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Does debt concentration depend on the risk-taking incentives in CEO compensation?☆

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ABSTRACT

Using a sample of US non-financial firms we show that an increase in risk-taking incentives in CEO pay is associated with a greater debt concentration by debt type. This result holds in various empirical settings that account for endogeneity and is in line with the view that a more concentrated debt structure in fewer debt types reduces coordination problems among creditors and the related financial distress costs. Along these lines, we find our results are stronger in riskier firms, in firms with more volatile cash-flows or less stakeholder-orientation and when CEO pay incentives are embedded in vested options that are expected to favor business choices with more immediate negative effects on debtholders' wealth. Overall, our findings are consistent with theoretical models in which the debt structure of a firm acts as a commitment device.

1. Introduction

There are important links between executive compensation and a firm's debt policy (Berger et al., 1997; Brockman et al., 2010; Chava and Purnanandam, 2007 and 2010; Coles et al., 2006). This paper provides new evidence on these links by focusing on the nexus between risk-taking incentives in executive compensation and a key aspect of a firm's debt policy ignored by previous studies; namely, the degree of concentration of the debt structure by debt type that we measure as in Colla et al. (2013), Li et al. (2016) and Lou and Otto (2020). We frame our analysis in the context of the trade-off between in-bankruptcy collection deadweight costs and pre-bankruptcy deadweight agency and/or signaling costs originating from the debt structure (Bris and Welch, 2005). We argue that the risk-taking incentives of executives increase the importance of agency and/or signaling costs, thus inducing a firm to opt for a more concentrated debt structure.

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Our point of departure is the evidence that more concentrated debt structures across debt types reduce coordination problems among creditors (Colla et al., 2013; Lou and Otto, 2020). With a more concentrated debt structure, therefore, creditors have more opportunities to avoid expropriation by shareholders (Bernardo and Talley, 1996; Bris and Welch, 2005; Gertner and Scharfstein, 1991) and costly debt renegotiation and liquidations in the case of default (Bris and Welch, 2005). In turn, creditors price ex ante these benefits in debt contracts.

However, in a simplified theoretical setting that does not incorporate agency and/or signaling costs, Bris and Welch (2005) show that in equilibrium it is optimal for shareholders to maximize the coordination problems among creditors, and hence the heterogeneity of the debt structure, as this leads to a larger equity value ex ante. In short, firms prefer to remunerate creditors ex ante with higher yields to have the possibility of fully expropriating them ex post in the case of bankruptcy. Nevertheless, by offering shareholders strong advantages against creditors in bankruptcy, a heterogeneous debt structure brings ex ante agency and/or signaling costs. When these costs are added to the initial theoretical setting, it becomes preferable for the firm to choose a more concentrated debt structure. This choice acts as a positive signaling mechanism for creditors as it increases their powers in financial distress. In other words, a more concentrated debt structure signals to creditors that the management commits to work harder to avoid distress or has confidence that a default will not occur (Bris and Welch, 2005).

From the above perspective we argue that the signaling benefits of increasing debt concentration should be more apparent for firms that offer larger risk-taking incentives to their executives. The motivation is as follows. Creditors view negatively a firm's choice to provide risk-taking incentives to executives, as documented by higher funding costs when these incentives increase (John and John, 1993; Kabir et al., 2013; Liu and Mauer, 2011; Ortiz-Molina, 2007). This negative view reflects the perception of creditors of being more exposed to excessive risk-taking by executives that might result in a higher bankruptcy risk (Coles et al., 2006; Dong et al., 2010; Gormley et al., 2013; Guay, 1999; Park and Vrettos, 2015). The positive signals arising when a firm empowers creditors in distress, through a more concentrated debt structure, can then attenuate the negative view of risk taking incentives of creditors and its effects on funding costs.

Our prediction is consistent with empirical studies showing that the negative impact of risk-taking incentives on funding costs decreases significantly when firms commit to debt contracts that give creditors better monitoring of managerial actions (Brockman et al., 2010; Chen and Qiu, 2017), and with theoretical models where the debt structure of a firm acts as a commitment device (Diamond, 2004; Hart and Moore, 1994; Meneghetti, 2012; Sorge et al., 2017).

However, the size of the benefits associated with a more concentrated debt structure when executives have high risk-taking incentives is not necessarily the same across different firms. Two firms offering similar incentives to their executives might have different advantages from opting for a more concentrated debt structure. Specifically, larger benefits should be expected for those firms that creditors perceive to be closer to the renegotiation threshold (high default risk) – see Bolton and Scharfstein (1996) for a related argument - or in firms with higher expected bankruptcy costs (Colla et al., 2013). Similarly, stronger benefits from a more concentrated debt structure should emerge when the governance mechanisms of the firm are less inclined to account for creditor interests ex ante.

We test the predictions described above on a sample of publicly traded US non-financial firms for the period 2001–2016. Following previous studies (see Armstrong et al., 2013; Low, 2009; Rego and Wilson, 2012) we rely on the sensitivity of compensation to stock return volatility (Vega) as our primary measure of the risk-taking incentives embedded in executive pay. A higher Vega has been associated with higher risk-taking by firms as executives can gain in compensation in the presence of a more volatile business (Coles et al., 2006; Dong et al., 2010; Gormley et al., 2013; Guay, 1999; Park and Vrettos, 2015). However, as in other studies (Armstrong et al., 2013; Low, 2009), we also account for the sensitivity of compensation to stock returns (Delta) to offer a more comprehensive view of the structure of pay incentives. We compute Vega and Delta for each CEO in our sample of firms. The focus on CEOs is a common choice in the literature on executive compensation given the centrality of this executive role in driving business choices at the firm level (Brockman et al., 2010; Coles et al., 2006; and Liu and Mauer, 2011).

We start our analysis by showing consistently an increase in debt concentration when the CEO Vega increases using a baseline Tobit specification (as in Colla et al., 2013) and an instrumental variable setting that accounts for the endogeneity of CEO pay-incentives (as in Francis et al., 2017, and Liu and Mauer, 2011). We find weaker evidence of a negative relationship between Delta and debt concentration, consistent with previous studies indicating that Delta and Vega lead to opposite risk-taking effects in the view of creditors (Billett et al., 2010). More generally, our stronger finding on Vega is in line with the presence of benefits for firms to reduce coordination problems among creditors via the debt structure when their CEOs have incentives that are negatively valued in the credit market.

Our key conclusion remains valid under different empirical settings, including when we exploit the adoption of FAS 123R in 2005 as a source of exogenous variation in Vega as in Hayes et al. (2012). Furthemore, we still find a positive relationship between debt concentration and CEO Vega when we control for firm unobserved heterogeneity via firm fixed effects, although under this setting the economic significance of our finding appears smaller. This result is in line with the evidence that the determinants of firm-capital structure matter primarily in explaining cross-sectional variation and not time-series variation (see Lemmon et al., 2008) and with studies reporting the influence of pay incentives on the cross-section of leverage and debt maturity (Brockman et al., 2010; Chava and Purnanandam, 2010; Coles et al., 2006).

To further corroborate the interpretation of our key results, we next show that CEO turnover events that lead to an increase in risk-taking incentives are accompanied by increases in the degree of debt concentration post-turnover. Similarly, we find an increase in the presence of a first-time inclusion of options in CEO pay leads to an increase in risk-taking incentives. Taken together these findings complement the results in Brockman et al. (2010), highlighting how a more concentrated debt structure is seen as preferable by the firm and creditors to moderate the negative effects of risk-taking incentives in credit relationships.

The positive relationship between debt concentration and CEO Vega is consistent with the presence of agency and signaling benefits from lowering the degree of heterogeneity of the debt structure. From this perspective, the benefits creditors assign to a more concentrated debt structure should emerge especially when firms are more likely to default (Hart and Moore, 1995; Hubert and Schafer, 2002; Ivashina and Scharfstein, 2010), when they have larger expected bankruptcy costs (Colla et al., 2013; Minton and Schrand, 1999) and when firms are less stakeholder oriented (Gao et al., 2020). In line with our expectations, we observe that the positive relationship between debt concentration and CEO Vega is stronger in riskier firms, in firms with larger cash-flow volatility (used as a proxy for bankruptcy costs) and in firms incorporated in states without constituency statutes-state-level laws (which allows corporate directors to consider stakeholders' interests when making business decisions).

In our theoretical framework, a firm intends to reassure creditors by opting for a more concentrated debt structure when CEO risk-taking incentives are high. This framework would then imply even stronger results when these incentives are shorter-term and push the executive to search for immediate wealth benefits through more risk-taking (Erkens, 2011). To test this prediction, we compute a proxy for the shorter-term compensation benefits by using only vested options and a proxy for the longer-term benefits by focusing on unvested options to compute Vega. Several papers have highlighted how mostly incentives from vested options (that have a short-term nature) give the CEO the opportunity to realize immediate wealth benefits through risky choices (Burns and Kedia, 2006; Devers et al., 2008; Efendi et al., 2007; Erkens, 2011). In line with these findings, we show that the incentives related to vested stock options primarily drive the positive relationship between Vega and debt concentration.

Our analysis extends the literature that examines the drivers of debt concentration by debt type. Existing studies have focused on the importance of firm characteristics related to the information environment, access to credit and accounting quality (Colla et al., 2013; Li et al., 2016) and have documented the importance of the existing debt concentration in reducing the demand for covenants when raising new debt (Lou and Otto, 2020). Our analysis documents the importance of the agency costs of debt that are associated with the design of compensation packages when modelling the determinants of debt concentration and confirms the importance of this concentration in mitigating coordination problems among creditors. In doing so, we complement the analyses that have linked executive incentives to firm leverage (Berger et al., 1997; Coles et al., 2006), to the types of debt (straight debt versus convertible debt) (Ortiz-Molina, 2007) and to the maturity of the debt contracts (Brockman et al., 2010).

The paper proceeds as follows. Section 2 reviews the theoretical background. Section 3 describes our data, the measurement of the key variables and our econometric method. Section 4 presents the empirical results, while Section 5 concludes the paper.

2. Theoretical background

Numerous studies argue that a more concentrated debt structure reduces coordination problems among creditors (Allen, 1990; Colla et al., 2013; Diamond, 1984; Lou and Otto, 2020). This is because creditors with similar cash flow rights, investment horizons, and relationships with the borrower, are more likely to share the same objectives, thus becoming more effective in coordinating their actions. The lower coordination problems diminish the risk of expropriation by shareholders (Bernardo and Talley, 1996; Bris and Welch, 2005; Gertner and Scharfstein, 1991) and the risk of costly debt renegotiation and liquidations for creditors in the presence of a distress (Bris and Welch, 2005; Hoshi et al., 1990). The highlighted benefits of a more concentrated debt structure for creditors are priced ex ante in the debt market (Giammarino, 1989; Hoshi et al., 1990; Li et al., 2016; Lou and Otto, 2020).

Nevertheless, in equilibrium the optimal degree of debt concentration for a firm is far from straightforward. This is well illustrated in the theoretical model of Bris and Welch (2005). In this model a firm with existing assets in place valued as V_0, has to realize a project with a given probability of success and to do so it has to acquire risky external financing (that is endogenously chosen).[1] If the project succeeds, the firm can pay the creditors the promised payment, if the project instead fails the firm can reduce the claims of creditors in proportion to the collection costs they face (increasing with coordination problems). Under this theoretical setting, the choice of a more or less concentrated debt structure by the firm is the result of trading off in-bankruptcy collection deadweight costs against pre-bankruptcy deadweight agency and/or signaling costs.

Specifically, in the absence of agency and signaling costs, more coordination problems among creditors are preferred by shareholders because they result in equilibrium in a larger equity value of the firm ex ante. In other words, dispersed creditors are adequately remunerated ex ante with higher yields for being perfectly expropriated ex post. This relates to in-bankruptcy collection deadweight costs for shareholders that decrease when coordination problems among creditors become larger. Ultimately, when agency and signaling costs are not accounted for, firms should commit to fully expropriating creditors in distress

[1] The assumption that financing choices are driven by the demand side is often adopted in studies on how executive compensation influences debt contracts (see, among others, Albring et al., 2011; Brockman et al., 2010; Meneghetti, 2012). In the context of our analysis, this assumption has some credibility: it only implies that the firm influences debt concentration by deciding ex ante which type of debt to require in the market. Notably, the consequent effect on debt concentration is independent on whether the required funding is subsequently provided by new or old creditors (that might have some incentives to acquire additional amount of the same debt they already hold in their portfolio). Furthermore, in the theory setting described in this section, in equilibrium the firm is willing to pay adequate yields to raise funding (the debt is fairly priced). This should ensure that some creditors will respond positively to the funding request.

by using an extremely heterogeneous debt structure and this is the optimal choice to maximize the value of equity ex ante. In general, this value increases when the potential claims of creditors in financial distress decrease and when the strength of shareholders in the liquidation process rises.

However, when the agency and signaling costs associated with the choice of the debt structure are considered, the model of Bris and Welch (2005) indicates that it is not optimal to opt for an extreme degree of debt heterogeneity. In particular, in the presence of a high degree of debt heterogeneity, the agency costs arise by managers expending less effort avoiding distress because the creditors can be fully expropriated ex post under bankruptcy. Furthermore, a higher degree of debt heterogeneity results in a negative signaling effect because creditors perceive a firm commits ex ante to fully expropriating them ex post in the case of distress. In equilibrium, therefore, the choice of a more or less concentrated debt structure is the result of trading off in-bankruptcy collection deadweight costs (that materialize ex post and lead to more debt heterogeneity) against pre-bankruptcy deadweight agency and/or signaling costs (that materialize ex ante and induce firms to opt for more debt concentration).

Taking the perspective above, we argue that risk-taking incentives in executive pay amplify the importance of agency or signaling costs for a firm and this should favor a more concentrated debt structure. Specifically, when creditors observe ex ante that managers have increased risk-taking incentives when they undertake business choices, one response is to impose more costly funding conditions (see, for instance, Liu and Mauer, 2011). In summary, creditors understand and rationally price managers' pay incentives in debt contracts (see Billett et al., 2010; Daniel et al., 2004; Liu and Mauer, 2011) and firms pay higher credit spreads when their CEOs have higher risk-taking incentives in their compensation packages (Brockman et al., 2010; Chen and Qiu, 2017). This evidence indicates that creditors negatively perceive increasing risk-taking incentives in executive pay. In the context of Bris and Welch (2005), where the quality of corporate projects are measured by their default risk, the presence of high risk-taking incentives can be seen by creditors as indicating a higher probability that a default will occur.

However, the negative perception of risk-taking incentives by creditors can be mitigated by offering them more protection in the case of bankruptcy and this can be achieved via a more concentrated debt structure. In fact, by empowering creditors in distress through more debt concentration, executives with high risk-taking incentives can signal their commitment to put in effort to avoid bankruptcy or indicate their confidence that the distress of the firm will not occur (Bris and Welch, 2005). In short, especially in firms with high executive risk-taking incentives, the choice of a more concentrated debt structure acts as a valuable signaling mechanism to reassure creditors, as in the spirit of the model of Bris and Welch (2005). Along this line of argument, there is empirical evidence that firms display more concentrated debt structures when creditors see their interests being potentially more in danger (Colla et al., 2013; Li et al., 2016).[2]

The positive relationship between debt concentration and risk-taking incentives in executive pay is consistent with the evidence indicating that using debt contracts or establishing lending relationships that favor creditors mitigate the negative effects of these incentives in terms of funding costs. For instance, Brockman et al. (2010) show that the use of short-term debt contracts lowers the impact of risk-taking incentives on borrowing costs because of an improved ability of creditors to monitor managers (Barnea et al., 1980; Leland and Toft, 1996; Rajan and Winton, 1995). Similarly, Chen and Qiu (2017) document that the increasing credit spreads associated with risk-taking incentives are moderated by the presence of a relationship lender.

Furthermore, the choice of a more concentrated debt structure as a signaling mechanism when executives have more risk-taking incentives is also consistent with models on funding choices as a commitment device (Diamond, 2004; Hart and Moore, 1994; Sorge et al., 2017). For instance, Sorge et al. (2017) highlight that in the presence of ex post moral hazard in lending relationships, the use of short-term debt acts as a commitment device that reduces the risk of ex post cash flow diversion by firm managers. In a related study, Meneghetti (2012) shows that managers with more incentives to pursue asset substitution strategies avoid an increase in financing costs by committing to more creditor monitoring. Similarly, Albring et al. (2011) show that the probability of issuing a syndicated loan by a firm, and becoming subject to the stronger monitoring capacity of banks, is larger when CEOs have more risk-taking incentives and this is beneficial in terms of funding costs.

In our theoretical setting the choice of a more concentrated debt structure in the presence of high risk-taking incentives is related to the possibility of achieving significant agency and signaling benefits. These benefits, however, can vary with other firm characteristics; namely, two firms offering similar risk-taking incentives to their executives do not necessarily have the same signaling advantages from opting for a more concentrated debt structure. Larger benefits should be expected for those firms that creditors perceive to be closer to the renegotiation threshold (high default risk), and consequently show a higher risk that an expropriation of creditors in bankruptcy can occur – see Bolton and Scharfstein (1996) for a related argument. Similarly, the benefits from a more concentrated debt structure should be stronger when expected bankruptcy costs are higher (Colla et al., 2013) or when the commitment of the firm to fully expropriate creditors in distress in the presence of a more heterogeneous debt structure is more credible (as when the governance mechanisms of the firm are less aligned to a stakeholder perspective ex ante).

Overall, the theoretical frameworks discussed above suggest there should be a positive relationship between risk-taking incentives in executive pay and the degree of debt concentration. In addition, this positive relationship is expected to be stronger in firms with a higher distress risk, in firms with larger expected bankruptcy costs and in the presence of more shareholder oriented governance mechanisms.

[2] Our theoretical setting does not imply that, in equilibrium, it is not optimal to include risk-taking incentives in executive pay. In particular, as shown by Dittman et al. (2017), if the CEO not only exerts costly effort but also influences the firm's strategy, risk-aversion would induce the CEO to privilege strategies that avoid risk and depress firm value when the compensation contract does not provide sufficient risk-taking incentives. Indeed, risk-taking incentives still remain necessary to induce the CEO to take risks that benefit well-diversified shareholders.

3. Data overview and variable measurement

3.1. Data sources and sample selection

We base our empirical analysis on four data sources: Capital IQ, ExecuComp, Compustat, and CRSP. We obtain data on the debt structure of firms (needed to compute the degree of debt concentration as detailed in Section 3.2) from Capital IQ for the period from 2001 (the first year debt data are available) to 2016. Following previous studies on debt concentration (see, Colla et al., 2013; Lou and Otto, 2020), we remove firms from regulated industries (SIC codes from 4900 to 4999) and financial firms (SIC codes from 6000 to 6999) from the sample.

Next, by using the GVKEY identifier, we match the initial Capital IQ sample with firm accounting data from Compustat and market data from CRSP. We then exclude observations with missing or zero values for total assets or total debt, firm-years with market or book leverage outside the unit interval and where the difference between total debt, as reported in Compustat, and the sum of the different debt types reported in Capital IQ exceeds 10% of total debt (as in Colla et al., 2013). Furthermore, we remove the few observations where the debt maturity ratio (defined by the ratio between debts with maturity lower than three years over total debts) is less than 0 or greater than 1, since they are potentially erroneous (Brockman et al., 2010).

We finally match (via the GVKEY identifier) the remaining firms with the firms included in Standard and Poor's ExecuComp database that contains executive compensation data. Notably, in our specifications, we employ lag values of the explanatory variables. It follows that the explanatory variables refer to the period 2000–2015.

In Panel A of Table 1, we report the sample distribution by year. Our final sample contains 8942 firm-year observations for 1397 unique firms. The number of firms ranges from a minimum of 369 in the year 2005 to a maximum of 656 in the year 2016. Panel B of Table 1 reports the sample distribution by industry breakdown based on the Fama and French 30-industry classification and shows that none of the industries has a share of the sample in terms of total observations larger than 11.75%.

3.2. Measuring debt concentration by debt type

Following Colla et al. (2013) and Li et al. (2016) our proxy of debt concentration is the normalized Herfindahl-Hirschman Index (**HHI**) of the usage of different debt types. To compute this index we first calculate the total sum of the squares of the share of the seven mutually exclusive debt types reported in Capital IQ over the total amount of debt for firm *i* in year *t* as shown below:

$$SS_{it} = \left(\frac{CP_{it}}{TD_{it}}\right)^2 + \left(\frac{DC_{it}}{TD_{it}}\right)^2 + \left(\frac{TL_{it}}{TD_{it}}\right)^2 + \left(\frac{SBN_{it}}{TD_{it}}\right)^2 + \left(\frac{SUB_{it}}{TD_{it}}\right)^2 + \left(\frac{CL_{it}}{TD_{it}}\right)^2 + \left(\frac{Other_{it}}{TD_{it}}\right)^2 \tag{1}$$

Where *TD* refers to total debt, *CP* refers to commercial paper, *DC* to drawn credit lines, *TL* to term loans, SBN to senior bonds and notes, *SUB* to subordinated bonds and notes, *CL* to capital leases, and *Other* to the remaining debt in a firm's capital structure (for instance securities sold under an agreement to repurchase and other unclassified borrowing). We then compute the normalized Herfindahl-Hirschman Index (HHI) of debt types as follows:

$$HHI_{it} = \frac{SS_{it} - 1/7}{1 - 1/7} \tag{2}$$

This index ranges from zero to one. HHI equals one when a firm employs only one debt type (indicating a lack of borrowing diversity), whereas if a firm simultaneously employs all seven types of debt in equal proportion, HHI equals zero (maximum borrowing diversity). As explained in Section 4, we obtain similar results when we employ an alternative measure of debt concentration.

Panel A of Table 2 presents summary statistics of the share of each debt type and for the measure of debt concentration. The majority of the debt is in the form of senior bonds and notes (with a sample mean of 53.1% of total debt) followed by drawn credit lines (15.6%) and term loans (14.7%). The shares for the remaining types of debt are relatively low, ranging from an average of 6.8% for subordinated bonds and notes to 2.0% for commercial paper.[3] Furthermore, only the share of senior bonds and notes has a sample median different from zero. HHI has a mean value of 0.701 that is similar to the value reported by Colla et al. (2013). Panel B of Table 2 reports the correlation between HHI and the share of each debt type. There is no evidence of any particularly high correlation between HHI and debt shares, although HHI is significantly and negatively correlated with CP/TD and TL/TD, and positively correlated with SBN/TD. This is in line with the evidence reported in Colla et al. (2013).

A possible concern is that executives could have limited influence on debt concentration in the short-run because most of the debt has a long-term maturity. However, unreported tests show that, on average, about 37% of corporate debts have a maturity

[3] Total adjustment is the difference between the total debt obtained from Compustat and the sum of seven debt types from Capital IQ. We show that the mean and median of the total adjustment to total debt are nearly zero.

Table 1
Sample distribution by year and by industry.
Table 1 shows the sample distribution by year for the period ranging from 2001 to 2016. The final sample contains 8942 observations from 30 industry sectors.

Panel A: Sample distribution by year			
		Observations	
		N.	%
2001		385	4.31%
2002		407	4.55%
2003		563	6.30%
2004		592	6.62%
2005		369	4.13%
2006		384	4.29%
2007		588	6.58%
2008		643	7.19%
2009		618	6.91%
2010		620	6.93%
2011		627	7.01%
2012		640	7.16%
2013		629	7.03%
2014		618	6.91%
2015		603	6.74%
2016		656	7.34%
Total		8942	100.00%
Panel B: Sample distribution by industry			
Industries	Fama-French 30 Industries	N	%
Food Products	1	313	3.50%
Beer & Liquor	2	38	0.42%
Tobacco Products	3	26	0.29%
Recreation	4	157	1.76%
Printing and Publishing	5	102	1.14%
Consumer Goods	6	219	2.45%
Apparel	7	139	1.55%
Healthcare, Medical Equipment, Pharmaceutical Products	8	885	9.90%
Chemicals	9	440	4.92%
Textiles	10	70	0.78%
Construction and Construction Materials	11	437	4.89%
Steel Works, etc.	12	182	2.04%
Fabricated Products and Machinery	13	502	5.61%
Electrical Equipment	14	138	1.54%
Automobiles and Trucks	15	211	2.36%
Aircraft, ships, and railroad equipment	16	147	1.64%
Precious Metals, Non-Metallic, and Industrial Metal Mining	17	96	1.07%
Coal	18	21	0.23%
Petroleum and Natural Gas	19	651	7.28%
Communication	21	307	3.43%
Personal and Business Services	22	908	10.15%
Business Equipment	23	1051	11.75%
Business Supplies and Shipping Containers	24	298	3.33%
Transportation	25	393	4.39%
Wholesale	26	399	4.46%
Retail	27	391	4.37%
Restaurants, Hotels, Motels	28	236	2.64%
Other	30	185	2.07%
Total		8942	100.00%

of 3 years or less and almost 62% have a maturity of 5 years or less. These figures are consistent with the evidence reported by Brockman et al. (2010) for an older sample period.

Table A.1 in the Online Appendix shows the sample distribution of debt concentration by industry. There is a considerable variation in the degree of debt concentration across the industries. All estimated specifications, therefore, contain industry dummies to avoid our results being driven by omitted industry controls.

Table 2
Debt types and debt concentration.
This table shows summary statistics for the ratios of different debt types to total debt, as well as for our measures of debt concentration (HHI). ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

		Obs.	Mean	5th perc.	25th perc.	Median	75th perc.	95th perc.	Std. Dev.
Panel A: Definition and summary statistics									
CP/TD	Commercial Paper/Total Debt	8942	0.020	0.000	0.000	0.000	0.000	0.143	0.081
DC/TD	Drawn Credit Line/Total Debt	8942	0.156	0.000	0.000	0.000	0.168	0.961	0.283
TL/TD	Term Loans/Total Debt	8942	0.147	0.000	0.000	0.000	0.160	0.898	0.273
SBN/TD	Senior Bonds and Notes/Total Debt	8942	0.531	0.000	0.008	0.631	0.918	1.000	0.395
SUB/TD	Subordinated Bonds and Notes/Total Debt	8942	0.068	0.000	0.000	0.000	0.000	0.625	0.214
CL/TD	Capital Leases/Total Debt	8942	0.042	0.000	0.000	0.000	0.007	0.165	0.166
OTHER/TD	Other Debt plus total Trust-Preferred Stock/Total Debt	8942	0.036	0.000	0.000	0.000	0.009	0.178	0.131
Total Adjustment	Total Debt − (CP + DC + TL + SBN + SUB + CL + Other)	8942	−0.001	−0.026	0.000	0.000	0.000	0.017	0.017
HHI	{[[CP(Total Debt)]^2 + [DC/(Total Debt)]^2 + [TL/(Total Debt)]^2 + [SBN/(Total Debt)]^2 + SUB/(Total Debt)]^2+ [CL/(Total Debt)]^2 + [(Other)/(Total Debt)]^2] − (1/7)}/(1 − (1/7))	8942	0.701	0.285	0.455	0.733	0.977	1.000	0.257

Panel B. Correlation analysis by debt type.

	HHI	CP/TD	DC/TD	TL/TD	SBN/TD	SUB/TD	CL/TD
CP/TD	−0.176***						
DC/TD	−0.049***	−0.106***					
TL/TD	−0.127***	−0.105***	−0.147***				
SBN/TD	0.143***	0.020**	−0.471***	−0.454***			
SUB/TD	−0.014	−0.072***	−0.119***	−0.097***	−0.330***		
CL/TD	0.097***	−0.052***	−0.089***	−0.095***	−0.247***	−0.068***	
OTHER	−0.055***	0.012	−0.091***	−0.096***	−0.143***	−0.063***	−0.047***

3.3. Measuring risk-taking incentives in CEO pay

Vega is a measure of risk-taking incentives in executive pay widely employed in the literature (see Brockman et al., 2010; Coles et al., 2006; Core and Guay, 2002, among others). Vega captures the change in the value of a CEO's stock and option portfolio due to a 1% increase in the standard deviation of the firm's stock returns.[4]

Delta is another widely employed measure of equity-based incentives. It quantifies the change in the value of a CEO's stock and option portfolio in response to a 1% increase in the price of a firm's common stock. Delta is, therefore, a measure of the incentives for CEOs to undertake value-enhancing investments. However, the impact of Delta on the decision of a risk-averse manager to undertake a risky project might be less clear than the impact of Vega.

One argument suggests that a higher Delta should increase the propensity of a risk-averse manager to undertake risky projects as Delta implies an increase in value for the manager's wealth (*a reward-effect* according to Armstrong et al., 2013). Alternatively, a higher Delta might induce a risk-averse manager to opt for more prudent behavior as Delta magnifies the impact of changes in price on manager wealth (*a risk-effect* according to Armstrong et al., 2013). Along these lines, Billett et al. (2010) show that shareholders react in opposite ways to increases in Vega and Delta.

Nevertheless, Armstrong et al. (2013) argue that the risk-taking incentives Vega provides to managers should materialize empirically so long as the regression controls for differences in the manager risk premium that, at least in part, is determined by Delta. Therefore, our analysis includes both Vega and Delta and jointly examines their impact on debt concentration.

The computation of Vega and Delta is based on the Black and Scholes (1973) option-pricing model adjusted for dividends by Merton (1973) and on the methodology proposed by Core and Guay (2002). To ease exposition, we discuss details of the methodology employed to compute the different measures of risk-taking incentives in the Online Appendix.

Panel A of Table 3 shows summary statistics for the measures of equity-based incentives. To reduce the skewness of the distribution of the measures of equity pay-incentives we employ the logarithmic transformation of Vega (LNVEGA) and Delta (LNDELTA) instead of the raw measures in the empirical tests.

[4] Although commonly used in the literature as a proxy for risk-taking incentives, Vega is characterized by some limitations as highlighted by Anderson and Core (2018) and Milidonis and Stathopoulos (2014).

Table 3
Summary statistics of explanatory variables.
This table presents descriptive statistics for the variables used in the debt concentration model. The sample contains 8942 observations and covers the 2001 to 2016 period.

Variable	Definition	Obs.	Mean	Std. Dev.	Min.	25th perc.	Median	75th perc.	Max.
Panel A: Pay variables									
LNVEGA	Logarithm of one plus the change in the value of a CEO's option portfolio due to a 1% change in the annualized standard deviation of stock returns plus one. Ln (1 + Vega)	8942	4.010	1.843	0.000	3.061	4.323	5.312	8.541
LNDELTA	Logarithm of one plus the change in the value of a CEO's stock and option portfolio due to a 1% increase in the value of the firm's common stock price plus one. Ln (1 + Delta)	8942	5.587	1.414	0.000	4.709	5.574	6.491	12.878
Panel B: Instruments									
TENURE	CEO tenure in years	8942	9.308	4.922	1.000	5.000	9.000	12.000	23.000
CEO_CASH	The ratio between CEO cash compensation and total compensation	8939	0.422	0.314	0.025	0.164	0.313	0.633	1.000
CEO_AGE	CEO age in years	8941	55.999	6.565	41.000	51.000	56.000	60.000	75.000
Panel C: Controls									
LEVERAGE	Total debt over total assets. Total debt is defined as debt in current liabilities plus long-term debt	8942	0.270	0.180	0.000	0.149	0.249	0.360	1.059
MARKET TO BOOK	MV of equity plus total debt plus preferred stock liquidating value minus deferred taxes and investment tax credit over total assets	8942	1.272	1.086	−0.155	0.588	1.011	1.621	6.947
PROFITABILITY	Operating income before depreciation over total assets	8942	0.139	0.090	−0.350	0.096	0.136	0.181	0.434
SIZE	Logarithm of total assets measured in millions US$	8942	7.865	1.494	2.935	6.796	7.739	8.823	13.569
TANGIBILITY	Net property, plant, and equipment over total assets	8942	0.284	0.226	0.010	0.111	0.213	0.399	0.898
DIVIDEND_PAYER	Equals one if common stock dividends are positive	8942	0.561	0.496	0.000	0.000	1.000	1.000	1.000
CF_VOL	Standard deviation of operating cash flows from operations calculated over a 5 year-period scaled by total assets	8942	0.043	0.034	0.006	0.021	0.034	0.054	0.215
R&D	Research and development expenses over total sales	8942	0.060	0.595	0.000	0.000	0.003	0.031	37.347
UNRATED	Equals one if a firm does not have a S&P rating on long-term debt, and zero otherwise	8942	0.363	0.481	0.000	0.000	0.000	1.000	1.000
FIRM_AGE	Logarithm of one plus the number of years since the firm appears in Compustat.	8942	3.193	0.679	1.609	2.708	3.219	3.829	4.174
Z_SCORE	Equals one if modified Altman's *Z*-score is lower than 2.99, and zero otherwise. Modified Altman's Z-score is computed as 3.107 ∗ (earnings before interest and taxes/total assets) + 0.717 ∗ (working capital/total assets) + 0.998*(sales/total assets) + 0.4 ∗ (market value equity/book value of total liabilities) + 0.847 ∗ (retained earnings/total assets)	8942	0.335	0.472	0.000	0.000	0.000	1.000	1.000
CEO_SHARES	Number of shares owned by the CEO scaled by total shares outstanding	8942	0.015	0.040	0.000	0.001	0.003	0.009	0.287
CEO_PAYSLICE	The percentage of the total compensation to the top five executives that goes to the CEO	8942	0.401	0.103	0.088	0.339	0.406	0.465	0.698

3.4. Estimation methods

To estimate how Vega and Delta influence the degree of debt concentration, we follow Colla et al. (2013) and (primarily) employ an econometric approach that deals with the censored nature of our main measure of debt concentration (HHI). Specifically, we estimate a pooled Tobit regression model with standard errors clustered at the firm level based on the specification reported below:

$$HHI_{it} = \beta_0 + \beta_1 LNVEGA_{it-1} + \beta_2 LNDELTA_{it-1} + \beta_3 \mathbf{x}_{it-1} + \beta_4 \mathbf{z}_{it-1} + \sum_{k=1}^{30} S_k + \sum_{t=2000}^{2016} Y_t + \varepsilon_{it} \quad (3)$$

where HHI_{it} is the degree of debt concentration of firm *i* in year *t*, $LNVEGA_{it-1}$ and $LNDELTA_{it-1}$ are the measures of equity incentives, $\mathbf{X}_{it-1}$ is a vector of firms' financial characteristics, $\mathbf{Z}_{it-1}$ is a vector of CEO control variables, β_0 is the constant term and the remaining β are the coefficients of the explanatory variables, S_k is a set of industry dummies, Y_t is a set of time dummy variables and ε_{it} is the error term. We winsorize all explanatory variables (with the exception of the log transformed variables) at 1% and 99% to remove the impact of outliers.

We initially estimate Eq. (3) by assuming that the lagged values of LNVEGA and LNDELTA are exogenous. However, corporate policy might affect the way the compensation packages offered to executives are designed (see, for instance, Coles et al., 2006; Guay, 1999). One obvious source of endogeneity is, therefore, the potential reverse causality between debt concentration and pay incentives. For instance, a higher concentration of the debt structure, and the related effect in terms of managerial discipline, might induce boards to increase incentives to CEOs in order to safeguard the interests of shareholders at the expense of creditors.

To address reverse causality, we also estimate an instrumental variable (IV) Tobit model that resembles the more conventional use of 2SLS in Bhagat and Bolton (2008) and Coles et al. (2006). Specifically, we estimate (via maximum likelihood) a Tobit model with two continuous endogenous covariates (the lag values of LNVEGA and LNDELTA) and standard errors clustered at the firm level. The maximum likelihood IV Tobit is based on the simultaneous estimation of the endogenous variable regressions and the HHI regression.

We select instruments as in Liu and Mauer (2011) and Francis et al. (2017). Accordingly, we use CEO tenure (TENURE) and CEO age (CEO_AGE) as instruments as in Liu and Mauer (2011) and the ratio between CEO cash compensation (salary plus bonus) and total compensation (CEO_CASH) as in Francis et al. (2017). Panel B of Table 3 offers summary statistics for the instruments. TENURE should correlate positively with LNVEGA (and LNDELTA) because CEOs with longer tenures are more likely to be entrenched (Berger et al., 1997). More problematic is the prediction of the sign of the relationships between CEO_AGE and LNVEGA (LNDELTA), and CEO_CASH and LNVEGA (LNDELTA). As described by Guay (1999), the impact of manager preference in terms of firm risk, and the related benefit of providing risk-taking incentives by boards, depends (positively) on a wealth effect and (negatively) on a risk aversion effect. These two effects are correlated with the two instruments (see Guay, 1999).

In addition to the IV setting, Section 4.2 presents additional tests that address endogeneity concerns without the use of instruments, including a setting based on the adoption of FAS 123R in 2005 as a source of exogenous variation in Vega and Delta following Hayes et al. (2012).

3.5. Control variables

We divide the control variables into two different categories: firm characteristics and CEO controls. Panel C of Table 3 presents details on how we construct these variables.

The vector of firm characteristics *(*X*)* as in Colla et al. (2013) includes book leverage (LEVERAGE), the market to book ratio (MARKET TO BOOK), profitability (PROFITABILITY), size (SIZE),[5] the degree of asset tangibility (TANGIBILITY), a dummy equal to one if a firm is a dividend payer (DIVIDEND_PAYER), cash flow volatility (CF_VOL), the value of R&D expenses divided by total assets (R&D), and a dummy equal to one if a firm is not rated by S&P (UNRATED). These controls capture the role of bankruptcy costs, incentives to monitor and access to capital markets as determinants of the degree of debt concentration (Colla et al., 2013). We add firm age to this set of controls; namely, (the logarithm of) the number of years since a firm appears in the COMPUSTAT database (FIRM_AGE). Older firms should show a wider access to capital markets with the consequence of having a lower degree of debt concentration. In addition, we include a financial distress dummy variable with a value of one if the Altman *Z*-score is lower than 2.99 (Z_SCORE).[6]

The vector of CEO controls (Z) includes CEO ownership, defined as the percentage of a company's shares owned by the CEO (CEO_SHARES), and as in Bebchuk et al. (2011), the ratio between CEO compensation and the total compensation of the top five executives in a given year (CEO_PAYSLICE). Both variables might influence firm risk-taking and consequently their omission may bias the effect of risk-taking pay incentives on the debt structure. However, the direction of this influence is a priori unclear.

For instance, some studies show that firm risk-taking is positively correlated with CEO equity ownership and this is often explained by CEOs with greater ownership having a lower probability of being dismissed if a risky strategy fails and by larger upside personal gains if a risky strategy is successful (Eisenmann, 2002; Esty, 1997; Saunders et al., 1990). Other studies suggest,

[5] Table A.2 of the Online Appendix shows that LNVEGA and LNDELTA are correlated with SIZE (0.42 and 0.48, respectively). However, controlling for firm size excludes the possibility that our results simply reflect a size effect. Furthermore, our results hold when we consider alternative measures of equity incentives, such as the ratio between Vega (Delta) and firm assets and the ratio of Vega (Delta) and total compensation as in Liu and Mauer (2011).

[6] The use of a dummy variable to classify firms on the basis of the z-score is a very conventional choice in the literature (see, for instance, Brockman et al. (2010) and Huang et al. (2016)). Our results remain qualitatively similar if we use the continuous variable.

however, that greater ownership should discourage undiversified, risk-averse managers from engaging in riskier strategies (Armstrong et al., 2013; Guay, 1999). Similarly, CEO_PAYSLICE can indicate larger tournament incentives within the firm that might lead to an increase in risk-taking (Kini and Williams, 2012). Alternatively, a larger CEO_PAYSLICE might exacerbate CEO risk-aversion thus resulting in lower risk-taking (Brown et al., 1996).

The summary statistics for our controls, reported in Panel C of Table 3, are consistent with those shown by Billett et al. (2007) and Colla et al. (2013), among others. The correlation matrix for all the explanatory variables, reported in Table A.2 of the Online Appendix, indicates that the selected variables are, generally, far from being highly correlated.

4. Empirical results

4.1. The impact of CEO risk-taking incentives on debt concentration

The first column of Table 4 reports the empirical results from the Tobit regression where we model HHI as a function of CEO pay incentives. We find that higher values of LNVEGA increase the degree of debt concentration in a firm's debt structure. This result supports the view that the positive signal for creditors associated with a reduction of coordination problems via a more concentrated debt structure is especially important when CEOs have pay incentives that creditors perceive as being more detrimental to their interests.

In terms of economic impact, we observe that an increase in the dollar value of Vega from the 25th to 75th of sample distribution increases the degree of debt concentration in the debt structure by about 5.2% (5.0%) as compared to the sample mean (median).[7] LNDELTA enters the model with a negative and highly significant coefficient; that is, an increase in the value incentives in CEO pay reduces the need for a more concentrated debt structure. The negative coefficient is, therefore, in line with the argument that an increase in Delta might encourage lower risk-taking by managers, thus being well perceived by creditors.

In terms of control variables, most of our results confirm the evidence provided by previous empirical studies on the determinants of debt concentration (Colla et al., 2013; Li et al., 2016). The coefficients on LEVERAGE and SIZE are negative and statistically significant at customary levels, while increases in MARKET TO BOOK, CF_VOL, and R&D increase the degree of debt concentration. Furthermore, the degree of debt concentration is greater in younger firms (as shown by the negative and significant coefficient for FIRM_AGE). It is worth noting that calculations of the economic impact of other significant explanatory variables show that Vega has a larger economic impact than firm age, the market-to-book ratio, cash flow volatility and CEO shares on debt concentration, and an impact similar to firm size. CEO_SHARES exercises a similar (positive) impact as Vega on the degree debt concentration.

From columns (2) to (4) of Table 4, we assess whether our results hold when we employ the IV setting described in Section 3.4. Columns (2) and (3) report the regressions for the endogenous variables (namely, the dependent variables are LNVEGA and LNDELTA, respectively) and show that the selected instruments are significant determinants of LNVEGA and LNDELTA. The Hansen J-statistic of over-identifying restrictions (where the null hypothesis is that the instruments are *jointly* valid) is insignificant at customary levels. More importantly, under the IV setting, and as shown in column (4), we still find that an increase in LNVEGA increases the degree of debt concentration in a firm's debt structure. In contrast, the coefficient of LNDELTA becomes insignificant.

Notably, the coefficient of LNVEGA in the second stage regression is larger than the coefficient in the baseline Tobit regression. This occurs frequently in the literature (Jiang, 2017) but it might be a sign of weak instruments. However, the Anderson-Rubin F-statistic allows us to test the null that the endogenous regressors are (jointly) zero and it is robust to instrument weakness (Prilmeier, 2017). As shown in Table 4, we find this statistic is highly significant.[8]

In columns (5) and (6) we further test whether our results depend on the estimation method and on how we measure debt concentration. In column (5) we re-estimate the model in the first column using OLS and still find a positive relationship between LNVEGA and HHI. Next, in column (6), we employ an alternative measure of debt concentration defined by a dummy variable (Excl90) equal to 1 if a firm *i* obtains at least 90% of its debt from one debt type in a given year (see Colla et al., 2013). This variable has a sample mean of approximately 45%. We then estimate a Probit model where Excl90 is the dependent variable and the explanatory variables are defined as in column (1). Column (6), where we report the marginal effect of each explanatory variable to ease the interpretation of our findings, indicates that the impact of LNVEGA on the degree of debt concentration remains positive. In all these additional specifications LNDELTA shows a negative and significant coefficient.

Notably, when the above results are combined with the fact that only the median value of the share of senior bonds and notes is different from zero (see Table 2), it seems that the higher debt concentration when CEO risk-taking incentives increase is mostly the result of firms increasing the use of only one type of debt or combining senior bonds and notes with only another debt type.

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[7] We calculate the economic impact of the dollar value of Vega using the following formula: $\Delta HH/HH_m = \frac{\hat{\beta} * \Delta Vega}{Median\_Vega} * \frac{1}{HH_m}$ where $\hat{\beta}$is the estimated coefficient of LNVEGA,$\Delta Vega$ is the difference between the 75th and 25th percentile of the sample distribution of Vega and *Median_Vega* is the sample median of Vega, $HH_m$is the mean or median of HHI.

[8] In Tables A.3 and A.4 of the Online Appendix we show that our results are similar if we estimate the instrumental variable Tobit model by using a two-step approach or if we use a 2SLS (GMM) estimator. However, to ease the comparability with other specifications, we present in the main analysis the maximum likelihood estimation as the Tobit two-step approach does not allow us to cluster the standard errors by firm.

Table. 4
Debt concentration and CEO risk-taking incentives.
This table presents regression results on relationship between the degree of debt concentration and the sensitivity of CEOs' compensation to stock return volatility (LNVEGA), controlling for the sensitivity of CEO compensation to changes (in percent) in stock prices (LNDELTA), for firm and CEO characteristics, industry dummies (based on Fama-French 30 industries) and year dummies. Debt concentration is the Herfindahl index of debt concentration by debt type (HHI) or a dummy equal to one if more than 90% of the debt structure is concentrated in one type of debt (Excl90). We control for LEVERAGE (total debt over total assets), MARKET TO BOOK (market value of equity plus total debt plus preferred stock liquidating value minus deferred taxes and investment tax credit over total assets), PROFITABILITY (operating income before depreciation over total assets), SIZE (logarithm of total assets measured in millions US$), TANGIBILITY (net property, plant, and equipment over total assets), R&D (research and development expenses over total sales), DIVIDEND_PAYER (a dummy equal to one if a firm pays common stock dividends), FIRM_AGE (the logarithm of one plus the number of years since a firm appears in Compustat), UNRATED (a dummy equal to one if a firm does not have a S&P rating on long-term debt, and zero otherwise), CF_VOL (the standard deviation of operating cash flows calculated over the 5 year-period divided by total assets), Z_SCORE (a dummy equal to one if the Altman's *Z*-score is lower than 2.99, and zero otherwise), CEO_SHARES (number of shares owned by the CEO scaled by total shares outstanding) and CEO_PAYSLICE (the percentage of the total compensation to the top five executives that goes to the CEO). The instruments employed in the IV regression are CEO tenure (TENURE), CEO age (CEO_AGE) and the ratio between CEO cash compensation and total compensation (CEO_CASH). The governance variables include BOARD_SIZE (the log transformation of the total number of directors on the board), BOARD_INDEPENDENCE (the proportion of the board that consists of independent directors), CO_OPTED_DIR (the ratio between directors appointed after the appointment of the CEO and the total number of board members) and ANALYSTS_COV (the log transformation of one plus the total number of stock analysts following the firm). Standard errors are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Tobit	IV Tobit			OLS	Probit	Tobit
		Endogenous Variables				Marginal Eff.	
Dependent variable	HHI	LNVEGA	LNDELTA	HHI	HHI	Excl90	HHI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LNVEGA	0.015***			0.097**	0.012***	0.017***	0.015***
	[0.004]			[0.045]	[0.004]	[0.007]	[0.005]
LNDELTA	−0.019***			−0.02	−0.015***	−0.032***	−0.023**
	[0.007]			[0.027]	[0.006]	[0.010]	[0.010]
LEVERAGE	−0.462***	−0.528***	−0.755***	−0.427***	−0.366***	−0.640***	−0.515***
	[0.036]	[0.204]	[0.116]	[0.047]	[0.031]	[0.056]	[0.052]
MARKET TO BOOK	0.028***	0.256***	0.459***	0.009	0.020***	0.034***	0.020*
	[0.008]	[0.036]	[0.020]	[0.016]	[0.006]	[0.012]	[0.011]
PROFITABILITY	0.055	1.143***	1.005***	−0.032	0.041	0.161	0.182
	[0.077]	[0.357]	[0.204]	[0.093]	[0.059]	[0.115]	[0.124]
SIZE	−0.015**	0.545***	0.551***	−0.059**	−0.009	−0.0164	−0.005
	[0.007]	[0.036]	[0.018]	[0.025]	[0.006]	[0.011]	[0.011]
TANGIBILITY	−0.059	−0.665***	−0.103	−0.008	−0.059	−0.145**	−0.088*
	[0.042]	[0.237]	[0.117]	[0.054]	[0.036]	[0.064]	[0.053]
R&D	0.390***	0.875***	0.139	0.319***	0.303***	0.501***	0.492***
	[0.082]	[0.303]	[0.175]	[0.092]	[0.056]	[0.120]	[0.127]
DIVIDEND_PAYER	0.005	0.015	−0.113***	0.003	0.007	0.013	0.004
	[0.013]	[0.078]	[0.040]	[0.015]	[0.011]	[0.019]	[0.017]
FIRM_AGE	−0.020**	0.036	−0.186***	−0.026**	−0.013	−0.024	−0.025*
	[0.010]	[0.057]	[0.031]	[0.013]	[0.008]	[0.015]	[0.013]
UNRATED	0.002	−0.028	−0.014	0.006	−0.003	−0.025	0.014
	[0.016]	[0.09]	[0.044]	[0.018]	[0.014]	[0.024]	[0.021]

	Tobit	IV Tobit			OLS	Probit	Tobit
		Endogenous Variables				Marginal Eff.	
Dependent variable	HHI	LNVEGA	LNDELTA	HHI	HHI	Excl90	HHI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CF_VOL	0.458**	−1.868**	−1.705***	0.613***	0.283**	0.637**	0.901***
	[0.186]	[0.823]	[0.480]	[0.217]	[0.144]	[0.263]	[0.241]
Z_SCORE	−0.005	0.079	0.051	−0.01	−0.003	0.006	0.018
	[0.014]	[0.078]	[0.039]	[0.015]	[0.012]	[0.021]	[0.017]
CEO_SHARES	0.419**	−4.646***	15.57***	0.804	0.310**	0.493*	0.664**
	[0.190]	[1.079]	[0.648]	[0.571]	[0.155]	[0.275]	[0.286]
CEO_PAYSLICE	−0.033	2.686***	1.395***	−0.241**	−0.017	−0.0154	−0.107*
	[0.045]	[0.294]	[0.143]	[0.119]	[0.038]	[0.070]	[0.060]
TENURE		0.027***	0.047***				
		[0.008]	[0.004]				
CEO_CASH		0.268***	−0.333***				
		[0.091]	[0.050]				

CEO_AGE		−0.010*	0.006**				
		[0.005]	[0.003]				
BOARD_SIZE							−0.058
							[0.038]
BOARD_INDEPENDENCE							0.241***
							[0.063]
CO_OPTED_DIR							−0.002
							[0.024]
ANALYSTS_COV							0.028***
							[0.010]
Constant	1.046***	−2.469***	−0.301	1.269***	0.965***	1.068***	0.872***
	[0.083]	[0.564]	[0.267]	[0.154]	[0.078]	[0.347]	[0.132]
Observations	8942	8938	8938	8938	8942	8942	4572
Industry dummies	YES	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES	YES
Pseudo R2	0.265					0.089	0.342
R2					0.145		
Hansen test				0.71			
(*p*-value)				−0.4			
Anderson-Rubin F-test				14.03***			
(p-value)				−0.002			

Finally, it might be argued that the governance structure of a firm also potentially influences debt financing (Berger et al., 1997). The exclusion of governance variables from the baseline specification might then bias our result. In the last column of Table 4, we report the results with the addition to the baseline specification of the logarithmic transformation of board size, the degree of board independence (both taken from BoardEx) and for a measure of co-opted boards (taken from Coles et al., 2014, and defined as the ratio between directors appointed after the appointment of the CEO and the total number of board members). We further add the logarithmic transformation of the number of analysts as a proxy for external governance mechanisms. Although the inclusion of these controls reduces the sample size by approximately 40%, our results remain qualitatively unchanged.

To recap, we consistently find that debt concentration increases when CEOs have a greater LNVEGA and some evidence this concentration declines with a higher LNDELTA. In short, when the design of CEO pay incentives has the potential to increase the conflicts between debtholders and shareholders, a firm opts for a concentrated debt structure that lowers coordination problems among its creditors in times of financial distress.[9]

4.2. Robustness tests and additional analyses

4.2.1. Additional tests to rule out endogeneity

This section presents additional tests to rule out endogeneity. We report the results of these tests in Table 5. In the interest of brevity, the Table shows only the coefficients of the key variables for each model. We initially address endogeneity by exploiting the adoption of FAS 123R in 2005 as a source of exogenous variation in Vega as in Hayes et al. (2012). The implementation of FAS 123R removed the accounting advantages related to option compensation thus producing large changes in Vega that are generally unrelated to other firm characteristics (Hayes et al., 2012). To capture this source of exogenous variation in CEO incentives, we implement the empirical setting adopted in Hayes et al. (2012) and estimate a difference equation where all variables are expressed as the difference between their mean values computed for the post- (from 2005 to 2008) and the pre- FAS 123R period (from 2002 to 2004).

We use all available firm-years to calculate the mean values and require all observations per firm in both periods. Furthermore, as in Hayes et al. (2012) we employ the dollar value of Vega and Delta (and not their logarithmic transformation) in our tests. Under this setting, we estimate the difference equation using both an OLS specification and a quantile (median) regression, with this latter approach accounting for the potential influence of extreme values on our results. The results shown in columns (1) and (2) confirm a positive impact of CEO risk-taking incentives on debt concentration.

We next follow Boone et al. (2007), Faleye et al. (2014) and Faleye (2015), among others, that deal with endogeneity by regressing the dependent variable on longer lagged values of the potentially endogenous explanatory variables. This choice is

[9] Chava and Purnanandam (2007 and 2010) document that the impact of CEO risk-taking incentives on a firm's debt structure can differ from the impact of CFO risk-taking incentives. In in Table A.5 of the Online Appendix, we also account for CFO risk-taking incentives, by initially re-estimating our baseline models using only the logarithmic transformation of CFO Vega and Delta as key incentive variables. We then report the results when we control for both CEO and CFO equity-based incentives in the regressions. The results of these tests (shown in Table A.5 of the Online Appendix) document that when we include only CFO incentives, there is a positive relationship between CFO Vega and debt concentration. However, when we include both (the logarithmic transformation of) CEO and CFO Vega, we find that only the former is positive and significant at customary levels.

Table 5
Additional endogeneity tests.
This table presents alternative specifications on the relationship between the degree of debt concentration and the sensitivities of CEOs' compensation to stock return volatility controlling for the sensitivity of CEO compensation to changes (in percent) in stock prices, for firm and CEO characteristics, industry dummies (based on Fama-French 30 industries) and year dummies. In the first two columns we address endogeneity following Hayes et al. (2012) and compute the changes in the dollar value of Vega (ΔVEGA) and Delta (ΔDELTA) from the post- (from 2005 to 2008) to pre- FAS 123R period (from 2002 to 2004), columns (3) and (4) address endogeneity by reporting the models with all right-hand side variables lagged two years. In column (5) we estimate a Fixed Effects model, while in columns (6) and (7) we employ Industry*Year Fixed Effects in our baseline models. The last three columns report a system of simultaneous equations estimated 3SLS. We control for LEVERAGE (total debt over total assets), MARKET TO BOOK (market value of equity plus total debt plus preferred stock liquidating value minus deferred taxes and investment tax credit over total assets), PROFITABILITY (operating income before depreciation over total assets), SIZE (the logarithm of total assets measured in millions US$), TANGIBILITY (net property, plant, and equipment over total assets), R&D (research and development expenses over total sales), DIVIDEND_PAYER (a dummy equal to one if a firm pays common stock dividends), FIRM_AGE (the logarithm of one plus the number of years since a firm appears in Compustat), UNRATED (a dummy equal to one if a firm does not have a S&P rating on long-term debt, and zero otherwise), CF_VOL (the standard deviation of operating cash flows calculated over the 5 year-period divided by total assets), Z_SCORE (a dummy equal to one if the Altman's *Z*-score is lower than 2.99, and zero otherwise), CEO_SHARES (number of shares owned by the CEO scaled by total shares outstanding) and CEO_PAYSLICE (the percentage of the total compensation to the top five executives that goes to the CEO). The 3SLS full specification is reported in section A.7 of the Online Appendix. In the first 7 columns, we cluster standard errors at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Exogenous Shock		Longer Lags		Panel Model	Industry*Year Fixed Effects			Simultaneous Equations		Inverse Equation
	OLS	Quantile	Tobit	Probit	Fixed Effects	Tobit	Probit (Marg. Eff.)		3SLS		
Dependent Variable:	ΔHHI (1)	ΔHHI (2)	HHI (3)	Excl90 (4)	HHI (5)	HHI (6)	Excl90 (7)	HHI (8)	LNVEGA (9)	LNDELTA (10)	LNVEGA (11)
ΔVEGA	0.079***	0.061**									
	[0.019]	[0.028]									
ΔDELTA	0.001	0.006									
	[0.002]	[0.002]									
LNVEGA			0.014***	0.017**	0.004*	0.014***	0.016**	0.038*		0.303***	
			[0.004]	[0.007]	[0.002]	[0.004]	[0.001]	[0.022]		[0.103]	
LNDELTA			−0.018**	−0.028**	−0.004	−0.016**	−0.028***	−0.005	−0.132		
			[0.007]	[0.0108]	[0.004]	[0.007]	[0.010]	[0.011]	[0.129]		
HHI									−1.634	−0.484	0.382
									[1.846]	[0.426]	[0.238]
Constant	−0.075	0.032	0.971***	0.677*	1.568***	4.736***	−141.4	0.801***	−0.318	0.412	−2.637***
	[0.104]	[0.051]	[0.083]	[0.354]	[0.088]	[0.006]	[131.1]	[0.061]	[1.395]	[0.479]	[0.823]
Observations	775	775	7995	7995	8942	8942	8846	11,444	11,444	11,444	860
Control Variables	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry dummies	NO	NO	YES	YES	NO	NO	NO	YES	YES	YES	YES
Time dummies	NO	NO	YES	YES	YES	NO	NO	YES	YES	YES	YES
Pseudo R2	.	0.041	0.243	0.078	0.048	0.328	0.118				
R2	0.105		.					0.147	0.257	0.758	0.379

based on the intuition that such historical values are largely predetermined (Faleye, 2015). Therefore, in columns (3) and (4) we re-estimate the Tobit (Probit) model reported in the previous section, with two period lags, respectively, of all explanatory variables. Our results remain qualitatively similar.

In column (5) we account for unobserved firm heterogeneity by estimating (via a within estimator) a fixed effects panel model. In columns (6) and (7) we further rule out the potential effects of omitted variables by adding to our baseline Tobit (Probit) model industry x year fixed effects. With this specification, therefore, we assess how LNVEGA influences the cross-sectional variation in debt concentration in a given year within an industry. All the specifications confirm a positive relationship between debt concentration and LNVEGA.

However, under the fixed effect regression the magnitude of the coefficient of LNVEGA declines significantly. This result is not surprising as this specification places emphasis only on the time-series variation of HHI induced by changes in LNVEGA, whereas it disregards the importance of cross-sectional variation. The decline in the magnitude of the coefficient of LNVEGA is thus in line with the findings of Lemmon et al. (2008) according to which much of importance of the determinants of capital structure materializes from cross-sectional variation and not from time-series variation (the focus on the fixed effect specification).

Brockman et al. (2010) and Coles et al. (2006) show that executive pay incentives can be jointly determined with firm policy choices. In the context of our analysis, this implies simultaneity between the degree of debt concentration, LNVEGA and LNDELTA.[10] To account for this, following Coles et al. (2006), we estimate a system of simultaneous equations (via 3SLS) where the dependent (endogenous) variables are HHI, LNVEGA and LNDELTA, jointly observed at time *t*. The explanatory variables in the debt concentration equation are those employed in our main analysis, while the explanatory variables in the LNVEGA (LNDELTA) equation include all the variables that enter with a significant coefficient in the regressions reported in columns (2) and (3) of Table 4. The key results of this additional specification, shown from columns (8) to (10) of Table 5, still confirm a positive relationship between debt concentration and LNVEGA. We report the full model in Table A.7 of the Online Appendix. Notably, our conclusion holds if we add further controls to the LNVEGA and LNDELTA equations.

Finally, we focus on the sub-sample of newly appointed CEOs and estimate whether lag values of debt concentration predict the value of risk-taking incentives in new CEO contracts. Any relationship would be indicative of reverse causality. As shown in the last column of Table 5, we do not find that debt concentration predicts the value of CEO risk-taking incentives.

4.2.2. Simultaneity between debt concentration, compensation financing and investment policies

The system of equations presented in the previous section does not account for the simultaneity of debt concentration with other financing and investment choices of a firm. For instance, Brockman et al. (2010) show that when CEOs are rewarded with pay incentives that amplify the risk of asset substitution, the debt maturity in a firm's capital structure declines. Furthermore, the maturity of the debt structure is jointly determined with executive pay and investment policy. In the context of our analysis, the use of shorter-term debt contracts might act as a potential substitute or as a possible complement to debt concentration.

To control for a possible interrelationship between debt concentration, debt maturity, and investment choices, we extend the system of three equations discussed previously by adding equations for 1) debt maturity, 2) leverage, 3) R&D and 4) capital expenditure. As in Brockman et al. (2010), we measure debt maturity as the ratio between debt with a maturity lower than 3 years and total debt, and leverage as the ratio of long term debt over total assets. We employ a similar set of controls as in Brockman et al. (2010).[11]

The results reported in Table 6 show that the estimated coefficient of LNVEGA in the HHI regression remains positive and highly significant even after we control for the possible simultaneity between debt concentration and debt maturity. Furthermore, we find a positive and significant relationship between debt concentration and the debt maturity ratio. This result provides evidence of a substitution effect between debt concentration and the use of shorter-term debt contracts.

4.2.3. Changes in CEO compensation and debt concentration

CEO turnovers might produce significant changes in the compensation structure between the old and the newly appointed CEO. This variation in compensation assumes a particular relevance in our setting. If our results are due to the risk-taking incentives in CEO pay that makes it beneficial for a firm to opt for a more concentrated debt structure, at minimum, we should observe an increase in debt concentration when a firm replaces a CEO with a low Vega with a CEO with a high Vega. To assess the validity of this conjecture, we estimate OLS regressions where the changes in debt concentration around a turnover event

[10] The possibility of simultaneity is also highlighted by Table A.6 in the Online Appendix where, following Coles et al. (2006), predicted and residual values of lagged LNVEGA from a first stage regression enter as predictors of HHI in a second stage regression. We find that both "predicted" and "residual" LNVEGA are positively associated with HHI. While Coles et al. (2006) offer three explanations for a significant coefficient of "residual" LNVEGA, one motivation is related to simultaneity with the dependent variable.

[11] In addition to the controls we use in our main analysis, we employ the following variables: SALES_GROWTH (annual growth rate of total sales), CEO_AGE (CEO's age), CEO_CASH (cash compensation (salary + bonus), scaled by annual total compensation), SURCASH (cash from assets-in-place scaled by total assets), SIZE2 (square of SIZE), TERM (yield on 10-year government bonds subtracted from the yield on 6-month government bonds at the fiscal year end), ASSET_MAT (book value-weighted average of the maturities of property plant and equipment and current assets), ABNEARN ((earnings in year $t + 1$ – earnings in year t)/(share price × outstanding shares in year t)), STD_RET (daily stock return standard deviation during the fiscal year multiplied by the ratio of the market value of equity to the market value of assets), NOL_DUM (dummy equal to one if the firm has an operating loss carryforward and zero otherwise), and ITC_DUM (equals one if the firm has an investment tax credit).

Table 6

System of seven equations - 3SLS.

Table 6 examines the robustness of the relation between debt concentration (HHI) and CEO incentives by allowing for the joint determination of debt concentration, managerial incentives, debt maturity, leverage, and investment policies based on 3SLS methodology. The dependent variables are debt concentration (HHI), debts with a maturity not longer than 3 years scaled by total assets (ST3), total debt over total assets (LEVERAGE), the sensitivities of CEOs' compensation to stock return volatility (LNVEGA), the sensitivity of CEO compensation to changes (in percent) to stock prices (LNDELTA), capital expenditures scaled by assets (CAPEX), and research and development expenses over total sales (R&D) from columns (1) to (7) respectively. All specifications control for firm and CEO characteristics, industry dummies (based on Fama-French 30 industries) and year dummies. The control variables consider in the regressions are: MARKET TO BOOK (market value of equity plus total debt plus preferred stock liquidating value minus deferred taxes and investment tax credit over total assets), PROFITABILITY (operating income before depreciation over total assets), SIZE (the logarithm of total assets measured in millions US$), TANGIBILITY (net property, plant, and equipment over total assets), DIVIDEND_PAYER (a dummy equal to one if a firm pays common stock dividends), FIRM_AGE (the logarithm of one plus the number of years since the firm was added to the Compustat database), UNRATED (a dummy equal to one if a firm does not have a S&P rating on long-term debt, and zero otherwise), CF_VOL (the standard deviation of operating cash flows from operations calculated over the 5 year period before the observation year over total assets), Z_SCORE (a dummy equal to one if the Altman *Z*-score is lower than 2.99, and zero otherwise), CEO_SHARES (Number of shares owned by the CEO scaled by total shares outstanding), CEO_PAYSLICE (The percentage of the total compensation to the top five executives that goes to the CEO), SALES_GROWTH (annual growth rate of total sales), TENURE (CEO's tenure), CEO_AGE (CEO's age), CEO_CASH (cash compensation (salary + bonus), scaled by annual total compensation), SURCASH (cash from assets-in-place scaled by total assets), SIZE2 (square of SIZE*)*, TERM (yield on 10-year government bonds subtracted from the yield on 6-month government bonds at the fiscal year end), ASSET_MAT (book value-weighted average of the maturities of property plant and equipment and current assets), ABNEARN ((earnings in year $t+1$ – earnings in year t)/(share price × outstanding shares in year t)), STD_RET (daily stock return standard deviation during the fiscal year multiplied by the ratio of the market value of equity to the market value of assets), NOL_DUM (dummy equal to one if the firm has an operating loss carryforward and zero otherwise), and ITC_DUM (equals one if the firm has an investment tax credit, and zero otherwise). Statistical significance is based on firm clustered standard errors. ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively.

	HHI (1)	ST3 (2)	LEVERAGE (3)	LNVEGA (4)	LNDELTA (5)	CAPEX (6)	R&D (7)
LNVEGA	0.115***	−0.080***	0.069***		0.745***	−0.043***	−0.007**
	[0.013]	[0.016]	[0.013]		[0.068]	[0.003]	[0.003]
LNDELTA	−0.060***	−0.022	−0.097***	0.201**		−0.001	−0.005***
	[0.013]	[0.014]	[0.011]	[0.096]		[0.001]	[0.001]
HHI		0.533***	−1.602***	2.472***	−9.519***	0.087**	0.378***
		[0.141]	[0.088]	[0.726]	[0.439]	[0.039]	[0.034]
ST3	0.155***		−0.141***	−2.729***		−0.188***	−0.011
	[0.060]		[0.034]	[0.325]		[0.018]	[0.015]
LEVERAGE	−0.263***	−0.297**		−1.674***	−4.889***	−0.169***	0.215***
	[0.085]	[0.140]		[0.476]	[0.219]	[0.023]	[0.020]
MARKET TO BOOK	−0.026**	0.064***	0.020***	0.313***	0.176***	0.018***	0.020***
	[0.011]	[0.012]	[0.007]	[0.057]	[0.031]	[0.002]	[0.002]
PROFITABILITY	0.518***	−0.413***	0.779***	−0.629	4.680***	0.062***	−0.568***
	[0.089]	[0.101]	[0.083]	[0.587]	[0.376]	[0.015]	[0.014]
SIZE	−0.032***	−0.087***	−0.014**	0.381***	0.011	0.017***	0.014***
	[0.007]	[0.024]	[0.007]	[0.045]	[0.041]	[0.002]	[0.002]
TANGIBILITY	0.010		0.020	−0.154**			
	[0.013]		[0.013]	[0.077]			
R&D	1.225***	−0.774***	1.799***	−2.876***	10.463***		
	[0.151]	[0.184]	[0.138]	[1.050]	[0.662]		
DIVIDEND_PAYER	−0.015***				−0.043**		
	[0.005]				[0.018]		
FIRM_AGE	−0.011*	−0.002	−0.032***		−0.250***	−0.003**	0.002
	[0.006]	[0.008]	[0.005]		[0.025]	[0.001]	[0.002]
UNRATED	0.024***	0.083***					
	[0.008]	[0.014]					
CF_VOL	0.092			0.542	−0.556**		
	[0.065]			[0.490]	[0.267]		
Z_SCORE	−0.010	−0.053***					
	[0.010]	[0.018]					
CEO_SHARES	1.253***	0.403	1.915***	−4.934***	18.467***		
	[0.244]	[0.290]	[0.216]	[1.616]	[0.437]		
CEO_PAYSLICE	−0.041**			0.511***	0.324*		
	[0.020]			[0.192]	[0.167]		
CAPEX	1.277***	−1.847***	−0.154***	−15.413***	4.960***		
	[0.049]	[0.076]	[0.058]	[0.275]	[0.267]		
SALES_GROWTH						0.002	0.017***
						[0.003]	[0.003]

TENURE				0.009*	0.022***	0.000*	0.001***
				[0.005]	[0.003]	[0.000]	[0.000]
AGE_CEO				−0.005***	0.006***		
				[0.002]	[0.001]		
CEO_CASH				0.217***	−0.201***	0.006*	−0.010***
				[0.076]	[0.034]	[0.003]	[0.002]
SURCASH						−0.061**	0.257***
						[0.025]	[0.022]
SIZE2		0.008***					
		[0.001]					
TERM		−0.628					
		[0.683]					
ASSET_MAT		−0.001	−0.000				
		[0.001]	[0.000]				
ABNEARN		−0.093	0.280				
		[0.389]	[0.263]				
STD_RET		0.005	−0.090***			−0.022**	0.106***
		[0.042]	[0.022]			[0.010]	[0.010]
NOL_DUM			0.000				
			[0.003]				
ITC_DUM			0.006				
			[0.018]				
Constant	0.495***	1.043***	1.414***	1.111*	6.945***	0.167***	−0.270***
	[0.095]	[0.169]	[0.073]	[0.661]	[0.439]	[0.035]	[0.032]
Observations	9477	9477	9477	9477	9477	9477	9477
R-squared	0.141	0.218	0.413	0.357	0.693	0.173	0.543
Industry dummies	YES	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES	YES

(namely the differences between HHI two years post-turnover and HHI one year prior to the turnover) are related to differences in CEO Vega between the newly appointed CEO and the old CEO. Further, the model includes as control variables firm characteristics observed at time *t-1* and differences in LNDELTA, CEO_SHARES and CEO_PAYSLICE between the new and the old CEO.

In the first column of Table 7, where we estimate the model with year fixed effects, we find that an increase in LNVEGA is associated with an increase in HHI post-turnover. We find a similar result in column (2) after we exclude year fixed effects from the specification. Ultimately, the results still indicate that CEOs with incentive structures that are expected to be more penalized in the credit market are associated with debt structures that mitigate the negative effects of these incentives on debt contracts.

We acknowledge, however, that the CEO turnover setting has limitations due to the fact that the events we examine are not random and fully exogenous as compared to firm characteristics.

To mitigate the above concerns, we proceed in two ways. First, columns (3), (4) and (5) show a system of simultaneous equations (3SLS) by using as dependent variables the changes in HHI, in CEO Vega and in CEO Delta between the new and the old CEO as defined earlier. In addition to the controls employed in our initial models we add the outgoing CEO tenure (TENURE), differences in age (ΔCEO_AGE new-old) and in cash compensation (ΔCEO_COMP new-old) between the new and the old CEO. The results of this additional specification are in line with our previous tests.

Second, we employ an additional setting based on variation in CEO pay as in Francis et al. (2017). Specifically, we identify a subsample of CEOs that began receiving stock options as a part of their compensation during our sample period and observe how the inclusion of these option grants influences Vega and Delta and debt concentration.

Panel A of Table 8 shows that such inclusion increases (on average) CEO Vega, but it is also accompanied by an increase in the average degree of debt concentration. These increases are significantly different from zero according to a *t*-test. Panel B achieves similar conclusions when we examine the significance of the median changes in LNVEGA, LNDELTA and debt concentration after the inclusion of new stock options via a Wilcoxon signed-rank test.

All in all, the results reported in this section, though characterized by some limitations, still offer consistent support for a positive influence of LNVEGA on debt concentration.

4.3. Are creditor concerns over coordination problems behind our findings?

In this section we provide further tests with the purpose of validating the interpretation of our findings that debt concentration is motivated by the need to reassure creditors from the negative consequences of coordination problems in the case of a firm's distress.

Table 7
Debt concentration, pay–incentives and CEO turnover.
This table presents the relationship between the change of debt concentration following a turnover (ΔHHI) and the change in the sensitivities of CEOs' compensation to stock return volatility obtained comparing the new and the old CEO (ΔLNVEGA_new-old). We control for the change in the sensitivity of CEO compensation to changes (in percent) to stock prices (ΔLNDELTA_new-old) obtained by comparing the new and the old CEO, for firm characteristics, for changes in CEO characteristics, industry dummies (based on Fama-French 30 industries) and year dummies in the first column. All models are estimated via OLS. The set of controls include LEVERAGE (total debt over total assets), MARKET TO BOOK (market value of equity plus total debt plus preferred stock liquidating value minus deferred taxes and investment tax credit over total assets), PROFITABILITY (operating income before depreciation over total assets), SIZE (the logarithm of total assets measured in millions US$), TANGIBILITY (net property, plant, and equipment over total assets), R&D (research and development expenses over total sales), DIVIDEND_PAYER (a dummy equal to one if a firm pays common stock dividends), FIRM_AGE (the logarithm of one plus the number of years since the firm was added to the Compustat database), UNRATED (a dummy equal to one if a firm does not have a S&P rating on long-term debt, and zero otherwise), CF_VOL (the standard deviation of operating cash flows from operations calculated over the 5 year period before the observation year over total assets), Z_SCORE (a dummy equal to one if the Altman *Z*-score is lower than 2.99, and zero otherwise), ΔCEO_SHARES new-old (change in the number of shares owned by the CEO scaled by total shares outstanding obtained by comparing the values for the new and old CEO) and ΔCEO_PAYSLICE new-old (the change in the percentage of the total compensation to the top five executives that goes to the CEO obtained by comparing the values for the new and old CEO). We cluster standard errors at the industry level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	OLS	OLS	3SLS	3SLS	3SLS
	ΔHHI	ΔHHI	ΔHHI	ΔLNVEGA_new-old	ΔLNDELTA_new-old
	(1)	(2)	(3)	(4)	(5)
ΔLNVEGA_new-old	0.033**	0.027**	0.175***		1.218***
	[0.013]	[0.012]	[0.049]		[0.099]
ΔLNDELTA_new-old	−0.007	0.003	−0.135***	0.755***	
	[0.014]	[0.018]	[0.029]	[0.053]	
LEVERAGE	0.0618	0.07	0.129*	−0.390*	0.541**
	[0.107]	[0.107]	[0.069]	[0.201]	[0.221]
MARKET TO BOOK	−0.016	−0.015	−0.030**	0.093**	−0.125***
	[0.018]	[0.018]	[0.015]	[0.042]	[0.047]
PROFITABILITY	−0.121	−0.133	−0.023	−0.050	0.081
	[0.131]	[0.120]	[0.173]	[0.494]	[0.549]
SIZE	0.030***	0.034***	0.030***	−0.021	0.034
	[0.010]	[0.010]	[0.009]	[0.029]	[0.032]
TANGIBILITY	−0.002	−0.0047	−0.034	0.147	−0.199
	[0.077]	[0.076]	[0.051]	[0.149]	[0.165]
R&D	−0.159	−0.175	−0.112	−0.104	0.132
	[0.184]	[0.189]	[0.157]	[0.451]	[0.501]
DIVIDEND_PAYER	−0.03	−0.028	−0.000	−0.117*	0.144*
	[0.028]	[0.028]	[0.025]	[0.069]	[0.077]
FIRM_AGE	0.015	0.01	0.025	−0.097**	0.122**
	[0.013]	[0.017]	[0.017]	[0.048]	[0.054]
UNRATED	0.049*	0.056**	0.067**	−0.193**	0.244**
	[0.027]	[0.027]	[0.030]	[0.085]	[0.096]
CF_VOL	0.584	0.634	0.635*	−1.063	1.413
	[0.373]	[0.377]	[0.331]	[0.973]	[1.083]
Z_SCORE	−0.015	−0.007	−0.007	−0.014	0.001
	[0.033]	[0.034]	[0.028]	[0.079]	[0.089]
ΔCEO_SHARES new-old	−0.191	−0.524	2.115**	−13.896***	18.371***
	[0.538]	[0.651]	[0.926]	[2.343]	[2.347]
ΔCEO_PAYSLICE new-old	−0.096	−0.109	−0.055	−0.173	0.226
	[0.068]	[0.068]	[0.083]	[0.244]	[0.270]
ΔHHI				1.247***	−1.783***
				[0.372]	[0.399]
ΔCEO_AGE new-old				−0.773	0.951
				[0.856]	[0.922]
ΔCEO_COMP new-old				0.000	−0.000
				[0.000]	[0.000]
TENURE				−0.014**	0.017**
				[0.006]	[0.007]
Constant	−0.161	−0.131	−0.357***	0.788***	−1.055***
	[0.151]	[0.152]	[0.098]	[0.302]	[0.335]
Observations	596	596	597	598	599
Industry dummies	YES	YES	YES	YES	YES

Table 7 (*Continued*)

	OLS	OLS	3SLS	3SLS	3SLS
	ΔHHI	ΔHHI	ΔHHI	ΔLNVEGA_new-old	ΔLNDELTA_new-old
	(1)	(2)	(3)	(4)	(5)
Time dummies	NO	YES	YES	YES	YES
R-squared	0.082	0.113	0.130	0.114	0.404

Table 8

First inclusion of the stock option grants in CEO compensation during the sample period and changes in debt concentration.

This table reports the univariate t-test (Panel A) and a Wilcoxon z-test (Panel B) on firms that began to first grant their CEOs with stock options during our sample period (2001–2016) and the related change in debt concentration. The change in the sensitivities of CEOs' compensation to stock return volatility (ΔLNVEGA), the change in the sensitivity of CEO compensation to changes (in percent) in stock prices (ΔLNDELTA), and the change in the firm's debt concentration (ΔHHI) are computed by comparing average values in the two-year period after the inclusion of stock option grants to average values in the two-year period before the inclusion.

Panel A: t-test			
	Mean	t-stat (Mean = 0)	p-value
	(1)	(2)	(4)
ΔLNVEGA	1.546	5.055	0.000
ΔLNDELTA	0.830	2.850	0.005
ΔHHI	0.089	1.774	0.039
Panel B: z-test			
	Median	z-stat (Median = 0)	p-value
	(1)	(2)	(4)
ΔLNVEGA	1.504	4.534	0.000
ΔLNDELTA	0.531	2.603	0.009
ΔHHI	0.194	1.734	0.083

4.3.1. Debt concentration, CEO incentives, firm default risk, cash flow volatility and stakeholder orientation

If our results reflect the need of a firm to reassure creditors so as to reduce funding costs, we should observe a stronger relationship between HHI and LNVEGA in riskier firms. There are at least two reasons that motivate this prediction.

First, coordination problems among creditors become evident when a firm is closer to a distress as a dispersed debt structure is inefficient in organizing and coordinating negotiation efforts (Hart and Moore, 1995; Hubert and Schafer, 2002; Ivashina and Scharfstein, 2010). This conclusion finds support in the theoretical models proposed by Bolton and Scharfstein (1996) and by Bris and Welch (2005) and in the empirical analysis of Lou and Otto (2020). This latter study documents that the bankruptcy filings of firms characterized by more heterogeneous debt structures are less likely to include a prearranged resolution plan. Second, firms that are closer to financial distress are more likely to engage in risk-shifting (Black and Scholes, 1973; Leland, 1998). This is because shareholders benefit from risky investments if the investments go well, while debtholders will bear the costs in the case of a negative outcome (Eisdorfer, 2008).

To test the validity of the above prediction, we interact our Z_Score dummy with LNVEGA. In the first three columns of Panel A of Table 9 we report the results for the Tobit, OLS and Probit regressions. Furthermore, to ease the interpretation of our findings we report in Panel B the coefficients and standard errors of the marginal effects of equity-based incentives computed for higher risk (*Z*-score dummy = 1) and lower risk (Z-score dummy = 0) firms.

In line with our prediction, we find that the impact of LNVEGA on debt concentration is stronger in riskier firms. The impact of risk-taking incentives in riskier firms is also economically larger as compared to the impact observed in the full sample. For instance, using the estimates in column (1) we find that in riskier firms (with a Z-Score dummy equal to one), an increase from the 25th to 75th percentile of the sample distribution of (the dollar value of) Vega increases debt concentration by approximately 6.3% (6.0%) as compared to the sample mean (median) of HHI.[12]

Firms with large cash-flow volatility should also benefit more from the positive signal arising from a more concentrated debt structure. These firms are characterized by larger bankruptcy costs (see Colla et al., 2013) that lead to a higher cost of debt

[12] Furthermore, in Table A.8 of the Online Appendix, we employ (minus) the distance to default (−DD) of Merton (1974) as an alternative measure of a firm's distress risk. The derivation of DD requires, reported in the Online Appendix, the estimation of two unknowns, the market value of assets and the volatility of asset returns, that we obtain by employing the interactive numerical approach based on option pricing used by, among others, Hillegeist et al. (2004) and Vassalou and Xing (2004). Using this alternative risk measure we find similar results.

Table 9

Debt concentration, CEO risk-taking incentives - the importance of corporate risk, cash flow volatility and stakeholder orientation.

Panel A presents regression results on how the firm risk, measured via the Z_SCORE (a dummy equal to one if the Altman's *Z*-score is lower than 2.99, and zero otherwise), cash-flow volatility and a firm's stakeholder orientation influence the relationship between debt concentration and the sensitivity of CEOs' compensation to stock return volatility (LNVEGA). We control for the sensitivity of CEO compensation to changes (in percent) in stock prices (LNDELTA), for firm and CEO characteristics, industry dummies (based on Fama-French 30 industries) and year dummies. Debt concentration is the Herfindahl index of debt concentration by debt type (HHI) or a dummy equal to one if more than 90% of the debt structure is concentrated in one type of debt (Excl90). The controls are LEVERAGE (total debt over total assets), MARKET TO BOOK (market value of equity plus total debt plus preferred stock liquidating value minus deferred taxes and investment tax credit over total assets), PROFITABILITY (operating income before depreciation over total assets), SIZE (the logarithm of total assets in millions US$), TANGIBILITY (net property, plant, and equipment over total assets), R&D (research and development expenses over total sales), DIVIDEND_PAYER (a dummy equal to one if a firm pays common stock dividends), FIRM_AGE (the logarithm of one plus the number of years since a firm appears in Compustat), UNRATED (a dummy equal to one if a firm does not have a S&P rating on long-term debt, and zero otherwise), CF_VOL (the standard deviation of operating cash flows calculated over the 5 year-period divided by total assets), Z_SCORE (a dummy equal to one if the Altman's Z-score is lower than 2.99, and zero otherwise), CEO_SHARES (number of shares owned by the CEO scaled by total shares outstanding) and CEO_PAYSLICE (the percentage of the total compensation to the top five executives that goes to the CEO). NON_STAKEHOLDER is a dummy equal to one if a firm is incorporated in a state that did not adopt constituency statutes-state-level laws. Panel B reports marginal effects of LNVEGA for Z_SCORE equal to one or zero, for values of CF_VOL equal to the 75th (25th) percentile of the sample distribution and for NON_STAKEHOLDER equal to one or zero. We cluster standard errors at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Tobit	OLS	Probit (Marg. Eff.)	Tobit	OLS	Probit (Marg. Eff.)	Tobit	OLS	Probit (Marg. Eff.)
	HHI	HHI	Excl90	HHI	HHI	Excl90	HHI	HHI	Excl90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Regression analysis									
	RISK = Z_SCORE			CF VOLATILITY			STAKEHOLDER		
LNVEGA	0.008	0.005	0.017***	0.016***	0.012***	0.018***	0.005	0.003	0.017***
	[0.005]	[0.004]	[0.007]	[0.004]	[0.003]	[0.006]	[0.006]	[0.005]	[0.007]
LNDELTA	−0.020***	−0.016***	−0.033***	−0.019***	−0.015***	−0.032***	−0.020***	−0.016***	−0.033***
	[0.007]	[0.006]	[0.010]	[0.007]	[0.006]	[0.010]	[0.007]	[0.006]	[0.010]
RISK *LNVEGA	0.011**	0.010**	0.040*						
	[0.005]	[0.004]	[0.023]						
RISK	−0.049*	−0.045**	0.005	−0.006	−0.003	−0.006	−0.005	−0.003	0.006
	[0.026]	[0.021]	[0.021]	[0.014]	[0.011]	[0.014]	[0.014]	[0.011]	[0.021]
LNVEGA* CF_VOL				0.175*	0.136*	0.677*			
				[0.093]	[0.075]	[0.389]			
CF_VOL	0.455**	0.280*	0.634**	0.489***	0.307**	0.489***	0.433**	0.264*	0.610**
	[0.186]	[0.144]	[0.263]	[0.189]	[0.146]	[0.189]	[0.186]	[0.144]	[0.263]
LNVEGA*NON_STAKEHOLDER							0.012*	0.012**	0.058**
							[0.006]	[0.006]	[0.029]
NON_STAKEHOLDER							−0.028	−0.031	0.018
							[0.029]	[0.025]	[0.023]
Constant	1.084***	0.950***	1.172***	1.134***	0.981***	1.134***	1.072***	0.942***	1.116***
	[0.086]	[0.072]	[0.359]	[0.086]	[0.073]	[0.086]	[0.086]	[0.072]	[0.350]
Observations	8942	8942	8942	8942	8942	8942	8942	8942	8942
Industry dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Pseudo R2	0.265		0.089	0.266		0.089	0.267		0.089
R2		0.14			0.145			0.14	

Panel B: Marginal effects			
A) LNVEGA (HIGHER RISK)	0.018***	0.015***	0.022***
B) LNVEGA (LOWER RISK)	0.008	0.005	0.008

	0.010**	0.010**	0.014*						
A-B	0.010**	0.010**	0.014*						
C) HIGH CASH FLOW VOLATILITY				0.018***	0.014***	0.021***			
D) LOW CASH FLOW VOLATILITY				0.012***	0.008**	0.012*			
C-D				0.006*	0.006*	0.008*			
E) LNVEGA (NON_STAKEHOLDER = 1)							0.017*	0.015**	0.075***
F) LNVEGA (NON_STAKEHOLDER = 0)							0.005	0.003	0.017***
E-F							0.012*	0.012**	0.058**

(Minton and Schrand, 1999). In the context our analysis, a key implication of the evidence reported above is that the positive relationship between HHI and LNVEGA should be significantly larger for firms with larger cash flow volatility.

Furthermore, Gao et al. (2020) show that the adoption of constituency statutes-state-level laws, which allow corporate directors to consider stakeholders' interests in business decisions, generates a decrease in the cost of debt. Essentially, creditors see these laws as beneficial for safeguarding their interests against shareholders. As a result, the signaling benefits from a more concentrated debt structure should be higher when corporate directors still show a low stakeholder orientation; namely, for firms incorporated in states that did not adopt constituency statutes-state-level laws.

To examine the validity of these two additional predictions, we interact our measure of cash-flow volatility with LNVEGA and we re-estimate the baseline Tobit, OLS and Probit models with the addition of this interaction term. We next create a dummy variable equal to one if a company is incorporated in a non-stakeholder oriented state and zero otherwise and add this dummy and its interaction with LNVEGA to our baseline models.[13]

We report the regression results in columns (4) to (9) of Panel A of Table 9. Panel B shows the coefficients and standard errors of the marginal effects of LNVEGA for firms with high and low cash flow volatility (equal to the 75th and 25th percentile of the sample distribution, respectively) and for firms incorporated in non-stakeholder oriented states and other firms.[14] We find that the impact of LNVEGA on debt concentration is significantly larger in firms with larger cash-flow volatility and in non-stakeholder oriented firms. For instance, in firms with high cash-flow volatility an increase from the 25th to 75th percentile of sample distribution of (the dollar value of) Vega increases debt concentration by approximately 6.3% (6.0%) as compared to the sample mean (median) of HHI. For firms with low cash-flow volatility the increase is 4.2% (4.0%).[15]

4.3.2. The role of short-term incentives

Two CEOs with an identical Vega may have different short-term benefits from an increase in firm volatility depending on when they might exercise their options. Consequently, under our theoretical framework, they can be perceived differently by creditors. In particular, we expect a stronger relationship between Vega and debt concentration when the CEO risk-taking incentives are primarily shorter-term and give the executive the opportunity to realize immediate wealth benefits through more risk-taking (Erkens, 2011). In this respect, Devers et al. (2008) show that when CEOs hold larger values of exercisable options corporate risk-taking increases, while Burns and Kedia (2006) and Efendi et al. (2007) find that managers with large holdings of vested options tend to engage in misreporting. More generally, shorter term incentives make it attractive for managers to choose riskier projects that boost short-term performance and enhance their reputation (Gopalan et al., 2014; Thakor, 1990). As a result, these incentives should be more penalized by creditors and should induce firms to select more concentrated debt structures.

To test the validity of the prediction above, similarly to Burns and Kedia (2006), Devers et al. (2008) and Efendi et al. (2007), we decompose Vega into vested (LNVEGA_VEST) and unvested components (LNVEGA_UNVEST). Vested Vega is the sensitivity to changes in stock return volatility of the portfolio consisting of all exercisable options. As such, a larger vested Vega indicates more pronounced short-term benefits for CEO pay from increases in stock return volatility. Unvested Vega is instead the sensitivity of the value of the portfolio of all unexercisable options (including those of newly granted options and existing Unvested options) to changes in stock return volatility.[16] Unvested options imply a longer-term managerial approach (Erkens, 2011). We then extend our baseline model by replacing LNVEGA with LNVEGA_VEST and LNVEGA_UNVEST, while maintaining LNDELTA in the specification as an explanatory variable (in addition to the full set of control variables defined in the previous section).

We initially estimate Tobit regressions where each component of LNVEGA enters separately in the model. The results, reported in the first two columns of Table 10, show a positive effect of both components on debt concentration (although the magnitude of the estimated coefficient is larger for LNVEGA_VEST). As shown in column (3) when both components enter the regression only the coefficient of LNVEGA_VEST remains positive and highly significant. Furthermore, in the final two columns of Table 10, where we estimate an OLS and a Probit regression with, respectively, HHI and Excl90 as dependent variables, although LNVEGA_UNVEST is significant its coefficient is significantly lower than the coefficient of LNVEGA_VEST. In essence, we find that the positive influence of Vega on debt concentration is primarily driven by the risk-taking incentives with the potential to generate shorter-term effects on creditors.

[13] We obtain information on the current state of incorporation of the sampled firms from Compustat and historical information from https://sraf.nd.edu/data/augmented-10-x-header-data/

[14] We obtain similar results when we compute the marginal effects of the Tobit model as the censored expected value. These marginal effects describe how the observed variable (HHI) changes with respect to the variations in LNVEGA for different levels of stakeholder orientation.

[15] Financially constrained firms should have more difficulties in accessing the credit markets (Almeida and Campello, 2001; Liu and Mauer, 2011; Whited and Wu, 2006) and this should also create more incentives to opt for a concentrated debt structure. To validate this prediction, we repeat our main tests for sub-samples of firms identified using measures of financial constraints. We employ the Hadlock and Pierce (2010), the Whited and Wu (2006), the 10-K text based measure of financial constraints taken from Hoberg and Maksimovic (2015) and a dummy to differentiate dividend payers from other firms. The results, reported in Table A.9 of the Online Appendix, consistently show that the impact of CEO Vega on debt concentration is stronger in financially constrained firms.

[16] It is worthwhile noting that high values of LNVEGA_UNVEST are not necessarily associated with high values of LNVEGA_VEST, the correlation between the two variables being equal to 0.65. Along these lines, we find that about 1659 yearly CEO observations (equivalent to about 18.5% of the full sample) have a LNVEGA_UNVEST equal to zero. In more than 55% of these observations (960), however, LNVEGA_VEST is larger than zero.

Table 10
CEO pay incentives vesting period and debt concentration.
This table reports the empirical results on the relationship between debt concentration and the components of CEO Vega. Specifically, we distinguish Vega computed from Vested options (LNVEGA_VEST) from Vega based on Unvested options (LNVEGA_UNVEST). All specifications control for the sensitivity of CEO compensation to changes (in percent) in stock prices (LNDELTA), firm and CEO characteristics, industry dummies (based on Fama-French 30 industries) and year dummies. In the first four columns the dependent variable is a Herfindahl index of concentration of debt structure by type of debt (HHI) in the last column (5) the dependent variable is a dummy equal to one if more than 90% of the debt structure is concentrated in only one type of debt (Excl90) and the model is estimated via a Probit regression. The set of controls include LEVERAGE (total debt over total assets), MARKET TO BOOK (market value of equity plus total debt plus preferred stock liquidating value minus deferred taxes and investment tax credit over total assets), PROFITABILITY (operating income before depreciation over total assets), SIZE (logarithm of total assets measured in millions US$), TANGIBILITY (net property, plant, and equipment over total assets), R&D (research and development expenses over total sales), DIVIDEND_PAYER (a dummy equal to one if a firm pays common stock dividends), FIRM_AGE (the log transformation of one plus the number of years since the firm was added to the Compustat database), UNRATED (a dummy equal to one if a firm does not have a S&P rating on long-term debt, and zero otherwise), CF_VOL (the standard deviation of operating cash flows from operations calculated over a 5 year-period divided by total assets), Z_SCORE (a dummy equal to one if the Altman's Z-score is lower than 2.99, and zero otherwise), CEO_SHARES (number of shares owned by the CEO scaled by total shares outstanding), and CEO_PAYSLICE (the percentage of the total compensation to the top five executives that goes to the CEO). We cluster standard errors at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Tobit	Tobit	Tobit	OLS	Probit (Marg. Eff.)
	HHI	HHI	HHI	HHI	Excl90
	(1)	(2)	(3)	(4)	(5)
LNVEGA_VEST	0.013***		0.012***	0.009***	0.013**
	[0.003]		[0.003]	[0.003]	[0.006]
LNVEGA_UNVEST		0.008**	0.003	0.003	0.003
		[0.004]	[0.003]	[0.003]	[0.006]
LNDELTA	−0.018***	−0.012**	−0.019***	−0.015***	−0.031***
	[0.007]	[0.006]	[0.007]	[0.006]	[0.010]
LEVERAGE	−0.465***	−0.459***	−0.464***	−0.367***	−0.642***
	[0.036]	[0.036]	[0.036]	[0.031]	[0.056]
MARKET TO BOOK	0.030***	0.026***	0.030***	0.021***	0.035***
	[0.008]	[0.008]	[0.008]	[0.006]	[0.012]
PROFITABILITY	0.059	0.055	0.057	0.043	0.164
	[0.077]	[0.077]	[0.077]	[0.059]	[0.115]
SIZE	−0.014**	−0.015**	−0.014**	−0.009	−0.016
	[0.007]	[0.007]	[0.0070]	[0.006]	[0.011]
TANGIBILITY	−0.059	−0.065	−0.059	−0.058	−0.144**
	[0.041]	[0.042]	[0.041]	[0.036]	[0.064]
R&D	0.381***	0.399***	0.383***	0.298***	0.493***
	[0.082]	[0.082]	[0.082]	[0.056]	[0.120]
DIVIDEND_PAYER	0.005	0.005	0.004	0.007	0.013
	[0.013]	[0.013]	[0.013]	[0.011]	[0.019]
FIRM_AGE	−0.021**	−0.019*	−0.021**	−0.013	−0.024
	[0.010]	[0.010]	[0.010]	[0.008]	[0.015]
UNRATED	0.002	0.003	0.002	−0.003	−0.025
	[0.016]	[0.016]	[0.016]	[0.014]	[0.024]
CF_VOL	0.456**	0.465**	0.461**	0.286**	0.639**
	[0.185]	[0.186]	[0.185]	[0.144]	[0.262]
Z_SCORE	−0.005	−0.005	−0.005	−0.002	0.007
	[0.014]	[0.014]	[0.014]	[0.012]	[0.021]
CEO_SHARES	0.387**	0.278	0.411**	0.308**	0.470*
	[0.184]	[0.181]	[0.188]	[0.153]	[0.274]
CEO_PAYSLICE	−0.017	−0.032	−0.024	−0.011	−0.003
	[0.044]	[0.045]	[0.045]	[0.03]	[0.071]
Constant	1.042***	1.043***	1.046***	0.971***	1.039***
	[0.083]	[0.085]	[0.084]	[0.079]	[0.353]
Observations	8942	8942	8942	8942	8942
Industry dummies	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES
Pseudo R2	0.263	0.260	0.264		0.088
R2				0.144	

In terms of economic impact, using the results for the model reported in column (1), we find that an increase from the 25th to the 75th percentile of the sample distribution of the dollar value of vested Vega increases debt concentration by approximately 5.0 (4.8)% as compared to the sample mean (median) of HHI. Overall, the findings reported in this section suggest that pay-incentives linked to stock return volatility influence the debt structure, especially when they potentially have immediate wealth gains for the CEO due to the lack of vesting restrictions.

5. Conclusions

By building on the theoretical framework proposed by Bris and Welch (2005), wherein the choice of the debt structure by a firm is the result of the trade-off between in-bankruptcy collection deadweight costs and pre-bankruptcy deadweight agency and/or signaling costs, we postulate the presence of a significant positive relationship between risk-taking incentives in executive compensation (measured by CEO Vega) and the degree of debt concentration by debt type.

Consistently with our theoretical prediction, we find that firms rely on fewer debt types when CEO pay contains more risk-taking incentives and, consequently, creditors see corporate choices against their interests as being more likely. This result is consistent with the choice of a more concentrated debt structure acting as a positive signaling mechanism for creditors as it increases their powers in financial distress.

In line with the above interpretation, additional tests demonstrate the effect of CEO risk-taking incentives on debt concentration is stronger in firms that are likely to face more costly conditions in the credit market - such as riskier firms. Furthermore, and in a similar vein, we find our results are stronger when borrowing firms show higher incentives to engage in risky projects in the short-term because of larger risk-taking incentives due to vested options (see Devers et al., 2008).

Overall, we show that the impact of risk-taking incentives in CEO pay on a firm's debt policy goes well beyond the effects documented on total leverage (see, Chava and Purnanandam, 2010; Coles et al., 2006) and debt maturity (Brockman et al., 2010).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcorpfin.2020.101684.

References

Albring, S M, Khurana, I K, Nejadmalayeri, A, Pereira, R, 2011. Managerial compensation and the debt placement decision. J. Corp. Finan. 17, 1445–1456.

Allen, F, 1990. The market for information and the origin of financial intermediation. J. Financ. Intermed. 1, 3–30.

H. Almeida M. Campello Financial Constraints and Investment-Cash Flow Sensitivities: New Research DirectionsWorking Paper, availablehttps://papers.ssrn.com/sol3/papers.cfm?abstract_id = 2980272001

Anderson, J D, Core, J E, 2018. Managerial incentives to increase risk provided by debt, stock, and options. Manag. Sci. 64, 4408–4432.

Armstrong, C S, Larcker, D F, Ormazabal, G, Taylor, D J, 2013. The relation between equity incentives and misreporting: the role of risk-taking incentives. J. Financ. Econ. 109, 327–350.

Barnea, A, Haugen, R A, Senbet, L W, 1980. A rationale for debt maturity structure and call provisions in the agency theoretic framework. J. Financ. 35, 1223–1234.

Bebchuk, L A, Cremers, K J M, Peyer, U C, 2011. The CEO pay slice. J. Financ. Econ. 102, 199–221.

Berger, P G, Ofek, E, Yermak, D L, 1997. Managerial entrenchment and capital structure decisions. J. Financ. 52, 1411–1438.

Bernardo, A E, Talley, E L, 1996. Investment policy and exit-exchange offers within financially distressed firms. J. Financ. 51, 871–888.

Bhagat, S, Bolton, B, 2008. Corporate governance and firm performance. J. Corp. Finan. 14, 257–273.

Billett, M T, King, T H D, Mauer, D C, 2007. Growth opportunities and the choice of leverage, debt maturity, and covenants. J. Financ. 62, 697–730.

Billett, M T, Mauer, D C, Zhang, Y, 2010. Stockholder and bondholder wealth effects of CEO incentive grants. Financ. Manag. 39, 463–487.

Black, F, Scholes, M, 1973. The pricing of options and corporate liabilities. J. Polit. Econ. 81, 637–654.

Bolton, P, Scharfstein, D S, 1996. Optimal debt structure and the number of creditors. J. Polit. Econ. 104, 1–25.

Boone, A L, Field, L C, Karpoff, J M, Raheja, C G, 2007. The determinants of corporate board size and composition: an empirical analysis. J. Financ. Econ. 85, 66–101.

Bris, A, Welch, I, 2005. The optimal concentration of creditors. J. Financ. 60, 2193–2212.

Brockman, P, Martin, X, Unlu, E, 2010. Executive compensation and the maturity structure of corporate debt. J. Financ. 65, 1123–1161.

Brown, K C, Harlow, W V, Starks, L T, 1996. Of tournaments and temptations: an analysis of managerial incentives in the mutual fund industry. J. Financ. 51, 85–110.

Burns, N, Kedia, S, 2006. The impact of performance-based compensation on misreporting. J. Financ. Econ. 79, 35–67.

Chava, S, Purnanandam, A, 2007. Determinants of the floating-to-fixed rate debt structure of firms. J. Financ. Econ. 85, 755–786.

Chava, S, Purnanandam, A, 2010. CEOs versus CFOs: incentives and corporate policies. J. Financ. Econ. 97, 263–278.

Chen, L, Qiu, J, 2017. CEO incentives, relationship lending, and the cost of corporate borrowing. Financ. Manag. 46, 627–654.

Coles, J L, Naveen, D D, Naveen, L, 2006. Managerial incentives and risk-taking. J. Financ. Econ. 79, 431–468.

Coles, J L, Naveen, D D, Naveen, L, 2014. Co-opted boards. Rev. Financ. Stud. 27, 1751–1796.

Colla, P, Ippolito, F, Li, K, 2013. Debt Specialization. J. Financ. 68, 2117–2141.

Core, J E, Guay, W R, 2002. Estimating the value of employee stock option portfolios and their sensitivities to price and volatility. J. Account. Res. 40, 613–630.

N. Daniel M. Spencer L. Naveen The Hidden Cost of Managerial Incentives: Evidence from the Bond and Stock MarketsWorking Paper, available at*https://papers.ssrn.com/sol3/papers.cfm?abstract_id = 6129212*004

Devers, C E, McNamara, G, Wiseman, R M, Arrfelt, M, 2008. Moving closer to the action: examining compensation design effects on firm risk. Organ. Sci. 19, 548–566.

Diamond, D W, 1984. Financial intermediation and delegated monitoring. Rev. Econ. Stud. 51, 393–414.

Diamond, D W, 2004. Presidential address, committing to commit: short-term debt when enforcement is costly. J. Financ. 59, 1447–1479.

Dittman, I, Yu, K C, Zhang, D, 2017. How important are risk-taking incentives in executive compensation? Rev. Financ. 21, 1805–1846.

Dong, Z, Wang, C, Xie, F, 2010. Do executive stock options induce excessive risk taking? J. Bank. Financ. 34, 2518–2529.

Efendi, J, Srivastava, A, Swanson, E P, 2007. Why do corporate managers misstate financial statements? The role of option compensation and other factors. J. Financ. Econ. 85, 667–708.

Eisdorfer, A, 2008. Empirical evidence of risk-shifting in financially distressed firms. J. Financ. 63, 609–637.

Eisenmann, T R, 2002. The effects of CEO equity ownership and firm diversification on risk taking. Strateg. Manag. J. 23, 513–534.

Erkens, D H, 2011. Do firms use time-vested stock-based pay to keep research and development investments secret? J. Account. Res. 49, 861–894.

Esty, B C, 1997. Organizational form and risk taking in the savings and loan industry. J. Financ. Econ. 44, 25–55.

Faleye, O, 2015. The costs of a (nearly) fully independent board. J. Empir. Financ. 32, 49–62.

Faleye, O, Kovacs, T, Venkateswaran, A, 2014. Do better-connected CEOs innovate more? J. Financ. Quant. Anal. 49, 1201–1225.

Francis, B B, Hasan, I, Hunter, D M, Zhu, Y, 2017. Do managerial risk-taking incentives influence firms' exchange rate exposure? J. Corp. Finan. 46, 154–169.

H. Gao K. Li Y. Ma Stakeholder Orientation and the Cost of Debt: Evidence from a Natural ExperimentWorking Paper available at*https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2878415*2020
Gertner, R, Scharfstein, D, 1991. A theory of workouts and the effects of reorganization law. J. Financ. 46, 1189–1222.
Giammarino, R M, 1989. The resolution of financial distress. Rev. Financ. Stud. 2, 25–47.
Gopalan, R, Milbourn, T, Song, F, Thakor, A V, 2014. Duration of executive compensation. J. Financ. 69, 2777–2817.
Gormley, T A, Matsa, D A, Milbourn, T, 2013. CEO compensation and corporate risk: evidence from a natural experiment. J. Account. Econ. 56, 79–101.
Guay, W R, 1999. The sensitivity of CEO wealth to equity risk: an analysis of the magnitude and determinants. J. Financ. Econ. 53, 43–71.
Hadlock, C J, Pierce, J R, 2010. New evidence on measuring financial constraints: moving beyond the KZ index. Rev. Financ. Stud. 23, 1909–1940.
Hart, O, Moore, J, 1994. A theory of debt based on the inalienability of human capital. Q. J. Econ. 109, 841–879.
Hart, O, Moore, J, 1995. Debt and seniority: an analysis of the role of hard claims in constraining management. Am. Econ. Rev. 85, 567–585.
Hayes, R M, Lemmon, M, Qiu, M, 2012. Stock options and managerial incentives for risk taking: evidence from FAS 123R. J. Financ. Econ. 105, 174–190.
Hillegeist, S A, Keating, E K, Cram, D P, Lundstedt, K G, 2004. Assessing the probability of bankruptcy. Rev. Acc. Stud. 9, 5–34.
Hoberg, G, Maksimovic, V, 2015. Redefining financial constraints: a text-based analysis. Rev. Financ. Stud. 28, 1312–1352.
Hoshi, T, Kashyap, A, Sharfstein, D, 1990. The role of banks in reducing the costs of financial distress in Japan. J. Financ. Econ. 27, 67–88.
Huang, R, Tan, K J K, Faff, R, 2016. CEO overconfidence and corporate debt maturity. J. Corp. Finan. 36, 93–110.
Hubert, F, Schafer, D, 2002. Coordination failure with multiple-source lending: the cost of protection against a powerful lender. J. Inst. Theor. Econ. 158, 256–275.
Ivashina, V, Scharfstein, D, 2010. Bank lending during the financial crisis of 2008. J. Financ. Econ. 97, 319–338.
Jiang, W, 2017. Have instrumental variables brought us closer to the truth. Rev. Corp. Financ. Stud. 6, 127–140.
John, T A, John, K, 1993. Top-management compensation and capital structure. J. Financ. 48, 949–974.
Kabir, R, Li, H, Veld-Merkoulova, V V, 2013. Executive compensation and the cost of debt. J. Bank. Financ. 37, 2893–2907.
Kini, O, Williams, R, 2012. Tournament incentives, firm risk, and corporate policies. J. Financ. Econ. 103, 350–376.
Leland, H E, 1998. Agency costs, risk management, and capital structure. J. Financ. 53, 1213–1243.
Leland, H E, Toft, K B, 1996. Optimal capital structure, endogenous bankruptcy, and the term structure of credit spreads. J. Financ. 51, 987–1019.
Lemmon, M L, Roberts, M R, Zender, J F, 2008. Back to the beginning: persistence and the cross-section of corporate capital structure. J. Financ. 63, 1575–1608.
N. Li Y. Lou C.A. Otto M. Wittenberg Accounting Quality and Debt Concentration: Evidence from Internal Control Weakness DisclosuresWorking Paper, available athttps://papers.ssrn.com/sol3/papers.cfm?abstract_id=25323862016
Liu, Y, Mauer, D C, 2011. Corporate cash holdings and CEO compensation incentives. J. Financ. Econ. 102, 183–198.
Lou, Y, Otto, C A, 2020. Debt Heterogeneity and Covenants. Manag. Sci. 66, 70–92.
Low, A, 2009. Managerial risk-taking behavior and equity-based compensation. J. Financ. Econ. 92, 470–490.
Meneghetti, C, 2012. Managerial incentives and the choice between public and Bank debt. J. Corp. Finan. 18, 65–91.
Merton, R C, 1973. Theory of rational option pricing. Bell J. Econ. Manag. Sci. 4, 141–183.
Merton, R C, 1974. On the pricing of corporate debt: the risk structure of interest rates. J. Financ. 29, 449–470.
Milidonis, A, Stathopoulos, K, 2014. Managerial incentives, risk aversion, and debt. J. Financ. Quant. Anal. 49, 453–481.
Minton, B A, Schrand, C, 1999. The impact of cash flow volatility on discretionary investments and the costs of debt and equity financing. J. Financ. Econ. 54, 423–460.
Ortiz-Molina, H, 2007. Executive compensation and capital structure: the effects of convertible debt and straight debt on CEO pay. J. Account. Econ. 43, 69–93.
Park, H, Vrettos, D, 2015. The moderating effect of relative performance evaluation on the risk incentive properties of executives' equity portfolios. J. Account. Res. 53, 1055–1108.
Prilmeier, R, 2017. Why do loans contain covenants? Evidence from lending relationships. J. Financ. Econ. 123, 558–579.
Rajan, R, Winton, A, 1995. Covenants and collateral as incentives to monitor. J. Financ. 50, 1113–1146.
Rego, S O, Wilson, R, 2012. Equity risk incentives and corporate tax aggressiveness. J. Account. Res. 50, 775–810.
Saunders, A, Strock, E, Travlos, N G, 1990. Ownership structure, deregulation, and Bank risk taking. J. Financ. 45, 643–654.
Sorge, M, Zhang, C, Koufopoulos, K, 2017. Short-term corporate debt around the world. J. Money Credit Bank. 49, 997–1029.
Thakor, A V, 1990. Investment "myopia" and the internal organization of capital allocation decisions. J. Law Econ. Org. 6, 129–154.
Vassalou, M, Xing, Y, 2004. Default risk in equity returns. J. Financ. 59, 831–868.
Whited, T M, Wu, G, 2006. Financial constraints risk. Rev. Financ. Stud. 19, 531–559.