to control for factors that affect the volatility in average dividend growth.

In Panel A, the estimated coefficients on *Tenure* are negative and statistically significant for both measures of volatility, regardless of the functional form used. The coefficients on $Tenure^2$ are positive and statistically significant, which indicates that volatility declines at a faster rate at the beginning of director tenure. There is therefore a negative and convex relationship between stock return volatility and director tenure in the data, which is in line with the predictions of the learning model.

[Insert Table 3-2, Panel A]

In Panel B, the estimated coefficients on *Tenure* are negative and almost always statistically significant. They are also larger in absolute value when compared to those in Panel A and the estimated coefficients on the interaction terms are positive. This suggests that directors appointed solo are associated with a smaller decline in volatility over their tenure on average. This is not surprising and supports the view that more directors joining adds more uncertainty. However, the estimated coefficients on the interaction terms are not statistically significant, suggesting that even single appointments are meaningful.

[Insert Table 3-2, Panel B]

Similar results are shown in Panel C of Table 3-2, where the tenure variables are interacted with an indicator variable equal to one when there is no other directors appointed during the two year period preceding the appointment as well as during the two year period following the appointment.

[Insert Table 3-2, Panel C]

The results in the three panels of Table 3-2 indicate that investors behave according to the predictions of the learning model when updating their assessment of a new director's ability.

4.2 Samples of plausibly exogenous director appointments

A potential alternative interpretation for the results derived above is that firms may appoint new directors in times of crisis, when volatility is high. For example, poor firm performance may prompt the need to bring a fresh perspective on the board. In addition, board changes frequently occur concurrently with management turnover (see Hermalin and Weisbach, 1988 and Denis and Sarin, 1999), which may also coincide with a period of high volatility. It is therefore important to identify changes in board composition that are unlikely to occur as a response to corporate turbulences to ensure that the patterns documented in the previous section hold for exogenous director appointments.

In the tests below, only director appointments occurring when the firm is performing well in a low volatility environment are included. Specifically, the firm’s stock return performance the year preceding the appointment must exceed that of the S&P 500 and its average monthly stock return volatility over the three months preceding the appointment must be inferior to its average monthly return volatility over the previous two years. Director appointments must not overlap with a CEO turnover within a year and directors must remain on the board for at least five years.

The first subsample of exogenous director appointments is constructed by selecting appointments that were specifically designed to ensure that the board would satisfy the new board independence requirements. Governance reforms in the early 2000s led the NASDAQ and NYSE exchanges to impose stricter listing requirements regarding the independence of corporate boards.

The introduction of new exchange listing requirements has been used in the literature to study the effect of board structure on firm value (Wintocki, 2007; Duchin et al. 2010), CEO compensation (Chhaochharia et al. 2009), and firm transparency (Armstrong et al. 2014).

The sample of exogenous appointments is constructed by restricting appointments to those that resulted in the board complying with the new 50% independence requirement when it did not prior to that director's appointment. A director appointment therefore qualifies for this sample if the director joins the board between 2002 and 2005 and the firm previously did not comply with the 50% independence requirement.

The second exogenous sample consists of newly appointed directors who replace directors who passed away or who retired. To construct the retiree replacement sample, a new director is included if she joins the board within six months following the departure of a director who is older than 70. Fracassi and Tate (2012) show that director retirements are typically not related to firm conditions. This sample is augmented with directors who served simultaneously on multiple boards and left all of their boards within two years[49]. These directors arguably left the boardroom for reasons exogenous to the situation of one particular firm. Directors who retired due to health reasons before reaching the maximum age requirement would be included in this subsample. Director deaths are identified in BoardEx.

[49] Not including these directors does not affect the results.

Panel A of Table 3-3 shows regression results for the various subsamples of exogenous director appointments. For brevity, only results with the quadratic functional form and idiosyncratic volatility are shown, but the results also hold for the logarithmic and reciprocal specifications and realized volatility. Specification 1 in Table 3-3 provides regression results for the two subsamples pooled together. Specification 2 uses only the exchange mandated appointments while Specification 3 uses only the replacement directors. The results are unaltered: volatility decreases over the tenure of newly appointed directors and does so at a decreasing rate.

[Insert Table 3-3, Panel A]

To confirm that the documented relation between director tenure and volatility is not affected by the endogeneity of director appointments, Specifications 3 to 6 use the full sample of director appointments and *Tenure* is interacted with an indicator variable for each exogenous appointment type. The estimated coefficients on the interaction terms are insignificant. This suggests that there is no significant difference in the volatility-tenure relationship between the full sample and the exogenous samples. The results in the previous section are therefore unlikely to be driven by the potential endogeneity of director appointments.

Panel B of Table 3-3 reports regression results for the subsamples of exogenous director appointments when the departing and replacing directors have a high similarity score. Such a score is constructed by looking at six attributes: gender, generation, job expertise, level of board experience, previous directorship in the same industry and job experience in the same industry. Two directors are considered to have a similar profile if they share at least four attributes out of the six, which is the median score for all incoming-departing director pairs for death or retirement replacements when the firm operates in an environment of good stock return performance and low return volatility. Appendix 3-C provides details on the construction of the similarity score. Panel B of Table 3-3 uses only exogenous appointments occurring when the firm is performing well, its stock return volatility is low, the appointment does not overlap with a CEO turnover and the departing and incoming directors have a very similar profile. The conclusion from this exercise remains the same: volatility declines over the tenure of newly appointed directors.

[Insert Table 3-3, Panel B]

4.3 Additional tests

The evidence above is consistent with learning-induced declines in volatility and supports the hypothesis that directors make a difference in the fortunes of their firm. Importantly, this pattern does not appear to be the product of the potential endogeneity of director appointments. Follow-on tests provide additional evidence that investors learn about incoming directors.

4.3.1 Young vs. seasoned boards

If the decline in stock return volatility reflects the resolution of governance related uncertainty, we should observe a stronger decline for young boards than for seasoned boards. Consistent with this idea, stock return volatility declines sharply over the average board tenure for relatively young boards but does not decline for mature boards, even after controlling for firm age and board size. If the documented volatility patterns were due to the endogenous nature of director appointments or to directors learning about their job, rather than investors learning about directors, there would be no reason to expect different patterns based on the average tenure of board members. If anything, we should expect it to be easier for directors to learn to do their job if the board is more mature and can more effectively coach a newly appointed director.

Panel A of Table 3-4 shows the estimated coefficients for the volatility and average board tenure relationship for all boards in Specification 1, for young boards in Specification 2 and for seasoned boards in Specification 3. Boards are categorized into terciles based on the average tenure of their members. Young (seasoned) boards are defined as those whose members' average tenure is in the first (third) tercile.

[Insert Table 3-4, Panel A]

Figure 3-2 graphs firm volatility as a function of average director tenure for young and seasoned boards in Panels A and B, respectively. It shows a distinct decline in volatility as young boards become more mature. In contrast, there is no apparent relation between average board tenure and volatility for seasoned boards.

[Insert Figure 3-2]

4.3.2 All firm-months, ex-ante uncertainty and professional directors

Specification 1 in Panel B of Table 3-4 shows regression results using all firm-months as opposed to restricting the sample to the first years of director tenure. *First 3 yrs* is an indicator variable equal to one for the first three years of tenure and is interacted with *Tenure*. The purpose of this exercise is to broaden the analysis to ensure that the relation between return volatility and tenure is not inflated when the estimation is restricted to the first years of tenure.

The coefficients on the interaction term is negative and significant. Therefore, volatility declines significantly more over the first three years of tenure than over other periods. Note that the estimated coefficient on *Tenure* is insignificant, which indicates that volatility does not significantly decrease over tenure outside the first three year window.

[Insert Table 3-4, Panel B]

Learning by market participants should be more important when prior uncertainty about the new director is high. This is an intuitive prediction derived from the model. To test whether the decline in volatility is reduced when the new director is well-known, *High uncertainty* is an indicator variable equal to one for directors who do not have previous board experience and do not have experience as CEO. *Low uncertainty* is an indicator variable equal to one for directors who have experience as the CEO of a public firm and have served on at least four corporate boards prior to joining this one.

Because the *ex-ante* uncertainty of a director is constant, regressions using the level of *ex-ante* uncertainty include firm fixed effects rather than board fixed effects. Specifications 3 and 4 in Panel B of Table 3-4 show that stock return volatility declines significantly more over director tenure for directors characterized by high *ex-ante* uncertainty. Although the estimated coefficient on the interaction term does not satisfy traditional levels of significance, it is positive which shows that well-known directors are associated with smaller declines in return volatility over their tenure. Because low initial uncertainty corresponds to more visible directors, this exercise rules out the interpretation that larger declines in volatility reflect more visible directors.

Specification 5 in Panel B of Table 3-4 reports regression results for "professional" directors. The director learning alternative explanation is grounded in the idea that directors come on the board having little idea how to do their job, thus creating a lot of noise around their decisions. Directors get better over time and develop skills to produce better decisions in the interest of the company. The analysis exploits the fact that some directors are better equipped than others to produce better decisions when joining new boards: directors with experience in the industry who have held previous directorships will arguably be quicker to adapt to the production function of a particular firm and should be associated with a smaller decline in return volatility over their tenure. The investor learning hypothesis predicts the opposite: controlling for how much the market knows about these directors, directors with industry expertise with a history of directorships should be a wealth of resources for the board and should be more relevant for firm value. Controlling for the level of *ex-ante* uncertainty about the ability of directors (using director age, number of previous boards, number of previous jobs and whether the director has been a CEO of a public company), Specification 5 in Panel B of Table 3-4 supports the investors learning hypothesis: professional directors are associated with bigger declines in stock return volatility over their tenure.

4.3.3 Matched sample

A matched sample test is performed to ascertain that the drop in volatility exceeds what would be observed in firms that do not experience the arrival of new directors. Firms are matched based on industry and size. Each firm belongs to one of ten industries based on the Fama-French ten-industry classification. Each firm in the treated group is assigned to a control firm, which is the closest in size (assets) and operates in the same industry. The control firm must not experience a director appointment at least one year prior and one year after the appointment of a director in the treated firm.

Regressions similar to those in Panel A of Table 3-2 are run for the matched sample. If the decline in volatility for the treated firms indeed reflects learning about incoming directors by market participants, we should not observe a systematic decline in volatility for the control firms. Results are reported in Panel C of Table 3-4. As expected, there is no decline in the stock return volatility of control firms following the appointment of directors on the board of treated firms.

[Insert Table 3-4, Panel C]

4.4 The importance of directors

4.4.1 How much do directors matter?

Pan et al. (2015) estimate that around a CEO turnover, the uncertainty about the new CEO accounts for about a quarter of overall stock return volatility. This section uses Pan et al.'s estimate as a benchmark. CEOs undoubtedly have more impact on firm value than directors. But how much more is an open question. How do investors perceive the importance of directors relative to that of the CEO?

This section directly relies on the methodology derived in Pan et al. (2015), which is summarized in Appendix 3-D. It uses estimates of the average decline in volatility over director tenure, the average volatility in corporate dividends (σ) and the average volatility at the time directors joins (Vol_0).

The average estimated decline in volatility over the first three years of tenure is 1.5%, the average volatility of corporate dividends (σ) is 23% and the average realized annual volatility when a director joins (Vol_0) is 38%. Therefore, on average the uncertainty about new directors accounts for about 7% ($\frac{\delta_0}{Vol_0} = \sqrt{\frac{1}{3}\left[\frac{1}{1-1.5\%\times\frac{38\%}{38\%-23\%}} - 1\right]} \times \frac{23\%}{38\%}$) of return volatility when there is a new director, which implies that on average, the governance related uncertainty associated with the arrival of a new director is about a third of the uncertainty associated with new leadership (Pan et al., 2015). The authors however do not account for learning about directors, which may potentially affect their estimates of learning about the CEO, in particular when new directors join the board around CEO turnover.

4.4.2 Importance of directors and value creation

The results derived above are consistent with the predictions of the learning model and imply that directors are relevant for firm value. While the model is agnostic about the sign and cannot speak to whether a larger decline in volatility implies that the director will be a "better" director, this is potentially an interesting question in itself. How does the average performance of firms after the appointment of directors for whom we observed a large decline in volatility over their tenure compare to the performance of those that appointed directors associated with small decline in volatility? The learning slope is a metric for each incoming director measuring the average decline in volatility over the first years of her tenure.

Pan et al. (2015) construct learning slopes for CEOs and although the intuition is similar here, the execution is different. Specifically, whereas Pan et al. regress return volatility on CEO tenure in individual regressions for the first 36 months in office and use the estimated coefficient on tenure as a measure of the learning slope, idiosyncratic volatility is regressed on tenure controlling for factors expected to affect the level of volatility:

$$vol_{i,t} = \beta_{1,k,i} + \beta_{2,i,j} tenure_{i,j,t} + \beta_{3,i} X_{i,t} + \lambda_t + \varepsilon_{i,t} \tag{2}$$

With $vol_{i,t}$ the idiosyncratic volatility of firm *i* at time *t*,

$\beta_{1,k,i}$ the board fixed effect for board *k* of firm *i*,

$X_{i,t}$ a vector of firm level covariates: ln(assets), M/B, ROA, dividend payer, leverage,

$tenure_{i,j,t}$ the tenure of director *j* on the board of firm *i* at time *t*,

λ_t the calendar-month fixed effect.

Residual volatility is then defined as :

$$vol_{i,t}^{residual} = vol_{i,t} - \widehat{\beta_{1,k,t}} - \widehat{\beta_{3,t}} X_{i,t} - \widehat{\lambda_t} \quad (3)$$

Residual volatility is then regressed on tenure in individual regressions for each director-firm pair for the first three years of director tenure. This procedure produces estimates of the average decline in volatility over the tenure of the director, over and above the variation in volatility predicted by firm covariates and macroeconomic factors:

$$vol_{i,t}^{residual} = \alpha_i + \beta_{i,j} tenure_{ij} + \varepsilon_{i,t} \quad (4)$$

The coefficient estimates $\beta_{i,j}$ are multiplied by (-1) for ease of interpretation and normalized by their cumulative distribution function to yield a ranking between 0 and 1. They are referred to as the learning slope for each director, for each board she joins.

Figure 3-3 shows the performance paths as measured by return on assets for high learning slope vs. low learning slope directors. Performance clearly improves following the appointment of directors in the top learning slope decile, while it tends to deteriorate for directors in the bottom learning slope decile.

[Insert Figure 3-3]

Similarly, Figure 3-4 reports the performance paths for high and low learning slope directors as measured by the abnormal stock return performance relative to the firm's industry over the three year period following their appointment. Again, directors with high learning slope are associated with improved performance. Taken together, these results provide suggestive evidence that high learning slope directors are not only more important, as the learning model suggests, but are actually better agents for shareholders.

[Insert Figure 3-4]

The results in this section indicate that governance-related uncertainty accounts for a substantial percentage of overall stock return volatility. Furthermore, there is suggestive evidence supporting the idea that larger declines in volatility can not only be interpreted as directors making a bigger difference, but also that this difference has positive effects. Taken together, these findings suggest that directors matter and are not simple rubber stampers. These results have important implications for governance research inasmuch as they help us better understand the value of board members and provide an estimate of the overall importance of governance in corporations.

5. The marginal return to ability of directors

5.1 Prior empirical evidence on board and director characteristics

Hermalin and Weisbach (2003), Yermack (2006) and Adams et al. (2010) provide surveys of the literature on boards of directors. One of the most studied features related to board composition is the degree of board independence. Weisbach (1988) shows that CEO turnover is more sensitive to firm performance for more outsider-dominated boards. However, Hermalin and Weisbach (1991) and Bhagat and Black (2000) report no relation between the percentage of outside directors and firm value (as measured by Tobin's Q) or accounting measures of performance. On the other hand, Brickley, Coles and Terry (1994) find a positive association between the percentage of outside directors and announcement returns following the adoption of poison pills. Their findings are consistent with the hypothesis that outside directors act in the best interest of shareholders. Harris and Raviv (2008) propose a model in which insider-dominated boards may be optimal. Overall, the evidence in the literature on the value of independent directors is mixed.

Concerns about the size of corporate boards are described in Lipton and Lorsch (1992) and in Jensen (1993). Yermack (1996) and Wu (2000) provide detailed evidence that smaller boards are beneficial for firm value. These papers document that small boards are more likely to replace CEOs based on poor performance and that smaller boards are associated with increased CEO pay-for-performance.

A number of studies have examined the effect of CEO power on the ability of the board to perform its role. Hermalin and Weisbach (1998) argue that CEOs are likely to increase their bargaining power vis-à-vis the board over the course of their tenure, as their perceived ability is higher given that they repeatedly passed the replacement option test. Shivdasani and Yermack (1999) find that powerful CEOs, as measured by the extent to which they are involved in the board nomination process, are able to select less independent boards. Baker and Gompers (2000) find similar results when CEO power is proxied by CEO tenure. Coles et al. (2014) show that co-opted boards are less effective monitors, as evidenced by lower pay-for-performance and lower sensitivity of CEO turnover to performance.

The literature has also studied the effect of personal director attributes on either firm value or some measure of performance or board actions. In particular, a number of empirical studies examine the effect of director gender. The evidence on the value of female board members is mixed. Adams and Ferreira (2009) show that women are better monitors, although increased monitoring comes at the cost of lower firm performance. On the other hand, using data on mandatory announcements of director appointments, Adams, Gray and Nowland (2012) find that investors value female directors more than their male counterparts and Schwartz-Ziv (2015) shows that gender-balanced boards are more active. In particular, she finds that a critical mass of at least three female directors on a board changes the board dynamics, especially in times when the CEO is being replaced. Using the 2003 law on female board representation in Norway, Ahern and Dittmar (2012) find that the quota was associated with deteriorating performance.

Researchers have studied the effect of the number of current directorships and provided mixed evidence as to whether busy directors are beneficial or detrimental to firm value. On the one hand, additional board seats bring experience and business connections that are potentially useful resources to be passed on to the firm's management. On the other hand, overly committed board members do not have time to be effective monitors or deeply understand the business. Their contribution is therefore potentially adversely affected. Ferris et al. (2003) report positive announcement returns to the appointments of busy directors. In contrast, Fich and Shivdasani (2006) find that investors react positively to the departure of busy directors, thus suggesting that busyness is not a desirable director attribute. Core et al. (1999) show that busy outside directors are associated with increased CEO compensation. Recently, Field, Lowry and Mkrtchyan (2013) shed some light on the subject by providing evidence that the firm's life cycle is an important factor to consider when examining the value effect of busy directors. The authors argue that while large established firms benefit relatively more from monitoring than advising services on the part of directors, young firms derive more value from their network and experience. In line with this argument, the authors show that busy directors are beneficial for younger firms because they rely more on advising than monitoring, and detrimental for large corporations because they require the opposite.

This succinct review of the literature on board attributes highlights that the way the literature traditionally studies boards of directors is to select a board or director attribute, examine its effect on firm value or some measure of performance or board action and conclude that boards or directors with this attribute are better or worse than those without. In this paper, the analysis relies on the learning-based framework to revisit part of this literature and offers new results on the importance of some governance attributes. Specifically, this paper exploits the cross-sectional variation of the learning-induced changes in return volatility following the arrival of new directors. The learning model implies that a higher marginal return to ability is associated with larger declines in stock return volatility. Therefore, examining the effect of firm, board and individual attributes on the volatility-tenure relationship is a convenient novel approach to studying the importance of directors. A summary of the findings is included in Table 3-5, alongside a comparison with the results previously derived in the literature.

[Insert Table 3-5]

5.2 Cross-sectional analysis

The learning framework proposed in this paper offers an alternative method to measure the expected contribution of different kinds of directors and boards. The model shows that the uncertainty about director ability decreases at a predetermined rate over time due to Bayes' rule, and that this rate is faster for higher *ex-ante* levels of uncertainty. Hence, after controlling for *ex-ante* uncertainty, cross-sectional analysis of declines in return volatility provides estimates of directors' marginal return to ability. In other words, the magnitude of the decline in volatility over the tenure of a director reflects her marginal value. Panels A and B of Table 3-6 report regression results with interaction variables to document the effect of director attributes on the decline in volatility following director appointments. Controls for *ex-ante* uncertainty include director age, number of previous jobs, number of previous board seats and whether the director has experience as the CEO of a public company. Directors appointed within a year around a CEO turnover are excluded. The median (mean) ratio of the average return volatility over the three month period prior to the arrival of a new director to the average return volatility over the two year period preceding the director appointment is 0.94 (1.00). This sample of director appointments is thus unlikely to coincide with fundamental shifts in strategy.

5.2.1 Director characteristics

5.2.1.1 Position on the board

In Specification 1 in Panel A, the coefficient estimate on the interaction term is negative and significant. This suggests that investors expect chairmen to be important elements of the board and have more impact on firm value than the average director. Note that CEOs are not included in the sample and that directors appointed within a year of a CEO turnover are removed. This result is therefore not attributable to chairmen cumulating the CEO and chairman functions.

[Insert Table 3-6, Panel A]

Specification 2 investigates the role of independent directors. The literature on director independence provides mixed evidence regarding the effect of independent directors on firm value. Researchers have therefore looked at alternative settings (Choi et al., 2007) and alternative definitions of independence (Fracassi and Tate, 2012). In this sample, independent directors (as traditionally defined in the literature) are not expected to matter more, as evidenced by the insignificant coefficient on the interaction term. However, Specification 3 provides evidence that independent directors with industry expertise do have a stronger effect on value, consistent with evidence in Masulis et al. (2012) and Faleye et al. (2012). In addition, Specification 4 shows that when the firm has high monitoring needs, independent directors are expected to be more important. Firms with high monitoring needs are large firms with an entrenched board.

Specification 5 provides insights into which board committees are more important by looking at the volatility-tenure relationship for committee chairs. Chairs of the audit and compensation committees appear to be particularly relevant.

5.2.1.2 Personal attributes

Panel B of Table 3-6 reports the effect of personal attributes on the learning-induced decline in volatility. Adams and Ferreira (2009) show that female directors are better monitors. However, they find that the additional monitoring comes at the cost of lower firm performance, especially for well-governed firms which do not need extensive monitoring. The results from the learning-based approach suggest that for the average firm, female board members do not contribute to firm value as much as their male counterparts. However, similarly to the case of independent directors, female directors appear to be especially important when the firm has high monitoring needs, as evidenced by the negative and significant interaction term in Specification 2. This result provides evidence that female directors are particularly valuable when the need for monitoring services is acute.

[Insert Table 3-6, Panel B]

The literature on busy directors provides mixed evidence (Fich et al., 2006 and Ferris et al., 2003). Using the learning-based approach, the results indicate that busy directors are on average more important contributors.

Specifications 4 and 5 show that directors with previous board experience in the same industry and directors with work experience in the same industry have higher marginal value.

5.2.2 Board characteristics

This section relies on the premise that different types of boards have varying marginal contributions to firm value. In other words, some firms may provide their directors with an environment conducive to leveraging their ability as board members, while others may impede directors to engage fully, play their role and make a difference. For example, investors may be skeptical when a new director joins an entrenched board as they might not expect him to be able monitor management effectively. CEOs who have been in place for multiple years gained more bargaining power over their board (see Hermalin and Weisbach, 1998), so that the balance of power rests in favor of the CEO. Fracassi and Tate (2012) consider CEOs who cumulate the titles chairman of the board and president to be powerful CEOs. The results indicate that investors in firms with captured boards, which are prone to more agency costs, expect their directors to face obstacles in their ability to sway the fortunes of the firm.

[Insert Table 3-6, Panel C]

Coles et al. (2015) use the fraction of directors with long tenures as a proxy for groupthink, and find that groupthink has a negative effect on firm value for firms in dynamic industries. Consistent with their findings, this proxy for groupthink is associated with decreased marginal value.

Investors should expect directors in firms that provide generous compensation to its board members relative to its CEO to contribute more. To test this hypothesis, the variable *Board Pay Slice* is constructed by dividing the sum of independent director compensation by CEO total compensation. *High BPS* is an indicator variable equal to one for boards in the top BPS quartile. The negative significant coefficient on the interaction term suggests that directors joining better compensated boards are expected to have significantly more impact. Yermack (1996) and Eisenberg et al. (1998) show that smaller boards are associated with higher firm value. *Large Board* is an indicator variable equal to one for boards with more than ten members, which is the sample mean. The results based on the learning framework suggest that directors sitting on large boards are associated with lower marginal value.

These findings depict how board characteristics affect investors' expectations regarding the contribution of their directors. In particular, the results in this section highlight that market participants believe that corporate directors are more important when their boards are small, not entrenched, not prone to groupthink and compensate their directors generously relative to the CEO.

5.2.3 Firm level characteristics

Panel D of Table 3-6 reports the effect of firm level attributes. *Large Firm* is an indicator variable equal to one for firms with total assets in the top quartile. The positive coefficient on the interaction term in Specification 1 shows that directors are less relevant in large firms.

[Insert Table 3-6, Panel D]

Directors arguably play a more central role for firms experiencing poor performance. *Poor performance* is an indicator variable equal to one for firms with a stock return performance inferior to that of the S&P500 over the one year period preceding the appointment. The estimates indicate that directors are more important for firms with weak performance.

The learning-induced decline in volatility varies with industry complexity. The technology (consumer durables) industry is arguably a relatively more (less) complex and human capital intensive industry which faces greater (fewer) sources of risk. Firms in the technology (consumer durables) industry exhibit larger (smaller) valuation updates upon the arrival of new directors, thereby suggesting that directors are especially (less) valuable for firms that operate in more (less) complex environments.

Using the learning-based framework, this section revisited part of the literature on boards and confirmed prior findings. It shed new light on the importance of some governance attributes. The results are summarized in Table 3-5.

6. Conclusion

This paper is based on the idea that part of a firm's stock return volatility is related to the uncertainty about its governance. As governance-related uncertainty dissipates, the governance component of volatility declines. By relying on the theory to relate the decline in volatility to the marginal return to ability of directors, this article explores the importance of governance attributes.

The estimates provide empirical support for the view that directors matter. Results suggest that governance related uncertainty accounts for about 7% of stock return volatility when a new director joins the board, which is a third of the estimate for new leadership estimated by Pan et al. (2015). The learning-based decline in volatility documented in this paper is shown not to be driven by endogeneous director appointments and is independent from learning about the CEO. Going beyond the overall decline in volatility to study whether directors make a difference, the learning-based approach can be used to estimate the importance of different kinds of directors and boards.

Chairmen, chairs of the audit and compensation committees, busy directors, independent directors with industry expertise and those joining firms with high monitoring needs have higher marginal returns to ability. While female directors do not have as much impact as their male counterparts on average, the evidence suggests that they are particularly important when the firm's monitoring needs are acute.

Large boards, entrenched boards and boards prone to groupthink impede their directors' ability to influence the firm’s actions, while directors joining better compensated boards are expected to be more important. Directors are more important when their firms recently experienced poor performance, in small firms and firms that operate in more complex industries.

The findings in this paper help delineate the channels through which directors can make a difference. In addition, the findings highlight that the importance of various governance attributes is highly context-specific. Taking the heterogeneity in firms' governance optimization problem into account is a necessary step to expand our understanding of the role governance. The learning-based framework may provide a potentially fruitful approach to examine this issue.

Figure 3-1 Volatility and Director Tenure

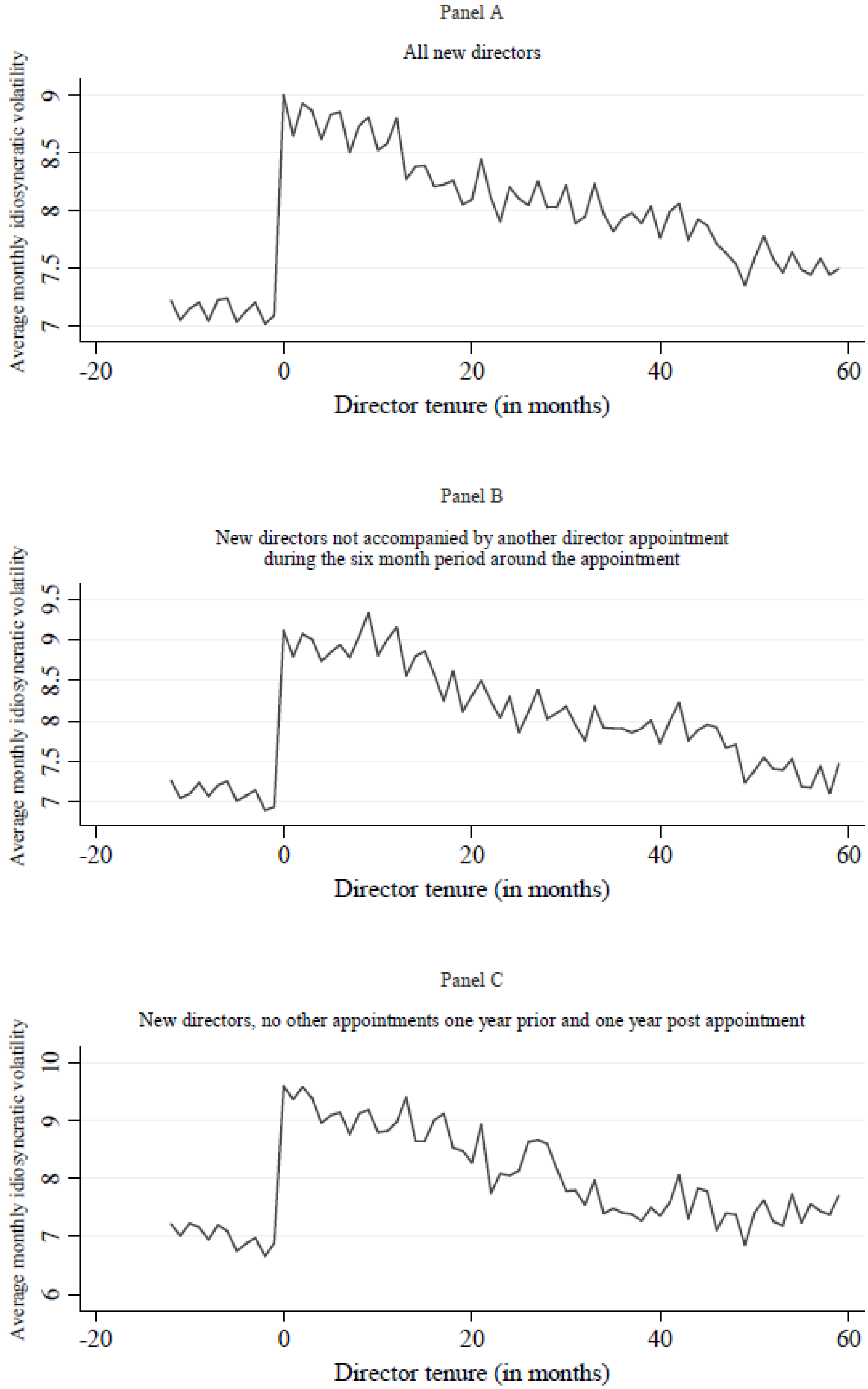

Figure 3-2 Volatility and Average Board Tenure
Boards are categorized into terciles based on the average tenure of their members

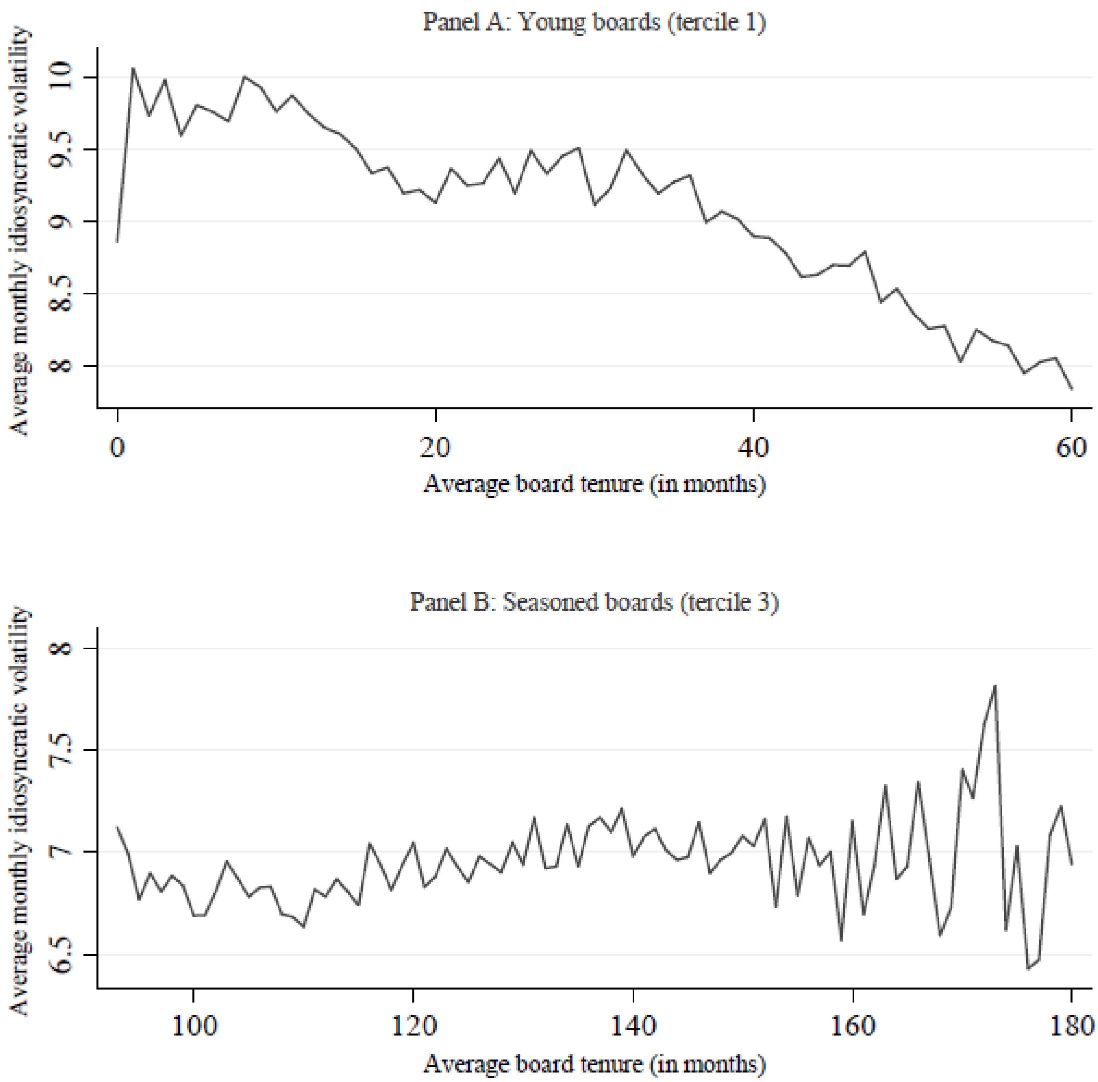

Figure 3-3 Learning Slopes and Firm Performance
This figure shows the performance path for the directors with high learning slopes (highest deciles) and those with low learning slopes (smallest deciles)

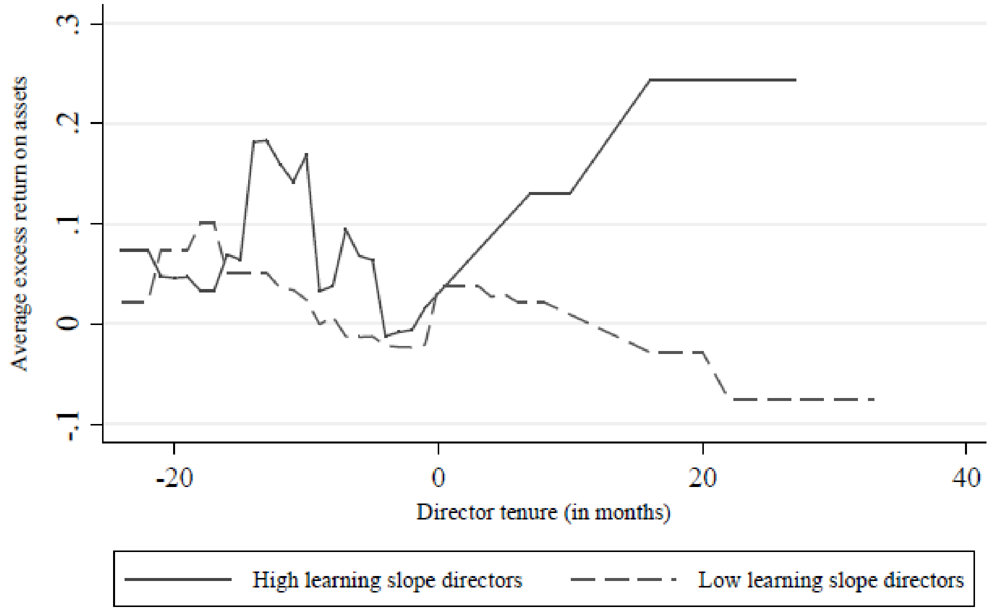

Figure 3-4 Learning Slopes and Stock Performance
This graph shows for each month of tenure, the average forward looking one year stock return relative to the firm's industry.

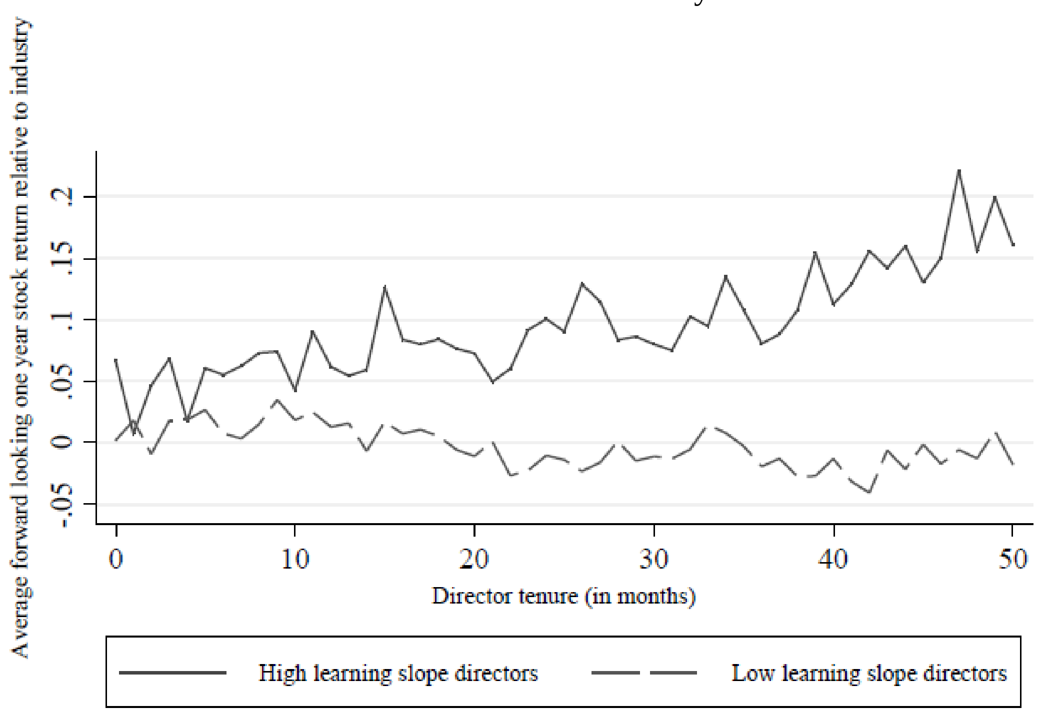

Table 3-1 Descriptive Statistics

This table provides summary statistics for board characteristics, volatility and beta variables as well as firm financial attributes. Board characteristics and financial attributes are at the firm-year level whereas market variables are at the firm-month level. The definition of all variables is in Appendix 3-A.

Panel A: Director and Board Characteristics

	Obs	Mean	Std. Dev.	25%	Median	75%
Tenure	24,870	6.45	3.50	3.96	6.07	8.46
Time between appointments	20,866	1.83	1.28	1.05	1.50	2.17
Time stay on board	24,870	11.26	4.44	8.26	10.87	13.91
Female	24,805	0.12	0.14	0.00	0.10	0.19
Age	21,928	61	6	58	62	65
Independent	24,870	0.79	0.19	0.71	0.84	0.93
Board size	24,870	9.38	2.62	7.50	9.00	11.00
Nomination member	23,678	0.42	0.32	0.00	0.43	0.61
Compensation member	23,678	0.52	0.26	0.38	0.50	0.67
Audit member	23,678	0.56	0.23	0.42	0.59	0.68
Member all three committees	23,678	0.12	0.24	0.00	0.00	0.14
Network size	24,847	850	528	476	753	1101
Busy	24,870	0.15	0.19	0.00	0.09	0.22
Entrenched board	19,474	0.35	0.47	0.00	0.00	1.00
Board Pay Slice	6,499	0.25	0.30	0.07	0.15	0.34
Other public directorships, total	24,870	3.19	1.52	2.02	3.00	4.04
Other public directorships, current	24,870	1.99	0.81	1.43	1.87	2.37
Tenure superior 9 years (groupthink)	24,870	0.43	0.30	0.20	0.43	0.62
CEO experience	24,870	0.19	0.20	0.00	0.15	0.31
CFO experience		0.07	0.12	0.00	0.00	0.14

	24,870					
Professional directors	24,870	0.05	0.11	0.00	0.00	0.18
Previous directorship in same industry	24,870	0.10	0.17	0.00	0.00	0.15

Panel B: Market Variables

	Obs	Mean	Std. Dev.	25%	Median	75%
Realized volatility	290,015	11.43	8.06	6.41	9.30	13.84
Idiosyncratic volatility	290,015	8.44	6.42	4.51	6.74	10.31
Market beta	290,015	1.05	1.04	0.57	1.01	1.48
SMB beta	290,015	0.64	1.57	-0.18	0.51	1.34
HML beta	290,015	0.22	2.08	-0.70	0.19	1.13

Panel C: Firm Level Variables

	Obs	Mean	Std. Dev.	25%	Median	75%
Firm age	23,016	23.06	18.71	10.00	18.00	33.00
G-index	10,391	9.39	2.56	8.00	9.00	11.00
Ln (assets)	24,864	7.66	1.76	6.42	7.54	8.76
Dividend payer	24,334	0.54	0.50	0	1	1
Leverage	24,773	0.19	0.19	0.02	0.15	0.29
M/B	24,843	3.41	52.37	1.42	2.15	3.49
ROA	24,862	0.04	0.14	0.01	0.04	0.08

Table 3-2A Volatility and Director Tenure – Panel A

This table reports regression results for the volatility-director tenure relation estimated with three functional forms for two measures of stock return volatility, realized volatility and idiosyncratic volatility. The first five years of director tenure are used in all specifications. The sample does not include CEOs and excludes all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

	(1) Idiosyncratic Volatility	(2) Realized Volatility	(3) Idiosyncratic Volatility	(4) Realized Volatility	(5) Idiosyncratic Volatility	(6) Realized Volatility
Tenure	-0.099***	-0.119**				
	(-2.622)	*(-2.503)*				
$Tenure^2$	0.018**	0.022**				
	(2.407)	*(2.289)*				
Ln(1+tenure)			-0.045**	-0.050**		
			(-2.546)	*(-2.337)*		
-1/(1+tenure)					-0.135**	-0.152**
					(-2.501)	*(-2.341)*
Ln(assets)	-0.940***	-1.064***	-0.942***	-1.067***	-0.942***	-1.066***
	(-5.814)	*(-5.232)*	*(-5.821)*	*(-5.242)*	*(-5.820)*	*(-5.241)*
Dividend Payer	-1.154***	-1.314***	-1.152***	-1.313***	-1.153***	-1.313***
	(-4.040)	*(-3.937)*	*(-4.032)*	*(-3.928)*	*(-4.034)*	*(-3.930)*
Leverage	1.558***	1.801***	1.555***	1.797***	1.555***	1.797***
	(3.751)	*(3.640)*	*(3.734)*	*(3.624)*	*(3.738)*	*(3.627)*
MB	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(2.654)	*(2.593)*	*(2.673)*	*(2.616)*	*(2.667)*	*(2.610)*
ROA	-1.343***	-1.481***	-1.342***	-1.480***	-1.343***	-1.481***
	(-4.077)	*(-3.866)*	*(-4.066)*	*(-3.855)*	*(-4.071)*	*(-3.860)*
Market Beta		0.964***		0.964***		0.964***
		(12.123)		*(12.119)*		*(12.121)*
SMB Beta		0.418***		0.418***		0.418***
		(20.345)		*(20.340)*		*(20.343)*
HML Beta		0.077***		0.077***		0.077***
		(2.896)		*(2.897)*		*(2.897)*
Constant	17.108***	18.981***	17.197***	19.093***	17.015***	18.887***
	(13.630)	*(12.178)*	*(13.672)*	*(12.227)*	*(13.503)*	*(12.084)*
Observations	428,746	428,746	428,746	428,746	428,746	428,746
R-squared	0.285	0.555	0.285	0.555	0.285	0.555
Board fixed effect	yes	yes	yes	yes	yes	yes
Month fix. effect	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3-2B Volatility and Director Tenure – Panel B

Panel B: Director appointments not accompanied by another appointment around arrival
This table reports regression results for the volatility-director tenure relation estimated with three functional forms for two measures of stock return volatility. It documents the effect of director appointments not accompanied by another director appointment six month around the appointment. The first five years of director tenure are used in all specifications. The sample does not include CEOs and excludes all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

	(1) Idiosyncratic Volatility	(2) Realized Volatility	(3) Idiosyncratic Volatility	(4) Realized Volatility	(5) Idiosyncratic Volatility	(6) Realized Volatility
Tenure	-0.114***	-0.128**				
	(-2.660)	*(-2.511)*				
Tenure^2	0.018**	0.022**				
	(2.435)	*(2.313)*				
Single appointment	-0.047	-0.032	-0.101	-0.104	0.099	0.106
	(-0.820)	*(-0.434)*	*(-1.250)*	*(-1.066)*	*(1.609)*	*(1.439)*
Single appointment*Tenure	0.022	0.013				
	(0.939)	*(0.438)*				
Ln(1+tenure)			-0.107*	-0.109		
			(-1.815)	*(-1.559)*		
Single appointment*Ln(1+tenure)			0.092	0.088		
			(1.307)	*(1.021)*		
-1/(1+tenure)					-0.314**	-0.361**
					(-2.089)	*(-2.116)*
Single appointment*-1/(1+tenure)					0.267	0.311
					(1.570)	*(1.569)*
Ln(assets)	-0.940***	-1.064***	-0.943***	-1.067***	-0.942***	-1.067***
	(-5.814)	*(-5.231)*	*(-5.823)*	*(-5.243)*	*(-5.826)*	*(-5.244)*
Dividend Payer	-1.153***	-1.314***	-1.152***	-1.312***	-1.154***	-1.314***
	(-4.035)	*(-3.933)*	*(-4.030)*	*(-3.926)*	*(-4.037)*	*(-3.933)*
Leverage	1.558***	1.801***	1.556***	1.797***	1.556***	1.798***
	(3.749)	*(3.639)*	*(3.733)*	*(3.624)*	*(3.739)*	*(3.628)*
MB	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(2.662)	*(2.597)*	*(2.691)*	*(2.630)*	*(2.694)*	*(2.636)*
ROA	-1.342***	-1.481***	-1.342***	-1.480***	-1.343***	-1.482***
	(-4.078)	*(-3.867)*	*(-4.071)*	*(-3.859)*	*(-4.081)*	*(-3.870)*
Market Beta		0.964***		0.964***		0.964***
		(12.123)		*(12.120)*		*(12.124)*
SMB Beta		0.418***		0.418***		0.418***
		(20.345)		*(20.343)*		*(20.349)*
HML Beta		0.077***		0.077***		0.077***

		(2.897)		*(2.897)*		*(2.897)*
Constant	17.134***	18.999***	17.269***	19.165***	16.974***	18.842***
	(13.681)	*(12.219)*	*(13.759)*	*(12.312)*	*(13.445)*	*(12.022)*
Observations	428,746	428,746	428,746	428,746	428,746	428,746
R-squared	0.285	0.555	0.285	0.555	0.285	0.555
Board fixed effect	yes	yes	yes	yes	yes	yes
Calendar month fix. effect	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3-2C Volatility and Director Tenure – Panel C

Panel C: Director Appointments, no other appointments over two year period

This table reports regression results for the volatility-director tenure relation estimated with three functional forms for two measures of stock return volatility. It documents the effect of directors appointments not accompanied by another director appointment over the one year period prior to and the one year period following the appointment. The first five years of director tenure are used in all specifications. The sample does not include CEOs and excludes all directors' appointments overlapping with a CEO turnover over a one year period. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

	(1) Idiosyncratic Volatility	(2) Realized Volatility	(3) Idiosyncratic Volatility	(4) Realized Volatility	(5) Idiosyncratic Volatility	(6) Realized Volatility
Tenure	-0.098**	-0.114**				
	(-2.465)	*(-2.365)*				
$Tenure^2$	0.018**	0.022**				
	(2.404)	*(2.286)*				
Single appointment2yrs	-0.007	0.006	-0.048	-0.054	0.042	0.052
	(-0.131)	*(0.094)*	*(-0.659)*	*(-0.598)*	*(0.751)*	*(0.743)*
Single appointment2yrs*Tenure	-0.001	-0.009				
	(-0.030)	*(-0.309)*				
Ln(1+tenure)			-0.06	-0.064		
			(-1.437)	*(-1.271)*		
Single appointment2yrs*Ln(1+tenure)			0.031	0.028		
			(0.477)	*(0.350)*		
-1/(1+tenure)					-0.211**	-0.255**
					(-1.987)	*(-2.069)*
Single appointment2yrs*-1/(1+tenure)					0.157	0.213
					(1.060)	*(1.181)*
Ln(assets)	-0.940***	-1.064***	-0.943***	-1.067***	-0.943***	-1.068***
	(-5.819)	*(-5.235)*	*(-5.826)*	*(-5.247)*	*(-5.827)*	*(-5.248)*
Dividend Payer	-1.154***	-1.314***	-1.153***	-1.313***	-1.154***	-1.314***

	(-4.040)	*(-3.938)*	*(-4.033)*	*(-3.930)*	*(-4.038)*	*(-3.935)*
Leverage	1.558***	1.801***	1.555***	1.797***	1.556***	1.799***
	(3.751)	*(3.641)*	*(3.735)*	*(3.626)*	*(3.740)*	*(3.631)*
MB	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(2.653)	*(2.591)*	*(2.679)*	*(2.621)*	*(2.684)*	*(2.630)*
ROA	-1.343***	-1.482***	-1.342***	-1.480***	-1.342***	-1.481***
	(-4.078)	*(-3.867)*	*(-4.067)*	*(-3.856)*	*(-4.074)*	*(-3.864)*
Market Beta		0.964***		0.964***		0.964***
		(12.123)		*(12.120)*		*(12.123)*
SMB Beta		0.418***		0.418***		0.418***
		(20.345)		*(20.342)*		*(20.346)*
HML Beta		0.077***		0.077***		0.077***
		(2.896)		*(2.897)*		*(2.897)*
Constant	17.109***	18.971***	17.227***	19.124***	17.032***	18.910***
	(13.683)	*(12.223)*	*(13.753)*	*(12.312)*	*(13.519)*	*(12.104)*
Observations	428,746	428,746	428,746	428,746	428,746	428,746
R-squared	0.285	0.555	0.285	0.555	0.285	0.555
Board fixed effect	yes	yes	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05,
* p<0.1

Table 3-3A Exogenous Director Appointments – Panel A

Panel A: Exogenous appointments, good performance, low volatility
This table reports regression results for the volatility-director tenure relation using samples of exogenous director appointments. The first five years of director tenure are used in all specifications. In all regressions, only director appointments occurring when the firm is performing well in a low volatility environment are included. Specifically, the firm's stock return performance the year preceding the appointment must exceed that of the S&P 500 and its average monthly stock return volatility over the six months preceding the appointment must be inferior to its average monthly return volatility over the previous two years. Specification 1 restricts the sample to directors appointed to meet the new exchange independence requirement as well as directors appointed to replace directors who either retired or passed away. Specification 2 includes only exchange mandated directors and Specification 3 only replacement directors. In Specifications 4, 5 and 6, the full sample is used in the regression and indicator variables corresponding to the type of appointment are used. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

Dependent var.: Idio. Vol.	(1)	(2)	(3)	(4)	(5)	(6)
Tenure	-0.550**	-0.650**	-0.196	-0.101***	-0.100***	-0.099***
	(-2.131)	*(-2.194)*	*(-0.253)*	*(-2.676)*	*(-2.670)*	*(-2.633)*
Pooled exogenous				-0.100		
				(-1.495)		
Pooled exogenous*Tenure				0.022		
				(0.734)		
Exchange mandated					-0.090	
					(-1.263)	
Exchange mandated*Tenure					0.017	
					(0.538)	
Retirement/death replacement						-0.261
						(-1.556)
Retirement/death replacement*Tenure						0.087
						(0.941)
$Tenure^2$	0.070*	0.072	0.075	0.018**	0.018**	0.018**
	(1.722)	*(1.556)*	*(0.609)*	*(2.431)*	*(2.431)*	*(2.407)*
Ln(assets)	-1.065**	-0.880**	-4.568**	-0.940***	-0.940***	-0.940***
	(-2.387)	*(-2.072)*	*(-2.497)*	*(-5.813)*	*(-5.813)*	*(-5.812)*
Dividend Payer	-1.324**	-1.603**	-0.732	-1.154***	-1.154***	-1.155***
	(-2.343)	*(-2.562)*	*(-1.081)*	*(-4.040)*	*(-4.039)*	*(-4.043)*
Leverage	1.715	0.774	6.015*	1.557***	1.557***	1.558***
	(1.303)	*(0.536)*	*(1.981)*	*(3.747)*	*(3.748)*	*(3.752)*
MB	-0.007	-0.006	-0.082	0.001***	0.001***	0.001***
	(-1.565)	*(-1.311)*	*(-1.341)*	*(2.651)*	*(2.651)*	*(2.653)*
ROA	0.378	-1.054	6.221***	-1.342***	-1.342***	-1.343***
	(0.315)	*(-0.855)*	*-4.774*	*(-4.076)*	*(-4.076)*	*(-4.078)*
Constant	16.884***	15.945***	50.645***	17.111***	17.112***	17.104***
	(4.384)	*(4.551)*	*(3.687)*	*(13.633)*	*(13.635)*	*(13.627)*

Observations	18,035	15,965	2,415	428,746	428,746	428,746
R-squared	0.322	0.31	0.436	0.285	0.285	0.285
Board fixed effect	yes	yes	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3-3B Exogenous Director Appointments – Panel B

Panel B: This table reports regression results for the volatility-director tenure relation using a sample of exogenous director appointments. The first five years of director tenure are used in all specifications. In all regressions, only director appointments occurring when the firm is performing well in a low volatility environment are included. Specifically, the firm's stock return performance the year preceding the appointment must exceed that of the S&P 500 and its average monthly stock return volatility over the six months preceding the appointment must be inferior to its average monthly return volatility over the previous two years. In addition, the departing director and replacement director must share a very similar profile, i.e. a SimScore ≥ 4. Specification 1 restricts the sample to directors appointed to meet the new exchange independence requirement as well as directors appointed to replace directors who either retired or passed away. Specification 2 includes only exchange mandated directors and Specification 3 only replacement directors. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

Dependent var. Idio. Vol.	(1)	(2)	(3)
Tenure	-0.571**		
	(-2.078)		
$Tenure^2$	0.078		
	(1.626)		
Ln(1+tenure)		-0.803**	
		(-2.112)	
-1/(1+tenure)			-1.137*
			(-1.865)
Ln(assets)	-0.962*	-0.978*	-0.977*
	(-1.722)	*(-1.733)*	*(-1.732)*
Dividend Payer	-1.280	-1.295	-1.298
	(-1.468)	*(-1.488)*	*(-1.489)*
Leverage	0.495	0.505	0.491
	(0.284)	*(0.289)*	*(0.280)*
MB	-0.017***	-0.017***	-0.017***
	(-2.981)	*(-3.023)*	*(-3.021)*

ROA	0.84	0.806	0.782
	(0.745)	*(0.709)*	*(0.686)*
Constant	15.474***	15.518***	14.554***
	(3.453)	*(3.432)*	*(3.154)*
Observations	10,964	10,964	10,964
R-squared	0.305	0.305	0.305
Board fixed effect	yes	yes	yes
Calendar month fixed effect	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3-4A Additional Tests – Panel A

Panel A: This table reports regression results for the volatility-director tenure relation using the average board tenure for all board in Specification 1, for young boards (average board tenure, tercile 1) in Specification 2 and seasoned boards (average board tenure, tercile 3) in Specification 3. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

Dependent var. Idio. Vol.	(1)	(2)	(3)
Average board tenure	-0.127***	-0.326*	-0.004
	(-4.563)	*(-1.814)*	*(-0.050)*
Average board tenure^2	0.005***	0.072**	-0.001
	(3.443)	*(2.497)*	*(-0.280)*
Board size	-0.109***	-0.038	-0.044
	(-5.190)	*(-1.110)*	*(-1.021)*
Firm age	0.823***	1.438***	-0.072
	(26.278)	*(9.775)*	*(-1.228)*
Ln(assets)	-1.082***	-0.847***	-0.563*
	(-10.604)	*(-3.979)*	*(-1.941)*
Dividend Payer	-1.508***	-0.898***	-1.009***
	(-11.742)	*(-3.098)*	*(-3.281)*
Leverage	1.594***	1.579***	1.429*
	(4.598)	*(2.672)*	*(1.663)*
MB	0.000**	0.001	0.001***
	(2.236)	*(1.012)*	*(6.951)*
ROA	-3.675***	-1.260***	-2.191***
	(-8.784)	*(-3.616)*	*(-2.644)*
Constant	6.221***	12.118***	14.332***
	(6.660)	*(4.732)*	*(6.949)*
Observations	1,656,575	419,320	409,427
R-squared	0.343	0.213	0.249
Board fixed effect	yes	yes	yes
Calendar month fixed effect	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3-4B Additional Tests – Panel B

Panel B: All firm-months, first 3 years, ex-ante uncertainty and professional directors.
This table reports regression results for the volatility-director tenure relation using all firm-months in Specification 1 and using an indicator variable for the first three years of tenure. The first five years of tenure are used in Specifications 2 through 5.CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

Dependent var.: Idio. Vol.	(1)	(2)	(3)	(4)	(5)
Tenure	0.001	-0.174***	-0.147***	-0.149***	-0.108**
	(0.326)	*(-3.984)*	*(-3.170)*	*(-3.208)*	*(-2.158)*
First3	0.087**				
	(2.315)				
First3*Tenure	-0.036**				
	(-2.094)				
Low uncertainty		-0.13		-0.063	
		(-0.621)		*(-0.298)*	
Low uncertainty*Tenure		0.096		0.072	
		(1.518)		*(1.134)*	
High uncertainty			0.117*	0.114*	
			(1.701)	*(1.651)*	
High uncertainty*Tenure			-0.041*	-0.039*	
			(-1.771)	*(-1.646)*	
Pro director					0.171
					(1.174)
Pro director*Tenure					-0.094**
					(-1.983)
$Tenure^2$	0.000	0.034***	0.034***	0.034***	0.029***
	(0.364)	*(4.190)*	*(4.161)*	*(4.162)*	*(3.225)*
Ln(assets)	-0.844***	-1.035***	-1.031***	-1.031***	-0.733***
	(-6.387)	*(-8.264)*	*(-8.234)*	*(-8.240)*	*(-4.983)*
Dividend Payer	-0.895***	-1.499***	-1.500***	-1.502***	-1.211***
	(-4.991)	*(-8.190)*	*(-8.202)*	*(-8.207)*	*(-7.020)*
Leverage	1.196***	1.726***	1.721***	1.722***	1.303**
	(3.823)	*(4.057)*	*(4.037)*	*(4.044)*	*(2.443)*
MB	0.001***	0.001**	0.001**	0.001**	0.001***
	(6.636)	*(2.242)*	*(2.276)*	*(2.272)*	*(3.159)*
ROA	-1.790***	-2.688***	-2.689***	-2.689***	-3.461***
	(-6.253)	*(-5.170)*	*(-5.172)*	*(-5.174)*	*(-6.602)*
Director age					0.003
					(0.897)
Number previous jobs					-0.050**

					(-2.286)
Number previous boards					-0.001
					(-0.153)
Experience CEO public company					0.077
					(1.045)
Constant	17.895***	18.787***	18.750***	18.749***	16.204***
	(11.888)	*(20.160)*	*(20.137)*	*(20.135)*	*(13.798)*
Observations	1,388,539	419,220	419,220	419,220	235,380
R-squared	0.262	0.351	0.351	0.351	0.36
Board fixed effect	yes	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, *
p<0.1

Table 3-4C Additional Tests – Panel C

Panel C: Matched Sample

This table reports regression results from estimating the volatility-director tenure relation for a matched sample. Specifications replicate those of Panel A of Table 3-2 but for a matched sample. Each firm for each of the three original samples is matched to the firm closest in size, based on total assets, that belongs to the same industry. Industries are based on the Fama-French 10 industry classification. Control firms must not experience a director appointment at least one year before and one year after the appointment of a director in the sample firm. In these regressions, all variables are control firm variables, except for the tenure variables, which track the tenure of the new director in the sample firm. The first five years of director tenure are used in all specifications. The sample does not include CEOs and excludes all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include board fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

	(1) Idiosyncratic Volatility	(2) Realized Volatility	(3) Idiosyncratic Volatility	(4) Realized Volatility	(5) Idiosyncratic Volatility	(6) Realized Volatility
Tenure	-0.007	-0.013				
	(-0.158)	*(-0.236)*				
$Tenure^2$	0.005	0.004				
	(0.614)	*(0.422)*				
Ln(1+tenure)			0.049	0.024		
			(1.089)	*(0.444)*		
-1/(1+tenure)					0.086	0.036
					(0.864)	*(0.301)*
Ln(assets)	-0.840***	-0.783***	-0.840***	-0.783***	-0.840***	-0.783***
	(-7.251)	*(-5.676)*	*(-7.251)*	*(-5.676)*	*(-7.255)*	*(-5.678)*
Dividend Payer	-1.783***	-1.813***	-1.783***	-1.813***	-1.783***	-1.813***
	(-11.035)	*(-9.863)*	*(-11.031)*	*(-9.861)*	*(-11.028)*	*(-9.860)*
Leverage	1.060***	1.073***	1.059***	1.073***	1.059***	1.072***
	(2.970)	*(2.773)*	*(2.967)*	*(2.771)*	*(2.966)*	*(2.771)*
MB	0.001	0.001	0.001	0.001	0.001	0.001
	(0.793)	*(1.071)*	*(0.802)*	*(1.075)*	*(0.804)*	*(1.076)*
ROA	-2.988***	-3.264***	-2.990***	-3.266***	-2.992***	-3.267***
	(-7.755)	*(-7.156)*	*(-7.761)*	*(-7.160)*	*(-7.766)*	*(-7.163)*
Market Beta		1.118***		1.118***		1.118***
		(24.236)		*(24.236)*		*(24.234)*
SMB Beta		0.461***		0.461***		0.461***
		(20.773)		*(20.773)*		*(20.773)*
HML Beta		0.110***		0.110***		0.110***
		(5.681)		*(5.679)*		*(5.679)*
Constant	16.868***	18.216***	16.911***	18.247***	16.982***	18.270***
	(17.646)	*(15.747)*	*(17.706)*	*(15.819)*	*(17.377)*	*(15.468)*
Observations	386,981	386,981	386,981	386,981	386,981	386,981
R-squared	0.283	0.539	0.283	0.539	0.283	0.539
Board fixed effect	yes	yes	yes	yes	yes	yes
Calendar month fix. Eff.	yes	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3-5 Summary of Previous Empirical Evidence and Evidence from the Learning-based Methodology

	Study	**Finding**	**Evidence from Learning-based Approach**
Position on the Board			
Chairman	Nguyen and Nielsen (2010)	Larger stock price reaction to death of chairman	Chairman has higher marginal value
Audit member	Nguyen and Nielsen (2010)	Larger stock price reaction to death of audit committee member	Chair of audit committee has higher marginal value
Compensat. member	N/A	N/A	Chair of compensation committee has higher marginal value
Nominating member	Nguyen and Nielsen (2010)	Larger stock price reaction to death of nominating committee member	No significant effect
Independent directors	Bhagat and Black (2000); Hermalin and Weisbach (1991)	No relation between % outside directors and Tobin's Q/accounting measures	Independent directors with industry expertise and independent directors joining firms with high monitoring needs have higher marginal value
	Duchin, Matsesaka, Ozbas (2010)	Independent directors improve performance when their information cost is low	
	Weisbach (1988)	Boards dominated by outside directors more likely to replace CEO in bad times	
	Masulis, Ruzzier, Xiao and Zhao (2012)	Positive correlation between the presence of independent directors with industry expertise and firm performance	
	Gillan, Hartzell and Starks (2011)	Powerful boards are substitute for the market of corporate control	

Director Characteristics

Gender	Adams and Ferreira (2009)	Female directors are better monitors, but at the cost of lower firm performance	Female directors have lower marginal value on average. However, when the need for monitoring services is acute, female directors have higher marginal value
	Matsa and Miller (2012); Ahern and Dittmar (2012)	Female directors are associated with decreased firm value and profitability	
Busyness	Fich and Shivdasani (2006)	Busy directors are associated with lower firm value	Busy directors have higher marginal value
	Core, Holthausen and Larcker (1999)	Busy outside directors are associated with increased CEO compensation	
	Ferris, Jagannathan and Pritchard (2003)	Positive announcement returns to appointments of busy directors	
	Falato, Kadyrzhanova and Lel (2014)	Busy directors are detrimental to board monitoring quality and shareholder value	
	Field, Lowry and Mkrtchyan (2013)	Busy directors are beneficial for small young firms but detrimental for large firms	

Board Level Characteristics

Entrenched boards and powerful CEOs	Hermalin and Weisbach (1998)	Model predicts increased CEO bargaining power vis-a-vis the board over CEO tenure	Boards with powerful CEOs have lower marginal value
	Shivdasani and Yermack (1999)	More powerful CEOs are able to select a less independent board	
	Fracassi and Tate (2012)	Powerful CEOs appoint directors with ties to the CEO resulting in weaker monitoring	
Groupthink	Coles, Daniel and Naveen (2015)	Groupthink has a negative effect on firm value for firms in dynamic industries	Directors joining boards prone to groupthink (with a high percentage of directors with long tenure) have lower marginal value

Board size	Yermack (1996); Eisenberg, Sundgren and Wells (1998)	Inverse association between board size and Tobin's Q	Smaller boards have higher marginal value
Board Pay Slice	N/A	N/A	Better compensated boards have higher marginal value
Firm Level Characteristics			
Firm size	N/A	N/A	Directors have higher marginal value in small firms
Prior performance	Mace (1971) Larcker, So and Wang (2013)	Interview evidence that boards' activiness is limited to crisis situations Board network resources are most valuable for firm with poor performance	Directors have higher marginal value when the firm has recently performed poorly
Industry	Coles, Daniel and Naveen (2015)	Groupthink is more detrimental for firms in more dynamic industries	Directors have higher marginal value in complex and human capital intensive industries

Table 3-6A Cross-sectional Tests – Panel A

Panel A: Position on the board
This table reports regression results using interaction variables to identify director attributes that affect the volatility-director tenure relation. Individual terms for committee chairs, control variables, including controls for the ex-ante level of uncertainty are included but not reported for brevity. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include firm fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

Dependent variable: Idiosyncratic volatility	(1)	(2)	(3)	(4)	(5)
Tenure	-0.058	-0.082*	-0.104*	-0.137**	-0.06
	(-1.537)	*(-1.658)*	*(-1.725)*	*(-2.071)*	*(-1.473)*
$Tenure^2$	0.009	0.009	0.019**	0.002	0.016**
	(1.314)	*(1.297)*	*(2.512)*	*(0.273)*	*(2.005)*
Independent		-0.232**	-0.304**	-0.441***	
		(-2.168)	*(-2.157)*	*(-2.839)*	
Independent*Tenure		0.022	0.046	0.096*	
		(0.617)	*(0.901)*	*(1.835)*	
Job experience same industry			0.055		
			(0.255)		
Job experience same industry*Tenure			-0.041		
			(-0.572)		
Independent*Job experience same industry			0.411*		
			(1.925)		
Independent*Job experience same industry*Tenure			-0.134*		
			(-1.868)		
Chairman	0.345**				
	(2.431)				
Chairman*Tenure	-0.081*				
	(-1.783)				
High monitoring needs				-0.668*	
				(-1.872)	
High monitoring needs*Tenure				0.276***	
				(2.888)	
Independent*High monitoring needs				0.905***	
				(2.707)	
Independent*High monitoring needs*Tenure				-0.216**	
				(-2.228)	
Nomination committee chair*Tenure					-0.044
					(-0.553)
Audit committee chair*Tenure					-0.157***
					(-4.368)
Compensation committee chair*Tenure					-0.086**

					(-2.290)
Governance committee chair*Tenure					-0.06
					(-0.813)
Risk committee chair*Tenure					0.253
					(1.293)
Social committee chair*Tenure					0.062
					(0.636)
Strategy committee chair*Tenure					0.217
					(1.251)
Technology committee chair*Tenure					0.024
					(0.158)
Constant	17.231***	17.393***	17.275***	18.708***	19.967***
	(14.517)	*(14.561)*	*(14.393)*	*(12.895)*	*(17.792)*
Observations	369,321	369,321	369,321	170,499	330,506
R-squared	0.352	0.352	0.353	0.349	0.348
Firm fixed effect	yes	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3-6B Cross-sectional Tests – Panel B

Panel B: Personal attributes
This table reports regression results using interaction variables to identify director attributes that affect the volatility-director tenure relation. Control variables are included but not reported for brevity. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include firm fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

Dependent variable: Idiosyncratic volatility	(1)	(2)	(3)	(4)	(5)
Tenure	-0.072*	-0.06	-0.026	-0.05	-0.049
	(-1.861)	*(-1.233)*	*(-0.608)*	*(-1.303)*	*(-1.271)*
$Tenure^2$	0.009	0.002	0.009	0.009	0.009
	(1.311)	*(0.288)*	*(1.166)*	*(1.242)*	*(1.191)*
Female	-0.171**	-0.163			
	(-2.223)	*(-1.525)*			
Female*Tenure	0.066**	0.068*			
	(2.391)	*(1.792)*			
High monitoring needs		0.144			
		(1.037)			
High monitoring needs*Tenure		0.092***			
		(3.095)			
Female*High monitoring needs		0.207			

		(1.172)			
Female*High monitoring needs*Tenure		-0.104*			
		(-1.757)			
Busy			0.119*		
			(1.770)		
Busy*Tenure			-0.042*		
			(-1.830)		
Board experience same industry				0.156	
				(1.535)	
Board experience same industry*Tenure				-0.054*	
				(-1.739)	
Job experience same industry					0.156
					(1.376)
Job experience same industry*Tenure					-0.113***
					(-3.296)
Director Age	0	-0.002	0.002	0	0
	(-0.140)	*(-0.677)*	*(0.600)*	*(-0.108)*	*(-0.154)*
Number previous jobs	-0.040*	-0.050**	-0.027	-0.040*	-0.03
	(-1.882)	*(-2.207)*	*(-1.311)*	*(-1.889)*	*(-1.401)*
Number previous boards	0.002	-0.001	-0.001	0.001	0.001
	(0.228)	*(-0.053)*	*(-0.125)*	*(0.098)*	*(0.156)*
Experience CEO public firm	0.07	0.073	0.011	0.069	0.067
	(1.044)	*(1.129)*	*(0.194)*	*(1.030)*	*(1.000)*
Constant	17.246***	18.454***	20.989***	17.210***	17.186***
	(14.513)	*(12.898)*	*(20.357)*	*(14.502)*	*(14.469)*
Observations	369,321	170,499	266,480	369,321	369,321
R-squared	0.352	0.349	0.331	0.352	0.352
Firm fixed effect	yes	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3-6C Cross-sectional Tests – Panel C

Panel C: Board characteristics
This table reports regression results using interaction variables to identify board attributes that affect the volatility-director tenure relation. Control variables are included but not reported for brevity. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include firm fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

Dependent variable: Idiosyncratic volatility	(1)	(2)	(3)	(4)

Tenure	-0.092**	-0.026	-0.133***	-0.047
	(-2.279)	*(-0.395)*	*(-3.179)*	*(-0.999)*
$Tenure^2$	0.008	0.009	0.009	0.002
	(1.136)	*(0.718)*	*(1.320)*	*(0.240)*
Groupthink	0.057			
	(0.623)			
Groupthink*Tenure	0.063***			
	(2.904)			
High BPS		1.288*		
		(1.862)		
High BPS*Tenure		-0.530**		
		(-2.444)		
Large board			-0.492***	
			(-4.883)	
Large Board*Tenure			0.115***	
			(4.723)	
High monitoring needs				0.177
				(1.302)
High monitoring needs*Tenure				0.075***
				(2.735)
Director Age	0	-0.007*	0	-0.002
	(-0.094)	*(-1.869)*	*(-0.110)*	*(-0.683)*
Number previous jobs	-0.040*	-0.063***	-0.039*	-0.050**
	(-1.902)	*(-2.865)*	*(-1.859)*	*(-2.218)*
Number previous boards	0.002	0.005	0.002	-0.001
	(0.238)	*(0.531)*	*(0.269)*	*(-0.061)*
Experience CEO public firm	0.068	0.031	0.071	0.07
	(1.024)	*(0.510)*	*(1.058)*	*(1.091)*
Constant	17.364***	11.394***	17.284***	18.424***
	(14.675)	*(6.122)*	*(14.743)*	*(12.863)*
Observations	369,321	113,998	369,321	170,499
R-squared	0.353	0.355	0.353	0.349
Firm fixed effect	yes	yes	yes	yes
Calendar month fixed effect	yes	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3-6D Cross-sectional Tests – Panel D

Panel D: Firm characteristics
This table reports regression results using interaction variables to identify firm characteristics that affect the volatility-director tenure relation. Control variables are included but not reported for brevity. CEOs are excluded and the samples also exclude all directors appointments overlapping with a CEO turnover over a one year period. All model specifications include firm fixed effects as well as month fixed effects. Standard errors are clustered at the firm level. The definition of all variables is in Appendix 3-A.

Dependent variable: Idiosyncratic volatility	(1)	(2)	(3)
Tenure	-0.131***	-0.069	-0.028
	(-3.206)	*(-1.468)*	*(-0.726)*
Tenure^2	0.008	0.001	0.008
	(1.162)	*(0.182)*	*(1.104)*
Large firm	-0.807***		
	(-4.876)		
Large firm*Tenure	0.133***		
	(5.336)		
Poor performance		-0.550***	
		(-6.014)	
Poor performance*Tenure		0.122***	
		(3.906)	
Consumer durables*Tenure			0.149*
			(1.793)
High tech*Tenure			-0.180***
			(-4.871)
Director Age	0.000	0.003	0.000
	(-0.005)	*(1.101)*	*(-0.029)*
Number previous jobs	-0.036*	-0.022	-0.034
	(-1.706)	*(-1.126)*	*(-1.604)*
Number previous boards	0.000	0.000	0.000
	(-0.047)	*-0.018*	*(-0.019)*
Experience CEO public firm	0.064	0.033	0.061
	(0.948)	*(0.574)*	*(0.901)*
Constant	11.112***	22.260***	10.703***
	(23.859)	*(93.469)*	*(24.094)*
Observations	369,321	245,060	369,321
R-squared	0.350	0.328	0.349
Firm fixed effect	yes	yes	yes
Calendar month fixed effect	yes	yes	yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 1-A: Interim IRR

In this Appendix, we present estimates of future fundraising as a function of a fund's interim, as opposed to final, IRR (see the discussion in Section 3.3). Preqin provides interim IRR data for a subset of our main sample of preceding funds, but the time series of interim IRRs for a given fund is almost always incomplete (so it is not possible for us to use these data to estimate, for example, hazard models to predict future fundraising). Similarly, Preqin provides cash flow data for another (partially overlapping) subset, making it possible for us to compute interim IRRs, but the cash flow data for a given fund generally appear to be incomplete. Using these two sources of interim IRR data, we obtain interim IRR at the time of next fundraising for 801 of our 1,745 preceding funds (using the Preqin interim IRR when both are available because the cash flow data are often incomplete). For preceding funds that do not raise a follow-on fund, we use the interim IRR after three years of life, matching the average time between successive fundraisings in our data.

Panel A of Table A-1 shows that the correlation between this interim IRR for a fund and the fund's final IRR is high. The correlation is 0.607 for all funds taken together, 0.551 for buyout funds, 0.618 for venture capital funds, and 0.228 for real estate funds. In Panel B we estimate probit regressions to explain whether a follow-on fund is raised, analogous to Panel A of Table 2-3. The estimated marginal effects are all positive and significant with the exception of real estate funds. For all fund types, the difference between the marginal effects reported in Panel B of Table A-1 and those reported in Panel A of Table 2-3 are statistically insignificant. In Panel C of Table A-1 we estimate regressions predicting (log) fund growth from preceding to follow-on fund, analogous to those reported in Panel C of Table 2-3. Again, all of the estimated coefficients are positive, all are significant except for buyout funds that narrowly miss significance, and none are statistically significantly different from the analogous coefficients reported in Panel C of Table 2-3.

Overall, the evidence presented in Table A-1 suggests that, even if interim IRR were the right way for the econometrician to summarize the information set used by investors in assessing performance at the time of next fundraising (which is questionable, see the discussion in Section 3.3), our results are unlikely to be materially biased by using the fund's final IRR instead, and by doing so we gain the advantage of a substantially greater number of observations and enhanced statistical power.

Table A-1: Correlation between Interim and Final IRRs and Follow-on Fundraising Regressions with Interim IRRs

Panel A presents correlations between interim IRR at time of fundraising and final IRR for all preceding funds for which interim IRR data are available. For preceding funds that do not raise a follow-on, we use the interim IRR after three years (the sample average time to next fundraising). Panels B and C present preceding fund-level regressions to explain follow-on fundraising using this interim IRR. Panel B presents probit regressions in which the dependent variable is 1 if a follow-on is raised and 0 otherwise. There are no estimates for real estate funds because the dependent variable is always equal to one when interim IRR is available. Marginal effects are reported and z-scores are given in parentheses. Panel C presents OLS regressions for preceding funds that raise a follow-on fund. In Panel C, the dependent variable is the natural logarithm of fund growth plus one. In Panels B and C,"All Funds" regressions include fund type fixed effects and model (2) includes vintage year fixed effects. Heteroskedasticity-robust standard errors are clustered at the PE firm level. In Panel C, t-statistics are given in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Correlation between Interim IRR at time of fundraising and Final IRR

	All Funds	Buyout
Correlation	0.607	0.551
Number of observations	801	304

(continued)

	Venture Capital	Real Estate
Correlation	0.618	0.228
Number of observations	433	64

Panel B: Probit regressions for the probability of raising a follow-on fund

	All Funds		Buyout	
	(1)	(2)	(1)	(2)
Preceding fund interim IRR	0.383***	0.459***	0.484***	0.574***
	(3.165)	(3.400)	(3.361)	(3.437)
Number of observations	801	715	304	255
Pseudo R2	0.076	0.124	0.096	0.142

(continued)

	Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)
Preceding fund interim IRR	0.345*	0.399**	0.159	1.048*
	(2.117)	(2.229)	(1.486)	(1.738)
Number of observations	433	383	64	18
Pseudo R2	0.055	0.140	0.034	0.198

Panel C: OLS regressions for log(fund growth + 1) conditional on raising a follow-on fund

	All Funds		Buyout	
	(1)	(2)	(1)	(2)
Preceding fund interim IRR	0.126***	0.099***	0.203**	0.217**
	(3.549)	(2.860)	(2.090)	(2.202)
Constant	0.947***	1.108***	0.934***	1.125***
	(39.406)	(5.390)	(32.746)	(4.432)
Number of observations	651	651	251	251
Adjusted R2	0.042	0.116	0.013	0.123

(continued)

	Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)
Preceding fund interim IRR	0.099***	0.062*	0.816***	0.660**
	(2.655)	(1.685)	(2.925)	(2.410)
Constant	0.825***	0.960***	0.685***	0.796**
	(42.086)	(2.841)	(8.916)	(2.274)
Number of observations	339	339	61	61
Adjusted R2	0.018	0.120	0.112	0.263

Appendix 2-A: Timeline of the D&O insurance acquisition and information release

Firm operates as a private enterprise

D&O insurance purchased or not (no public information) as a private enterprise (the insurer conducts an audit and negotiates with the firm the coverage and premium)

Firm decides to go public

Firm contacts investment banker and decides whether to purchase D&O insurance as a "new" public firm (no public information). The Offering prospectus that includes a pro-forma annual statement, the date of the IPO and the offering price is made public

IPO

End of fiscal year (not necessarily 12 months after the IPO)

First annual report as a public firm is released

First management proxy is released. This is usually the first occurrence of public information about D&O insurance. The information relates to the previous year in all instances in the dataset.

Appendix 2-B: Examples.

Two examples of how the information related to the D&O insurance contract is release and appears in management proxies to illustrate the timing of D&O insurance purchase.

> "Associated Brands (IPO on November 15th 2002): the management proxy dated May 5th 2003 states that "directors and officers ... are covered under a directors' and officers' insurance policy that provides aggregate coverage to the insured individuals of $15 million, subject to a $150,000 deductible on securities claims and a $75,000 deductible on other claims. The premium paid by the Fund for this coverage for the period from November 1, 2002 to October 31, 2003 was $180,965."

> "Bridgewater Systems Corporation (IPO on December 14th 2007): the management proxy dated May 13th 2008 states that "The Corporation maintains directors' and officers' liability insurance coverage with a deductible of $25,000 for each non-securities claim and $50,000 for each securities claim with a $10 million limit in aggregate. Coverage includes errors, omissions or breach of fiduciary duty by the directors and officers during the discharge of their legal duties. The Corporation's annual premium is $73,576 (plus tax) which covers a twelve month period from December 1, 2007 to December 1, 2008."

Appendix 2-C: Definition of control variables.

Unless noted otherwise, all independent variables are measured using accounting information available in the firms' first annual report post-IPO.

Financial variables

We use *FirstDayReturn* as a control variable to account for the possible underpricing of IPO shares on the first day of trading to attract risk-averse investors (for a more thorough discussion, see Ritter, 1987, *inter alia*). This variable is computed as the price at the end of the first day divided by the offer price.[50] *MarketRet* is the one-year post-IPO return of the stock market as calculated by the total return of Canada's main stock index. It should be positively correlated with the stock market return. *RiskFree*, *SMB* and *HML* are the risk free rate, and the two Canadian Fama-French size and growth portfolios (available until 2009 only) respectively.

We measure firm size by the log of the firm's market value of equity at the time of the IPO (*lnMVE_IPO*). Large firms should be less volatile and have less idiosyncratic risk, and have higher returns because more investors will scrutinize the activities of larger firms. We use a firm's market value of equity at the time of the IPO to make sure that this measure of size is not confounded with stock market returns. The *lnMVE_IPO* variable is calculated as the log of the product of the offer price by the number of shares outstanding on the day of the IPO.

$$Growth = \frac{market\ value\ of\ equity\ at\ time\ of\ IPO + book\ value\ of\ liabilities}{book\ value\ of\ assets}$$ (see Core, 1997)

measures a firm's growth opportunities. A firm with a high growth ratio should be more profitable if the

[50] For 16 firms, we do not have the price on the first day post-IPO (but only 3 of those have an IPO completion date post 1996, and only 1 gives us the information to calculate the rate-on-line). Instead of dropping the observation from our analysis, we decided to first assign a value of 0 for the first day return, and second to use the impute command in Stata using the first year return, the market return and the firm's industry to impute the return on the first day.

growth options turn out to be in the money. Consequently, we expect high growth firms to have higher first year returns on average. We also expect firms experiencing higher growth to have more volatile returns. *ROA* is the return on assets computed as $\frac{NetIncome}{Total\ Assets}$. We expect firms with a higher ROA to have a better stock market performance.

Finally, the last financial variable we use is the firm's book leverage (or *Debt_Ratio*), which is $\frac{Total\ Liabilities}{Total\ Assets}$. Stock market volatility and idiosyncratic risk should be lower if debt holders are exercising a greater level of monitoring. On the other hand, the more levered is the firm the higher should be its stock return volatility since it is more at risk of going bankrupt. The net effect is undetermined.

Governance variables

We collected several variables related to governance: CEO and chairman of the board duality, board composition and independence as well as the presence of a blockholder. We also control for the corporate structure.

Duality is an indicator variable taking on the value one if the chairman of the board is also the company's chief executive officer and zero otherwise. This particular feature of a board is usually viewed as an entrenchment red flag. If entrenchment is an issue then *Duality* could be associated with low volatility and a low idiosyncratic risk (because the CEO/COB does not want to risk bankruptcy), and low returns (if firm resources are spent on negative NPV projects). Because *Duality* affects both risk and return in the same direction, we do not expect to see much impact on the Sharpe ratio variables.

Blockholder is an indicator variable equal to one if a shareholder owns 10% or more of the firm's voting shares according to its first proxy statement. Similar to debtholders, blockholders should have more at stake in monitoring the firm. Consequently, *Volatility* and *Idiosyncratic* is expected to be lower when a blockholder is present.

Independence is the percentage of unrelated directors on the board of directors as reported in the firms' proxy statements. The presence of a more independent board could increase returns if it prevents the entrenchment of management and if it reduces the likelihood of cash flow misappropriation.

The *ITCE* variable is an indicator variable equal to one if the company is an income trust and zero otherwise. We include this variable since Halpern (2004), Gillen (2005), Zetzsche (2005) and Huson and Pazzaglia (2007) argue that income trusts are riskier than stock companies from a governance standpoint. Boyer and Stern (2012) find that firms incorporated as income trusts pay more to protect their directors and officers, *ceteris paribus*. Income trusts are required to pass along more of their operating cash flows to their investors, which reduces volatility as well as returns since earnings are typically not reinvested, which makes capital gains infrequent. *Volatility* and *Idiosyncratic* should also be lower since income trusts distribute more dividends, and are typically older and more mature firms than stock companies. The relationship between *ITCE* and the Sharpe ratio is therefore undetermined as the numerator and the denominator are expected to be lower if the firm is an income trust.

Other variables

Risky_Industry is an indicator variable equal to one if the firm belongs to one of the ten two-digit SIC codes risky industries as identified in Bajaj *et al.* (2000). Firms that belong to one of these ten risky industries that were deemed riskier based on the number of cases settled as well as the average settlement amount should have more volatile stock returns and risk, and higher returns on average. Firms operating in risky industries should also be more likely to purchase D&O insurance if only because of the higher frequency of lawsuits.

Age measures the number of years since the start of the company's operations at the time of the IPO announcement. We expect this variable to have a negative relationship with stock market volatility and idiosyncratic risk since the more mature firms becoming public should have more stable cash flows, everything else equal.

The service offered by the investment banker at the time of the IPO is represented by the variable *IPOfeerat*, which is calculated as the total fees paid at the time of the IPO divided by the product of the offer price and the number of shares issued.[51] We expect firms that purchase a higher level of service to have higher returns in the first year and lower volatility and idiosyncratic risk.

Float is the ratio of the number of shares issued at the IPO on the total number of shares outstanding after the IPO. We expect that firms that have a higher float should have less volatile market returns because more investors are likely to follow the firm, therefore disseminating the appropriate information to the markets[52]. With respect to the decision to purchase D&O insurance or not, *Float* should be positively correlated with the decision to purchase. The reason is that the more shares are issued, the greater the probability of litigation and the greater should be the expected loss conditional on a claim arising (see Gutiérrez, 2003, and Boyer, 2003) since minority shareholders are the most likely originator of lawsuits against managers. At the same time, a greater float means that the "firm's entrepreneur" has gotten rid of a larger portion of the firm, which should be a bad signal to markets. If such adverse selection is present, stock returns should be negatively related to the float.

US_Presence is a dummy variable equal to one if the firm reports any activity in the United States (sales, assets, etc.). The variable was collected by reading annual reports for the year following the IPO.

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[51] For 21 firms, we do not have the fee paid. Since we felt that the cost of dropping these observations was too high (10% of our sample), we instead decided to impute a value for the fee ratio. 40% of the firms pay an IPO fee of exactly 6%, and 90% of the firms paid a fee ratio between 4.5% and 7%. We first opted to assign a value of 6% to the missing *IPOfeerat* variable values. We also calculated the predicted fee using the first day return, the log of the market value of the firm at the time of the IPO, whether the firm is incorporated as an income trust and the number of shares issued at the time of the IPO (a regression that has an adjusted R^2 of 78%), and then calculated the *IPOfeerat* variable value using the same aforementioned rule (or assigned value 2% if the imputed value is negative). In all cases, the results are sensibly the same.

[52] It could also be the case that a higher float implies more differences of opinion which would generate more trading and more volatility. In this case, the net effect of *Float* on *Volatility* and *Idiosyncratic* is undetermined. We thank a referee for suggesting this possibility.

The United States being a more fertile environment for potential litigation (Clarkson and Simunic, 1994, Heys and Berenblut, 2012), we expect this variable to be positively correlated with the decision to purchase D&O insurance. A related measure to *US_Presence* is *US_Sales* that is measured as the ratio of sales that a firm reports doing in the United States to total sales. Sales in the United States should increase stock returns since it is a proxy for the potential growth in sales and profitability of the company.

Hard is a dummy variable equal to one if the year the firm completed its IPO is deemed to be a hard market year by D&O insurance experts, and zero otherwise. A hard market is characterized by lower policy amounts with higher prices. We used the annual premium index available in the Towers Perrin reports to compute the ten year average premium and labeled as 'hard' all years above the ten year average. This resulted in years 2002 through 2006 to be considered a hard market, which is in line with the general consensus of D&O insurance market specialists.

Big5 is a dummy variable equal to one if the lead IPO underwriter is one of the five main investment bankers in Canada. The five largest underwriters represent 70% of the Canadian market. Investment banker reputation is used as a proxy for the level of information asymmetry during the IPO process.

Appendix 3-A: Variable Definitions

All board and director variables are from BoardEx, financial variables are from Compustat and market variables are from CRSP.

Director Attributes	
Tenure	Time since a director joined a board (in years). Constructed from BoardEx start and end role dates.
First3	Indicator variable equal to one each month of the first three years of the director's tenure
Director age	Age of the director (in years)
Female	Indicator variable equal to one if the director is female. From BoardEx and manually collected
Independent	Indicator variable equal to one if the director is independent
Chairman	Indicator variable equal to one if the director is the chairman of the board
Busy	Indicator variable equal to one if the director serves simultaneously on three or more boards
Experience CEO public firm	Indicator variable equal to one if the director is or has previously been CEO of a public corporation
Board exp same industry	Indicator variable equal to one if the director is serving or has previously served on the board of a firm in the same industry. Industries are based on the Fama-French ten-industry classification
Job exp same industry	Indicator variable equal to one if the director is working or has previously worked for a firm in the same industry. Industries are based on the Fama-French ten-industry classification
Number previous boards	Number of previous directorships held
Low uncertainty	Indicator variable equal to one for directors who have experience as the CEO of a public firm and have served on at least four corporate boards
High uncertainty	Indicator variable equal to one for directors who do not have previous board experience and do not have experience as CEO
Pro director	Indicator variable equal to one for directors who have held at least four previous directorships and have held directorships in the same industry
Single appointment	Director appointed solo, i.e. no other directors were appointed during the six month period around her appointment
Single appointment2yrs	Director appointments for which there are no other appointments during the two year period around her appointment

Exchange mandated	Appointments designed to meet the new exchange independence requirement. Director arrival results in the board complying with the new 50% independence requirement when it did not prior to that director's appointment. A director appointment therefore qualifies for this sample if the director joins the board between 2002 and 2005 and the firm previously did not comply with the 50% independence requirement. These appointments must occur when the firm's stock return has outperformed the S&P500 over the year preceding the appointment and the firm's average monthly stock return volatility over the six month period preceding the appointment is lower than the average over the two years preceding the appointment
Retirement/death replacement	Appointments within six months following the departure of a director who was over 70 years old, or of a director who served simultaneously on multiple boards and left all of her directorships within three years, or who passed away. These appointments must occur when the firm's stock return has outperformed the S&P500 over the year preceding the appointment and the firm's average monthly stock return volatility over the six month period preceding the appointment is lower than the average over the two years preceding the appointment
Pooled exogenous	Includes exchange mandated appointments and retirement/death replacements
SimScore	Similarity score for each incoming-departing director pair. See Appendix 3-C for details

Appendix 3-A (continued)

Board Attributes	
Avg board tenure	Average tenure of the directors of a board in a given month (in years)
Avg board tenure square	Square of *Average board tenure*
Young boards	Boards are ranked based on the average tenure of their members, each month. Young boards are those in the first tercile
Seasoned boards	Boards are ranked based on the average tenure of their members, each month. Young boards are those in the third tercile
Gender diverse board	Indicator variable equal to 1 if at least one woman serves on the board
Board size	Number of directors on the board
Large board	Indicator variable equal to 1 if board size is larger than the sample mean
Entrenched	Indicator variable equal to 1 if the CEO has been in office for 5 or more years and cumulates the titles of CEO, Chairman and President
Groupthink	Percentage of directors on the board with tenure greater than 9 years
Board Pay Slice	Ratio of total independent directors compensation over CEO compensation (salary + bonus)
High Board Pay Slice	Indicator variable equal to 1 if Board Pay Slice is in the top quartile

Firm Level Variables	
Ln(assets)	Natural logarithm of total firm assets (item AT in Compustat)
Dividend payer	Indicator variable to one if the firm pays dividends (item DVC in Compustat)
Leverage	Long-term debt over total assets (item DLTT/AT in Compustat)
MB	Market to book ratio: Stock price at year end*common shares outstanding over total common equity ((PRCC_C*CSHO)/CEQ in Compustat)
ROA	Return on assets: net income over total assets (NI/AT in Compustat)
Firm age	Age of the firm measured as the number of years since the first appearance of the firm in CRSP, as in Fama and French (2004)
High monitoring needs	Indicator variable equal to one for large firms with entrenched boards
Poor performance	Indicator variable equal to one for firms with a stock return performance inferior to that of the S&P500 over the one year period preceding the appointment
Large firm	Indicator variable equal to one if the firm's assets is in the top quartile

Market Variables	
Idiosyncratic volatility	Variance of the residuals of a daily Fama-French three factor model as in Ang et al. (2006), aggregated monthly, winzorized at the 1% cutoff
Realized volatility	Standard deviation of daily stock returns, aggregated monthly, winzorized at the 1% cutoff
Market beta	Estimated coefficient on the excess market return in a daily Fama-French three factor model, aggregated monthly
SMB beta	Estimated coefficient on the SMB factor in a daily Fama-French three factor model, aggregated monthly
HML beta	Estimated coefficient on the HML factor in a daily Fama-French three factor model, aggregated monthly

Appendix 3-B: Learning Model

The learning model is based on the theoretical work of Pastor and Veronesi (2003). The setup is similar to the stylized model in Pan, Wang and Weisbach (2015). In the model, the ability of directors refers to their capacity to facilitate the generation of cash flows. When newly appointed directors join a board, their personal aptitude and capacity to influence this particular board are uncertain, as is the degree of complementarity between their expertise and that of current board members. The uncertainty surrounding the ability of new board members resolves over time as these parameters are gradually revealed to the market. In the model, dividend growth follows a geometric Brownian motion:

$$\frac{dD_{it}}{D_{it}} = \left(\sum_{j=1}^{n} \alpha_j^i\right)dt + \sigma dW_t \qquad \text{(A1)}$$

where D_{it} is dividend for firm *i* at time *t*,

$\sum_{j=1}^{n} \alpha_j^i$ is the sum of directors' unobserved abilities, which affects the average dividend growth rate,

σ is dividend growth volatility.

Director *j* has the ability α_j^i to contribute to the generation of cash flows for firm *i*. This ability is unknown and unobservable but subject to learning. The ability of each director is assessed by investors over time. For each firm, the sum of directors' assessed abilities may be thought of as investors' assessment of the quality of the board. The ability of a director may depend on firm characteristics. For example, a director with relevant industry expertise may contribute more to firm value for a firm which operates in that particular industry.

It is assumed that there is symmetric information (see Holmström, 1999; Gibbons and Murphy, 1992; Berk and Green, 2004 and Chung, Sensoy, Stern and Weisbach, 2012 for symmetric information about managers' abilities). Assuming that α_j^i follows a truncated normal distribution with prior mean $\theta_{j,0}^{i}$ and variance $\delta_{j,0}^{i2}$ and that director abilities are independent and identically distributed, individual assessed ability at time *t* is normally distributed:

$$\alpha_{j,t}^{i} \sim N\left(\theta_{j,t}^{i}, \delta_{j,t}^{i2}\right), \qquad \alpha_{j,t}^{i} < r \tag{A2}$$

The sum of assessed abilities also follows a normal distribution:

$$\sum_{j=1}^{n} \alpha_{j,t}^{i} \sim N\left(\sum_{j=1}^{n} \theta_{j,t}^{i}, \sum_{j=1}^{n} \delta_{j,t}^{i2}\right) \tag{A3}$$

Under these assumptions, Bayesian updating by market participants leads to posterior assessments of directors' ability (Pastor and Veronesi, 2003):

$$d\left(\sum_{j=1}^{n} \theta_{j,t}^{i}\right) \approx m_t \left[\frac{dD_{i,t}}{D_{i,t}} - \left(\sum_{j=1}^{n} \theta_{j,t}^{i}\right) dt\right] \tag{A4}$$

$$with \quad m_t = \frac{\sum_{j=1}^{n} \delta_{j,t}^{i2}}{\sigma^2} = \frac{\sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right) t} \tag{A5}$$

The revised assessment of ability is a function of two terms: m_t and the expression in brackets. Agents observe a higher-than-expected signal about the ability of a group of directors when $\left[\frac{dD_{i,t}}{D_{i,t}} - \left(\sum_{j=1}^{n} \theta_{j,t}^{i}\right) \mathrm{dt}\right]$ is positive, and revise their expectations upwards accordingly. This revision depends on m_t, which is the ratio of uncertainty about directors to uncertainty about the firm's dividends. This implies that conditional on the realization of the signal, the larger the uncertainty about directors, the larger the revision of assessed ability. Therefore, the Bayesian learning framework predicts a positive relationship between the uncertainty about the ability of directors and the magnitude of the revision of assessed ability. Bayesian updating generates posterior variance of the assessment of ability of the form:

$$\sum_{j=1}^{n} \delta_{j,t}^{i2} = \frac{\sigma^2 \sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right) t} \tag{A6}$$

The posterior variance of assessment of directors' ability $\sum_{j=1}^{n} \delta_{j,t}^{i2}$ does not depend on the realization of the signal but has a negative and convex relationship with *t*. Therefore, the model predicts a decreasing and convex learning curve: the uncertainty about ability dissipates over time and learning is faster at the beginning of director tenure. The revised variance $\delta_{j,t}^{2}$ is always smaller than the initial variance $\delta_{j,0}^{i2}$ and represents the uncertainty about parameter θ. Ability α_j^i is assumed constant for each director. As market participants learn about ability, the uncertainty dissipates and eventually $\delta_{j,t}^{i2} \rightarrow 0$. Timmermann (1993) shows that when agents do not know the true data-generating process for dividends, learning generates excess stock return volatility. Pastor and Veronesi (2003, 2009) formalize this intuition and derive an approximation for return volatility. In the context of this paper:

$$\text{Return Volatility} \approx \text{Dividend Growth Volatility} \times \left[1 + \left(\frac{\partial \log\left(\frac{P}{D}\right)_t}{\partial\left(\sum_{j=1}^{n} \theta_{j,t}\right)}\right)\left(\frac{\sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right)t}\right)\right] \quad \text{(A7)}$$

Equation (A7) directly motivates the empirical analysis in this paper. In the above equation, $\frac{\partial \log\left(\frac{P}{D}\right)_t}{\partial\left(\sum_{j=1}^{n} \theta_{j,t}^{i}\right)}$ represents the sensitivity of the $\log(\frac{P}{D})$ to the mean assessment of ability and can therefore be interpreted as the marginal return to directors' ability. $\left(\frac{\sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right)t}\right)$ is m_t, and can be interpreted as the ratio of uncertainty about directors to uncertainty about the firm's dividends (see Equation (A5)). Equation (A7) therefore implies that three components affect stock return volatility: fundamental volatility, *ex-ante* uncertainty about directors' ability and marginal return to ability (MRA). Equation (A7) can be rewritten as:

$$Vol \approx \sigma\,(1 + MRA_t \times m_t) \quad \text{(A8)}$$

If directors take actions that influence the generation of cash flows, then MRA>0. In that case, return volatility is positively related to the uncertainty about directors' ability *via* m_t. Note that we know from Equation (A5) that m_t declines at a predetermined rate over time due to Bayes' rule and that this rate is faster for higher *ex-ante* levels of uncertainty about ability. This implies that after controlling for *ex-ante* uncertainty, cross-sectional analysis of declines in volatility provides estimates of directors' marginal value. In other words, the extent of the decline in volatility depends on the marginal value of that director.

In sum, the model presented above implies that if directors do not engage in window-dressing but do in fact make a difference in the fortunes of the companies onto which boards they sit, then we should observe a decline in volatility over director tenure. Moreover, the decline should be more pronounced when directors are more value relevant. By exploiting the empirical analysis stemming from these predictions, this article offers a new methodological approach to evaluating corporate boards.

Appendix 3-C: SimScore

SimScore counts the number of shared characteristics from a pool of six characteristics for incoming-departing director pairs when the departing director left due to death or retirement and the firm operates in an environment of good stock return performance and low return volatility at the time of appointment. All variables are constructed from BoardEx data and supplemented with manual data collection when necessary. An incoming-departing director pair gets one point for each characteristic in common, for a total of six possible points.

Gender	from BoardEx, supplemented with manual collection.
Generations	depression babies (born before 1926) mature generation (born 1927-1945) baby boomers (born 1946-1964) generation X (born 1965-1980) generation Y (born after 1981)
Job expertise	based on the directors' job history in BoardEx. Word searches are used to define eleven categories: management academia politics military human resources technology science marketing law finance consulting
Board experience	indicator variable equal to one for directors who have held a minimum of two public directorships.
Industry directorship	indicator variable equal to one for directors who have held directorships in the same industry as the firm they are joining/leaving.
Industry work experience	indicator variable equal to one for directors who have worked in the industry of the firm they are joining/leaving.

SimScore summary statistics	
Mean	3.49
25%	3
Median	4
75%	4
Std dev	1.22
Min	0
Max	6

Appendix 3-D: Estimating Director Related Uncertainty

The methodological approach in this paper allows estimating the percentage of overall volatility imputable to the uncertainty surrounding the ability of directors at the time of their appointment (δ_0/Vol_0). This section directly relies on the methodology derived in Pan et al. (2015). It involves estimates of the average decline in volatility over director tenure, the average volatility in corporate dividends (σ) and the average volatility at the time directors joins (Vol_0).

From the return volatility approximation (see Appendix B for details):

$$\text{Vol} \approx \sigma \times \left[1 + \left(\frac{\partial \log\left(\frac{P}{D}\right)_t}{\partial\left(\sum_{j=1}^{n} \theta_{j,t}\right)}\right)\left(\frac{\sum_{j=1}^{n} \delta_{j,0}^{i2}}{\sigma^2 + \left(\sum_{j=1}^{n} \delta_{j,0}^{i2}\right)t}\right)\right]$$

let $Vol' = \frac{Vol}{\sigma} - 1$ be the percentage excess volatility. Then, $Vol' = MRA_t m_t$, and the percentage change in excess volatility from time 0 to time *t* is $\frac{\Delta Vol'}{Vol'_0} = \frac{\Delta m}{m_0} + \frac{\Delta MRA}{MRA_0} \times \left(1 + \frac{\Delta m}{m_0}\right)$.

The marginal return to ability is hypothesized constant over time, therefore, $\frac{\Delta Vol'}{Vol'_0} = \frac{\Delta m}{m_0}$. Then, $\frac{\Delta m}{m_0} = \frac{1}{1+m_0 t} - 1 = \frac{\Delta Vol'}{Vol'_0} = \frac{\Delta Vol}{Vol_0} \times \frac{Vol_0}{Vol_0 - \sigma}$. When *t* = 3, the percentage of overall volatility attributable to the uncertainty about new directors, $\frac{\delta_0}{Vol_0} = \sqrt{\frac{1}{3}\left[\frac{1}{1 - \frac{\Delta Vol'}{Vol'_0}} - 1\right]} \times \frac{\sigma}{Vol_0}$.

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Ph.D. Finance student The Ohio State University, Fisher College of Business, Columbus, OH	2009-2011
M.Sc. Finance HEC Montréal, Montréal, Canada	2007 – 2009
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Professional Experience

Acting Assistant Professor of Finance Foster School of Business, University of Washington	2016 – present
Teaching Assistant Whitman School of Management, Syracuse University	2013-2016
Research Assistant Fisher School of Business, The Ohio State University	2009-2011

Best Paper Awards

Outstanding Paper Award, International Conference on Asia-Pacific Financial Markets, 2012
Wharton-WRDS Award for Best Paper on Empirical Finance, WFA meetings, 2011
Bank of Canada Best Paper Award, Northern Finance Association Conference, 2010

Doctoral and M.Sc. Research Grants

Doctoral Award, Social Sciences and Humanities Research Council of Canada, 2009 – 2015
Summer Research Grant, Whitman Research Committee, 2013-2015
Master Award, Social Sciences and Humanities Research Council of Canada, 2008 – 2009
Research Grant, HEC Montréal, Finance Department, 2007

Other Grants

AFA Doctoral Student Travel Grant, 2015

Awards of Excellence
Women in Finance Association, 2009
National Bank of Canada, 2008
Standard Life-Edouard Montpetit, 2008

Special distinctions
Mercure Excellence Profile, HEC Montréal, 2007
Honors Profile, HEC Montréal, 2007