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Owners' portfolio diversification and firm investment: Theory and evidence from private and public firms *

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Abstract

Portfolio diversification of firms' controlling owners influences their firms' capital investment. Empirically, the effect of owners' portfolio diversification on their firms' investment levels is positive for publicly-traded firms and tends to be negative for privately-held ones. These findings are consistent with predictions of a model in which a risk-averse investor simultaneously chooses her portfolio structure, and both the level and riskiness of capital investment of the firm she controls, and in which the firm can be potentially constrained in its capital investment choices. Overall, our results indicate that owners' portfolio underdiversification and firms' financial constraints can impact firms' resource allocation.

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In this paper we examine theoretically and empirically the relation between the portfolio diversification of firms' controlling owners and their firms' capital investment. Portfolio diversification of a firm's controlling owner may influence her choice of riskiness of firm strategies, since an expected-utility-maximizing risk-averse owner takes into account the variance of her overall wealth when making decisions on behalf of the firm she controls. Higher portfolio diversification reduces both the variance of the owner's portfolio return and its covariance with the firm's cash flow. As a result, higher portfolio diversification of the firm's owner lowers her risk avoidance incentives and leads to increased risk taking by the firm.

Existing empirical evidence is generally consistent with firm owners' portfolio diversification having a positive relation with their firms' risk-taking (e.g., Amihud and Lev (1981) and Faccio, Marchica and Mura (2011)). The general theme in the existing literature is that firm riskiness can be reduced primarily by means of choosing safer investments, i.e., investments that result in lower cash flow volatility or stock return volatility (e.g., Low (2009) and Faccio, Marchica and Mura (2011)), or lower correlation with the rest of the firm's decision makers' cash flows (e.g., Amihud and Lev (1981), Anderson and Reeb (2003), and Gormley, Matsa and Milbourn (2013)).¹ However, in addition to the mix of relatively risky and safe investment projects, a firm's riskiness depends on its *level of capital investment*. For example, substituting cash for risky capital investments and/or raising external financing and investing the proceeds in risky projects increases the firm's cash flow variability (e.g., Petersen (1994), Kothari, Laguerre and Leone (2002), and Amir, Guan and Livne (2007)).

Understanding the effects of owners' portfolio diversification on firms' strategies, in particular investment decisions, is important, since firms' controlling owners, and decision makers more generally, tend to be underdiversified (e.g., Benartzi and Thaler (2001), Moskowitz and Vissing-Jørgensen (2002), Agnew, Balduzzi and Sunden (2003), Heaton and Lucas (2004), Faccio, Marchica and Mura (2011), and Thesmar and Thoenig (2011)). One important reason for this underdiversification is the cost of achieving full diversification, which we refer to as *limits to diversification*. The efficient frontier of risky assets includes both publicly-traded assets and privately-held ones, private firms' equity in particular. Because of several capital market frictions, investment in non-publicly-traded assets is costly, and portfolios on the efficient frontier

¹An additional channel through which firms' decision-makers may influence their equity holders' cash flow variability is capital structure and payout policy (e.g., Anderson and Reeb (2003), Chen, Miao and Wang (2010), Hayes, Lemmon and Qiu (2012), and Gormley, Matsa and Milbourn (2013)).

are typically unattainable.² The degree of underdiversification due to limits to diversification is likely to be large, as the majority of firms are privately-held, and private firms are responsible for a large part of aggregate investment and output.³

Our model shows that in order to understand the impact of the limits to diversification of a firm's controlling owner on the firm's investment strategy, it is crucial to consider simultaneous choices of both the *level* and *riskiness* of the firm's investment. Our analysis, which focuses on the equilibrium relation between portfolio diversification and firm's investment *level*, complements and extends existing literature focusing on the *riskiness* of the firm's investment (e.g., Amihud and Lev (1981) and Faccio, Marchica and Mura (2011)). The interaction between these two decisions results in a non-trivial and somewhat surprising relation between an owner's portfolio diversification and the level of her firm's capital investment.

The sign and magnitude of this relation depend crucially on financial constraints faced by a firm. In what follows, we refer to a firm that can obtain external financing for additional capital investment projects as financially unconstrained. A firm that has exhausted its capacity to raise external funds is referred to as financially constrained. Our main finding is that in equilibrium, the level of capital investment of an unconstrained firm is predicted to be increasing in its owner's portfolio diversification. Interestingly, this relation is expected to be weaker and possibly negative for a constrained firm.

The intuition for an unconstrained firm is as follows. The direct effect of higher owner's portfolio diversification on the firm's optimal capital investment strategy works through the reduction in the variance of the owner's wealth and the resulting decrease in her risk-avoidance incentives. A more diversified owner is less concerned with higher cash flow volatility of her controlled firm, resulting from higher operating leverage, and consequently chooses a higher level of capital investment, as well as riskier investment with higher expected return. The result is a positive relation between the owner's portfolio diversification and the firm's capital investment level.

The intuition for a constrained firm is more nuanced. Consider a constrained firm whose owner faces a positive shock to her portfolio diversification, resulting in lower variance of portfolio return and lower

²Examples of frictions include costly information acquisition due to, for instance, underdeveloped institutions (e.g., Guiso, Haliassos and Jappelli (2003) and Van Nieuwerburgh and Veldkamp (2010)), asymmetric information (e.g., Gaspar and Massa (2007) and Goetzmann and Kumar (2008)), and/or cultural and historical experiences leading to lack of trust (e.g., Guiso, Sapienza and Zingales (2008) and Badarinta, Campbell and Ramadorai (2016)).

³Privately-held companies are responsible for over 70% (50%) of total investment in fixed assets and revenues in Europe (U.S.) (e.g., Asker, Farre-Mensa and Ljungqvist (2015)), and for 86% of total non-government employment (e.g., Marchica and Mura (2013)).

covariance with controlled firm’s cash flows, thus reducing the owner’s risk avoidance incentives. Such an owner would like to increase the expected return to the firm’s investment at a cost of higher investment risk. Unlike an unconstrained firm’s owner, who can achieve higher expected return by raising both the level of capital investment and its riskiness, a constrained firm’s owner cannot increase its capital investment level in response to an increase in portfolio diversification, as the firm’s investment is determined by the financial constraint. The only channel the constrained firm can use to increase the expected cash flows from its capital investment is to increase the riskiness of its investment. Thus, higher portfolio diversification reduces the owner’s risk avoidance incentives and leads to higher optimal investment riskiness. However, the resulting higher cash flow volatility tightens the firm’s financial constraint further. As a result, as the constrained firm’s owner becomes more diversified, the firm’s investment *level* declines, while its *riskiness* increases.

To test our model’s predictions we use a sample of about 480,000 observations belonging to over 150,000 privately-held and publicly-traded firms across 34 European countries between 1999 and 2010. The key to our empirical analysis is the construction of proxies for owners’ portfolio diversification. Measures of owners’ diversification are impossible to obtain from standard (U.S.) data sources.⁴ Instead, Bureau Van Dijk’s Amadeus Top 250,000 database contains comprehensive accounting and ownership data for the universe of European firms satisfying certain size requirements. Amadeus has been used by an increasing number of scholars and policy-making institutions, and we undertake further checks to verify the quality of the data.⁵

To measure the degree of firms’ financial constraints, we use firms’ mode of incorporation, once we show that privately-held European firms tend to be more constrained than publicly-traded ones, consistent with Farre-Mensa and Ljungqvist (2016). To build measures of firm owners’ portfolio diversification, we identify all shareholders of each firm in the sample, while accounting for ownership pyramids, and define the ultimate controlling owner as the shareholder with the highest voting rights in the firm. Amadeus allows us to reconstruct substantial parts of firms’ controlling owners’ equity portfolios and define two measures of portfolio diversification: 1) the number of companies (across the entire Amadeus database) in which the controlling owner holds any stake, and 2) the Herfindahl index of the owner’s portfolio holdings.

Our measures of portfolio diversification are not perfect: they are constructed using only equity in-

⁴Existing studies tend to use ownership concentration as an indirect proxy for controlling owners’ diversification (e.g., Amihud and Lev (1981), Anderson and Reeb (2003), and John, Litov and Yeung (2008)).

⁵Previous studies have verified the accuracy of Amadeus data with respect to representation of the population (e.g., Arellano, Bai, and Zhang (2012) and Bena and Ortiz-Molina (2013)) and both accounting and ownership data (e.g., Faccio, Marchica, and Mura (2011), Marchica and Mura (2013), and Michaely and Roberts (2012)).

vestments; omit indirect equity investments, such as mutual fund, hedge fund, and pension fund holdings; capture only European equities; and do not capture small equity stakes. However, using 1) supplementary analysis of European households' holdings, 2) findings in the literature on investment patterns in Europe, and 3) equilibrium implications of our model, we show that while imperfect, our proxies are correlated with true unobserved diversification and are, therefore, useful in the empirical analysis.

Our empirical results show that public (relatively unconstrained) firms' capital investment level is positively related to their owners' portfolio diversification. This relation is highly statistically significant and economically large: *ceteris paribus*, a one-standard-deviation increase in owner's diversification is associated with a 7%-8% increase in the firm's capital investment-to-assets ratio relative to its mean. In contrast, the association between private (relatively constrained) firm owners' portfolio diversification and their firms' investment is negative. A one-standard-deviation increase in private firm owner's portfolio diversification is associated with a 3.5% reduction in the firm's investment-to-assets ratio relative to its mean. These results are consistent with our model and, in particular, with the negative effect of constrained firm owner's portfolio diversification on the firm's investment level due to tightening of financial constraints in response to better diversified owner choosing riskier capital investment projects.

These results are echoed by the evidence from an exogenous shock to the degree of portfolio diversification of firms' controlling owners. We argue that cuts in capital gains tax rates are likely to lead to increased investors' portfolio diversification due to both increased demand for equity investments and increased supply of shares, and examine empirically changes in owners' portfolio diversification and in firms' capital investment rates around these tax cuts. Using seemingly unrelated regression equations, we find that portfolios of both public and private firm owners become more diversified following the tax cuts. At the same time, public firms' investment-to-assets ratio increases following a tax cut, while that of private firms' decreases. This evidence, in particular that of a negative relation between private firms' capital investment and their owners' portfolio diversification, is consistent with the predictions of our model and the full-sample results.

Owners' portfolio diversification is not chosen in isolation. One potential source of endogeneity is reverse causality: larger capital investment by a firm may lead its owner to diversify her external portfolio in order to partially offset the effect of the firm's higher cash flow riskiness due to higher operating leverage. We use an instrumental variable approach to capture the part of the owners' portfolio diversification that is more likely

to be independent of their firms' investment decisions. Our instrument for owner's portfolio diversification is based on the number of firms available for investment to investors that are similar to the owner of our interest (to satisfy the relevance restriction), yet located in countries *neighboring* that of the owner and that are *dissimilar* to the controlled firms in terms of investment opportunities and financial constraints (to satisfy the exclusion restriction). We find that the relation between *predicted* owner's portfolio diversification and firm's capital investment is significantly positive for public firms and significantly weaker – i.e., negative and close to zero – for private ones, consistent with the model's predictions.

Firms' mode of incorporation is another potential source of endogeneity. Thus, we examine whether self-selection of the mode of incorporation is responsible for our results by using a two-stage selection model, in which the first stage estimates the choice between public and private modes of incorporation. The exogenous variable in the first stage is industry-level underwriter concentration (e.g., Gao, Harford and Li (2013)). While our second-stage results show that there is indeed self-selection of the mode of incorporation, controlling for it does not affect the qualitative results.

We perform a battery of additional tests to examine the robustness of our results to potential measurement errors. Our findings are robust to using alternative measures of investment; are unlikely to be driven by owners who may not be the primary decision makers in their firms; are not driven by possible separation of firm ownership and control; and are not due to potentially subpar accounting and reporting standards in certain countries. As an additional validation of the model, we examine the relation between public and private firm owners' and the riskiness of their firms' capital investment. Consistent with the model's comparative statics, we find that this relation is positive for both public firms and private ones.

Our paper contributes to several strands of literature. First, we extend the literature that examines the effects of firm owners' portfolio diversification on firm strategies (e.g., Amihud and Lev (1981) and Faccio, Marchica and Mura (2011)) by analyzing theoretically and empirically how diversification of firm owners' portfolios impacts firms' capital investment decisions. We show that the relation between a firm's investment and its owner's portfolio diversification depends crucially on the firm's degree of financial constraints. One implication of our theoretical and empirical findings is that it is crucial to decouple the effects of financial constraints from the effects of firm owners' portfolio diversification when analyzing firms' investment strategies. In particular, our results relate to the literature on family firms (e.g., Caprio, Croci and Del Giudice (2011), Anderson, Duru and Reeb (2012), Lins, Volpin and Wagner (2013)), which finds that family

firms tend to a) invest less than non-family firms and b) choose safer investment projects that lead to lower returns/profitability. While the latter result is consistent with family firm owners being less diversified, the former result cannot be explained by owners' portfolio diversification and is likely attributable to family firms being more financially constrained.

In addition, our paper contributes to a small but growing empirical literature that examines differences between public and private firms' strategies. Specifically, previous studies that investigate differences between public and private firms' investment find contrasting results. Similar to us, Mortal and Reisel (2013) document that European public firms tend to invest more than private ones. On the other hand, Asker, Farre-Mensa and Ljungqvist (2015) report that private firms in the U.S. invest more than public ones and attribute this finding to more severe agency costs within public firms. Our findings suggest that owners' portfolio diversification is an important and so far overlooked driver of firms' capital investment.

1 Model

1.1 Setup and assumptions

1.1.1 The controlling owner

The model features a risk-averse investor, who maximizes expected utility of her terminal wealth, w . The investor's utility, $u(w)$, is given by

$$u(w) = \frac{1 - \exp(-aw)}{a}, \quad (1)$$

where $a = u''(w)/u'(w)$ is the investor's Arrow-Pratt coefficient of absolute risk aversion.

The investor's wealth consists of two components. First, the investor is entitled to a proportion λ of cash flows produced by the firm she controls. Hence, in what follows, we refer to the investor as the firm's *controlling owner*. We assume that the controlling owner is the only decision-maker in the firm.⁶

Second, the investor is endowed with initial wealth x , which she invests *externally*, i.e., outside of the controlled firm. We first describe the investor's external investment opportunity set and optimal portfolio choice, and then discuss the decisions that the investor makes on behalf of the firm she controls.

⁶This assumption is more likely to hold in Europe, where the ownership of both public and private firms tends to be more concentrated than in a typical U.S. public firm. Please refer to Section IA1 of the Internet Appendix (IA hereafter) for evidence on controlling owners of European firms.

1.1.2 Investment opportunity set and portfolio choice

There are two types of assets the investor can hold in addition to the stake in the firm she controls. The first is a risky asset that has a normally distributed return with mean gross return R_{pub} and standard deviation s_{pub} . This asset can be thought of as an efficient portfolio of publicly-traded risky assets, hence the subscripts.

Second, to move closer to the efficient frontier that is composed of both publicly-traded and privately-held assets, the investor can acquire non-controlling stakes in privately-held firms, whose returns are also normally distributed. There are two possible motives for investing in privately-held firms. The first one is enhancement of the expected return of the investor's portfolio by means of investing in high-expected-return private firms. While there is no conclusive evidence documenting that private firms' expected returns are higher than those of public ones *on average*, it is possible and likely that *some* private firms have high expected returns. The second motivation for investing in privately-held firms is portfolio diversification. Investing in private firms allows to expand the efficient frontier of risky assets and achieve lower portfolio volatility for a given level of expected return.⁷

In order to focus on the diversification motive for investing in private firms, we assume that the expected gross return of each private firm i , R_i , equals the return of the portfolio of publicly-traded assets: $R_i = R_{pub} \equiv R$. Importantly, as we discuss below, this restrictive assumption does not drive the results. The return of private firm i has standard deviation s_i and correlation $\rho_{i,pub}$ with the efficient portfolio of publicly-traded assets. The correlation matrix of private firms' returns is given by $\mathbb{P}$, where an element $\rho_{i,j}$ denotes the correlation between returns of private firms' i and j .

Investment in privately-held firms is not frictionless. We model market frictions associated with investing in private firms by assuming that the cost associated with such investments equals ϕn , where ϕ is the parameter describing the severity of the frictions and n is the number of private firms in the owner's portfolio. We refer to ϕ as the "*limits to diversification*".

The assumption regarding the two types of investment opportunities available to the investor is consistent with the evidence regarding investment patterns of firm owners in our data. First, as we describe in detail in

⁷A number of studies find that returns to private equity are no higher than the returns of public firms both in the U.S. and European markets (e.g., Moskowitz and Vissing-Jørgensen (2002), Kaplan and Schoar (2005), Cochrane (2005), Phalippou and Gootschlag (2008), and Croci and Del Giudice (2014)). On the other hand, Ljungqvist and Richardson (2003) document overperformance by U.S. private equity firms relative to the aggregate public equity market.

Section 3.2.2, firms' controlling owners tend to invest in two main asset classes: a) equities of publicly-traded and privately-held firms, and b) real estate. The correlation between real estate returns and equity returns is low, resulting in a limited impact of owners' real estate holdings on their firms' capital investment decisions. In addition, as we argue in Section 3.2.2, real estate holdings are likely to be mostly used for consumption rather than investment and, as a result, mostly exogenous to portfolio choice.

Second, over 96% of all firms in Europe with sales or assets exceeding roughly €10M are private. Even if we abstract from the relative lack of popularity of indirect equity investments (i.e., investments through mutual funds, hedge funds, pension funds etc.) in Europe, the high fraction of privately-held companies in the population of European firms, coupled with the significant home bias (e.g., French and Poterba (1991) and Coval and Moskovich (1999)), which we document in our sample, indicate that stakes in private firms constitute a significant fraction of a typical European investor's portfolio.

Assume that the investor decides to hold non-controlling stakes in n private firms. While it is possible to solve explicitly for the optimal composition of her portfolio (i.e., the set of n private firms the investor holds and the weights of the n private firms and of the portfolio of publicly-traded assets), this is not necessary for our purposes. Instead, since the investor can always choose to have a zero weight on a particular stock in her portfolio, and since the motivation for investment in private firms is diversification (i.e. reduction of portfolio volatility), the standard deviation of the optimally chosen portfolio consisting of an efficient portfolio of publicly-traded assets and stakes in n privately-held firms, $s^*(n)$, is decreasing in the number of private firms in the portfolio: $\frac{\partial s^*}{\partial n} \equiv s'^*(n) < 0$. In addition, to ensure that $s^*(n)$ is positive for any n , we assume that $s^*(n)$ is convex in n : $\frac{\partial^2 s^*}{\partial n^2} \equiv s''^*(n) > 0$. Following a large body of industrial organization literature, in the analytical solution of the model, we treat the number of private firms in the owner's portfolio, n , as a continuous variable, so that $s^*(n)$ is a continuous function.⁸ We then focus on integer values of n in a numerical illustration of the model.⁹

⁸See, for example, Ruffin (1971), Okuguchi (1973), Dixit and Stiglitz (1977), Loury (1979), and Mankiw and Whinston (1986). See Suzumura and Kiyono (1987) for a discussion of the effect of departure from a continuous number of firms on equilibrium conditions. Seade (1980) justifies the practice of treating the number of firms as continuous by arguing that it is always possible to use continuous differentiable variables and restrict attention to integer realizations of these variables.

⁹To ensure that the assumption that $s^*(n)$ is decreasing in n is sensible not just for the case in which the sole motive for investment in private firms is reduction in portfolio volatility, we solve the investor's portfolio problem numerically, while allowing for the possibility that the distribution of private firms' expected returns is different from that of public firms. In particular, we allow private firms to have higher mean expected return and/or higher dispersion of expected returns. Simulation results show that the diversification motive is sufficiently strong for the negative relation between $s^*(n^*)$ and n^* to survive in equilibrium even if there is significant return-enhancement motivation for investment in private firms (see Section IA2).

1.1.3 The firm's investment technology

The firm, partially owned and controlled by the investor, is endowed with the following production technology. A capital investment of size K^2 produces uncertain cash flow αK , where the stochastic component of the return on the firm's investment, α , is normally distributed with mean $\mu(\sigma)$ and standard deviation σ . The mean of α is a function of its volatility. In other words, by choosing σ , the firm trades off the riskiness of its investment against its expected return. This assumption is a reduced-form way of modeling the choice of the *riskiness* of investment, σ , in addition to the choice of the *level* of investment, K^2 .

To make the trade-off between the expected return on the firm's investment and its volatility meaningful, we assume that expected return to the investment is increasing and concave in the chosen volatility of return: $\frac{\partial \mu}{\partial \sigma} \equiv \mu'(\sigma) > 0$ and $\frac{\partial^2 \mu}{\partial \sigma^2} \equiv \mu''(\sigma) < 0$. An implicit assumption in $\mu'(\sigma) > 0$ is that the firm cannot hedge risks associated with its capital investment.¹⁰ The product $K\sigma$ is the firm's resulting cash flow volatility. We denote the correlation between the return on the firm's investment and the return to the owner's portfolio by ρ and assume that $\rho > 0$.¹¹

1.1.4 The firm's financial constraint

We assume that the firm does not have internal funds to finance the initial investment, K^2 , and relies on external financing obtained from risk-neutral outside financiers. As a result, the firm may, but need not, be financially constrained in equilibrium. In particular, we assume that the firm faces a capacity constraint on the amount of external financing it can raise for capital investment, which we refer to as the firm's financial constraint, $\overline{K^2}$. This assumption is consistent with financial constraints taking the form of credit rationing by banks (e.g., Jaffe and Russell (1976) and Stiglitz and Weiss (1981)), which are the primary source of external financing for firms in our sample.

The choice of riskiness of the firm's capital investment has two effects on the tightness of the constraint. The first (direct) effect is negative: the constraint is tighter the higher the chosen riskiness of the firm's investment, σ , $\frac{\partial \overline{K}}{\partial \sigma} < 0$. The second (indirect) effect is positive: expected return on the firm's investment

¹⁰Survey evidence on risk management practices among European companies and, more in particular, within privately-held firms, shows that the use of derivatives is less widespread in Europe than in North America (e.g., Alkeback and Hagelin (1999) and Loderer and Pichler (2000)). In addition, both academic and practitioner studies show that private firms are less likely to adopt hedging methods than public ones (e.g., Bodnar, Consolandi, Gabbi and Jaiswal-Dale (2013) and 2013 Chubb survey).

¹¹More precisely, we assume that the correlation between the return of *each* of the assets in the controlling owner's portfolio and the return on the firm's investment is ρ . This assumption is needed in order to prevent feedback from the firm's investment choice to the *identity* (as opposed to the number) of the private firms in the portfolio, which would lead to analytical intractability.

is increasing in investment riskiness, $\mu'(\sigma) > 0$, and the constraint is less tight the higher the expected return on the investment, $\frac{\partial \bar{K}}{\partial \mu} > 0$. In addition to the firm's riskiness, we assume that there is an exogenous parameter, η , which is negatively related to the tightness of the financial constraint for any given level of the firm's riskiness, i.e. $\frac{\partial \bar{K}}{\partial \eta} < 0$.

The overall effect of the riskiness of the firm's investment on the tightness of the constraint is:

$$\frac{d\bar{K}}{d\sigma} = \frac{\partial \bar{K}}{\partial \sigma} + \frac{\partial \bar{K}}{\partial \mu} \frac{\partial \mu}{\partial \sigma}. \quad (2)$$

We assume that the direct negative effect of σ on $\bar{K}$ is larger in magnitude than the indirect positive effect, i.e., that $\frac{d\bar{K}}{d\sigma} < 0$.¹²

1.2 Solution

The objective of the firm's controlling owner is to maximize her expected utility by choosing the level and riskiness of the firm's capital investment, K^2 and σ respectively, as well as the composition of her external portfolio, which is summarized by the number of privately-held firms that the owner holds, n . Since both the return on the firm's investment and the return on the controlling owner's external portfolio are assumed to be normally distributed, investor's expected utility maximization simplifies into the mean-variance criterion:

$$\mathbb{E}u(w) = \mathbb{E}w - \frac{a}{2} \text{Var}(w). \quad (3)$$

Thus, the owner's objective function is:

$$\max_{K, \sigma, n} \mathbb{E}u(w) = \max_{K, \sigma, n} \left[-\lambda K^2 + \lambda \mu(\sigma) K + xR - \phi n - \frac{a}{2} ((\lambda K \sigma)^2 + (xs^*(n))^2 + 2\lambda K \sigma xs^*(n)\rho) \right], \quad (4)$$

$$\text{subject to } K \leq \bar{K}(\eta, \sigma).$$

The first term on the right-hand-side of (4), $-\lambda K^2$, is the controlling owner's share of the expected payment for capital investment. The second term, $\lambda \mu(\sigma) K$, is the owner's share of the firm's expected cash flow. The third term, xR , is the expected value of the owner's external portfolio. The fourth term, ϕn , reflects the

¹²Section IA3 shows, using simulation calibrated to real data, that the direct negative effect of investment riskiness on the tightness of financial constraint can indeed dominate the indirect positive effect.

limits to diversification, i.e., the cost of investing in n privately-held firms in the owner's external portfolio. The next three terms represent the reduction in expected utility due to the variance of the owner's terminal wealth. In particular, $(\lambda K \sigma)^2$ is the variance of the owner's share of the firm's cash flow, $(xs^*(n))^2$ is the variance of the value of the owner's external portfolio, and $\lambda K \sigma xs^*(n)\rho$, is the covariance between the firm's cash flow and the external portfolio's value.

We begin by examining the owner's portfolio problem while fixing the firm's investment policy. Then we analyze the unconstrained and constrained firms' choices of capital investment level and riskiness while taking into account optimal portfolio composition of the controlling owner. Finally, we examine the equilibrium relations between the unconstrained and constrained firms' investment choices on one hand and their owners' portfolio choices on the other hand, which lead to the model's comparative statics.

Differentiating the owner's expected utility in (4) with respect to the number of privately-held firms in the owner's portfolio, n , leads to the equilibrium condition for the number of private firms in her portfolio, n^* , and the equilibrium portfolio volatility, $s^*(n^*)$, as functions of the level and riskiness of the firm's investment, K and σ respectively:

$$s^{*'}(n^*) = -\frac{\phi}{ax(K\lambda\rho\sigma + xs^*(n^*))}. \quad (5)$$

Assume first that the financial constraint does not bind in equilibrium, $K_u^* \leq \bar{K}(\eta, \sigma_u^*)$, where the subscript refers to an unconstrained firm. Maximizing the owner's expected utility in (4) with respect to the level and riskiness of the firm's investment, leads to a system of equations describing the equilibrium investment policy of an unconstrained firm, given by K_u^{*2} and σ_u^* :

$$K_u^* = \frac{\mu(\sigma_u^*) - a\sigma_u^*xs^*(n)\rho}{2 + a\lambda\sigma_u^{*2}}, \quad (6)$$

$$\mu'(\sigma_u^*) = axs^*(n)\rho + a\lambda K_u^*\sigma_u^*. \quad (7)$$

Totally differentiating the equilibrium level and riskiness of an unconstrained firm's investment in (6) and (7) and the equilibrium portfolio volatility in (5) with respect to the limits to diversification, ϕ , and solving the resulting system of 3 equations, leads to the following result:

Proposition 1. *If a firm is unconstrained in equilibrium, $K_u^* \leq \bar{K}(\eta, \sigma_u^*)$, then:*

1) *the equilibrium number of private firms in firm owner's portfolio, n_u^* , is decreasing in the limits to*

diversification, ϕ ;

2) the equilibrium volatility of firm owner's portfolio, $s^*(n_u^*)$, is increasing in ϕ ;

3) the equilibrium level of firm's capital investment, K_u^{*2} , is decreasing in ϕ ;

4) the equilibrium riskiness of firm's capital investment, σ_u^* , is decreasing in ϕ .

Assume now that the financial constraint is binding in equilibrium, $K_u^* > \bar{K}(\eta, \sigma_u^*)$, and the firm's investment level is determined by the constraint, $K_c^* = \bar{K}(\eta, \sigma_c^*)$, where the subscript refers to a constrained firm. Maximizing the owner's expected utility in (4) with respect to the riskiness of the firm's investment, while equating the level of firm's investment to the financial constraint, leads to the following equilibrium condition for the riskiness of the firm's investment:

$$\mu'(\sigma_c^*) = a\lambda\sigma_c^*\bar{K}(\eta, \sigma_c^*) + ax\rho s^*(n) + \frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma} \left(2 + a\lambda\sigma_c^{*2} + \frac{ax\rho\sigma_c^*s^*(n)}{\bar{K}(\eta, \sigma_c^*)} - \frac{\mu(\sigma_c^*)}{\bar{K}(\eta, \sigma_c^*)} \right). \quad (8)$$

Totally differentiating the equilibrium condition in (8) and the equilibrium condition for portfolio volatility in (5) with respect to the limits to diversification, ϕ , and solving the resulting system of 2 equations, leads to the following proposition:

Proposition 2. *If a firm is constrained in equilibrium, $K_u^* > \bar{K}(\eta, \sigma_u^*)$, then:*

1) the equilibrium number of private firms in firm owner's portfolio, n_c^* , is decreasing in the limits to diversification, ϕ ;

2) the equilibrium volatility of firm owner's portfolio, $s^*(n_c^*)$, is increasing in ϕ ;

3) the equilibrium level of firm's capital investment, K_c^{*2} , is increasing in ϕ ;

4) the equilibrium riskiness of firm's capital investment, σ_c^* , is decreasing in ϕ .

1.3 Comparative statics and empirical predictions

We are ultimately interested in the equilibrium relations between a firm's controlling owner's portfolio diversification on one hand, and the firm's level and riskiness of capital investment on the other hand, for both constrained and unconstrained firms. In what follows, we illustrate the comparative statics in Propositions 1 and 2 using a numerical example, and discuss their intuition.

1.3.1 Comparative statics

We consider the following example. First, we assume that the relation between the risk of the firm's investment and its expected return is given by $\mu(\sigma) = \sqrt{\sigma}$. Second, we assume that private firms are symmetric, specifically that they have the same standard deviation of returns: $s_i = s_j \equiv s_{pri}$ for all i and j ; the same correlation with the efficient portfolio of risky assets: $\rho_{i,pub} \equiv \rho_{pri}$ for all i , which also equals the correlation between returns of each two private firms: $\rho_{i,j} = \rho_{pri}$ for all i and j . We vary the limits to diversification, ϕ , between 0.001 and 0.05, solve the model numerically, and compute the equilibrium quantities of interest: the number of firms in the owner's portfolio, n^* , the portfolio's standard deviation, $s^*(n^*)$, the level of capital investment in the controlled firm, K^{2*} , and the riskiness of this investment, σ^* .

The results are presented in Figure 1. Figure 1A depicts the relation between the limits to diversification, ϕ , and equilibrium portfolio size, n^* , for both value-at-risk thresholds. n^* is obtained as a result of numerically solving the system of three equations – (5), (6), and (7) – for the case of an unconstrained firm, and by solving the system of two equations – (5) and (8) – for the case of a constrained firm. These relations correspond to the dotted lines in Figure 1A. We also present n^* constrained to integer values of n (dashed lines). The relation between ϕ and n^* is clearly negative, consistent with part 1) of Propositions 1 and 2. For $\phi = 0.01$, the firm's controlling owner chooses to acquire non-controlling stakes in three additional private firms, while for $\phi > 0.025$, the owner only invests in one additional private firm.

Figure 1B presents the relation between the equilibrium volatility (standard deviation) of the owner's portfolio, $s^*(n^*)$, and ϕ . As in Figure 1A, we present both the portfolio volatility computed using equilibrium number of firms in the owner's portfolio, n^* (dotted lines), as well as the volatility corresponding to the integer solution for n^* (dashed lines). The relation between $s^*(n^*)$ and ϕ is clearly positive, as part 2) of Propositions 1 and 2 states. This result is consistent with portfolio volatility decreasing in the number of firms in the portfolio, which, in turn, is decreasing in the limits to diversification.

Figure 1C depicts the relation between the limits to diversification, ϕ , on one hand, and the firm's optimal capital investment level, K^{2*} , and its financial constraint, $\overline{K^2}(\eta, \sigma^*)$, for two values of financial constraint on the other hand. In particular, the solid line depicts K^{2*} , the level of capital investment that maximizes the owner's expected utility without accounting for the potential financial constraint; the dashed line depicts the constraint, $\overline{K^2}(\eta, \sigma_c^*)$, for $\eta = 0.15$; and the dashed-dotted line depicts the constraint for $\eta = 0.25$.

Whenever the financial constraint is not binding, which is the case for $\eta = 0.25$ (dashed-dotted line), the firm is unconstrained in equilibrium, and its capital investment is given by the solid line, $K_u^{2*} = K^{2*}$. When the financial constraint is binding in equilibrium, as in the case of $\eta = 0.15$ (dashed line), the investment of a constrained firm is given by the constraint, $K_c^{2*} = \overline{K^2}(\eta, \sigma_c^*)$.

Figure 1D presents the relation between equilibrium riskiness of the firm's investment, σ^* , and the limits to diversification, ϕ , for the two levels of financial constraints. The solid (dashed) line corresponds to the case of $\eta = 0.15$ ($\eta = 0.25$). As in Figures 1A and 1B, dotted lines in Figures 1C and 1D represent corresponding solutions to cases in which n^* is not constrained to integer values. When the financial constraint is not binding, the equilibrium relations between investment level and riskiness on one hand, and the limits to diversification on the other, are given by the solid lines in Figures 1C and 1D. Consistent with part 3) of Proposition 1, the equilibrium relation between the limits to diversification, ϕ , and the unconstrained firm's optimal capital investment, K_u^* , is negative, as shown by the solid line in Figure 1C. Consistent with part 4) of Proposition 1, the equilibrium relation between ϕ and the unconstrained firm's investment riskiness, σ_u^* , is negative as well, as illustrated by the solid line in Figure 1D.

The intuition is as follows. As shown in part 1) of Propositions 1 and 2 and in Figure 1A, the equilibrium number of private firms in the owner's portfolio is increasing in ϕ . As the portfolio volatility is decreasing in the number of firms in the portfolio by assumption, the equilibrium relation between portfolio volatility and ϕ is positive, as shown in part 2) of Propositions 1 and 2 and in Figure 1B.

A reduction in the owner's portfolio volatility reduces the impact of both the level of investment, K , and its riskiness, σ , on the variance of the owner's terminal wealth, as follows from the last element of (4). In other words, an increase in firm owner's portfolio diversification caused by a decrease in the limits to diversification, reduces the marginal costs of both the level and riskiness of investment. In contrast, the expected return to capital investment, $\mu(\sigma)$, is not affected directly by owner's portfolio volatility, i.e., the marginal benefits of investment level and riskiness are unrelated to portfolio diversification. As a result, a reduction in an unconstrained firm owner's limits to diversification, ϕ , leads to higher optimal portfolio diversification, n_u^* , and lower portfolio volatility, $s^*(n_u^*)$, and ultimately results in both higher optimal level of capital investment, K_u^* , and higher investment riskiness, σ_u^* .

When the financial constraint is binding in equilibrium, the level of investment is determined by the

constraint, which is a function of the chosen riskiness of investment. The constrained firm's equilibrium investment riskiness is depicted by the dashed line in Figure 1D. The corresponding level of constraint, which determines the level of capital investment is shown by the dashed line in Figure 1C.

When the firm is constrained in equilibrium, the relation between its capital investment level, K_c^* , and the limits to diversification, ϕ , is positive (dashed line in Figure 1C). The intuition is as follows. The binding financial constraint, $\bar{K}(\eta, \sigma_c^*)$, which determines the level of investment, is tighter the higher the chosen riskiness of investment. A reduction in the limits to diversification, ϕ , leading to higher equilibrium portfolio diversification, n_c^* , and lower portfolio volatility, $s^*(n_c^*)$, leads to a lower impact of the riskiness of the firm's capital investment, σ_c^* , on the owner's expected utility, as discussed above. As a result, equilibrium investment riskiness is higher the more diversified (less volatile) the owner's portfolio is, as shown in part 4) of Proposition 2 and depicted by the dashed line in Figure 1D. While higher capital investment riskiness chosen by an owner with less volatile portfolio raises the expected return on investment for a given level of capital, $\mu(\sigma^*)$, it also tightens the financial constraint. Thus, higher equilibrium portfolio diversification is associated with capital investment that is riskier but is performed on a smaller scale.

The striking result is that the sign of the relation between the limits to owner's portfolio diversification and the firm's capital investment depends crucially on whether the firm is financially constrained in equilibrium. Another notable result is that the relation between the limits to diversification and the equilibrium riskiness of the firm's investment is negative for both constrained and unconstrained firms. This negative relation for both unconstrained and constrained firms is consistent with Faccio, Marchica and Mura (2011), who find that firms' cash flow volatility is increasing in their owners' portfolio diversification.

1.3.2 Empirical predictions

Propositions 1 and 2, as well as Figure 1C lead to the following empirical predictions:

Prediction 1. *For financially unconstrained firms, the relation between the level of a firm's capital investment and owner's portfolio diversification is expected to be positive.*

Prediction 2. *For financially constrained firms, the relation between the level of a firm's capital investment and owner's portfolio diversification is expected to be less positive than for unconstrained firms, or negative.*

The deep variable in the model that influences all equilibrium quantities is the limits to diversification,

ϕ , which can vary by country, industry, individual investor, and time. Unfortunately, ϕ cannot be observed empirically. However, parts 1) and 2) of Propositions 1 and 2, as well as Figures 1A and 1B show that the equilibrium relation between ϕ and empirically observable quantity – the number of privately-held firms in an owner’s portfolio, n^* , and resulting portfolio diversification – is negative for both constrained and unconstrained firms. This result justifies the use of owner’s portfolio diversification, and the number of private firms in her portfolio in particular, as an (inverse) proxy for her limits to diversification.

Note that Prediction 2 compares the relation between a constrained firm’s investment and its owner’s portfolio diversification to that relation for an unconstrained firm. This is different from part 3) of Proposition 2, which states that constrained firm’s investment is increasing in ϕ and, as a result, is negatively related to its owner’s portfolio diversification. The reason for this formulation of Prediction 2 is as follows. Part 3) in Proposition 2 refers to the relation between a firm’s capital investment and its owner’s portfolio diversification for a firm that is constrained *in equilibrium*. However, even if a firm is potentially financially constrained, it does not have to be constrained in equilibrium. It is reasonable that for some firms that we classify as potentially constrained, the constraint does not bind. Thus, it is possible that the relation between owner’s portfolio diversification and firm’s capital investment is positive for some potentially constrained firms. It is even possible that this relation is positive for potentially constrained firms on average. However, if this relation is positive, it has to be weaker within a relatively constrained subsample than within a relatively unconstrained one, which is what Prediction 2 states.

2 Data and variables

2.1 Sample

The data are assembled from Amadeus Top 250,000. From this database we gather ownership and accounting information for European publicly-traded firms and also for privately-held companies that meet a minimum size threshold. For France, Germany, Italy, Spain, and the U.K., the database includes all companies that meet at least one of the following criteria: (a) revenues of at least €15m, (b) total assets of at least €30m, (c) at least 200 employees. For other countries, the criteria are: (a) revenues of at least €10m, (b) total assets of at least €20m, (c) at least 150 employees. Disclosure requirements in Europe obligate private companies to publish annual information. Consequently, we are able to gather accounting and ownership information

for a very large set of firms.¹³

We collect the data from Amadeus Top DVDs using the April issue of each year during the period 1999-2010. Information is typically incomplete for the year that just ended. Further, Amadeus removes firms from the database five years after they stop reporting financial data. In order to avoid biases related to both survivorship and incomplete information, we ensure that no firm-year observations are dropped from the sample because of delisting. We do so by collecting accounting data starting with the 2012 DVD and progressively moving backwards in time, each year collecting data on firms that were alive in that year. By doing so, we ensure that no firms are dropped from the sample. We gather accounting data for all firms with available data for at least one year during the period 1999-2010.

We undertake several steps to further confirm the quality of our data by comparing them to alternative sources. First, we randomly select 500 privately-held companies from Amadeus with available information on revenues in 2010 and we search for them in two alternative databases: Dun & Bradstreet Private Company database (D&B) and Thomson Reuters Worldscope. We then compute the correlation between revenues reported in Amadeus, and those reported in D&B and Worldscope respectively. The correlation is 0.98 in the case of D&B and 0.99 in the case of Worldscope.

Following Claessens, Djankov and Lang (2000), Faccio and Lang (2002) and Faccio, Marchica and Mura (2011), we calculate voting rights of each ultimate shareholder as the weakest link along the ownership chain. After tracing each ownership stake to its ultimate shareholders, we call the shareholder controlling the largest percentage of voting rights in each firm the firm's ultimate controlling owner.^{14,15} We exclude all firms in which the government is a shareholder, as these firms may have objectives other than shareholder value maximization. We also remove firms whose ultimate owner is an institutional investor. In our sample, non-institutional investors own controlling equity stakes in 88% of cases, consistent with Ferreira and Matos (2008), who show that institutional investors in Europe own on average less than 20% of market capitaliza-

¹³There are cross-country differences in the level of disclosure of financial statements. Our results are robust to excluding countries with low compliance to the requirements, with voluntary disclosure or undefined disclosure requirements. They are also robust to excluding countries with subpar accounting standards and with low business ethics ranking (see Section IA5).

¹⁴One limitation of our calculation of each ultimate shareholder's voting rights is that we are unable to take into account the presence of dual class shares. The omission of dual class shares may potentially create a measurement error in the construction of our proxies for controlling owners' portfolio diversification. The results are robust to exclusion of countries with extensive use of dual class shares (see Section IA5).

¹⁵As discussed in Section 2.1.1, the assumption that our ultimate controlling owners are the firms' decision makers seems reasonable. However, in some cases a firm's ultimate controlling owner owns only a relatively small fraction of the firm, making it is less clear whether this shareholder determines the firm's investment strategy. The results are robust within the sample of firms whose controlling owners have at least 10% voting rights in their firms or sit on their firms' board (see Section IA5).

tion. After combining accounting and ownership information, we end up with the final sample of 479,941 firm-year observations for 156,035 unique firms across 34 countries.¹⁶

2.2 Measures of firm owners' portfolio diversification

Measuring firm owners' portfolio diversification is a difficult task, as we only observe investments in equity of European companies, which are just one part of the owners' portfolios. First, we describe two measures of diversification of this observable part of owners' portfolios. We then discuss potential drawbacks of these measures and empirically justify their use as proxies for diversification of owners' overall portfolios.

2.2.1 Equity-based measures of diversification

Our first, equally-weighted, measure of a controlling owner's portfolio diversification is $\ln(1 + \# \text{ firms})$, defined as one plus the natural logarithm of the total number of firms in which the owner holds shares, directly or through a pyramid, in a given year, across all countries in Amadeus. Diversification of the observable part of the portfolio is increasing in the number of stocks in it.

Our second, value-weighted, measure of portfolio diversification is one minus the Herfindahl index of owner's portfolio holdings, 1-Herfindahl index. To compute the Herfindahl index of owner's holdings, we first calculate the dollar value investment in each firm in her portfolio as the book value of the company's equity multiplied by the owner's ultimate cash flow rights in the firm. We use book equity instead of market equity because our sample consists predominantly of private firms. We then compute the weight of each stock in the owner's portfolio. The Herfindahl index of portfolio holdings is the sum of these squared weights. In the analysis, we use 1-Herfindahl index, as it is increasing in portfolio diversification, similar to the number-of-firms-based measure.

2.2.2 Equity-based diversification measures and overall portfolio diversification

While our direct equity-based measures of firm owners' portfolio diversification are common in the literature (e.g., Barber and Odean (2000), Bodnaruk, Kandel, Massa and Simonov (2008), Goetzman and Kumar (2008), and Faccio, Marchica and Mura (2011)), they may not fully capture the true diversification of owners' portfolios, which may include non-equity components, such as real-estate holdings and bonds, indirect equity

¹⁶Table IA3 reports the geographical distribution of our sample. The most represented countries are U.K. (21.7%), France (20.9%), Spain (11.5%), and Italy (9.5%).

investments, investments outside Europe, and small stakes in large firms. In what follows, we examine the suitability of our measures of diversification of observable parts of owners' portfolios as proxies for true, unobserved portfolio diversification.

Omission of non-equity investments

Our diversification measures capture equity investments only, omitting other investment classes, such as cash, bonds, and real estate. Thus, it is possible that investors who appear poorly diversified in the equity part of their portfolios are well diversified across other asset classes. To address this concern, we analyze patterns of portfolio composition of European investors. Due to data availability, in our investigation of investors' portfolio structures we employ alternative data based on the first wave of the Eurosystem Household Finance and Consumption Survey (HFCS, 2013), which we obtained access to. The survey provides detailed household-level information on wealth, assets, and portfolio composition, collected in a harmonized way in 15 Euro area countries. Asset holdings data at the household level provide us with suggestive, yet informative, evidence on the portfolio composition of individuals that are similar across several dimensions to controlling owners of firms in Amadeus data. The sample of the survey includes 62,521 households from Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovenia, Slovak Republic, and Spain, interviewed in 2010/2011, with the exception of France (2009/2010), Spain (2008/2009) and Greece (2009). These countries cover approximately 60% of firms in our sample.

HFCS contains detailed information on market values of households' holdings across 14 asset classes, which we group into seven categories: 1) *Ownership in companies*, which includes shares in controlled firms, shares in other private companies, and shares in other public companies; 2) *Bonds*; 3) *Deposits*; 4) *Real estate*, which includes the household's main residence and other real estate (e.g., holiday homes/apartments, land); 5) *Mutual funds and managed accounts*; 6) *Other financial assets* (e.g., loans to private individuals, voluntary private pension plans); 7) *Other real assets* (e.g., vehicles, valuables). The total value of each household's portfolio is the sum of values of its holdings across these seven categories.

The median household portfolio has a value of about \$189K, with the highest value (unreported) in Luxembourg (\$658K) and the lowest value in Slovak Republic (\$85K). In addition to the overall sample, we examine two subgroups that are likely to be more representative of controlling owners of firms in Amadeus.

First, we focus on the top 1% of households in terms of total wealth, “top percentile of households” henceforth. The median portfolio value of the top percentile of household distribution equals \$5.8M, 38% of which, or about \$2.2M, is invested in equities. Owners of firms that appear in Amadeus hold somewhat larger portfolios on average: the median value of total equity investments of controlling owners of Amadeus firms is \$5.7M. Thus, in terms of wealth level, households in the top percentile are more representative of firm owners in Amadeus than the general household sample. Given our focus on firms’ controlling owners, the second group of households that we focus on are those that identify themselves as “self-business owners”. The median portfolio value of self-business owners is \$1.02M, 37% of which, or about \$375K, is invested in equities. As self-business owners in HFCS hold an order-of-magnitude-smaller portfolios than controlling owners of Amadeus firms, we examine below both the subsamples of top percentile of households and self-business owners separately.

Table 1 reports the average portfolio composition for the entire HFCS sample (column 1), for the sub-group of top percentile of households (column 2), and for the sub-group of self-business owners (column 3). Several interesting findings emerge. First, investment in companies in the form of either shares in their own business or shares in other private and public firms (“Ownership in companies”) is a larger fraction of top percentile of households’ portfolios (38.4%) and of self-business owners’ portfolios (36.7%) than of portfolios of the overall population of households in HFCS (11.4%). If these two subsamples are representative of Amadeus firm owners, then this evidence suggests that although equities constitute the second largest asset class in owners’ holdings, it is important to examine the effects on portfolio diversification of investments in other asset classes.

The second finding in Table 1 is that investment in bonds represents only a small fraction of overall household portfolios. It represents a mere 2% of portfolio value on average for the top percentile of households and 0.7% of portfolio value of self-business owners. To the extent that these two groups of households in HFCS are comparable to controlling owners of Amadeus firms, excluding bond holdings from our measures of portfolio diversification is unlikely to significantly bias the diversification measures. The same is true for cash holdings (“Deposits”), which represent 3.4% of top percentile of households’ portfolios and 3.8% of self-business owners’ portfolios.

Unlike bonds and cash, real estate holdings constitute the largest part of households’ portfolios: these

holdings represent 48% and 51% of portfolio values of top percentile of households and self-business owners respectively. The comparison of these figures with the mean proportion of real estate holdings in the portfolios of the overall HFCS sample (70%) suggests that the fraction of real estate in household portfolios is decreasing in household wealth. Although the median wealth of controlling owners of Amadeus firms is larger than that in each of the two subsamples of households we focus on, it is likely that real estate is a large part of the portfolios of controlling owners in Amadeus as well.

However, real estate differs from other parts of household portfolios in that it is used for both investment and consumption (e.g., Ranney (1981), Schwab (1982), and Henderson and Ioannides (1983)). Because of this dual role, households tend to have larger-than-optimal shares of real estate in their asset portfolios, i.e., the value of a typical household’s residence far exceeds the optimal investment in real estate from the portfolio optimization view. In other words, the “housing constraint” tends to bind (e.g., Brueckner (1997)).¹⁷ In addition, 61% (23%) of top percentile of households and 67% (21%) of self-business owners have taken out exactly one mortgage (two mortgages), suggesting that they tend not to own real estate other than their main residence and, perhaps, a vacation home. All this evidence points in the direction of real estate in investors’ asset portfolios being used mostly for consumption purposes and are not part of an optimal investment portfolio, mitigating the concern that investors may compensate for underdiversification of the equity side of their portfolios by higher diversification of the real estate side of the portfolios.

It is still possible, however, that significant investment in real estate, even if for consumption purposes, can impact a firm owner’s optimal non-real-estate portfolio composition and the choice of the level and riskiness of her controlled firm’s capital investment. This can happen if returns to real estate investments covary with the returns to the rest of the investor’s portfolio, affecting the volatility of investor’s terminal wealth. To examine the severity of this concern, we analyze 1) the correlation between returns to real estate and stock returns within 16 countries in our sample with available data, which correspond to 94% of our sample’s observations, and 2) the effects of this correlation on the relation between investors’ non-real-estate portfolio diversification and their controlled firms’ capital investment.

We find that the correlations between country-level real estate index returns and country-level stock

¹⁷Flavin and Yamashita (2002) estimate that when the housing constraint is binding, optimal investment in the risk-free asset is zero. The fact that in the HFCS data, holdings of riskless assets by households are close to zero is consistent with binding housing constraint for a typical household. Englund, Hwang and Quigley (2002) estimate that for a typical household, the unconstrained optimal share of real estate in a portfolio ranges between 9% and 15%. These figures are 3-5 times lower than the share of real estate investments in subsamples of top percentile of households and of self-business owners.

market index returns are relatively low – the average is 11.7% and the median is 14%. In only 5 countries out of 16 the correlation is positive at 5% significance level (see Table IA8). This is consistent with previous studies showing no or weak relation between real estate returns and excess equity returns (e.g., Anderson and Beracha (2012) and Fan, Huszar and Zhang (2013)), and suggests that the effect of real estate investments on optimal non-real-estate portfolio diversification and controlled firm’s capital investment is unlikely to be large. Our main results, discussed below, continue to hold in a subsample of countries with relatively high correlation between real estate returns and equity returns, suggesting that the findings are unlikely to be affected by real estate investments biasing our measures of portfolio diversification (see Table IA9).

Overall, the evidence above suggests that omission of other asset classes, such as cash, bonds, and real estate is unlikely to invalidate the use of our equity-based diversification measures as proxies for unobserved overall portfolio diversification.

Omission of indirect equity investments

Our diversification measures do not account for indirect equity investments, such as holdings of mutual funds and hedge funds (“Mutual funds and managed accounts”). However, indirect equity investments constitute a very small part of portfolios of both the top percentile of households and of self-business owners – 2.3% and 1% respectively. This is consistent with the fact that the presence of mutual and hedge funds in Europe is not as pervasive as in the U.S.: the average fraction of stocks held by institutional investors (mutual funds) in Europe equals 20% (4%), while the corresponding figures in the U.S. are 66% (18%). Also, data from National Accounts show that in 16 countries out of 22 with available data, the fraction of stocks held by mutual funds is lower than 10%. Similarly, Ferreira and Matos (2008) report that in only 6 countries (out of 34 in our sample) the fraction of market capitalization held by mutual funds as of 2005 is larger than 5%. To the extent that these patterns also hold for Amadeus firms’ controlling owners, an omission of indirect equity investments from our portfolio diversification measures is unlikely to generate a significant bias. In addition, the results continue to hold when we exclude countries with higher-than-10% fraction of equities held by mutual funds and/or higher-than-5% fraction of market capitalization held by mutual funds.

Omission of investments outside Europe

Our diversification measures do not capture stakes in firms incorporated outside Europe. Thus, we may possibly understate the diversification of investors who are well diversified across continents. However, since

investors typically exhibit home bias (e.g., French and Poterba (1991) and Coval and Moskowitz (1999)), the magnitude of this measurement error is unlikely to be large. Only a very small proportion of European firms' controlling owners hold reportable shares of equity in non-European firms. For example, out of 15,696 largest shareholders, Faccio, Marchica and Mura (2011) identify only 72 such cases.¹⁸

Omission of small stakes in firms

When available, Amadeus reports ownership stakes that are lower than the country-specific disclosure thresholds, which vary across countries but are typically in the range of 2% (as in Italy) to 3% (as in the U.K.). However, in many cases we do not capture investments that correspond to relatively low stakes in firms. In other words, we often do not observe controlling owners' stakes in large (mostly publicly-traded) firms, in Europe or elsewhere. While this concern is potentially serious, we argue that our measures of diversification, based on the observable part of controlling owner portfolios' reportable stakes in (mostly private) European firms, are positively correlated with the overall, unobserved, portfolio diversification.

First, our model shows that in equilibrium there is a positive relation between the diversification of the part of the portfolio consisting of stakes in privately-held firms and the diversification of the overall portfolio that contains, in addition, investments of publicly-traded risky assets. Second, HFCS data suggests that direct equity investments are positively correlated with overall portfolio diversification. In particular, households that invest in direct equity tend to diversify their portfolios across more types of asset classes than those that do not invest in equity. For example, top percentile of households invest in 8 different asset classes if they hold shares in either private or public companies, and they invest in only 6 asset classes if they do not invest in equities. While HFCS does not provide data on the number of distinct equity investments by a household, hence preventing us from computing the correlation between the number of stocks in a household portfolio and its diversification across asset classes, this binary result suggests a positive association between the diversification of the equity part of an investor's portfolio and her overall portfolio diversification.

Overall, the discussion and evidence above indicate that our equity-based measures of portfolio diversification of firms' controlling owners are likely to be positively associated with true unobserved diversification of their portfolios, justifying the use of our measures as proxies for overall portfolio diversification.

¹⁸In addition, only 4% (3%) of European (U.S.) companies have non-zero direct foreign ownership, according to Fons-Rosen, Kalemli-Ozcan, Sfiensen, Villegas-Sanchez and Volosovych (2013).

2.3 Other variables

2.3.1 Measure of investment

The dependent variable is *Investment-to-assets* ratio. Since Amadeus does not contain information on annual capital expenditures, we calculate annual capital investment as the year-to-year change in gross fixed assets (e.g., Eckbo and Thorburn (2003), Tang (2009), Wu, Zhang and Zhang (2010), and Farre-Mensa and Ljungqvist (2016)). We then normalize capital investment by beginning-of-year total assets, computed as the sum of fixed and current assets. To reduce the impact of outliers, the investment-to-assets ratio is winsorized at the top and bottom 1% of its distribution.¹⁹

2.3.2 Measure of financial constraints

The measure of a firm’s financial constraints is a binary indicator that equals one for privately-held firms and zero for publicly-traded ones. Farre-Mensa and Ljungqvist (2016) show that in a sample of U.S. companies, public firms appear to behave in ways consistent with being financially unconstrained, whereas private firms tend to behave as if they were constrained. They also show that traditional measures of financial constraints may fail to correctly identify constrained firms. We replicate one of Farre-Mensa and Ljungqvist’s (2016) tests within our sample and conclude that in Europe, similar to the U.S., public firms appear less financially constrained than private ones, justifying the use of a firm’s listing status as a proxy for the degree of its financial constraints (see Section IA4). This result is also consistent with evidence in Pagano, Panetta and Zingales (1998), Derrien and Kecskés (2007), Brav (2009), Hsu, Reed and Rocholl (2010), Schenone (2010), and Saunders and Steffen (2011), who show that public firms tend to have easier access to external funds than private ones.

2.3.3 Control variables

Sales growth proxies for investment opportunities, since we can construct it for both publicly-traded and privately-held firms. This measure is commonly used in studies of private firms’ strategies (e.g., Lehn and Poulsen (1989), Michaely and Roberts (2012), Mortal and Reisel (2013), and Asker, Farre-Mensa and

¹⁹Since R&D expenditures may be as important as capital expenditures for some firms, we define an alternative dependent variable, which takes into account R&D expenditures in addition to capital expenditures. Our main findings are robust to this alternative definition of investment (see Table IA12).

Ljungqvist (2015)). It is defined as the annual relative growth rate in total revenues. As sales growth exhibits large positive skewness, it is winsorized at the bottom 1% and at the top 5% of its distribution.

Cash flow, which was shown to be related to investment (e.g., Fazzari, Hubbard and Petersen (1988) and Cleary (1999)) is the ratio of income plus depreciation to beginning-of-year total assets. Cash flow is winsorized at the top and bottom 1% of its distribution.

Firm age was shown to be related to investment opportunities, as investment opportunities of mature firms may be different from those of young firms (e.g., Anderson and Reeb (2003)). Firm age is defined as the number of years since a firm’s incorporation. Because of its skewness, we winsorize age at the top 1% of its distribution and use $\ln(1 + age)$.

Cash flow rights can affect the incentives of firms’ decision makers (e.g., Jensen and Meckling (1976)). For example, decision makers may have empire-building tendencies (e.g., Jensen (1986)) or enjoy private benefits of control (e.g., Hart and Moore (1995)); both of which may lead to larger investment expenditures. Alternatively, they may enjoy the “quiet life” (e.g., Bertrand and Mullainathan (2003)), which may lead to lower capital investment. Larger cash flow rights align the incentives of firms’ decision makers with firm value maximization and may reduce misinvestment incentives. We follow Claessens, Djankov and Lang (2000), Faccio and Lang (2002), and Faccio, Marchica and Mura (2011), and measure cash flow rights of each ultimate shareholder as the product of ownership stakes along the ownership chain. Cash flow rights variable is winsorized at the top and bottom 1% of its distribution.

2.4 Descriptive statistics

Table 2 reports descriptive statistics. Panel A reports statistics related to diversification of the equity part of controlling owners’ portfolios, at the owner level. Public (private) firms’ controlling owners are those that control at least one publicly-traded (privately-held) firm. The mean (median) number of firms in the portfolio of a public firm’s controlling owner is 4.2 (2). The corresponding figures for private firm owners are 2.8 (1), i.e., public firm owners are typically more diversified than private firm owners.

Overall, a typical controlling owner is only moderately diversified in terms of direct equity investments: only 9% of firm owners hold shares in more than 5 firms, while less than 1% hold shares in more than 30 companies. This is consistent with Faccio, Marchica and Mura (2011) within a similar sample, with the U.S.

evidence in Barber and Odean (2000), Moskowitz and Vissing-Jørgensen (2002), and Goetzman and Kumar (2008), and with the Finnish evidence in Karhunen and Keloharju (2001). It is also consistent with *limits to diversification* – i.e., costs associated with direct investments in (mostly privately-held) firms. The number of firms in controlling owners’ portfolios exhibits substantial variation – the standard deviation is 11.5 (6.7) for public (private) firm owners. The same is true for 1 - Herfindahl index, whose interquartile variation (0.44 for public firm owners and 0.3 for private firm owners) is twice the respective mean Herfindahl indexes (0.19 and 0.15). The mean (median) number of 3-digit SIC industries represented in a public firm’ controlling owner’s portfolio is 2.3 (1), whereas it is 1.7 (1) in a private firm owner portfolio. This evidence suggests that owners tend to invest in firms similar to those they control. The mean (median) number of countries in a firm owner’s portfolio is 1.2 (1) for both public and private firm owners. In particular, only about 9% of firm owners invest in multiple countries and less than 1% of them invest in more than 5 countries, suggesting that owners in our sample are affected by home bias.

Panel B reports descriptive statistics at the firm level, separately for the subsamples of public and private firms. The mean (median) investment-to-assets ratio of publicly-traded firms is 0.106 (0.058), whereas the respective numbers for privately-held firms are 0.068 (0.031). The differences in both means and medians are statistically significant.²⁰ Further, public firms tend to grow more, be more cash-flow-rich, older, and larger than private ones. On the other hand, public firms are typically less indebted than private ones. Volatility of ROA is similar for public and private firms, although the difference in medians is significant.

The mean (median) number of firms in a public firm owner’s portfolio is 15 (3), whereas the corresponding figures for private firm owners are 10.4 (2), the difference in both means and medians being statistically significant. Similarly, the value-weighted measure of portfolio diversification, 1-Herfindahl index of owner’s holdings, is significantly higher for public firm owners. Importantly, the statistics of owners’ portfolio diversification computed at the firm level overweigh owners that control multiple firms, explaining the large differences with the corresponding values in Panel B, in which all owners are weighed equally.

Controlling owners hold substantial stakes in firms they control, both in absolute terms and relative

²⁰Table IA4 reports additional summary statistics for four subsamples: public/private firms controlled by undiversified/diversified firm owners, where (un)diversified owners are those holding stakes in multiple firms (single firm) respectively. It shows that differences between mean/median capital investment rates of firms controlled by diversified owners and those controlled by undiversified ones are positive within the subsample of public firms, whereas they are negative within the private firm subsample. This pattern is consistent with our model, suggesting that firms’ public/private status is crucial for the relation between owners’ diversification and firms’ capital investment.

to their overall equity portfolio size. The median stake of a controlling owner in a public firm is \$10.7M, corresponding to 75% of her overall equity portfolio, while the median stake in a controlled private firm is \$4.9M, corresponding to 87% of owner’s portfolio. The mean (median) cash flow and voting rights of public firm owners are 34% and 36% (28% and 30%) respectively, while the corresponding figures for private firms are 66% and 67% (68% and 70%).

3 Empirical tests

Our model delivers equilibrium relations between a firm’s owner’s portfolio diversification on one hand and both the level and riskiness of the firm’s investment on the other hand. In our empirical tests, we focus mainly on the relation between owner’s diversification and the level of capital investment, since the association between owner’s diversification and firm’s riskiness has been already examined in past literature (e.g., Low (2009), Faccio, Marchica and Mura (2011), and Gormley, Matsa and Milbourn (2013)). We test Predictions 1 and 2, derived in Section 2.3.2, which state that the relation between controlling owner’s portfolio diversification and firm investment should be positive for publicly-traded (relatively unconstrained) firms and it should be weaker and potentially negative for privately-held (relatively constrained) ones.

3.1 Basic regression

We begin by estimating the differential relations between private and public firms’ investment-to-asset ratios and their owners’ portfolio diversification using a simple version of the q-model of investment, as in Fazzari, Hubbard and Petersen (1988), augmented by the private firm indicator, firm owner’s portfolio diversification, and the interaction between the two:

$$Inv_to_assets_{i,t} = \alpha + \beta Pri_{i,t} + \gamma Diver_{i,t} + \delta(Pri_{i,t} \times Diver_{i,t}) + \Theta \mathbf{X}_{i,t} + OwnerFE + YearFE + u_{i,t}, \quad (9)$$

where $Pri_{i,t}$ is a indicator variable that equals one if company i is privately-held in year t , and zero otherwise; $Diver_{i,t}$ stands for one of our two measures of portfolio diversification; $Pri_{i,t} \times Diver_{i,t}$ is the interaction of private firm indicator and one of the diversification measures; $\mathbf{X}_{i,t}$ is a vector of control variables that includes sales growth, cash flow, $\ln(1+age)$, and controlling owner’s cash flow rights. All regressions include

controlling owner fixed effects and year fixed effects. Standard errors are clustered at the owner level.^{21,22}

Table 3 reports separate results for our two measures of portfolio diversification. The negative coefficients on the private firm dummy indicate that public firms invest more than private ones – the difference in investment-to-assets ratio is 1.2–1.4 percentage points, *ceteris paribus*. More importantly, controlling owners’ portfolio diversification has significantly different impacts on capital investment rates of public and private firms. Consistent with Prediction 1, across both measures of portfolio diversification, the relation between owners’ diversification and their firms’ investment-to-assets ratios is positive and significant for public firms. This result is also economically important. A one-standard-deviation increase in $\ln(1+\# \text{ firms})$ is associated with an average increase of 0.72 percentage points in public firms’ investment-to-assets ratio, *ceteris paribus*, which corresponds to 6.7% of public firms’ mean investment rate. A one-standard-deviation increase in 1-Herfindahl is associated with 0.84 percentage point increase in public firms’ investment-to-assets ratio, corresponding to 8% of its mean.²³

The effect of a one-standard-deviation increase in portfolio diversification on public firms’ investment rates is not only sizable in absolute terms, but is also significant in relative terms. For example, one-standard-deviation increases in $\ln(1+\text{age})$ and in cash flow rights are associated with changes in investment-to-assets ratio corresponding to around 2% of public firms’ mean investment, roughly one third of the magnitude of the effect of a one-standard-deviation increase in each of the measures of diversification.

Consistent with Prediction 2, the impact of portfolio diversification on private firms’ investment rates is significantly smaller than that on public firms’ investment, as evident from the significantly negative coefficients on the interaction between private firm indicator and measures of owners’ portfolio diversification. The overall effect of private firm owners’ portfolio diversification on their firms’ investment rates – the sum of $\hat{\gamma}$ and $\hat{\delta}$ – is negative and statistically significant at 1% level for both measures of diversification. The economic effect here is smaller than that for public firms. A one-standard-deviation increase in private firm

²¹We obtain results similar to those reported below when: 1) we estimate (9) without owner fixed effects; and 2) when we perform a “between estimation”, i.e., when we compute time-series firm-level means of the dependent and all independent variables and estimate cross-sectional regressions without fixed effects (see Table IA11).

²²We use sales growth as a proxy for Tobin’s q in the investment regression, instead of the more commonly-used market-to-book ratio (M/B), which is only available for publicly-traded firms. We also estimate equation (9) for the subsample of public firms only, replacing sales growth with M/B ratio and using high-order-moment GMM procedure, as discussed in detail in Erickson, Parham and Whited (2017). The GMM results are similar to the OLS estimates for public firms (see Table IA10).

²³Here and below, we compute the economic significance of the relation between public firm owners’ portfolio diversification and firms’ capital investment as follows. We multiply the coefficient estimate of $Diver_{i,t}$, $\hat{\gamma}$, by the standard deviation of portfolio diversification measure for public firms (1.19 for $\ln(1+\# \text{ firms})$ and 0.335 for 1-Herfindahl), and divide the resulting product by the mean investment-to-asset ratio of public firms (0.106).

owner's portfolio diversification is associated with roughly 3.5% reduction in her firm's investment-to-assets ratio relative to mean investment of private firms.²⁴

3.2 Capital gains tax cuts

To further examine the effects of controlling owners' portfolio diversification on their firms' capital investment, we employ a shock to owners' portfolio diversification that involves cuts in capital gains tax rates. There were five capital gains tax reduction events that occurred in Europe over our sample period: Spain (2000), Netherlands (2001), Hungary (2004), Finland (2005), and the U.K. (2008). The average tax cut across these events is about 21 percentage points.²⁵

A reduction in capital gains taxes can have two effects on firms' optimal capital investment. The first effect is direct. A reduction in capital gains tax rate raises investors' after-tax cash flows, which, in turn, increases expected return on investment and optimal investment level. This positive effect of capital gains tax cut on investment is common to both public and private firms. The second effect is indirect and works through the effect of lower capital gains tax rates on investors' portfolio diversification. Importantly, if a capital gains tax cut has a similar effect on portfolio diversification of owners of public and private firms, then our model predicts that the sign of the indirect effect of the tax cut on a firm's capital investment depends crucially on a firm's mode of incorporation. Public (relatively unconstrained) firms' capital investment is expected to rise in response to an increase in owner's portfolio diversification, while capital investment of private (relatively constrained) firms is expected to decline.

The effect of a capital gains tax cut on investors' portfolio diversification is twofold. First, it is likely to raise the *demand* for equity investments. To the extent that investors substitute their non-equity holdings with investments in equity and invest not solely in shares they already own, a capital gains tax cut is likely to lead to more diversified equity portfolios.²⁶ The second potential effect of a capital gains tax cut on

²⁴Here and below, the economic impact of private firm owners' diversification on their firms' investment is computed as the product of $\hat{\gamma} + \hat{\delta}$ and the standard deviation of private firm owners' portfolio diversification measure (1.080 and 0.325 for $\ln(1 + \# \text{ firms})$ and 1-Herfindahl respectively), divided by the mean investment-to-assets ratio of private firms, 0.068.

²⁵Spain witnessed a further reduction in capital gains tax rate in 2004. However, we consider only the first tax rate cut to preserve the exogenous nature of this event.

²⁶It is difficult to detect increased demand for shares from equity price data. However, it is possible to examine changes in trading volume around a tax cut. Increased trading volume would be consistent with investors rebalancing their portfolios following the tax cut. While data on aggregate trading volume are not available for most countries that experienced the tax cuts, they are available for the case of London Stock Exchange, which experienced an increase from 142 million trades in 2007 (the year before the year of the tax cut) to 199 million trades in 2008 (the year of the tax cut), and 159 million trades in 2009 (the year following the year of the tax cut), consistent with the demand channel.

investors’ portfolio diversification is the *supply* effect, also known as the “tax capitalization hypothesis”. Higher expected cash flows raise investors’ valuation of equity (e.g., Brennan (1970) and Dai, Maydew, Shackelford, and Zhang (2008)). Higher equity valuations lead firms to issue new equity. If new shares issued by firms are acquired, at least partially, by investors who previously did not own these firms’ equity, then these investors’ portfolios are expected to become more diversified.²⁷

To summarize, both the demand and supply effects are likely to lead to an increase in investors’ portfolio diversification following a capital gains tax cut. In addition, the tax cut is expected to have a positive *direct* effect on capital investment of both public and private firms. However, the tax cut would have an additional – *indirect* – effect on firms’ capital investment through increased owners’ portfolio diversification. Our model implies that the direct and indirect effects are mutually reinforcing (positive) in the case of public firms, but they are competing in the case of private ones, as the indirect effect is predicted to be negative for private firms. This allows us to design a test that focuses on the differential effect of capital gains tax cut on capital investment of public and private firms.

To examine this differential effect, we employ a system of seemingly unrelated regression equations (SURE), which we estimate within the subsample of countries that experienced a capital gains tax cut during years surrounding the cut. In the first equation, we regress our main proxy for owner’s portfolio diversification – the logarithm of the number of firm in a firm owner’s portfolio – on the indicator variable equaling one for years $t + 1$ and $t + 2$, where t is the year of the tax cut, and equaling zero in years $t - 1$ and t (“post-tax-cut dummy” hereafter),²⁸ and an interaction between post-tax-cut dummy and private firm dummy. The set of control variables is as in our main tests: sales growth, cash flow, age, cash flow rights, and a private firm indicator, as well as owner fixed effects and year fixed effects.

In the second equation, the dependent variable is investment-to-asset ratio, and the set of independent variables is the same as in the owner’s portfolio diversification equation, as well as firm fixed effects and year fixed effects. The SURE estimation method allows for the possibility that the investment model and the portfolio diversification model are correlated via the error terms.

²⁷While we cannot trace equity issues of privately-held firms, an analysis of issues by publicly-traded companies in affected countries provides an indication of general trends in equity issuance activity around tax cut events. The number of seasoned equity offerings (SEOs) in the five affected countries increased from 581 in the year prior to the tax cut year to 695 in the year of the cut, and 1,043 in the year following the cut. Even more strikingly, the number of primary shares issued in these SEOs increased from 28 billion in the pre-tax-cut year to 72 billion in the tax-cut year and 219 billion in the post-cut year.

²⁸The results are robust to modifications of the pre- and post-event windows, in particular to using years $t - 1$ and $t + 1$.

Table 4 reports the estimates of the portfolio diversification regression in the first column and the capital investment regression in the second column. The positive and significant coefficient on the post-tax-cut dummy in the portfolio diversification regression is consistent with a tax cut leading to increases in portfolio diversification of public firm owners. The positive and significant sum of the coefficients on the post-tax-dummy and its interaction with private firm dummy indicates that private firm owners' portfolio diversification also increases following a tax cut, although the negative and significant coefficient on the interaction term shows that the effect on private firm owners' portfolio diversification is smaller than that on the diversification of owners of public firms.

The positive coefficient on the capital gains tax cut dummy in the investment regression suggests that public firms' investment-to-asset ratio increases following the tax cut. This is consistent with both the direct effect of a tax cut on public firms' investment and with the indirect effect through an increase in owners' portfolio diversification. On the contrary, the coefficient on the interaction between post-tax dummy and private firm dummy is negative and significant, suggesting a differential impact of the tax cut on capital investment of public and private firms. Further, the negative coefficient on the interaction variable is somewhat larger in magnitude than the positive coefficient on the tax cut dummy, suggesting that the overall effect of the tax cut on private firms' investment rate is negative.

These changes in investment rates of public and private firms suggest strongly that the negative indirect effect operating through an increase in constrained (private) firm owners' portfolio diversification is present and, moreover, it dominates the positive direct effect. This result supports the prediction of a differential effect of owners' portfolio diversification on public and private firms' capital investment, which is due to the interaction between owners' portfolio diversification and firms' financial constraints.

3.3 Instrumental variables analysis

A possible concern that arises when firms' investment rates are regressed on measures of their owners' portfolio diversification is that the latter may be endogenous. In particular, a potential source of endogeneity is reverse causality, i.e., feedback effects from a firm's investment decisions to its owner's portfolio diversification: an owner of a firm with high investment rate may be tempted to diversify her portfolio in order to compensate for the high risk of the firm's cash flows. We employ an instrumental variable approach to capture the part of owners' diversification that is arguably independent of their firms' investment decisions.

As a first step, we compute the number of firms that are headquartered around each controlling owner in our sample and are not controlled by the owner. We argue that a controlling owner’s *limits to diversification*, which is the exogenous variable in our model, are inversely related to the number of firms headquartered closely to her. We refer to these as *investable firms*. Diversification of the equity part of an owner’s portfolio is expected to be positively related to her number of investable firms. This argument relies on home bias in equity investments, i.e. preference for familiar companies, where the source of familiarity can be language, culture, and geographical distance, as shown in past studies (e.g., Coval and Moskowitz (1999), Grinblatt and Keloharju (2001), and Zhu (2003)). As we show in Section 3.4, home bias in our sample is indeed strong, as only 9% of firm owners’ holdings span multiple countries.

For each controlling owner with available postal code information, we record her location and find its latitude and longitude. Similarly, for each firm included in Amadeus we identify its location, and calculate the spherical distance between owner j and company i .²⁹ For the median controlling owner, the number of investable firms within a five-mile radius is 75.

There is a strong and significant positive relation between the number of investable firms and portfolio diversification of controlling owners, suggesting that the relevance restriction of the instrument is likely to be satisfied. However, the home bias itself could be endogenous. That is, controlling owners may tend to invest locally because of similarities in e.g., *local* investment opportunities or financial constraints between their controlled firm and investable firms. These similarities may lead to a positive relation between the number of investable firms and capital investment level of controlled firm through channels other than the owner’s portfolio diversification. In other words, local conditions, such as better investment opportunities and/or weaker financial constraints may lead to both a larger number of local investable firms and a higher level of capital investment of the controlled firm, violating the exclusion restriction.

To mitigate this concern, we measure the number of investable firms not in the owner’s country but, instead, in *neighboring countries*. It may be argued, however, that even in neighboring countries, the number of investable firms is correlated with investment opportunities and/or financial constraints. To the extent

²⁹We compute the spherical distance as follows: $d_{j,i} = \arccos(\cos(lat_j) * \cos(lon_j) * \cos(lat_i) * \cos(lon_i) + \cos(lat_j) * \sin(lon_j) * \cos(lat_i) * \sin(lon_i) + \sin(lat_j) * \sin(lat_i)) \times r$, where lat and lon refer to the latitude and longitude in radians and r is the radius of Earth in miles. An alternative measure of the distance between two addresses is road distance. Computing road distance between two points is more computationally challenging than computing spherical distance. In fact, computing road distance for every 130 billion investor-company pairs in our sample is computationally infeasible. Nonetheless, we calculated road distances for a random sample of 50,000 owner-company pairs and regressed them on the respective spherical distances. The R-squared of 99.4% suggests that our results are unlikely to be affected by potential measurement errors in owner-firm distances.

that investment opportunities and/or financial constraints in neighboring countries are correlated with those in the owner’s country, controlled firm’s capital investment and the number of investable firms in neighboring countries may be correlated for reasons unrelated to owner’s portfolio diversification.

In an attempt to address this concern, we further modify our instrument as follows. First, within each (local) country each year we assign controlling owners to quintiles of portfolio diversification. Then, we construct the distribution of portfolio diversification of owners in all neighboring countries in order to match local owners in a specific quintile of portfolio diversification distribution with owners in neighboring countries that belong to the same quintile of portfolio diversification.

Second, to each diversification quintile in the local country we assign an indicator that equals one if firms in that quintile have above(below)-average investment opportunities or below(above)-average financial constraints, where averages are computed within the (local) country-year. Within each quintile of the neighboring countries’ distribution of owners’ portfolio diversification, we compute the average number of investable firms across owners of firms with below(above)-average investment opportunities if the corresponding quintile in the local country is indicated as “above(below)-average investment opportunities” or above(below)-average financial constraints if the corresponding quintile in the local country is indicated as “below(above)-average financial constraints”.

In other words, we purposely mismatch investment opportunities and financial constraints of firms in a local country and their owner-portfolio-diversification-matched firms in neighboring countries. Thus, the exclusion restriction is unlikely to be violated due to similarity of local and matched firms’ investment opportunities and/or financial constraints. Given that most firms in our sample are privately-held, a firm’s investment opportunities are proxied by year-over-year sales growth. A firm’s financial constraints are proxied by the distance from the firm’s country’s capital market.

In the first stage, we regress each of our two portfolio diversification measures on the logarithm of $(1 + \#$ of investable firms in neighboring countries), along with all exogenous variables. In the second stage, we use predicted values of owner’s portfolio diversification and estimate the regression of investment-to-assets ratio on predicted portfolio diversification and control variables.³⁰ The number of investable firms in neighboring

³⁰Since portfolio diversification is interacted with the private/public indicator, it is possible that this interaction term is also endogenous. Therefore, following Wooldridge (2010), we use the product between the number of investors in neighboring countries and the private firm public indicator as an instrument for that interaction term and estimate an additional first-stage model, in which we regress the interaction term on its corresponding instrument along with all other exogenous variables. The results of the second-stage regressions are similar to those reported. For brevity, we only show the first-stage regressions with

countries, with *mismatched* investment opportunities and financial constraints, is significantly positively correlated with owner’s portfolio diversification measures, and the F-statistics suggest that this is not a weak instrument, as discussed in Staiger and Stock (1997) (see columns 1 and 2 of Table 5).

Columns 3 and 4 report the second-stage estimates, which are consistent with Predictions 1 and 2, and with the baseline results in Table 3. That is, the relation between capital investment and the (predicted) owner’s portfolio diversification proxies is positive and significant for public firms, while it is significantly less positive – in fact negative and close to zero – for private firms. Overall, the instrumental variables estimation is consistent with the differential relation between public and private firms’ investment-to-asset ratios on one hand and their controlling owners’ portfolio diversification on the other hand.

3.4 Self-selection of the mode of incorporation

As evident from Panel B of Table 2, subsamples of public and private companies differ significantly along many dimensions. Thus, it is important to examine whether our results are affected by firms’ self-selection into the public and private modes of incorporation. We address this issue by estimating a two-stage Heckman (1979) selection model. In the first stage, we explicitly estimate the choice of public/private incorporation using a probit regression. In the second stage, we re-estimate our baseline model while augmenting it by the inverse Mills ratio from the first-stage regression to correct for potential self-selection.

For this model to be correctly specified, it is important to include at least one exogenous variable in the first-stage choice model (e.g., Lennox, Francis, and Wang (2011)). For this purpose, we follow Gao, Harford and Li (2013) and use industry-level underwriter concentration. The idea is that the higher the underwriter concentration, the more expensive it is for firms to go public. In other words, the probability of staying private increases with the level of concentration in the underwriting market. We collect information from 3,563 IPOs across Europe over our sample period from SDC, and for each 3-digit SIC industry we construct the ratio of the number of IPOs underwritten by one of the 5 underwriters with the largest market shares in that industry (“*top-5 underwriters*”) over the total number of IPOs.

The concentration in the underwriting market is likely to satisfy the exclusion restriction, as it is unlikely that the average underwriter concentration in a certain industry directly affects capital investment decisions of firms operating in that industry. Rather, competition among underwriters is related to the size of the IPO portfolio diversification as dependent variable.

market, the ancillary services that top-tier underwriters are able to provide, and the typical number of book runners per IPO (e.g., Liu and Ritter (2011) and Ellis, Michaely and O’Hara (2011)). In our sample, there is no significant relation between firms’ investment-to-asset ratio and our proxy for underwriter concentration in their industry. Nonetheless, to further address the concern that our underwriting market concentration measure may be correlated with other characteristics that influence firms’ investment decisions, we also include industry, country, and year fixed effects in the first-stage regressions.

Columns 1 and 2 of Table 6 report first-stage estimates, where the coefficient on the underwriting market concentration is positive and significant for both portfolio diversification measures. Columns 3 and 4 report the second-stage estimates, including the inverse Mills ratio from the first stage. A significantly negative coefficient on the inverse Mills ratio in both specifications suggests that there is indeed self-selection of the mode of incorporation. In particular, the error terms in the choice model of the mode of incorporation and in the second-stage regression are negatively correlated. That is, (unobserved) factors that are correlated with firms’ choice to remain privately-held tend to be associated with lower levels of investment.

More importantly, after controlling for this potential self-selection bias, the results are qualitatively consistent with the baseline results. Consistent with Prediction 1, investment-to-assets ratio of public firms is positively associated with both measures of portfolio diversification. The relation is somewhat weaker than in the baseline specification in Table 3: a one-standard-deviation increase in each of the two measures of portfolio diversification is associated with an increase of 1.9-2.2% in investment-to-assets ratio of public firms relative to its mean. Consistent with Prediction 2, the sensitivity of private firms’ investment to their owners’ portfolio diversification remains significantly lower than public firms’ investment. The sum of the estimated coefficients on portfolio diversification and on the interaction term shows that the overall private firms’ investment sensitivity to their owners portfolio diversification remains significantly negative, with magnitudes roughly similar to the baseline specification.

3.5 Owners’ portfolio diversification and investment riskiness

In addition to the relation between a firm owner’s portfolio diversification and the level of the firm’s capital investment, our model delivers an empirical prediction regarding the relation between diversification and investment riskiness. The theoretical relation between the limits to owner’s diversification and the riskiness of the firm’s investment is negative for both unconstrained and constrained firms. Stated differently, the

equilibrium relation between firm owner’s portfolio diversification and the riskiness of that firm’s investment is positive for both unconstrained and constrained firms, as stated in part 4) of Propositions 1 and 2 and illustrated in Figure 1D.

Thus, as an additional test of our model, we examine this predicted relation empirically, by estimating the following regression.

$$VolROA_{i,t} = \alpha + \beta PRI_{i,t} + \gamma Diver_{i,t} + \delta(PRI_{i,t} \times Diver_{i,t}) + \Theta \mathbf{X}_{i,t} + OwnerFE + YearFE + u_{i,t}. \quad (10)$$

The dependent variable is the volatility of the firm’s returns on assets (ROA), which is an accepted measure of firms’ risk taking (e.g., John, Litov and Yeung (2008) and Faccio, Marchica and Mura (2011)) and is especially suitable within our sample that is dominated by private firms. ROA is the ratio of earnings before interest and taxes to total assets. We measure the volatility of ROA over 5-year overlapping periods. Control variables include sales growth, leverage, ROA, ln(sales), age, and cash flow rights. The regression is estimated with owner and year fixed effects, and standard error clustered as in the baseline specification in equation (9). We estimate this regression using $\ln(1 + \#firms)$ as the measure of diversification. The results, reported in column 1, are consistent with the model’s comparative statics. The coefficient on portfolio diversification, 0.001, is positive and statistically significant, indicating a positive relation between owners’ portfolio diversification and the riskiness of capital investment for public firms. The sum of the coefficient on portfolio diversification and the interaction of portfolio diversification and private firm indicator, which measures the relation between diversification and investment riskiness for private firms, is also positive, $0.001 + 0.00004 = 0.00104$ and significant. The economic effects are non-negligible: a one-standard-deviation increase in a public (private) firm owner’s portfolio diversification is associated with 2.3% (2.2%) increase in the volatility of the firm’s ROA relative to public (private) firm’s mean ROA volatility. This relation is consistent with the positive relation between owners’ portfolio diversification and the riskiness of firms’ capital investment, established in Faccio, Marchica and Mura (2011).

Separate tests of the relations between owners’ portfolio diversification on one hand and a) firms’ investment levels and b) their investment riskiness on the other hand, are econometrically valid, since our model’s comparative statics rely on *equilibrium* relations between owners’ diversification and the level and riskiness of their firms’ capital investment. Note, however, that while used in past literature as a measure

of investment riskiness, in our model the volatility of profits is the product of both the level and riskiness of investment, as discussed in Section 2.1.3. Thus, to ensure that the test of the relation between owners' portfolio diversification and the volatility of firm's ROA is consistent with the theoretical relation between owners' portfolio diversification and the riskiness of firm's capital investment, we need to control for the choice of the level of investment in the volatility of ROA model. Capital investment may be determined by firm's and owner's characteristics that also determine the volatility of ROA, part of which are potentially unobservable. Thus, we employ a two-stage instrumental variable approach, where in the first stage we estimate the investment model, and in the second stage we estimate the volatility of ROA model as in equation (10) augmented by the predicted value of investment from the first stage regression. As to the first stage, we use the baseline model of investment as in equation (9), in which cash flow is the variable not included in the volatility of ROA model. For better identification purposes, in the investment model we include one additional exogenous variable – the average investment across all other firms operating each year in the same sector of the company of interest. This variable is unlikely to be correlated with $u_{i,t}$ in equation (10).

The second column of Table 7 reports the first-stage estimates of the investment-to-assets ratio regressed on all exogenous variables. Importantly, we are unable to reject the hypothesis that the instruments are not correlated with the error term (p-value=0.255), confirming the validity of the excluded instruments. To assess the relevance of our instruments, we also report the first-stage F-statistics, which suggests that the instruments are not weak, as discussed in Staiger and Stock (1997).

Most importantly, in the third column of Table 7, we report estimates of the second-stage volatility of ROA equation augmented by predicted investment level from the first-stage estimation. The results are similar to those in column 1: the coefficient on portfolio diversification and the sum of the coefficients on the product of portfolio diversification and on the private firm indicator are both statistically significant. This result mitigates the possible concern that the positive relation between owners' portfolio diversification and the volatility of firm's ROA reported in column (1) may be driven by the choice of the level of investment, as opposed to its riskiness. In addition, consistent with volatility of ROA increasing in investment, the coefficient on the investment-to-assets ratio is significantly positive.

Overall, while the positive relation between owners' portfolio diversification and the riskiness of firms' capital investment is not surprising in light of past literature, the fact that we obtain this relation for both

privately-held and publicly-traded firms is reassuring and provides further validation of the model.

4 Conclusions

We investigate theoretically and empirically the relation between firms' capital investment and diversification of their owners' portfolios. Existing literature concentrates mainly on the effects of an owner's portfolio diversification on her firm's risk taking. We take one step further and examine the joint choice by a firm's controlling owner of the *level* and *riskiness* of the firm's capital investment, as well as her optimal portfolio structure. The interaction between the choices of investment level and riskiness drives the relation between firm owner's portfolio diversification and firm's investment strategy. Our model shows that the sign of this relation depends crucially on whether the firm is financially constrained.

For an unconstrained firm, higher owner's portfolio diversification raises the owner's incentives to choose larger and riskier capital investment projects on her controlled firm's behalf, leading to a positive relation between owner's portfolio diversification and the firm's capital investment level. For a constrained firm, higher owner's portfolio diversification leads to similar incentives. However, higher capital investment riskiness tightens the firm's financial constraint, leading the firm to take smaller but riskier capital investment projects, resulting in a negative equilibrium relation between owner's portfolio diversification and the firm's level of capital investment.

Empirically, we examine the relation between owners' portfolio diversification and firms' capital investment rates using Amadeus Top 250,000 database, which provides comprehensive accounting and ownership data on both private and public firms in 34 European countries. We are able to reconstruct equity portfolios of a large number of firms' controlling owners, which we use to build measures of owners' portfolio diversification. While we can only measure the equity component of the firm owners' portfolios, we show that our measures are likely to be positively correlated with the overall, unobserved, owners' portfolio diversification.

Consistent with the model's predictions, we find that capital investment of publicly-traded firms, which are likely to be less financially constrained on average, is positively related to their owners' portfolio diversification and that this relation is typically economically significant. In contrast, the relation between firms' investment and their owners' portfolio diversification is negative for privately-held firms, which are likely to be more financially constrained on average.

These results are not likely to be driven by the endogeneity of firm owners' portfolio diversification

and of firms' mode of incorporation. First, we estimate owners' portfolio diversification and firms' capital investment regressions simultaneously within a subsample of firms that were subject to an exogenous shock to their owners' portfolio diversification. Second, we use an instrument for owners' portfolio diversification that is unlikely to be related to firms' investment opportunities and financial constraints. Third, we employ a two-stage selection model that controls for endogeneity of a firm's mode of incorporation. Finally, our results are robust to: 1) alternative measures of investment and owner's control; 2) tunneling; and 3) cross-country differences in disclosure requirements and accounting and reporting standards.

Overall, our theoretical and empirical results suggest that a firm's controlling owner's portfolio diversification is an important determinant of the firm's capital investment. The relation between the owner's diversification and the firm's investment level is more subtle than the relation between the owner's diversification and the riskiness of the firm's investment. While the latter relation is positive for both constrained and unconstrained firms, as shown in our model and in the existing empirical studies, the effect of owner's diversification on the *level* of her firm's investment depends crucially on whether the firm is constrained. For relatively unconstrained firms, diversification has a first-order importance in determining capital investment.

The real effects of firm owners' portfolio diversification can have important policy implications. In particular, if a goal of policymakers' is to improve the allocation of capital and thereby foster economic growth through capital investment, then it is important not only to reduce firms' financial constraints by enhancing capital market development, but also to reduce barriers to firm owners' portfolio diversification by fostering their participation in capital markets.

Appendix

Proof of Proposition 1

The total differential of n^* with respect to ϕ is:

$$\frac{dn^*}{d\phi} = \frac{\partial n^*}{\partial \phi} + \frac{\partial n^*}{\partial \sigma_u} \frac{\partial \sigma_u^*}{\partial s^*(n)} \frac{\partial s^*(n^*)}{\partial n} \frac{\partial n^*}{\partial \phi} + \frac{\partial n^*}{\partial K_u} \frac{\partial K_u^*}{\partial s^*(n)} \frac{\partial s^*(n^*)}{\partial n} \frac{\partial n^*}{\partial \phi}. \quad (11)$$

Differentiating the first order condition for $s^{*'}(n^*)$ in (5) with respect to ϕ produces:

$$s^{*''}(n^*) \frac{\partial n^*}{\partial \phi} = - \frac{ax(K_u^* \lambda \rho \sigma_u^* + xs^*(n^*)) - \phi ax^2 s^{*'}(n^*) \frac{\partial n^*}{\partial \phi}}{ax(K_u^* \lambda \rho \sigma_u^* + xs^*(n^*))^2}. \quad (12)$$

Simplifying (12) and plugging the first order condition in (5) results in:

$$\frac{\partial n^*}{\partial \phi} = - \frac{1}{s^{*''}(n^*) ax(K_u^* \lambda \rho \sigma_u^* + xs^*(n^*)) + ax^2 (s^{*'}(n^*))^2}. \quad (13)$$

Since $s^{*''}(n^*) > 0$ by assumption, the denominator of (13) is positive, and

$$\frac{\partial n^*}{\partial \phi} < 0. \quad (14)$$

Differentiating the first order condition for $s^{*'}(n^*)$ in (5) with respect to σ produces:

$$s^{*''}(n^*) \frac{\partial n^*}{\partial \sigma} = - \frac{-\phi ax(K_u^* \lambda \rho + xs^{*'}(n^*)) \frac{\partial n^*}{\partial \sigma}}{(ax(K_u^* \lambda \rho \sigma_u^* + xs^*(n^*)))^2}. \quad (15)$$

Simplifying (15) and plugging in the first order condition in (5) results in:

$$\frac{\partial n^*}{\partial \sigma} = - \frac{K_u \lambda \rho s^{*'}(n^*)}{s^{*''}(n^*) (K_u \lambda \rho \sigma_u^* + xs^*(n^*)) + x(s^{*'}(n^*))^2}. \quad (16)$$

Since $s^{*'}(n^*) < 0$ by assumption, the numerator of (16) is negative. Since $s^{*''}(n^*) > 0$ by assumption, the denominator of (16) is positive, and

$$\frac{\partial n^*}{\partial \sigma_u} > 0. \quad (17)$$

Differentiating the first order condition for $s^{*'}(n^*)$ in (5) with respect to K_u produces:

$$s^{*''}(n^*) \frac{\partial n^*}{\partial K_u} = - \frac{-\phi ax(\lambda \rho \sigma_u + xs^{*'}(n^*))}{(ax(K_u^* \lambda \rho \sigma_u^* + xs^*(n^*)))^2}. \quad (18)$$

Simplifying (18) and plugging the first order condition in (5) results in

$$\frac{\partial n^*}{\partial K_u} = - \frac{s^{*'}(n^*) K_u^* \lambda \rho \sigma_u x}{s^{*''}(n^*) (K_u^* \lambda \rho \sigma_u^* + xs^*(n^*)) + (s^{*'}(n^*))^2}. \quad (19)$$

Since $s^{*'}(n^*) < 0$ by assumption, the numerator of (19) is negative. Since $s^{*''}(n^*) > 0$ by assumption, the denominator of (19) is positive, and

$$\frac{\partial n^*}{\partial K_u} > 0. \quad (20)$$

Differentiating the first order condition for $\mu'(\sigma_u^*)$ in (7) with respect to $s^*(n)$ produces:

$$\mu''(\sigma_u^*) \frac{\partial \sigma_u^*}{\partial s^*(n)} = ax\rho + a\lambda K_u^* \frac{\partial \sigma_u^*}{\partial s^*(n)}, \quad (21)$$

leading to:

$$\frac{\partial \sigma_u^*}{\partial s^*(n)} = \frac{ax\rho}{\mu''(\sigma_u^*) - a\lambda K_u^*}. \quad (22)$$

Since $\mu''(\sigma^*) < 0$ by assumption,

$$\frac{\partial \sigma_u}{\partial s^*(n)} < 0. \quad (23)$$

Differentiating the first order condition for K_u in (6) with respect to $s^*(n)$ produces

$$\frac{\partial K_u^*}{\partial s^*(n)} = \frac{-ax\rho\sigma_u^*}{2 + a\lambda\sigma_u^{*2}} < 0. \quad (24)$$

Combining the assumption that $\frac{\partial s^*(n)}{\partial n} < 0$ with the results on the signs of partial derivatives in (14), (17), (20), (23), and (24), leads to

$$\frac{dn^*}{d\phi} < 0. \quad (25)$$

Given the assumption $\frac{\partial s^*(n)}{\partial n} < 0$, we have:

$$\frac{ds^*(n^*)}{d\phi} > 0. \quad (26)$$

The total differential of K_u^* with respect to ϕ is:

$$\frac{dK_u^*}{d\phi} = \frac{\partial s^*(n^*)}{\partial n} \frac{\partial n^*}{\partial \phi} \left(\frac{\partial K_u^*}{\partial s^*(n)} + \frac{\partial K_u^*}{\partial \sigma_u} \frac{\partial \sigma_u^*}{\partial s^*(n)} \right). \quad (27)$$

Differentiating the first order condition for K_u^* in (6) with respect to σ_u gives:

$$\frac{dK_u^*}{d\sigma_u} = \frac{-a\lambda\sigma_u^* K_u^*}{2 + a\lambda\sigma_u^{*2}} < 0. \quad (28)$$

Combining the assumption that $\frac{\partial s^*(n)}{\partial n} < 0$ with the results on the signs of the partial derivatives in (14), (23), (24), and (28) leads to:

$$\frac{dK^*}{d\phi} < 0. \quad (29)$$

The total differential of σ_u^* with respect to ϕ is:

$$\frac{d\sigma_u^*}{d\phi} = \frac{\partial s^*(n^*)}{\partial n} \frac{\partial n^*}{\partial \phi} \left(\frac{\partial \sigma_u^*}{\partial s^*(n)} + \frac{\partial \sigma_u^*}{\partial K_u} \frac{\partial K_u^*}{\partial s^*(n)} \right). \quad (30)$$

Differentiating the first order condition for $\mu'(\sigma_u^*)$ in (7) with respect to K_u produces

$$\mu''(\sigma_u^*) \frac{\partial \sigma_u^*}{\partial K_u} = a\lambda\sigma_u^* + a\lambda K_u^* \frac{\partial \sigma_u^*}{\partial K_u}, \quad (31)$$

leading to:

$$\frac{\partial \sigma_u^*}{\partial K_u} = \frac{a\lambda\sigma_u^*}{\mu''(\sigma_u^*) - a\lambda K_u^*}. \quad (32)$$

Since $\mu''(\sigma_u^*) < 0$ by assumption,

$$\frac{\partial \sigma_u^*}{\partial K_u} < 0. \quad (33)$$

Combining the assumption that $\frac{\partial s^*(n)}{\partial n} < 0$ with the results on the signs of the partial derivatives in (14), (23), (24), and (33) leads to:

$$\frac{d\sigma_u^*}{d\phi} < 0. \quad (34)$$

Proof of Proposition 2

The total differential of n^* with respect to ϕ when $K = \bar{K}(\eta, \sigma_c^*)$ is:

$$\frac{dn^*}{d\phi} = \frac{\partial n^*}{\partial \phi} + \frac{\partial n^*}{\partial \sigma_c} \frac{\partial \sigma_c^*}{\partial s^*(n)} \frac{\partial s^*(n)}{\partial n} \frac{\partial n^*}{\partial \phi}. \quad (35)$$

Differentiating the first order condition for $\mu'(\sigma_c^*)$ in (8) with respect to $s^*(n)$ produces:

$$\mu''(\sigma_c^*) \frac{\partial \sigma_c^*}{\partial s^*(n)} = ax\rho + \frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma_c} \left(\frac{ax\rho\sigma_c^*}{\bar{K}(\eta, \sigma_c^*)} - \frac{\mu'(\sigma_c^*)}{\bar{K}(\eta, \sigma_c^*)} \frac{\partial \sigma_c^*}{\partial s^*(n)} \right). \quad (36)$$

Rearranging (36) leads to:

$$\frac{\partial \sigma_c^*}{\partial s^*(n)} = \frac{ax\rho + \frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma_c} \frac{ax\rho\sigma_c^*}{\bar{K}(\eta, \sigma_c^*)}}{\mu''(\sigma_c^*) + \frac{\mu'(\sigma_c^*)}{\bar{K}(\eta, \sigma_c^*)} \frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma_c}}. \quad (37)$$

Since $\mu''(\sigma_c^*) < 0$ by assumption, $\mu'(\sigma_c^*) > 0$ by assumption, and $\frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma_c} < 0$ by assumption, the denominator of (37) is negative. The sign of the numerator depends on the sign of $1 + \frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma_c} \frac{\sigma_c^*}{\bar{K}(\eta, \sigma_c^*)}$.

It follows from (37) that

$$\frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma_c} = \frac{\bar{K}(\eta, \sigma_c^*)}{\sigma_c^*} + \frac{1}{\sigma_c^*} (\mu'(\sigma_c^*)\sigma_c^* - \mu(\sigma_c^*)), \quad (38)$$

and

$$\frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma_c} \frac{\sigma_c^*}{\bar{K}(\eta, \sigma_c^*)} = -1 - \frac{(\mu'(\sigma_c^*)\sigma_c^* - \mu(\sigma_c^*))}{\bar{K}(\eta, \sigma_c^*)}. \quad (39)$$

$\mu'(\sigma_c^*)\sigma_c^* - \mu(\sigma_c) < 0$ for $\sigma_c \rightarrow 0$. In addition, differentiating $\mu'(\sigma_c^*)\sigma_c^* - \mu(\sigma_c^*)$ with respect to σ_c results in:

$$\frac{\partial(\mu'(\sigma^*)\sigma^* - \mu(\sigma^*))}{\partial \sigma} = \mu''(\sigma^*) < 0. \quad (40)$$

Thus, $\frac{\mu'(\sigma_c^*)\sigma_c^* - \mu(\sigma_c^*)}{\bar{K}(\eta, \sigma_c^*)} < 0$ and $1 + \frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma_c} \frac{\sigma_c^*}{\bar{K}(\eta, \sigma_c^*)} > 0$.

Therefore, the numerator of (37) is positive and

$$\frac{\partial \sigma_c^*}{\partial s^*(n)} < 0. \quad (41)$$

Combining the results on the signs of the partial derivatives in (13), (16), and (41) with the assumption that $s^*(n)' < 0$ leads to:

$$\frac{dn^*}{d\phi} < 0. \quad (42)$$

Given the assumption $s^*(n)' < 0$, we have:

$$\frac{ds^*(n^*)}{d\phi} > 0. \quad (43)$$

The total differential of σ_c^* with respect to ϕ is given by:

$$\frac{d\sigma^*}{d\phi} = \frac{\partial \sigma_c^*}{\partial s^*(n)} \frac{\partial s^*(n^*)}{\partial n} \frac{\partial n^*}{\partial \phi}. \quad (44)$$

Combining the assumption that $s^*(n)' < 0$ with the signs of partial derivatives in (13) and (41) leads to:

$$\frac{d\sigma_c^*}{d\phi} < 0. \quad (45)$$

Given the assumption that $\frac{d\bar{K}(\eta, \sigma_c^*)}{d\sigma} < 0$, we obtain:

$$\frac{d\bar{K}(\eta, \sigma_c^*)}{d\phi} > 0. \quad (46)$$

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Figure 1. Equilibrium number of portfolio firms, portfolio volatility, firm's capital investment level and riskiness, firm's expected profit, and limits to diversification

In this figure we depict the relations between the limits to diversification, ϕ , and the following equilibrium quantities: the number of firm's in the owner's portfolio, n^* , the portfolio's standard deviation, $s^*(n^*)$, the level of capital investment in the controlled firm, K^{*2} , the riskiness of this investment, σ^* , and firm's expected profit, $-K^{*2} + \mu(\sigma^*)K^*$. The relation between the risk of the firm's investment and its expected return is given by $\mu(\sigma) = \sqrt{\sigma}$. The private firms in the owner's portfolio are assumed symmetric: $s_i = s_j \equiv s_{pri}$ for all i and j ; $\rho_{i,pub} = \rho_{pri}$ for all i ; and $\rho_{i,j} = \rho_{pri}$ for all i and j . We use the following parameter values: $\lambda = 0.5$, $a = 1$, $x = 5$, $R = 1.1$, $\rho = 0.5$, $\rho_{pri} = 0.5$, $s_{pub} = 0.2$, and $s_{pri} = 0.3$. We examine two levels of financial constraints. In the less (more) constrained case, $\eta = 0.25$ ($\eta = 0.15$). We vary the limits to diversification, ϕ , between 0.001 and 0.05. In all figures, solid lines correspond to the case of $\eta = 0.15$, while the dashed lines correspond to $\eta = 0.25$. Dotted lines represent solutions to cases in which n^* is not constrained to integer values. Panel A depicts the relation between ϕ and n^* . Panel B presents the relation between ϕ and $s^*(n^*)$. Panel C depicts the relation between ϕ on one hand, and K^* . Panel D presents the relation between ϕ and σ^* .

Figure 1A: Number of private firms and the limits to diversification

Figure 1B: Portfolio volatility and the limits to diversification

Figure 1C: Capital investment level and the limits to diversification

Figure 1D: Investment riskiness and the limits to diversification

Table 1. Household investment portfolio composition

This table presents mean proportions of European households' wealth invested in different asset classes. The data are from the first wave of the Eurosystem Household Finance and Consumption Survey (HFCS, 2013) in 15 Euro area countries. The sample of the survey includes 62,521 households from Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovenia, Slovak Republic, and Spain, interviewed in 2010/2011 with the exception of France (2009/2010), Spain (2008/2009), and Greece (2009). HFCS contains detailed information on market values of households' holdings across 14 asset classes, which we group into 7 categories: 1) Ownership in companies, which includes shares in controlled firms, shares in other private companies, and shares in other public companies; 2) Bonds; 3) Deposits; 4) Real estate, which includes a household's main residence and other real estate (e.g., holiday homes/apartments, land); 5) Mutual funds and managed accounts; 6) Other financial assets (e.g., loans to private individuals, voluntary private pension plans); 7) Other real assets (e.g., vehicles, valuables). The total value of each household's portfolio is the sum of values of its holdings across the seven categories, expressed in \$U.S. The first column reports mean portfolio allocation for all households in the survey. The second column reports mean portfolio allocation of the top 1% of households in terms of total wealth. The third column reports mean portfolio allocation of households that identify themselves as "self-business owners".

	Whole sample	Top percentile	Self-business owners
Ownership in companies	0.114	0.384	0.367
Bonds	0.011	0.020	0.007
Deposits	0.072	0.034	0.038
Real estate	0.695	0.476	0.511
Mutual funds and managed accounts	0.016	0.023	0.010
Other financial assets	0.051	0.044	0.038
Other real assets	0.042	0.020	0.029
Total portfolio value	342.4	5,762.8	1,023.8

Table 2. Summary statistics

Panel A reports descriptive statistics at the controlling owner level, separately for public and private firm owners. A private firm's owner is defined as an investor controlling at least one private firm. A public firm's owner is defined as an investor controlling at least one public firm. # of firms in controlling owner's portfolio is the total number of firms in Amadeus in which the controlling owner holds shares, directly or through a pyramid, in a given year, across all countries in our sample. To compute the Herfindahl index of firm owner's holdings, we first calculate the dollar value of her investment in each firm in her portfolio as the book value of the firm's equity multiplied by her ultimate ownership stake in the firm. # sectors refers to the number of 3-digit SIC industries represented in an investor's portfolio. # of countries refers to the number countries represented in an investor's portfolio. The stars in the column reporting private firms' means (medians) refer to the significance of the difference in means (medians) between private and public firm owners, computed using the Wald (Wilcoxon rank sum) test. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels respectively.

Panel B reports descriptive statistics at the firm-level separately for subsamples of public and private firms. Investment-to-assets ratio is year-to-year change in gross fixed assets divided by lagged total assets, where total assets are computed as the sum of fixed and current assets. Sales growth annual relative growth rate in total revenues. Cash flow-to-assets ratio is the ratio of income plus depreciation to beginning-of-year total assets. Firm age is defined as the number of years since the firm's incorporation. Book assets are reported in thousands \$U.S. and expressed in 1999 prices. Sales are total revenues reported in thousands \$U.S. and expressed in 1999 prices. Book equity is the difference between book assets and total debt, where total debt includes non-current liabilities (long term debt and other non-current liabilities) and current liabilities (loans, accounts payable, and others). Leverage is defined as the ratio of total debt to total assets. Volatility of ROA is the 5-year volatility of a firm's return on assets, ROA, where ROA is the ratio of EBIT to total assets. # of firms, and 1-Herfindahl index are defined as in Panel B. Controlling owner's \$ holdings equal the book value of controlled firm's book equity multiplied by the owner's ultimate ownership stake in the firm (cash flow rights). Cash flow rights are defined as the product between ownership stakes along the ownership chain. Fraction of controlling owner's holdings is the ratio of controlling owner's \$ holdings of firm's equity to the value of owner's equity portfolio. Controlling owner's voting rights are defined as the weakest link along the ownership chain. The stars in the column reporting private firms' means (medians) refer to the significance of the difference in means (medians) between private and public firm owners, computed using the Wald (Wilcoxon rank sum) test. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels respectively.

Panel A. Controlling-owner-level variables							
	Mean	p25	Median	p75	St. dev.	Skew	# obs.
Public firms' controlling owners							
# firms	4.24	1.00	2.00	4.00	11.46	10.70	11,661
ln(1+# firms in controlling owner's portfolio)	1.21	0.69	1.10	1.61	0.72	1.92	11,661
1- Herf. index of controlling owner's portfolio	0.19	0.00	0.00	0.44	0.27	1.02	11,484
# sectors	2.35	1.00	1.00	2.00	4.71	11.75	11,661
# countries	1.24	1.00	1.00	1.00	0.92	6.97	11,661
Private firms' controlling owners							
# firms	2.77***	1.00	1.00***	2.00	6.72	14.67	319,683
ln(1+# firms in controlling owner's portfolio)	1.04***	0.69	0.69***	1.10	0.58	2.34	319,683
1- Herf. index of controlling owner's portfolio	0.15***	0.00	0.00***	0.30	0.24	1.35	311,117
# sectors	1.67***	1.00	1.00***	2.00	2.36	17.67	319,683
# countries	1.21***	1.00	1.00***	1.00	0.91	7.85	319,683

Panel B. Firm-level variables – public and private firms

	Mean	p25	Median	p75	St. dev.	Skew	# obs.
Public firms							
Investment-to-assets	0.106	-0.001	0.058	0.148	0.226	2.525	16,841
Sales growth	0.184	-0.102	0.049	0.233	0.823	5.329	16,841
Cash flow-to-assets	0.074	0.021	0.072	0.130	0.126	0.471	16,841
ln(1+age)	3.21	2.56	3.14	3.91	0.88	-0.02	16,841
Book assets	804,371	23,823	69,474	242,154	5,232,683	21.175	16,841
Sales	254,534	17,263	58,991	219,706	448,425	2.291	16,841
Book equity	121,598	12,413	36,853	123,634	188,221	1.987	16,499
Leverage	0.536	0.395	0.554	0.685	0.202	-0.273	16,841
Volatility of ROA	0.051	0.019	0.035	0.065	0.047	2.066	8,060
# firms in controlling owner's portfolio	14.95	1.00	3.00	8.00	37.53	3.99	16,841
ln(1+# firms in controlling owner's portfolio)	1.71	0.69	1.39	2.20	1.19	1.39	16,841
1- Herf. index of controlling owner's portfolio	0.334	0.000	0.293	0.636	0.335	0.364	16,662
Controlling owner's \$ holdings	108,707	3,182	10,672	38,154	843,964	39	16,662
Fraction of controlling owner's equity holdings	0.618	0.206	0.750	1.000	0.396	-0.371	16,662
Controlling owner's cash flow rights	0.339	0.137	0.279	0.500	0.244	0.772	16,841
Controlling owner's voting rights	0.356	0.159	0.300	0.500	0.239	0.724	16,841
Private firms							
Investment-to-assets	0.068***	0.002	0.031***	0.096	0.156	3.336	463,100
Sales growth	0.106***	-0.086	0.050	0.209	0.490	7.360	463,100
Cash flow-to-assets	0.087***	0.029	0.072	0.133	0.114	1.090	463,100
ln(1+age)	2.967***	2.48	2.944***	3.50	0.75	-0.09	463,100
Book assets	101,006***	10,087	20,830***	49,300	2,008,435	346.688	463,100
Sales	85,894***	18,404	31,106***	66,260	196,662	5.674	463,099
Book equity	28,004***	2,680	7002***	19,291	77,596	5.935	442,516
Leverage	0.631***	0.494	0.654***	0.789	0.211	-0.470	463,100
Volatility of ROA	0.050	0.021	0.037***	0.065	0.043	2.124	183,522
# firms in controlling owner's portfolio	10.436***	1.00	2.000***	6.00	27.62	5.11	463,100
ln(1+# firms in controlling owner's portfolio)	1.526***	0.69	1.099***	1.95	1.08	1.52	463,100
1- Herf. index of controlling owner's portfolio	0.298***	0.000	0.149***	0.594	0.325	0.481	454,172
Controlling owner's \$ holdings	33,122***	1,685	4,937***	14,788	417,735	99	463,100
Fraction of controlling owner's equity holdings	0.613	0.126	0.866***	1.000	0.421	-0.372	463,100
Controlling owner's cash flow rights	0.659***	0.403	0.683***	0.990	0.329	-0.392	454,172
Controlling owner's voting rights	0.673***	0.470	0.695***	0.990	0.316	-0.397	454,172

Table 3. Regressions of firms' capital investment on measures of owners' portfolio diversification

This table reports results of estimating the regression in (9) for the full sample of public and private firms during the period 1999-2010. In column 1, the measure of diversification is $\ln(1+\# \text{ firms in controlling owner's portfolio})$. In column 2, the measure of diversification is 1 - Herfindahl index of controlling owner's holdings. See Table 2 for variable definitions. All regressions are estimated using OLS. Standard errors, reported in square brackets, are clustered at the owner level. Curly brackets underneath the coefficient on portfolio diversification and its standard error report the economic significance of the coefficient. It is computed as the product of the coefficient on portfolio diversification multiplied by the standard deviation of one of the two firm-level measures of portfolio diversification of public firm owners, and divided by mean investment-to-assets ratio of public firms. Curly brackets underneath the coefficient on the interaction between portfolio diversification and private firm indicator report the economic significance of the sum of the coefficient on portfolio diversification and the coefficient on the interaction variable. It is computed as the product of the sum of the coefficient on portfolio diversification and the coefficient on the interaction variable multiplied by the standard deviation of one of the two firm-level measures of portfolio diversification of private firm owners, and divided by mean investment-to-assets ratio of private firms. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels respectively.

	$\ln(1+\# \text{ firms})$	1-Herfindhal Index
Private	-0.0123** [0.0054]	-0.0135** [0.0062]
Portfolio diversification	0.0060*** [0.0023] {6.719%}	0.0253** [0.0101] {7.981%}
Portfolio diversification $\times$ private	-0.0082*** [0.0020] {-3.461%}	-0.0329*** [0.0099] {-3.606%}
Sales growth	0.0551*** [0.0019]	0.0553*** [0.0019]
Cash flow-to-assets	0.2446*** [0.0070]	0.2487*** [0.0072]
$\ln(1+\text{age})$	-0.0024*** [0.0007]	-0.0025*** [0.0007]
Cash flow rights	0.0069*** [0.0025]	0.0070*** [0.0025]
Intercept	0.0254*** [0.0064]	0.0257*** [0.0069]
R-squared	0.221	0.22
# Obs.	479,941	470,834

Table 4. Changes in owners' diversification and private and public firms' capital investment following capital gain tax changes

This table reports results of estimating Seemingly Unrelated Regression Equations (SURE), where the dependent variables are 1) its owner's portfolio diversification and 2) firm's capital investment. The five capital gains tax reduction events are Spain (2000), Netherlands (2001), Hungary (2004), Finland (2005) and the U.K. (2008). Capital gain tax change is an indicator that takes the value of zero for the year of the tax cut and the year before it (t and $t - 1$) and the value of one for the year after the tax cut and two years after it ($t + 1$ and $t + 2$). In column one, the dependent variable is $\ln(1 + \# \text{ firms in controlling owner's portfolio})$. In column two, the dependent variable is investment-to-assets ratio. See Table 2 for variable definitions. Standard errors are reported in square brackets. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels respectively.

	Diversification model	Investment model
Private	0.072*** [0.000]	0.067*** [0.000]
Capital gains tax change	0.110*** [0.000]	0.024*** [0.000]
Capital gains tax change $\times$ private	-0.065*** [0.000]	-0.026*** [0.000]
Sales growth	0.005** [0.026]	0.044*** [0.000]
Cash flow-to-assets	-0.042*** [0.026]	0.165*** [0.000]
$\ln(1 + \text{age})$	-0.000 [0.978]	0.098*** [0.000]
Cash flow rights	-0.111*** [0.000]	0.001 [0.564]
Intercept	0.000 [1.000]	-0.009*** [0.000]
R-squared	0.014	0.086
# Obs.	46,802	46,802

Table 5. Regressions of firms' capital investment on measures of owners' portfolio diversification: Instrumental variables

This table reports results of estimating the relation between investment-to-assets ratio and owners' portfolio diversification, for the full sample of public and private firms during the period 1999-2010, while using an instrument for portfolio diversification, based on the number of investable firms in neighboring countries. The construction of the instrument is described in detail in Section 3.3. Columns 1 and 2 report results of first-stage regressions, in which we regress measures of portfolio diversification on the instrument and control variables. We also report F-statistics of excluded instruments from the first stage regressions. Columns 3 and 4 report estimates of the second-stage regressions, in which we replace portfolio diversification with its predicted value from the first stage and estimate the investment-to-assets regressions. See Table 2 for variable definitions. Standard errors, reported in square brackets. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels respectively.

	First-stage regressions		Second-stage regressions	
	ln(1+# firms)	1-Herfindhal Index	ln(1+# firms)	1-Herfindhal Index
IV: ln(1+# investable firms in neighboring countries)	0.152*** [0.029]	0.024*** [0.007]		
Private	0.169 [0.174]	-0.018 [0.040]	0.048 [0.037]	0.123 [0.092]
(Predicted) portfolio diversification			0.057** [0.027]	0.446* [0.268]
(Predicted) portfolio diversification × private status			-0.065** [0.028]	-0.484* [0.274]
Sales growth	0.057*** [0.007]	0.010*** [0.002]	0.056*** [0.002]	0.056*** [0.002]
Cash flow-to-assets	-0.054 [0.068]	-0.009 [0.017]	0.279*** [0.011]	0.285*** [0.011]
Age	0.039*** [0.011]	0.007*** [0.003]	-0.004*** [0.001]	-0.005*** [0.001]
Cash flow rights	-0.974*** [0.038]	-0.181*** [0.008]	-0.017*** [0.005]	-0.016*** [0.005]
Intercept	0.000 [0.000]	0.000 [0.000]	0.000 [0.035]	0.000 [0.088]
F test of excluded instruments	59.35	49.03		
R-squared	0.092	0.075	0.128	0.107
# Obs.	265,349	261,516	265,349	261,516

Table 6. Regressions of investment-to assets ratio on measures of portfolio diversification: Treatment effect model

This table reports results of estimating the relation between investment-to-assets ratio and owners' portfolio diversification using a two-stage Heckman model. The exogenous variable in the first-stage model is the (3 digit SIC) industry-level underwriter concentration, which equals the ratio of the number of IPOs underwritten by one of the 5 underwriters with the largest market shares in an industry over the total number of IPOs in that industry. Columns 1 and 2 report results of first-stage regressions, in which we regress the private firm indicator on the underwriting concentration in the industry, measures of portfolio diversification, and control variables. First-stage regressions are estimated using probit. Columns 3 and 4 report estimates of second-stage regressions, of investment on measures of portfolio diversification and control variables, augmented by the inverse Mills ratio from the first-stage regressions. Standard errors are reported in square brackets. Curly brackets report economic significance. See Table 3 for the detailed description of its calculation. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels respectively.

	First-stage regressions		Second-stage regressions	
	ln(1+# firms)	1-Herfindhal Index	ln(1+# firms)	1-Herfindhal Index
Underwriter concentration	0.4950*** [0.0541]	0.4990*** [0.0546]		
Private			0.0245*** [0.0045]	0.0248*** [0.0045]
Portfolio diversification	0.0624*** [0.0032]	0.2402*** [0.0139]	0.0017** [0.0008] {1.904%}	0.0069* [0.0503] {2.177%}
Portfolio diversification $\times$ private			-0.0036*** [0.0000] {-2.989%}	-0.0139*** [0.0000] {-3.322%}
Sales growth	-0.1447*** [0.0061]	-0.1480*** [0.0062]	0.0567*** [0.0005]	0.0568*** [0.0005]
Cash flow-to-assets	0.5351*** [0.0367]	0.5593*** [0.0376]	0.2495*** [0.0020]	0.2574*** [0.0020]
ln(1+age)	-0.2318*** [0.0058]	-0.2308*** [0.0058]	-0.0015*** [0.0003]	-0.0015*** [0.0003]
Cash flow rights	1.7489*** [0.0160]	1.7151*** [0.0158]	-0.0129*** [0.0008]	-0.0128*** [0.0008]
Inverse Mills ratio			-0.0280*** [0.0022]	-0.0286*** [0.0022]
Intercept	0.9148*** [0.0499]	0.9184*** [0.0504]	-0.0031 [0.0043]	-0.0051 [0.0044]
(Pseudo) R-squared	0.271	0.27	0.147	0.149
# Obs.	455,343	446,631	455,343	446,631

Table 7. Regressions of volatility of ROA

This table reports results of estimating the regression of the volatility of firms' ROA on our main measure of owners' portfolio diversification, $\ln(1+\# \text{ firms in controlling owner's portfolio})$, augmented by controlling owner and year fixed effects, for the full sample of public and private firms during the period 1999-2010. Column 1 reports results of the baseline model of volatility of ROA regressed on sales growth, leverage, ROA, $\ln(\text{sales})$, $\ln(1+\text{age})$, and cash flow rights. Columns 2 and 3 report results of the two-stage instrumental variable estimation, where in the first stage we estimate the investment model, and in the second stage we estimate the volatility of ROA model as in column 1, augmented by the predicted investment-to-assets ratio. The investment-to-assets model is the same as our baseline model, augmented by a variable that captures the average investment-to-assets across all companies other than the firm of interest, within the same firm's industry in a given year. Volatility of ROA is measured over 5-year overlapping periods. ROA is the ratio of earnings before interests and taxes to beginning-of-period book assets. See Table 2 for the rest of variable definitions. Standard errors, reported in square brackets, are clustered at the owner level. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels respectively.

	OLS	Instrumental variables	
	Volatility	First stage Investment	Second stage Volatility
(Predicted) investment			0.0054*** [0.0015]
Private	0.001 [0.0014]	-0.0312*** [0.0064]	0.0005 [0.0008]
Portfolio diversification	0.0010* [0.0005]	0.0045* [0.0026]	0.0007** [0.0003]
Portfolio diversification $\times$ private	0.00004 [0.0004]	-0.0065*** [0.0022]	0.0003 [0.0003]
Sales growth	0.0002 [0.0002]	0.0553*** [0.0023]	-0.0003 [0.0002]
Leverage	0.0071*** [0.0009]	0.0602*** [0.0037]	0.0054*** [0.0006]
ROA	0.0119*** [0.0022]	-0.4794*** [0.0129]	0.0098*** [0.0013]
$\ln(\text{sales})$	-0.0023*** [0.0002]	0.0025*** [0.0007]	-0.0018*** [0.0001]
$\ln(1+\text{age})$	-0.0007*** [0.0002]	-0.0042*** [0.0008]	-0.0004*** [0.0001]
Cash flow rights	0.001 [0.0009]	0.0029 [0.0031]	0.0010* [0.0005]
Cash flow		0.5984*** [0.0156]	
Average year/3-digit-SIC investment		0.6249*** [0.0169]	
Intercept	0.0633*** [0.0025]	0.0004 [0.0007]	0.0009*** [0.0001]
F-test of excluded instruments		1,731	
Test of overidentifying restrictions (p-value)		0.255	
R-squared	0.427	0.178	0.008
# Obs.	455,343	455,343	455,343