Are European Corporations Fleecing Minority Shareholders?
Results from a new empirical approach

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Abstract
We put forward a novel methodological approach to estimate the effect of separation of ownership and control by dominant shareholders on firm value. The approach offers three major innovations relative to previous studies on that same subject. First, it uses the Shapley Value (SV) of the voting rights of the dominant shareholder rather than the proportion of votes under his control as a measure of his power of control within the firm. We argue that the SV is a more accurate metric and thus helps improving the quality of the estimation. Secondly, it frees the researcher from the necessity of having to make an ad hoc judgment call regarding which firms feature dominant shareholders with effective control and which don’t. Under our approach, the main shareholder achieves effective control over management when the SV of his voting rights crosses an unknown threshold that is estimated from the data jointly with the other model parameters. Thirdly, it generates a market-based estimate of the critical level of power at which a shareholder gains control over management. We apply this method to a sample of European firms and estimate a threshold equal to 0.27. Above the threshold we document a negative effect of separation of ownership and control, that is both statistically and economically significant; below the threshold, we find no statistically significant effect. These findings indicate that large shareholders use their power over management to expropriate minority shareholders.

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Abstract
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I. Introduction
Many European corporations feature a dominant shareholder who owns control rights well in excess of his cash-flow rights and who designates and closely monitors corporate managers (Barca and Becht (2000)). The principal issue raised by such a regime is not the traditional agency conflict between entrenched managers and dispersed shareholders studied by academics for decades, but rather the conflict between controlling shareholder and outside shareholders. The conflict arises because the controlling shareholder enjoys private benefits of control that are unavailable to outside shareholders. The consumption of private benefits is of concern to outsiders if it reduces the value of their equity stake in the firm, as when it entails the misappropriation of corporate resources or when it leads the firm to pursue inefficient operating and investment policies. When that occurs, the market value of shares held by outside investors is bound to suffer.

In this paper we use a sample of European corporations to investigate empirically how the consumption of private benefits of control by the firm’s largest shareholder impacts on corporate valuation. We do so using a novel methodological approach that addresses some of the econometric problems that typically plague this line of research.

In line with previous studies we posit that the market value of shares held by outside investors ought to reflect at least two effects: the incentive held by the firm’s dominant shareholder to consume private benefits at the expense of his fellow shareholders and his ability to do so. Traditionally, the literature has referred to these two effects as, respectively, the incentive effect and the entrenchment effect. For example, regarding the effect of managerial ownership on corporate valuation, several authors have argued that observed patterns in the USA can be explained by these two effects (Demsetz and Lehn (1985), Morck, Schleifer and Vishny (1988), McConnel and Servaes (1990)). The two effects are also prominent in recent papers relating corporate valuation to the ownership of the firm’s largest shareholder, such as La Porta, Lopez-de-Silanes, Schleifer and Vishny (2000) and Claessens, Djankov, Fan and Lang (2001).

The empirical estimation of the entrenchment and the incentive effect of the firm’s largest shareholder however, raises a number of econometric challenges. First, one needs to find a variable that measures accurately the degree of entrenchment of the firm’s dominant shareholder. Empirical studies of corporate governance have used the percentage of votes held or controlled by the largest shareholder as a gauge of his power of control (e.g., La Porta et al (2000) and Claessens and al.(2001)). Although such a measure has an intuitive appeal, it has obvious shortcomings. For one thing, the power of control of the largest shareholder is non-linearly related to his voting rights; for another, it depends on the distribution of votes across the remaining shareholders. If one could come up with an improved measure of control, it would be easier to isolate and detect the entrenchment effect in the data.

A second problem to address is that it is hard to pin down a reliable empirical estimate of the effect of the separation of ownership and control by the largest shareholder on firm value. That happens because the usual proxies for the entrenchment and the incentive effect of the main shareholder tend to be highly correlated. For example, a variable such as the equity stake held by the largest shareholder is a good proxy for his incentive to expropriate fellow shareholders and for his power to undertake opportunistic activities as well. La Porta et al.(2000) get around the confounding effects
generated by the equity stake by focusing on a sample of firms in which the largest shareholder controls over 20% of the votes. They argue that within their sample the power to expropriate remains relatively constant and thus the impact of the equity stake of the dominant shareholder on firm value can be entirely ascribed to the incentive effect.

Other authors have attempted to measure the impact of the separation of ownership and control by taking into account dual class shares, ownership chains and indirect stakes, as a vehicle to distinguish between the percentage of votes controlled by the largest shareholder and the percentage of cash-flow rights owned by him. Certainly, accounting for these institutional features of corporate governance inserts a wedge between ownership and control. Claessens at al.(2001) report that the various mechanisms used by East Asian firms to separate ownership from control yield a median wedge for the largest shareholder equal to 13%. A large wedge however, per se doesn’t assure a high quality estimate. The key to obtain a precise estimate of the effect of separation of ownership and control on corporate valuation is a high degree of sample variability in the wedge.

One last issue is that the incentive and the entrenchment effect ought to be active only when the main shareholder holds effective control over the firm. Indeed, if the main shareholder is not in charge of management – either directly or indirectly through a designated management team – proxies for either his incentive or his power to expropriate outside shareholders should not matter empirically for corporate valuation. Both La Porta et al.(2000) and Claessens et al.(2001) resolve this difficulty by limiting their samples to firms with main shareholders controlling a percentage of votes above a minimum threshold. Furthermore, they set the threshold at a high level to make sure that the main shareholder is indeed in control. This approach has a number of flaws. First, the approach is ad hoc since it relies on an arbitrary threshold. Second, their conservative bias toward a high threshold implies that many valid observations are discarded.

This paper proposes a methodological approach that deals with these three econometric issues. Regarding our choice of proxy for the entrenchment effect we work with the Shapley Value (SV) of the proportion of votes controlled by the dominant shareholder rather than the proportion of votes itself. Such measure takes into consideration the non-linear relationship that exists between the real power wielded by the dominant shareholder and his control over voting rights, and accounts for the distribution of votes across remaining shareholders as well. The SV or variants of it have been used in empirical corporate finance at least since Cubbin and Leach (1983). Prominent examples are found in Zingales (1994), Eckbo and Verma (1994) and, more recently, in Nicodamo and Sembenelli (2000) and Crespi-Cladera and Renneboog (2001). To the best of our knowledge, however, the SV has not been used in studies examining the effect of control by dominant shareholders on firms’ stock market performance. Besides being a better proxy for the entrenchment effect, the SV of the proportion of votes of the main shareholder also generates a measure for the wedge between ownership and control that displays more cross-sectional variability, thus yielding more precise estimates of the impact of the agency conflict between controlling shareholders and outside shareholders on firm value.

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3 Claessens et al. (2001) define the wedge as the % of votes controlled by the firm’s largest shareholder minus the % of cash-flow rights owned by the firm’s largest shareholder
The last methodological contribution is that we devise an estimation procedure that gets around the need of using an arbitrary rule telling which firms in the sample have main shareholder who are charge of management and which don’t. We hypothesize that the main shareholder of a firm achieves effective control if the SV of his vote stake is above an unobservable threshold; otherwise he holds no sway over the firm’s management. The threshold is jointly estimated with the other parameters of the model. Letting the threshold being determined by the data yields several benefits. First and foremost, it gives us a market-based empirical estimate of the critical level of the SV of the voting rights of the main shareholder at which he gains effective control over the firm’s management. To our knowledge, no one has yet produced such estimate from data on corporate valuation and ownership structure. A second advantage is that our procedure uses every available firm regardless of the percentage of votes held by its largest shareholder, rather than just a subset of firms with big and powerful shareholders. Such an efficient use of data further contributes to improve the quality of the estimates. Finally, our approach allows us to empirically verify the notion that the agency conflict between large shareholders and minority shareholders should impact negatively corporate value if and only if the firm is run on behalf of its largest shareholder. This notion yields not one but two distinct testable hypotheses, either one predicated by agency-based models of corporate governance centered on large shareholders. To support such models one should therefore empirically validate both hypotheses.

We illustrate the application of the approach on a sample of European firms. For this sample the estimated threshold in the SV of the voting rights of the main shareholder is equal to 0.27. The data indicates that at the estimated threshold, the relationship between the firm value and the wedge of the main shareholder undergoes a structural shift, giving rise to two distinct regimes. In the high-SV regime we document a negative effect of the wedge on firm value, that is both statistically and economically significant; in the low-SV regime we find no evidence of such an effect. The large majority of sample firms from the UK have a main shareholder with a SV below the estimated threshold. In contrast, more than half of continental firms feature a main shareholder whose power index is above the estimated threshold.

The rest of the paper is organized as follows. Section II presents the econometric model. Section III describes the data collection procedures, explains how the variables are constructed and presents descriptive statistics for the sample. The results from the model’s estimation are reported and discussed in section IV. Section V discusses an extension of the basic econometric model. Finally, section VI concludes.

II. The econometric model
This paper seeks to evaluate empirically the extent and the magnitude of the expropriation activities undertaken by the firm’s largest shareholder, through their impact on firm value. Our main hypothesis is that the influence of such activities on the market value of the firm depends critically on whether the main shareholder has effective control over managerial decisions. Where the main shareholder is in charge of management – either directly or indirectly through a proxy management team – he has the opportunity to engage in expropriation activities; in that case, the extent and scope of such activities should depend negatively on his ownership of cash-flow rights (the incentive effect) and positively on the tightness of his grip on control (the entrenchment
effect). In contrast, where the main shareholder holds no sway over management, he cannot expropriate fellow shareholders and thus we should find evidence of neither an incentive nor an entrenchment effect.

Our main hypothesis is formally stated as:

\[
E(L_i) = Pr\{\text{main shareholder has effective control}\} \times E\{L_i | \text{main shareholder has effective control}\} \\
= Pr\{\text{main shareholder has effective control}\} \times h(\text{incentive effect}_i, \text{entrenchment effect}_i) \\
\]

(1)

Where \( L_i \) is the loss in the equity value of firm \( i \) resulting from expropriation activities undertaken by its main shareholder. We further hypothesize that the Shapley Value of the votes controlled by the main shareholder determines whether he has effective control over the firm’s management. Specifically, we state that where the SV of his votes is above a threshold he gets to be in the driving seat of his firm’s management; otherwise, he has no control over management decisions. The threshold however, is unobservable by the researcher and so needs to be jointly estimated with the other model parameters. Hence we may write (1) as

\[
E(L_i) = Pr(\text{VS}>\text{VS}^*) h(\text{incentive effect}_i, \text{entrenchment effect}_i) \\
\]

(2)

Where \( \text{VS}^* \) is the critical threshold.

To estimate (2) some assumptions about function \( h(.) \) are required. First, we must find proxies capturing the incentive effect and the entrenchment effect. For the entrenchment effect we use once again the Shapley Value of the votes held by the main shareholder. The proportion of cash-flow rights held by the main shareholder is our proxy for the incentive effect. Secondly, we have to adopt a parameterization for function \( h(.) \). In order to conserve degrees of freedom in the estimation and additionally, for the sake of model parsimony, we assume that function \( h(.) \) is homogenous of degree one. Under such an assumption, the loss from expropriation depends solely on the wedge of the largest shareholder, i.e., on the ratio between his power and his incentive to expropriate fellow shareholders. Finally, we adopt a linear specification for \( h(.) \).

Under these assumptions, the loss in equity value from expropriation is now given by the expression

\[
E(L_i) = Pr(\text{VS}>\text{VS}^*)[a+b(\text{VS}_i/\text{CF}_i)] = Pr(\text{VS}_i>\text{VS}^*)[a+b\text{Wedge}_i] \\
\]

(3)

Where \( \text{CF}_i \) is the proportion of cash-flow rights held by the largest shareholder of firm \( i \). The linkage between expropriation and the market performance of the firm’s equity is established by the relationship

\[
V_i = f_i(...) - E(L_i) = \beta_0 + \beta_1 X_{i1} + \cdots + \beta_K X_{iK} - Pr(\text{VS}_i>\text{VS}^*)[a+b\text{Wedge}_i] \\
\]

(4)

Where \( V_i \) is a metric for the equity value of firm \( i \) and \( X_{i1}, \ldots, X_{iK} \) are control variables. In the empirical work we focus on the following general version of model (4):
Running the data on model (5) yields estimates of the coefficients $\beta_0, \beta_1, \ldots, \beta_K, a_0, b_0, a_1, b_1$ plus an estimate of the critical threshold $VS^*$. The key testable hypothesis can now be stated as $VS^*>0$, $b_1<0$ and $b_0=0$.

The advantages of our approach are manifold. We argue that the Shapley Value of the proportion of votes owned by the main shareholder is a better measure of his power to expropriate fellow shareholders than the proportion of votes itself. The proportion of votes ignores the distribution of votes across the remaining shareholders, which is a key determinant of the degree of real power yielded by any particular vote stake. For illustration, consider the following two firms. Firm A has two large shareholders - one with 40% and another with 35% of votes – and many small shareholders holding 1% of votes each. Firm B has only one large shareholder with 30% of votes and also many small shareholders with 1% of votes each. A power measure based on proportion of votes alone would lead us to conclude that the main shareholder of firm A is more powerful than that of firm B. That is however an erroneous conclusion since the SV of the main shareholder of firm A is equal to 0.365 whereas that of firm B is 0.423. The SV is also a better measure of control because it recognizes that any shareholder with more than 50% cannot be challenged, so assigning him a power index equal to one.

The usage of SVs comes with an unexpected bonus too. To obtain a high quality estimate the impact of the separation of ownership and control by the largest shareholder on firm value, the variable used in the empirical analysis to measure such separation – or, in other words, the variable used as the wedge - ought to exhibit a large degree of variability within the sample. In our study, the wedge of the main shareholder is defined as the ratio between his power and his incentive to expropriate minority shareholders, where the power to expropriate is proxied by the SV of his voting rights and the incentive to expropriate is proxied by his proportional ownership of cash-flow rights. Such a measure of the wedge contrasts with those of previous empirical studies, which have used the proportion of voting rights controlled by the largest shareholder to account for his power to expropriate. Because the SV is a non-linear function of the proportion of votes held by the main shareholder, on the one hand; and because the SV takes into account the distribution of votes across remaining shareholders - which ought to be largely independent of the cash-flow rights of the dominant shareholder - on the other hand; we conclude that a SV-based measure of the wedge will tend to display more cross-sectional variability than a measure based on the proportion of votes.

Last but not least, under our approach the researcher doesn’t need to make a judgement call, for each sample firm, regarding whether its largest shareholder is or is not in charge of management. Extant studies restrict their samples to firms for which it is reasonable to presume that their main shareholders hold effective control over management. That is achieved by a sampling procedure that excludes all firms featuring main shareholders whose control over voting rights is below a given threshold. Rather than relying on an arbitrary threshold, we choose instead to use all available firms and estimate the threshold jointly with the other parameters of the model. Our underlying hypothesis that the SV of the voting rights held by the main shareholder is the driving variable determining whether he has effective control of management. Hence our
threshold is defined in terms of the SV of the proportion of votes and not in terms of the proportion of votes itself, as in previous studies. We thus obtain a market-based estimate of the critical level in SV at which the main shareholder is empowered over the firm’s management. We also have a chance to empirically evaluate the impact of the wedge above and below the endogenously estimated threshold, and verify whether the estimated impacts are in accordance with the theory.

III. Sample selection and data
A. Sample selection
Our point of departure was the population of firms comprising the pan-European market index FTSE Eurotop 300 in December 1999. As in previous studies we removed from the index all financial corporations (i.e., firms with SIC codes between 6000 and 6999), yielding a net tally of 217 firms.

The information about ownership structure and firm characteristics is drawn from annual financial reports. Whenever possible we used the Internet to obtain companies’ reports. In the few instances where the Internet didn’t work out we contacted the companies directly, soliciting them to mail us the missing annual financial report. In only three cases we couldn’t obtain the desired documents and so we excluded those companies from the sample.

We sought to collect annual reports concerning the fiscal year 1999/2000. Although most companies close their fiscal years in December 31st, there are quite a few companies with other closing dates. The range of closing dates for the 217 firms fall between September 1999 and August 2000, with 74% of firms closing at December 31st 1999.

Sometimes the information about ownership and governance structure required to compute our variables of interest – for example, the distribution of ownership stakes above 5% of equity securities conferring voting rights - was unavailable in annual reports. When that happened we e-mailed the company, faxed it or just called it by phone asking their help to supply the necessary information. For 10 firms we could not get information either about the cash-flow rights, the voting rights of the largest shareholder or, yet, the distribution of vote stakes across shareholders with at least 5% of votes. The final sample was thus reduced to 204 firms.

Figures 1 and 2 report, respectively, the breakdown of sample firms by country and by industry. According to Figure 1 more than one-third of the sample is comprised of firms from the UK, mirroring the prominent role played by the UK in European stock markets. The distribution of firms across industries is computed on the basis of the first two digits SIC codes.4 Inspection of Figure 2 reveals that the industries represented in

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4 Our choice of two SIC digits as the criteria to assign firms to industries reflects a trade-off. To examine the effect of ownership and control on firm value one should control for other potential influences. One variable that is commonly used as a control is an industry dummy capturing the impact of industry-specific attributes of corporate valuation. The benefit of adopting a finer break-down of sample firms by industry – say, a break-down based on 3 or 4 SIC digits – is that industries would then become more homogenous. That however, would be achieved at a cost. As the number of sample firms assigned to each
the sample are fairly balanced, although there is a slight dominance of firms affiliated with telecommunication and chemical allied products.

B. The proxy for firm value

Extant research evaluating the influence of ownership and control variables on corporate valuation has used the market-to-book ratio of assets as the primary measure of firm value (La Porta et al. (2000), Claessens at al. (2001)). Likewise, we use the market-to-book value of assets as our proxy for firm value.

The market-to-book value of assets of firm i is defined as:

$$\text{MTBi} = \frac{(\text{Book Value of Assets}_i - \text{Book value of Equity}_i) + \text{Market value of Equity}_i}{\text{Book Value of Assets}_i} \quad (6)$$

The book value of assets and the book value of equity are obtained from annual reports, and thus reflect the status of balance sheets at the close of companies’ fiscal year. As in La Porta et al. (2000), we computed the market value of equity for each sample firm by multiplying the number of outstanding shares by the share price prevailing at the close of its fiscal year. Under such an approach, market data is collected at different points in time since fiscal years don’t fully overlap for all sample firms. The drawback is that market-to-book ratios will then reflect different market environments, which creates noise in the valuation proxy. The alternative would be to collect share prices only from one point in time, say December 31st 1999. That, however, would raise another problem. Because the annual reports of sample firms are based on fiscal years with different closing dates, we would then be disconnecting share prices from the balance sheet positions reported in annual reports.

Figure 3 plots the distribution of market-to-book ratios across sample firms. The distribution is skewed to the left reflecting the fact that the variable has a lower bound at zero but no upper bound. The average sample value is 2.94 whereas the median value is 1.82. These values appear too high if benchmarked against those reported in earlier studies. For example, the median value reported by La Porta et al. (2000) for their worldwide sample of firms is 1.22; likewise, Claessens et al. (2001) find a median value of 1.19 for a sample of East Asian firms. The differences between our value and theirs can be accounted by the fact that data is drawn from different periods and thus reflect very distinct market environments. Their studies cover data from 1995 and 1996 whereas our study covers the years 1999 and 2000. Between 1995/96 and 1999/00 European equity markets experienced one of the longest and biggest rallies of its history.

For the sake of comparability with La Porta et al. (2000) we also assign countries to either a common law group or a civil law group, according to their legal origin. The industry diminishes, the quality of the industry controls in the regressions would also deteriorate due to lack of degrees of freedom.

5 The range of closing dates of annual reports is between September 1999 to August 2000.

6 In order to check whether our results are influenced by the presence of outliers, we repeated all the empirical analysis using a smaller sample. The smaller sample excludes the observations corresponding to the 5% highest and 5% lowest MTB ratios. We didn’t find a qualitatively change in the results.
common law group includes the UK and Ireland; all other countries fall into the civil law group. Figure 4 shows how the valuation measure is distributed within each group of countries. Although common law countries display a higher median value for their MTB, a Chi-square of medians cannot reject the hypothesis median MTB values are identical across common law and civil law groups, which is at odds with the evidence of La Porta et al.

C. Proxies for ownership and control
We hypothesize that the degree of corporate control enjoyed by the largest shareholder is given by the Shapley Value (SV) of his vote stake, i.e., by the SV of the proportion of votes under his control. According to Shapley and Shubik (1954) the power of any given player in a game depends on his probability of becoming pivotal in a winning coalition. Consider a corporation with majority voting and n shareholder each holding his own voting stake. If we order shareholders randomly, each particular sequence of shareholders has a probability of occurrence equal to 1/n!. For each sequence, the pivot is the shareholder whose votes, once added to the votes already held by all the shareholders preceding him, yield the first coalition to cross the 50% vote threshold. The SV of shareholder i is the number of sequences in which shareholder i is a pivot (Pi) divided by the number of all possible sequences (n!), that is

$$SV_i = \frac{P_i}{n!}$$  \hspace{1cm} (7)

In games where the expected gain of a coalition equals 1 if the number of votes of members is above the required threshold and 0 otherwise, the SV of a shareholder is given by the expression:

$$SV_i = \frac{1}{n!} \sum_{t=1,...,n}^t (t-1)!(n-t)!k_t$$  \hspace{1cm} (8)

Where t is the number of shareholders in winning coalitions that feature shareholder i as pivot and k_t is the number of times shareholder i is pivot in winning coalitions of t shareholders. Shapley and Shubik (1954) refer to $SV_i$ as the power index of shareholder i.

To compute the power index of the largest shareholder for each firm in the sample we needed information about the distribution of vote stakes across all shareholders. Annual reports were the primary source of information for this purpose as well. Most European countries require listed corporations to disclose all equity stakes exceeding 5%. For most firms in the sample therefore, annual reports allow us to identify all stakes greater than 5%. Nonetheless, in those cases where we could track stakes of less than 5% we used that information too.\(^7\) In computing vote stakes we considered the effects of equity structures featuring multiple classes of shares with differential voting rights. We also took into account the information disclosed in annual reports regarding mechanisms of separation of ownership and control such as voting caps, programs assigning additional

\(^7\) For corporations from the UK there is information available about all equity stakes exceeding 3%, since that is the disclosure threshold required for listed firms. To gauge whether there is a significant downward bias in the SVs of the main shareholders from companies disclosing information about vote stakes of less than 5%, we recalculated those SVs ignoring such stakes. The results show that it makes little difference whether or not we account for for stakes between 3% and 5%.
votes for shares held for more than a certain period of time\textsuperscript{8} and golden shares held by entities such governments and state-controlled companies.

Recall that the computation of the SV of the firm’s main shareholder requires information about the vote stakes held by all shareholders. Since we only identify shareholders whose vote stake exceeds the disclosure threshold, we need to make some assumption about the distribution of votes across unidentified shareholders. We assume that unidentified shareholders hold 1% of votes each, and we add unidentified shareholders to the shareholder list until the joint votes held by all shareholders adds up to 100%.\textsuperscript{9}

Figure 5 shows the distribution of Shapley Values across sample firms. The median SV is 0.14 but the distribution is markedly bimodal: there is a large number of SVs equal to 1 and there is a large number of SVs clustered below 0.3 too. For 15% of sample firms the main shareholder enjoys complete control; conversely, for 39% of firms the main shareholder display SVs of less than 0.1, thus holding little power over fellow shareholders. The large proportion of firms with weak main shareholders is explained by the weight of British firms in the sample, which generally display a fragmented ownership structure.

Further insight is gained by examining the distribution of SVs by countries’ legal origins, as presented in Figure 6. The median value for common law countries is one order of magnitude lower than the corresponding value for civil law countries, evidencing the wide gulf in ownership patterns separating UK firms from continental firms. A Chi-square test of medians confirms the casual observation that the two medians are quite distinct from each other.

The remaining variable of interest in our econometric model is the proportion of cash-flow rights held by the firm’s largest shareholder (CF\textsubscript{i}). To compute this variable we identified the participation of the largest shareholder in all classes of equity securities conferring cash-flow rights. For firms with a single class of stock outstanding we assumed that the proportion of cash-flow rights held by the main shareholder is equal to the number of shares under his ownership divided by the total number of outstanding shares, unless stated otherwise in the annual report. For corporations with multiple classes of stock outstanding, we computed the cash-flow stake of the main shareholder by adding up all his cash-flow rights across all existing stock classes.

The Shapley Value of the votes controlled by the largest shareholder divided by his cash-flow stake is a measure of the wedge between his power and his incentive to expropriate fellow shareholders. Figure 7 reports the sample distribution of the wedge. The median wedge is equal to 1.23, indicating that the separation of ownership and control is substantial and widespread among European corporations. When we look at the distribution of the wedge by countries’ legal origin presented in Figure 8, we find that the large median wedge observed for the full sample is driven by the subset of firms from continental Europe. Indeed, while the median wedge for common law countries is

\textsuperscript{8} For example, certain French corporations assign additional voting rights to shares held for more than year.

\textsuperscript{9} A different procedure is used by Crespi-Cladera and Renneboog (2001). To compute Shapley Values these authors simply rescale the proportion of votes held jointly by all identified shareholders to 100%.
only 1,085 – a value suggesting that there is little separation of ownership and control north of the English channel - the median wedge for civil law countries is 1.6.\textsuperscript{10}

**D. Control Variables**

To isolate the impact of ownership and control on corporate performance one ought to control for other potential effects. We choose to work with two firm-specific control variables: firm size (i.e., the book value of firm’s assets) and firm leverage (i.e., book value of medium- and long-term liabilities divided by book value of equity). Companies in the sample are large with a median book value of assets of around 10 billion euros, reflecting the make-up of the FT-Eurotop 300 index. There is however, a wide variation in firm size: the smallest company in the sample reports 350 million euros of assets whereas the largest one reports 25.6 billion euros of assets, a higher figure by about two orders of magnitude.\textsuperscript{11} There is also substantial dispersion in leverage among firms. The sample features extremely highly levered companies (the highest leverage is equal to 9.5) and unlevered firms too (the minimum value is zero).

In addition to firm-specific controls we use industry dummies in the econometric model to account for possible industry-specific differences in corporate valuations. Finally, we consider a dummy associated with a country’s legal origin (i.e., common law versus civil law) to control for the legal protection granted to minority shareholders, as suggested by La Porta et al. (2000).

Table 1 summarizes key descriptive statistics for all firm-specific variables. The correlations between all pairs of firm-specific variables are reported in Table 2. We claim that our measure of the wedge allows for a more precise estimation of the effect of the separation of ownership and control on firm value than traditional measures, which employ the proportion of voting rights controlled by the main shareholder to account for his power to expropriate fellow shareholders. To sustain that claim we argued that the usage of SVs yields an empirical measure for the wedge with higher cross-sectional variability than traditional measures. We have now a chance to verify the validity of the argument. Table 1 reports sample statistics for our measure of the wedge and also for a “traditional” measure computed using the proportion of votes held by the main shareholder in the numerator of the ratio, rather than the SV of his voting rights. The “traditional” wedge displays a lower median value, which is largely a consequence of the fact that vote stakes above 50% are assigned a SV of one. More importantly, the “traditional” measure displays a much lower standard deviation thus supporting the argument that a measure of the wedge computed on the basis of SVs yields better empirical estimates of the effect of separation of ownership and control.

\textsuperscript{10} A Chi-square test strongly rejects the hypothesis of the equality of medians.

\textsuperscript{11} The largest firm in the sample is Vodafone.
positively related to the degree of separation between his control rights and cash-flow rights, as measured by the wedge.

In testing this set of hypotheses it is important to control for the effect of other potentially influent variables on market-to-book ratios of equity. With that in mind we estimate the model in two steps. On a first pass we regress the market-to-book ratios of sample firms the set of controls. We then collect the residuals from such a regression and test our hypotheses about the expropriation of minority shareholders directly on the residuals. By proceeding this way we avoid the need of re-estimating the effect of the controls on MTB ratios each and every time we run the model on subsamples of firms. This two-step procedure is acceptable as long as the influence of the controls on MTB ratios is not too different across the subsamples used in the analysis. Since our subsamples are created on the basis of variables that in theory are unrelated to the controls, there is a priori no reason to question why that shouldn’t be true.¹²

Table 3 shows the regression of MTB ratios on control variables. The controls include the two firm-specific variables (Size and Leverage), an industry dummy and a dummy associated with the legal origin of the country where the company is located. Both size and leverage have a significantly negative influence on MTB ratios. In contrast, the dummy associated with a country’s legal origin is not statistical significant.

Having removed from the data the influence of extraneous factors, we can now proceed to investigate the hypotheses described in the first paragraph of this section. Recall that we measure the degree of separation between the control rights and the ownership rights of the main shareholder by his wedge. The wedge of the main shareholder is the ratio between the Shapley Value of his votes and his proportional ownership of cash-flow rights. In Table 4 we take the residuals generated from the model of Table 3 and regress them on the wedge. Table 4 shows that the wedge has a marginally significant negative effect on MTB ratios. This regression however, includes all sample firms and thus throws in the same bag firms with strong main shareholders who control their firm’s management and firms with weak main shareholders who yield little influence in the boardroom. According to the theory the wedge should only influence a firm’s MTB ratio if the main shareholder has effective control of management, an occurrence that is likely to depend on his power index. So Table 4 also reports regressions on subsamples of low and high Shapley Values. These results should be viewed with care however, since the sample partitions are ad hoc. In one case, we simply split the sample in two halves, assigning all observations with SVs above the median value to one subsample and all remaining observations to the other subsample. In another case, the subsamples of high and low SVs correspond to the top third and the bottom third of the SV distribution. This analysis yields some preliminary evidence that the SV is indeed a relevant variable for understanding the empirical influence of the wedge on MTB ratios. In low-SV subsamples the wedge has a negative but statistically insignificant coefficient; in the high-SV subsamples the coefficients are also negative, but significant. So we may tentatively conclude that the negative influence of the wedge on MTB ratios found for the entire sample, is driven by a subset of observations with high SVs.

¹² The two step estimation also imparts a conservative bias to the results since part of the influence on MTB ratios caused by the independent variables used in the second step tends to be picked up by the controls in the first pass regressions.
To avoid partitioning the data in an arbitrary manner we would need to know for each sample firm whether or not it is run on behalf of its largest shareholder. Although such information is not directly available to the researcher, it should somehow be possible to retrieve it from our data. That however, requires a probabilistic model explaining how the chances of the main shareholder achieving effective control are related to his observable attributes. In section II we postulated that the power index of the largest shareholder is the key determinant of his probability of obtaining effective control. More specifically, we postulated that the main shareholder achieves effective control if and only if his power index is above an unknown threshold that is estimated from the data. We showed in section II that such a postulate yields the econometric model described in (5), which we now proceed to estimate from data.

Model (5) is fitted on the residuals obtained from the regression of MTB ratios on the control variables rather than on MTB ratios, as explained earlier. There are 5 parameters to estimate: the two linear coefficients associated with the impact of the wedge on MTB ratios in the low-SV regime; the two linear coefficients associated with the impact of the wedge on MTB ratios in the high-SV regime; and finally, the SV threshold determining the regime switch.

The estimation of models having discrete parameter variation has been studied by Goldfeld and Quandt (1972) and Hinkley (1970). Our approach is most closely fashioned after Hinkley (1970). He considers a discrete time process with independent observations in which a change in means occurs at an unknown point in the process. For the case where the error terms are normally distributed, Hinkley (1970) shows that the method of maximum likelihood involves finding the point in time where dividing the sample and estimating both means generates the smallest sum of squared errors. Although the model is non-linear, he finds that the mean in each regime typically conforms well to its asymptotic distribution, with variance equal to the variance of the residuals from the fitted model divided by the number of observations in each regime.

Our interest surrounds the process followed by the MTB ratio. In our application, the switch in regimes is determined by the SV of the main shareholder and not a time subscript. Moreover, within each regime we seek to estimate the linear influence of the wedge on the process rather than the mean value of the process. Our first step is to rank the observations on SV and find the switch that produces the minimum residual variance from the fitted model, where the latter comprises two independent linear regressions run separately on the observations belonging to each regime.\footnote{If the model is correct, the two slope coefficients for the wedge are consistent estimates of the true coefficients in the two regimes, with standard errors approximated by \((\sigma/\text{swedge})/\sqrt{(t_1)}\) and \((\sigma/\text{swedge})/\sqrt{(t-t_1)}\), where T and t\(_1\) are, respectively, the total number of observations and the number of observations in regime one. \text{swedge} is the standard deviation of the wedge and \(\sigma\) is the standard deviation of the residuals approximated by \(\sqrt{(\text{SSE}/(T-5))}\). Consistency of sample means can be shown for a limit as the number of observations in each regime increases.}

Several results are reported in Table 5. The estimated SV threshold is equal to 0.27, which splits the sample into 132 firms with SVs below and 72 firms with SVs above the threshold.\footnote{There are many distributions of voting rights that yield a Shapley Value of 0.27. For example, the main shareholder will display a SV of 0.27 if he controls 22% of votes and every other shareholder controls 1% each. A SV 0.27 will also be obtained if the main shareholder controls 36% of votes, a second shareholder controls 35% and every remaining shareholder controls 1% each.} Additionally, the estimated wedge coefficient in the high-SV regime is
negative and statistically significant at the 5%, as predicted by the theory. The coefficient is also economically significant: a one standard deviation increase in the wedge ratio produces a reduction of –0,46 in the MTB ratio of equity, a drop of about 15,5% relative to the sample’s average MTB ratio. In contrast, the wedge coefficient in the low-SV regime is statistically insignificant. Regarding the overall fit of the model, note that the threshold model nests as a particular case the linear model of table 4. Consequently, we may run a likelihood ratio test comparing the quality of the fit of the two models. The test shows that the threshold model provides a better fit to the data than the linear model without a threshold, thus providing evidence of a structural regime shift in the data occurring with respect to the influence of the wedge on firm value, as we move from low to high-SVs.

The estimated threshold is an interesting piece of evidence in itself because it is an estimate of what market participants believe is the critical level of power that gives the main shareholder effective control over his firm’s management. With the threshold at 0,27, there are 62 (50%) of firms from civil law countries above the threshold but only 10 (12,5%) from common law countries. The inference to be drawn from these results is that while in the UK large shareholders are generally too weak to force their will upon company managers, in continental Europe they are generally strong enough to drive their companies’ managerial policy.

V. An extension of the model
In this section the empirical tests are broadened to account for an extension of the model. The threshold model presented earlier assumes an abrupt transition between the two regimes governing the relationship between the wedge of the main shareholder and MTB ratios. We now consider a model where the transition occurs smoothly along the SV of the main shareholder. Such a model can be motivated on two grounds. First, there is the possibility that main shareholders from different firms face different SV thresholds but that the frequency of observations with main shareholders above their own thresholds increases in SV. Secondly, suppose that the SV of the main shareholder only captures imperfectly the process driving effective control. In this case, the probability of a main shareholder being in control of management depends positively on his SV; consequently, the frequency of firms run on behalf of their largest shareholder rises in SV as well.

A flexible functional form for a smooth transition of regime is provided by a non-linear model of the form

\[ V_i = \beta_0 + \beta_1 X_{i1} + \ldots + \beta_k X_{ik} + a_0 + b_0 \cdot \text{Wedge}_i + g(SV) \cdot [(a_1 - a_0) + (b_1 - b_0) \cdot \text{Wedge}_i] + u_i \]  

(9)

Where the transition function is given by the equation

---

15 The likelihood ratio statistic is equal to 7,13. Under the null hypothesis that the threshold model doesn’t outperform the linear model with no threshold, the statistic follows a Chi-square distribution with 2 degrees of freedom. The null hypothesis is rejected at standard significance levels.
\[ g(SV) = \frac{1}{1 + e^{-d \ln(SV)}} \quad \text{(d<0)} \]  

The model is estimated by maximum likelihood on the residuals generated by the regression of MTB ratios on the control variables. The results, which are reported in Table 6, show a poor fit for the model. The estimate for the coefficient \( b_1 - b_0 \) is negative as predicted, but it is statistically insignificant. More generally, all the parameter estimates - except that for \( d \) – are statistically insignificant. Since the model with an abrupt transition is a particular case of model (9)-(10), one may run a likelihood ratio test comparing the statistical performance of the two models. The test indicates that the particular model outperforms the general model thus supporting an abrupt transition in regime.\(^{16}\)

V. Conclusions
We have put forward a novel methodological approach to estimate the effect of separation of ownership and control by dominant shareholders on firm value. The approach uses the SV of the voting rights of the dominant shareholder rather than the proportion of votes under his control as a measure of his power of control within the firm. We argue that the SV is a more accurate metric and thus yields better estimates. Secondly, it frees the researcher from the necessity of having to make an ad hoc judgment call regarding which firms feature a dominant shareholder who effectively controls management and which don’t. Under our approach, the main shareholder achieves effective control when the SV of his voting rights crosses an unknown threshold that is estimated from the data jointly with the other model parameters. Such an approach allows the researcher to work with a sample that includes every firm regardless of the power index of its main shareholder; additionally, it allows him to verify the notion that the separation of ownership and control by the main shareholder ought not to matter for firm value if he is driving the firm’s management. Third, it generates a market-based estimate of the critical level in the power of the main shareholder at which he becomes the driving force behind the firm’s management.

We apply this method to a sample of European firms and estimate a threshold equal to 0.27. Almost every firm in the sample from the UK has a main shareholder with a SV below the estimated threshold; in contrast, more than half of the continental firms in the sample feature main shareholders whose power index is above the estimated threshold. We document a negative effect of separation of ownership and control above the threshold, which is both statistically and economically significant; below the threshold, the effect is statistically insignificant.

The major shortcoming of our empirical analysis is that we don’t account for pyramid structures, cross-holdings among firms and generally for mechanisms that extend the chain of ownership and control beyond the immediate shareholders of the firm. Thus our results should be taken with care and viewed as an illustration of an application of a novel econometric approach. Nonetheless, the approach has the potential to

\(^{16}\) The likelihood ratio statistic is equal to 0.58. Under the null hypothesis that the general model with a smooth transition doesn’t outperform the constrained model with an abrupt transition, the statistic follows a Chi-square distribution with 2 degrees of freedom. The data does not reject the null hypothesis.
accommodate chains of ownership and control and other governance structures that magnify the wedge between the main shareholder’s power and incentive to expropriate, and which were not considered in the paper. That task is left for future research.
References


Figure 1: Firms by country

N = 204

Country

Belgium

Sweden

Spain

Portugal

Norway

Netherlands

Italy

Ireland

Greece

Germany

France

Finland

Danmark

UK

0% 5% 10% 15% 20% 25% 30% 35%
Figure 2: Firms by industry

N = 204
Figure 3: MTB’s histogram and descriptive statistics

Observations 204
Mean 2.939890
Median 1.820665
Maximum 21.60676
Minimum 0.794930
Std. Dev. 3.647318
Skewness 3.515586
Kurtosis 15.84995
Figure 4: MTB distribution and descriptive statistics by groups of countries

N = 204

<table>
<thead>
<tr>
<th>Class</th>
<th>Common Law</th>
<th>Civil Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>2.6657 1.8761</td>
<td>2.6657 1.8761</td>
</tr>
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<td>Class 2</td>
<td>11 - 21</td>
<td>11 - 21</td>
</tr>
<tr>
<td>Class 3</td>
<td>2 - 3</td>
<td>2 - 3</td>
</tr>
<tr>
<td>Class 4</td>
<td>3 - 5</td>
<td>3 - 5</td>
</tr>
<tr>
<td>Class 5</td>
<td>5 - 8</td>
<td>5 - 8</td>
</tr>
<tr>
<td>Class 6</td>
<td>8 - 11</td>
<td>8 - 11</td>
</tr>
<tr>
<td>Class 7</td>
<td>11 - ... [11 - ...]</td>
<td>11 - ... [11 - ...]</td>
</tr>
</tbody>
</table>

Median equality test:

Chi-square statistic = 0.329032 (non significant at a 0.1 significance level)
Figure 5: SVs’ histogram and descriptive statistics

- Observations: 204
- Mean: 0.334411
- Median: 0.139800
- Maximum: 1.000000
- Minimum: 0.019600
- Std. Dev.: 0.359402
- Skewness: 0.978250
- Kurtosis: 2.330897
Figure 6: SVs distribution and descriptive statistics by groups of countries

<table>
<thead>
<tr>
<th>Class</th>
<th>Common Law</th>
<th>Civil Law</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Mean</td>
<td>Median</td>
</tr>
<tr>
<td>0.7</td>
<td>0.1308</td>
<td>0.0631</td>
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</tbody>
</table>

Median equality test:

Chi-square statistic = 43.51452***
Figure 7: Wedge’s histogram and descriptive statistics

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
<td>204</td>
</tr>
<tr>
<td>Mean</td>
<td>1.658235</td>
</tr>
<tr>
<td>Median</td>
<td>1.230000</td>
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<tr>
<td>Maximum</td>
<td>14.14000</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.200000</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1.441615</td>
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<tr>
<td>Skewness</td>
<td>5.530091</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>40.08601</td>
</tr>
</tbody>
</table>
**Figure 8: Wedge distribution and descriptive statistics by groups of countries**

![Wedge distribution and descriptive statistics by groups of countries](image)

### Median equality test:

**Chi-square statistic = 54.90167***

***Significance level = 0.01

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
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<td>Mean</td>
<td>Mean</td>
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<td>1.1995</td>
<td>1.9542</td>
</tr>
<tr>
<td>Median</td>
<td>Median</td>
</tr>
<tr>
<td>1.0850</td>
<td>1.6000</td>
</tr>
<tr>
<td>Max.</td>
<td>Max.</td>
</tr>
<tr>
<td>4.1900</td>
<td>14.1400</td>
</tr>
<tr>
<td>Min.</td>
<td>Min.</td>
</tr>
<tr>
<td>0.2000</td>
<td>0.8300</td>
</tr>
<tr>
<td>S. Dev.</td>
<td>S. Dev.</td>
</tr>
<tr>
<td>0.4833</td>
<td>4.6158</td>
</tr>
</tbody>
</table>

**N = 204**
Table 1: Descriptive statistics for firm-specific variables

<table>
<thead>
<tr>
<th></th>
<th>MTB</th>
<th>SV</th>
<th>Wedge</th>
<th>Wedge*</th>
<th>CF rights</th>
<th>Voting rights</th>
<th>Size</th>
<th>Leverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.9399</td>
<td>0.3344</td>
<td>1.6582</td>
<td>1.2972</td>
<td>0.2004</td>
<td>0.2268</td>
<td>18902.907</td>
<td>0.9619</td>
</tr>
<tr>
<td>Median</td>
<td>1.8207</td>
<td>0.1398</td>
<td>1.2300</td>
<td>1.1402</td>
<td>0.1110</td>
<td>0.1292</td>
<td>9904</td>
<td>0.5261</td>
</tr>
<tr>
<td>Maximum</td>
<td>21.6068</td>
<td>1.0000</td>
<td>14.1400</td>
<td>2.3073</td>
<td>0.8010</td>
<td>0.8260</td>
<td>256254</td>
<td>9.5205</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.7949</td>
<td>0.0196</td>
<td>0.2000</td>
<td>0.6800</td>
<td>0.0100</td>
<td>0.0100</td>
<td>350.62</td>
<td>0.0042</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>3.6473</td>
<td>0.3594</td>
<td>1.4416</td>
<td>0.3366</td>
<td>0.1949</td>
<td>0.2115</td>
<td>28019.2617</td>
<td>5.2668</td>
</tr>
<tr>
<td>Skewness</td>
<td>3.5156</td>
<td>0.9783</td>
<td>5.5301</td>
<td>0.8648</td>
<td>1.1342</td>
<td>0.9686</td>
<td>4.5483</td>
<td>10.8071</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>15.8500</td>
<td>2.3309</td>
<td>40.0860</td>
<td>2.6018</td>
<td>3.2462</td>
<td>2.7667</td>
<td>32.1159</td>
<td>127.6069</td>
</tr>
</tbody>
</table>

Wedge: (SV of % voting rights controlled by the main shareholder / % cash-flow rights owned by main shareholder)
Wedge*: (% voting rights controlled by the main shareholder / % cash-flow rights owned by main shareholder)

N = 204

Table 2: Correlation matrix for firm-specific variables

<table>
<thead>
<tr>
<th></th>
<th>MTB</th>
<th>SV</th>
<th>Wedge</th>
<th>Size</th>
<th>Leverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTB</td>
<td>1</td>
<td>0.267072</td>
<td>0.019171</td>
<td>-0.184704</td>
<td>-0.049596</td>
</tr>
<tr>
<td>SV</td>
<td>0.267072</td>
<td>1</td>
<td>0.278138</td>
<td>-0.113526</td>
<td>-0.070372</td>
</tr>
<tr>
<td>Wedge</td>
<td>0.019171</td>
<td>0.278138</td>
<td>1</td>
<td>-0.068855</td>
<td>-0.037995</td>
</tr>
<tr>
<td>Size</td>
<td>-0.184704</td>
<td>-0.113526</td>
<td>-0.068855</td>
<td>1</td>
<td>-0.040348</td>
</tr>
<tr>
<td>Leverage</td>
<td>-0.049596</td>
<td>-0.070372</td>
<td>-0.037995</td>
<td>-0.040348</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 3:

\[ MTB_i = a + b_1*D_{CountryLegal Origin} + b_2*Size_i + b_3*Leverage_i + c_i*SIC_i - 2\text{dig.} + u_i \]

where \( D_{CountryLegal Origin} \) is equal to 1 if legal origin is common law and equal to zero otherwise.

<table>
<thead>
<tr>
<th></th>
<th>( a )</th>
<th>( b_1 )</th>
<th>( b_2 )</th>
<th>( b_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coef.</strong></td>
<td>6.3025</td>
<td>-0.7541</td>
<td>-2.64E-05</td>
<td>-0.0954</td>
</tr>
<tr>
<td><strong>t-Statistic</strong></td>
<td>(4.7965)**</td>
<td>(-1.3340)</td>
<td>(-2.7427)**</td>
<td>(-3.0177)**</td>
</tr>
<tr>
<td><strong>R^2</strong></td>
<td>0.352586</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted R^2</strong></td>
<td>0.198627</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N = 204
(*) Significance level = 0.1
(**) Significance level = 0.05
(***) Significance level = 0.01

T-Statistics are White heteroscedasticity-consistent

Table 4:

\[ e_i = a + b*Wedge_i + u_i \]

<table>
<thead>
<tr>
<th></th>
<th>( a )</th>
<th>( b )</th>
<th>( a )</th>
<th>( b )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coef.</strong></td>
<td>0.2675</td>
<td>-0.1613</td>
<td>0.8539</td>
<td>-0.2528</td>
</tr>
<tr>
<td><strong>t-Statistic</strong></td>
<td>(0.9851)</td>
<td>(-1.8342)*</td>
<td>(1.7013)*</td>
<td>(-2.2594)**</td>
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<tr>
<td><strong>R^2</strong></td>
<td>0.006280</td>
<td></td>
<td>0.017932</td>
<td></td>
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<tr>
<td><strong>Adjusted R^2</strong></td>
<td>0.001360</td>
<td></td>
<td>0.008111</td>
<td></td>
</tr>
</tbody>
</table>

SV<0.14 (1/2 of the firms, N=102)  SV>0.14 (1/2 of the firms, N=102)

<table>
<thead>
<tr>
<th></th>
<th>( a )</th>
<th>( b )</th>
<th>( a )</th>
<th>( b )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coef.</strong></td>
<td>-0.4616</td>
<td>-0.2528</td>
<td>-0.4616</td>
<td>-0.3342</td>
</tr>
<tr>
<td><strong>t-Statistic</strong></td>
<td>(-1.2119)</td>
<td></td>
<td>(-1.2119)</td>
<td></td>
</tr>
<tr>
<td><strong>R^2</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Adjusted R^2</strong></td>
<td></td>
<td></td>
<td>-0.014379</td>
<td></td>
</tr>
</tbody>
</table>

SV<0.075 (1/3 of the firms, N=68)  SV>0.34 (1/3 of the firms, N=68)

<table>
<thead>
<tr>
<th></th>
<th>( a )</th>
<th>( b )</th>
<th>( a )</th>
<th>( b )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coef.</strong></td>
<td>1.3269</td>
<td>-0.3831</td>
<td>1.3269</td>
<td>-0.3831</td>
</tr>
<tr>
<td><strong>t-Statistic</strong></td>
<td>(1.6853)*</td>
<td></td>
<td>(1.6853)*</td>
<td></td>
</tr>
<tr>
<td><strong>R^2</strong></td>
<td>0.025554</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted R^2</strong></td>
<td>0.010789</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) Significance level = 0.1
(**) Significance level = 0.05
(***) Significance level = 0.01

T-Statistics are White heteroscedasticity-consistent
Table 5:

\[ e_i = a_i * D_{SVi} + a_0 * (1 - D_{SVi}) + (b_1 * D_{SVi} + b_0 * (1 - D_{SVi})) * Wedge_i + u_i \]

where \( D_{SVi} = 1 \) if \( SV_i > SV^* \), and \( D_{SVi} = 0 \) otherwise.

The highest Log LF is obtained when \( SV^* = 0.27 \)

<table>
<thead>
<tr>
<th></th>
<th>( a_i )</th>
<th>( a_0 )</th>
<th>( b_1 )</th>
<th>( b_0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef.</td>
<td>1.3198</td>
<td>-0.0222</td>
<td>-0.3187</td>
<td>-0.2256</td>
</tr>
<tr>
<td>t-Statistics</td>
<td>(1.8700)*</td>
<td>(-0.0757)</td>
<td>(-2.2365)**</td>
<td>(-1.4588)</td>
</tr>
<tr>
<td>Log LF</td>
<td></td>
<td></td>
<td></td>
<td>-504.3806</td>
</tr>
</tbody>
</table>

\( N = 204 \)

(*) Significance level = 0.1

(**) Significance level = 0.05

(***) Significance level = 0.01

t-Statistics are White heteroscedasticity-consistent.

Table 6: General model

\[ e_i = a_0 + b_0 * Wedge_i + g(SV) * [(a_i - a_0) + (b_1 - b_0) * Wedge_i] + u_i \]

Where:

\[ g(SV) = \frac{1}{1 + e^{c+d \ln(SV)}} \]

\( N = 204 \)

(*) Significance level = 0.1

(**) Significance level = 0.05

(***) Significance level = 0.01

<table>
<thead>
<tr>
<th>( a_0 )</th>
<th>( b_0 )</th>
<th>( c )</th>
<th>( d )</th>
<th>( (a_i - a_0) )</th>
<th>( (b_1 - b_0) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef.</td>
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<td>-0.2309</td>
<td>-19.9739</td>
<td>-185.5836</td>
<td>1.5939</td>
</tr>
<tr>
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<td>(-0.8846)</td>
<td>(-0.8361)</td>
<td>(-3564.1)**</td>
<td>(0.7021)</td>
</tr>
<tr>
<td>Log LF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) Significance level = 0.1

(**) Significance level = 0.05

(***) Significance level = 0.01