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Peer firms in relative performance evaluation

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ABSTRACT

Relative performance evaluation (RPE) in chief executive officer (CEO) compensation provides insurance against external shocks and yields a more informative measure of CEO actions. I argue that empirical evidence on the use of RPE is mixed because previous studies rely on a misspecified peer group. External shocks and flexibility in responding to the shocks are functions of, for example, the firm's technology, the complexity of the organization, and the ability to access external credit, which depend on firm size. When peers are composed of similar industry-size firms, evidence is consistent with the use of RPE in CEO compensation.

1. Introduction

Agency theory suggests that the compensation of chief executive officers (CEOs) should be linked to firm performance to motivate CEOs to maximize shareholder value. Further, the hypothesis of relative performance evaluation (RPE) (Holmstrom, 1982; Holmstrom and Milgrom, 1987) states that the firm performance measure used in CEO pay should exclude the component driven by exogenous shocks. Despite much research in this area, the lack of consistent empirical evidence supporting the use of RPE in CEO compensation is an important unresolved puzzle (Murphy, 1999; Abowd and Kaplan, 1999; Prendergast, 1999).

In this paper, I study how the choice of peer group affects tests of RPE, which is a joint test of how incentives are granted and of what constitutes a peer group. Previous tests potentially lack power to detect evidence that supports RPE because peer groups chosen by researchers are incorrect. The challenge in choosing a RPE peer group is to identify the set of firms that are exposed to common shocks and share a common ability to respond to those shocks.

Suppose, as many studies of RPE do, that firms' external shocks are best described by economy-wide shocks. Then the relevant group of peers are the Standard & Poor's 500 firms or the firms in some other market index (e.g., Jensen and Murphy, 1990; Aggarwal and Samwick, 1999a; Garvey and Milbourn, 2003). However, if external shocks are mostly dominated by industry-specific shocks, the S&P 500 is not an appropriate peer group. Studies have also tested RPE using industry peers (e.g., Antle and Smith, 1986; Jensen and Murphy, 1990; Janakiraman et al., 1992; Aggarwal and Samwick, 1999a, b). However, if common external shocks affect some firms in the industry negatively and others positively, then average industry performance fails to capture the external shock. For example, Thomas (1990) studies the impact of a Food

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and Drug Administration (FDA) regulation requiring increased pre-market testing. Thomas shows that the regulation raised the fixed costs of producing and marketing drugs. Small firms were negatively impacted by the decline in research productivity and exited the industry. Meanwhile, larger firms benefited because the reduced competition from smaller firms more than offset the negative impact of the regulation on their own research productivity. If firms within the industry are sufficiently heterogeneous, then an industry index is a noisy measure of peer performance. Perhaps not surprisingly RPE is difficult to detect using industry groups.

My main hypothesis is that firms of different size are exposed to different shocks and face different constraints in responding to those shocks. In characterizing such shocks and how these shocks affect firm performance, note that shocks to firm performance (i.e., equity value) are caused by either shocks to earnings or shocks to discount rates.

Shocks to earnings that are outside of management control, for example, oil price shocks or weather-related shocks, can be filtered out using industry performance. However, different firms face different costs in responding to the same shocks. For example, more diversified firms can take advantage of multi-segment flexibility to respond to industry shocks by shifting production across business segments (e.g., Kogut and Kulatilaka, 1994) and less financially constrained firms are more able to quickly respond to shocks (e.g., Gertler and Gilchrist, 1994). Moreover, industry shocks can affect earnings of firms in the industry differently. For instance, the change in regulation studied in Thomas (1990) points to firms of different sizes being affected differently.

Shocks to firm value can also arise from changes in discount rates. Within the context of the Fama and French (1992, 1993) models, predictable changes in discount rates (i.e., expected returns) arise from shocks to the aggregate risk premium, shocks that affect firms with similar size, and shocks that affect firms with similar market-to-book ratios. While shocks to the aggregate risk premium can be filtered out using industry or market performance, shocks that affect co-movement of firms with similar size or market-to-book cannot. CEOs should therefore be compensated only for actions that affect the loadings on these risk factors but not for changes on the premium associated with the risk factors.

The above discussion illustrates the difficulty in defining the ideal peer group. Such a group should include firms that are similar along several characteristics (e.g., industry, size, diversification, and financing constraints). Yet considering all such characteristics simultaneously is not practical because it could result in peer groups composed of too few firms, which would be too noisy to filter external shocks. In this paper, I show that industry and firm size capture many of these characteristics.

When peer groups consist of firms within the same industry and size quartile, my empirical results show systematic evidence supporting RPE usage in CEO pay. The analysis includes both the level and the growth of total compensation flow regressed on firm stock performance, peer stock performance, and control variables. To compare with previous studies, I test whether RPE is used when measuring peer performance with two common peer group definitions, namely, the S&P 500 index and firms within the same industry. I fail to find consistent evidence of RPE usage with either peer definition. I also find no evidence that accounting returns substitute for RPE in stock returns (Sloan, 1993), or evidence of RPE in accounting returns when using industry-size peers.

Last, I test for the presence of RPE when peer groups are formed based on industry plus other firm characteristics, such as diversification, financing constraints, and operating leverage. The evidence is inconsistent with RPE when using such peer groups. Evidence exists to support RPE usage in the level and growth of CEO pay when peers are defined as firms in the same industry and growth options quartile. However, when both industry-size and industry-growth options peer performance are included, the results show that only industry-size peer performance is filtered from CEO pay.

The evidence presented in this paper using industry-size-based peers for testing RPE in implicit CEO compensation contracts is corroborated by explicit evidence. Murphy (1999), Bannister and Newman (2003), and Bannister et al. (2004) show that companies using RPE seldom use broad-based market peer groups. The 2001 Annual Incentive Plan Design Survey by Towers Perrin says that 74% of firms that explicitly mention the practice of RPE in annual bonus plans report using a self-selected industry peer group. Bannister and Newman (2003), using the 1993 compensation committee reports for a sample of 160 large US firms, find that the peer groups employed in determining executive compensation generally consist of companies of the same industry or size.

In the next section, I provide an overview of the theory and empirical evidence on RPE and develop the arguments for why industry-size peers better capture external common shocks. Section 3 presents the empirical model to be estimated and the hypothesis to be tested. I describe the data in Section 4 and present the main results in Section 5. In Section 6, I contrast the ability of industry-size peers to filter external shocks against peers constructed using industry and other firm characteristics. Section 7 concludes.

2. Relative performance evaluation

2.1. Literature review

Current empirical evidence about the use of RPE in determining executive compensation is mixed. In Appendix A, I compare the different empirical models that have been used and briefly describe how the tests on RPE are related. Table 1 summarizes the empirical findings from previous tests of RPE and the respective peer groups. Here, I briefly discuss tests using ExecuComp and other data sets.

Table 1
Summary of empirical findings on implicit tests of RPE.

Study	Peer group	Weak-form RPE		Strong-form RPE	
Panel A. Studies of RPE using non-ExecuComp data					
Antle and Smith (1986)	Two-digit SIC	Y	Yes in RET, but only for 16 out of 39 firms	Y	Yes in ROA, but only for 16 out of 39 firms
Gibbons and Murphy (1990)	One-, two-, three-, and four-digit SIC and a market index	Y	Yes in RET		
		N	No in ROA		
Jensen and Murphy (1990)	Two-digit SIC and a market index	N			
Barro and Barro (1990)	Banks within the same geographical region	N		N	
Janakiraman et al. (1992)	Two-digit SIC	Y	Yes in RET	N	
		N	No in change in ROE		
Joh (1996)	Four-digit Japanese Development Bank Industry Code	N			
Hall and Liebman (1998)	A market index	Y			
Bertrand and Mullainathan (2001)	Two-digit SIC			N	
Panel B. Studies of RPE using ExecuComp data					
Aggarwal and Samwick (1999a)	Two-, three-, and four-digit SIC	N			
Aggarwal and Samwick (1999b)	Two-, three-, four-digit SIC and a market index		Mixed evidence in favor of RPE in RET	N	
Himmelberg and Hubbard (2000)	A market index			N	
Garvey and Milbourn (2003)	Market indexes	N			
Garvey and Milbourn (2006)	Two-digit SIC	N			
Rajgopal et al. (2006)	Two-digit SIC and a market index	Y	Yes only in S&P 500 firms	N	

Panels A and B summarize the peer group and the empirical findings of implicit tests of RPE. The studies that rely on non-ExecuComp data are presented in Panel A, and the studies that use the ExecuComp data are presented in Panel B. The symbols Y and N denote whether the study shows evidence supporting or not supporting the use of RPE, respectively. RET, ROA and ROE are stock returns, accounting returns and return on equity, respectively. For the definition of weak-form and strong-form RPE tests, see Appendix A.

Evidence from data sets other than ExecuComp. Regressing total compensation on both accounting and stock returns, Antle and Smith (1986) find support for RPE in only 16 out of 39 firms. Gibbons and Murphy (1990) find evidence supporting RPE using stock returns as the performance measure in the compensation contract. They find that changes in CEO pay are more likely to be evaluated relative to aggregate market movements than relative to the firm's industry.[1] Using the same sample as Gibbons and Murphy, but different compensation and performance measures, Jensen and Murphy (1990) do not find evidence supporting RPE.[2] Janakiraman et al. (1992) present evidence of RPE in stock returns but reject that RPE usage amounts to the theoretical value in Holmstrom and Milgrom (1987) (see also Section 5.4). Their results contrast with those in this paper as I do not find that changes in CEO pay are correlated with the performance of peer firms in the same industry but instead are correlated with the performance of those firms in the same industry and size group. Barro and Barro (1990) study the largest US commercial banks and find that CEOs are compensated based on average regional bank performance, contradicting RPE. Finally, Bertrand and Mullainathan (2001) argue that CEOs are rewarded for luck, i.e., changes in firm performance that are beyond the CEO's control (see also Garvey and Milbourn, 2006). Their findings suggest that pay for luck is more relevant for poorly governed firms.

Evidence from ExecuComp. Recent studies using the ExecuComp data generally find results inconsistent with RPE. Aggarwal and Samwick (1999a) present evidence in favor of RPE when compensation is defined in levels and the model is estimated using ordinary least squares with CEO-fixed effects, but no evidence when using changes in compensation. Garvey and Milbourn (2003) model and test whether RPE usage in stock returns varies with the level of CEO wealth diversification. Using a market-wide peer performance measure, they find evidence of RPE for younger and less wealthy managers, but no evidence for the average firm.

The mixed evidence with regard to RPE in stock returns for the average CEO has given rise to a new branch of RPE literature. In this new branch, researchers explore whether the use of RPE varies cross sectionally across industry, firm, or CEO characteristics. As the focus of my paper is on whether RPE is used on average in setting CEO pay, I only briefly describe this other branch of the RPE literature. Aggarwal and Samwick (1999b) show that RPE is used less in more concentrated industries. Using a sample of Japanese firms, Joh (1999) reports that firms collude in their product market decisions and are thus compensated positively for industry performance. Himmelberg and Hubbard (2000) argue that a manager's outside

[1] Dye (1992) relates the choice of industry versus market-wide performance measures in the use of RPE to managerial discretion in project choice.

[2] Jensen and Murphy use changes in compensation as the dependent variable and the change in shareholder wealth (stock return multiplied by beginning-of-year market value of equity), both gross and net of market performance, as performance measures. Gibbons and Murphy (1990, p. 45) mention that the different results obtained by Jensen and Murphy are mainly driven by their choice of performance measure, which "reduces the impact of heterogeneity by firm size."

job opportunities are a positive function of industry stock returns and that this is stronger for more talented CEOs. They find that RPE usage for smaller firms is less of a puzzle. Rajgopal et al. (2006) find that the lack of RPE is due to the fact that CEO pay varies with outside employment opportunities (as in Himmelberg and Hubbard, 2000).

Evidence from CEO turnover. Several empirical studies find that RPE is present in CEO turnover decisions, suggesting that boards rely on RPE particularly when firm performance is relatively poor.[3] I further explore whether such an asymmetry exists in CEO pay in Section 5.3. Jenter and Kanaan (2006) find evidence that CEO turnover is sensitive to poor market and industry performance contradicting RPE.

2.2. Identifying the peer group

One of the main challenges in implementing or testing RPE is to identify a firm's peer group. Gibbons and Murphy (1990) and Baker (2002) argue that the inability to identify an appropriate peer group can be a reason for firms not to use RPE in compensation contracts.[4] Alternatively, firms can use RPE, but researchers fail to correctly identify the firms' peers and hence fail to find evidence of RPE.[5]

Models of equity valuation are informative about the drivers of firm performance and can then be used as a tool to sift through performance due to CEO actions and performance due to exogenous shocks. For this purpose, I assume that, as in the dividend discount model, changes in equity value arise from shocks to earnings and from shocks to discount rates (i.e., expected equity returns).

Changes in earnings can result from either revenue or cost shocks. For example, energy price shocks are generally viewed as being outside of the CEO's control. As a common shock, energy price shocks should be filtered out, which can be done using an industry peer group. However, the extent to which energy price shocks are filtered out depends on the manager's policies, for example, the financial hedging policy, as compared with the policies of the average peer firm (the average peer performance is used to insulate CEO pay from external shocks). These policies can also be constrained by the manager's cost to respond to shocks. For example, a manager of a firm without a risk management department can find it more costly to systematically hedge energy price shocks, whereas CEOs with risk management departments in operation are likely to have a hedging policy in place. As another example, consider the CEO of a firm who is faced with a positive net present value project. A negative shock to market liquidity can force the CEO of a small firm to drop the project if he or she fails to get access to credit. In contrast, when faced with the same negative shock to market liquidity, a CEO of a larger firm can still find credit and adopt the project because he or she has access to a wider array of financing options (e.g., bank loans, private as well as public debt, domestic and international capital markets) (see Fazzari et al., 1988). The CEO of the small firm does not invest and, as a result, equity value fails to grow not because of his actions but because of the constraints he faces. In this case, a size, and not an industry, benchmark is appropriate.

Not all industry shocks affect all firms in the industry in the same way. Thomas (1990) describes the impact of an FDA regulation requiring increased pre-market testing on pharmaceutical firms of different sizes. This regulation raised the fixed costs of producing and marketing drugs for smaller firms more than for larger firms (e.g., larger firms had greater access to the physicians and pharmacologists on the staffs of research hospitals that ultimately conducted the clinical trials necessary for regulatory approval). Thomas finds that small firms were negatively impacted by the decline in research productivity and were driven out of the market, whereas larger firms benefited from the regulation because the sales gains due to the reduced competition from smaller firms more than offset the negative impact on their own research productivity. If the average performance of the industry is not affected by the regulatory shock, then using the industry peer benchmark implies that the poor performance of small firms is incorrectly attributable to CEO actions when it was caused by an external, regulatory shock.[6]

In addition, different firms can face different costs in responding to the same shocks. First, firms differ in their degree of diversification. Being more diversified confers an advantage in responding to shocks not only through the use of internal capital markets but also in smoothing industry shocks that affect the firm's businesses differently. As an example, Kogut and Kulatilaka (1994) show that multinational firms have managerial discretion to respond to an exchange rate shock by

[3] Examples of papers that find evidence of RPE in CEO turnover decisions are Coughlan and Schmidt (1985), Warner et al. (1988), Barro and Barro (1990), Jensen and Murphy (1990), Gibbons and Murphy (1990), Murphy and Zimmerman (1993), Blackwell et al. (1994), and DeFond and Park (1999).

[4] However, there is explicit evidence of RPE. Using Towers Perrin survey data for 177 large US firms in 1997, Murphy (1999) reports that 57% of financial services firms, 42% of utility firms, and 21% of industrial companies use RPE in bonus plans. Bannister et al. (2004) find that 30% of the S&P 500 firms in 1998 explicitly mention the use of RPE (see also Bannister and Newman, 2003). Moreover, Antle and Smith (1986) argue that RPE could occur largely in the implicit features of CEO pay.

[5] Parrino (1997) studies RPE in CEO turnover in the context of homogeneous industries and finds that more homogeneous industries can be expected to provide a more precise measure of shocks that need to be filtered out from firm performance.

[6] Examples of the disparity of treatment of small versus large firms abound with respect to regulatory shocks. Ball and Shivakumar (2004) report that the 1981 Companies Act in the UK allowed less rigorous reporting standards for small and medium-size firms (versus large firms) as a way of protecting these firms' financial affairs from public scrutiny. Similarly, Becker and Henderson (2000) show that the implementation of the Clean Air Act was nonuniform across firms of different sizes, leading to an increased presence of smaller and less regulated firms and causing larger plants to operate at less than efficient scales. Even though nonuniformity in the application of the regulation was not intended, nonuniformity was optimal as it conserved on regulatory resources by focusing on the biggest polluters. Finally, the PCAOB (Public Company Accounting Oversight Board) allowed smaller firms an extra year to comply with certain sections of the Sarbanes-Oxley Act of 2002. The Securities and Exchange Commission further postponed compliance with Section 404 on various occasions from 2003 through 2006 for smaller firms (see Gao et al., 2008).

shifting production between plants to the lowest cost producer. Second, firms differ in their degree of financing constraints. These constraints have been shown to affect the growth of firms as well as their ability to respond to shocks (e.g., Gertler and Gilchrist, 1994). Third, firms can differ in their operating leverage. By definition the degree of operating leverage affects a firm's profit sensitivity to industry demand shocks.

Consider now changes in equity value induced by changes in discount rates. Fama and French (1992, 1993) suggest that predictable changes in discount rates arise from shocks to the aggregate risk premium, shocks to firms with similar size, and shocks to firms with similar market-to-book. While shocks to the aggregate risk premium can be filtered out with industry peer performance, shocks that affect co-movement of firms with similar size or market-to-book cannot. CEOs should therefore be compensated only for actions that affect the loadings on these risk factors but not for changes on the premium associated with the risk factors.[7]

The previous discussion suggests that the ideal peer group should include firms that are similar along several characteristics: industry, size, diversification, financing constraints, operating leverage, and growth options. Arguably, creating such a group is not an easy task. Further, even if it were feasible, the outcome can be a peer group composed of too few firms, which can be too noisy to filter external shocks.

To reduce the dimensionality of the problem, I argue that the various firm characteristics indicated are not necessarily independent. Specifically, empirical evidence suggests that size can subsume information in many of these characteristics. For example, small firms tend to be less diversified, have greater financing constraints, and have less operating leverage. To make this point in a systematic way, I draw on existing empirical evidence and evidence from the sample of firms used in my analysis below and described in Section 4. Fig. 1 plots the mean and median levels of diversification, financing constraints, and operating leverage against size-ranked portfolios of firms. Size portfolios are constructed by ranking firms in each industry and year based on their market values of equity at the beginning of the year. Portfolio 1 (4) includes all firms in the bottom (top) quartile of market value of equity in each industry and year.[8]

First, consider diversification, defined as the number of business segments in which the firm operates. Fig. 1 shows that the larger firms in each industry (portfolio 4) typically have a greater number of business segments and should thus be more diversified. Similar evidence is found in Denis et al. (1997), though their study does not control for industry. Second, consider financing constraints constructed following the Kaplan and Zingales (1997) financing constraint index. Fig. 1 shows an inverse relation between industry-size and the level of (lagged) financing constraints. This evidence is corroborated in the existing literature. Perez-Quiros and Timmermann (2000) find that, during a recession, small firms are more adversely affected by worsening credit conditions such as an increase in interest rates. When bank liquidity falls, banks shy away from riskier borrowers, which are typically smaller firms. Gertler and Gilchrist (1994) empirically analyze the response of manufacturing firms to a tightening of monetary policy. They find that small firms contract more relative to larger firms, which can be due to financial factors. When sales decline, the presence of financial constraints limits the ability of small firms to smooth production and forces them to shed inventory. Third, consider operating leverage, defined as the percentage change in operating income for a percentage change in sales revenue (see Lev, 1974; Mandelker and Rhee, 1984).[9] Fig. 1 shows that the larger firms in each industry tend to have higher operating leverage.[10] Finally, for growth options, the asset pricing literature suggests that co-movement of stock returns induced by size does not subsume the co-movement induced by growth options. I study the construction of industry-growth options peers in detail in Section 6.

For other unrelated reasons, firms of different sizes can be exposed to different shocks. For example, smaller firms are more likely to rely on fewer customers or suppliers, thereby exposing them to more firm-specific distress risk in the event that a customer or supplier defaults. Also, larger firms contract with or are scrutinized by more parties (e.g., labor unions, the government as contractor or regulator, the media), which can constrain their actions more.

In conclusion, I do not claim that firm size is the only solution to the problem of identifying RPE peers. However, firm size has important properties. It has a direct role in identifying peer firms exposed to similar shocks, is monotonically related to other firm characteristics that are also important in identifying peer firms, is readily available in contrast to measures of financing constraints, and allows for a straightforward implementation of RPE by compensation committees. The purpose of this paper is to test the hypothesis that industry-size groups constitute better peers to benchmark CEO

[7] The corporate literature that studies managerial actions takes discount rates as a given, implicitly assuming that managerial actions do not affect discount rates.

[8] Constructing portfolios in this way results in a different portfolio composition than if firms were ranked by their size among all firms in each year. This portfolio construction controls for industry effects. The distinction can result in a weaker relation between the mean (or median) firm characteristic and size, but it is required if size is to succeed in grouping firms that are subject to similar shocks in a way that is not already captured in an industry grouping.

[9] The proxy for operating leverage is obtained in two steps. First, I run yearly firm-specific regressions of operating income after depreciation (DATA178) on sales (DATA12) using the last 10 years of observations. Second, I multiply the estimated firm-specific coefficients by the past 10-year mean of sales divided by the past 10-year mean of operating income to obtain the operating leverage measure. I used the lagged sensitivity of operating income to sales as a proxy for operating leverage.

[10] In addition, Brickley et al. (2001) argue that a firm's organizational structure can condition the readiness with which it responds to shocks. Fig. 1 does not include any evidence regarding organizational structures for lack of an empirical measure of organizational complexity. However, Rosen (1982) argues that larger firms can suffer from a loss of control associated with deeper hierarchical organizations, which in turn implies that larger firms can be slower or less flexible in responding to shocks.

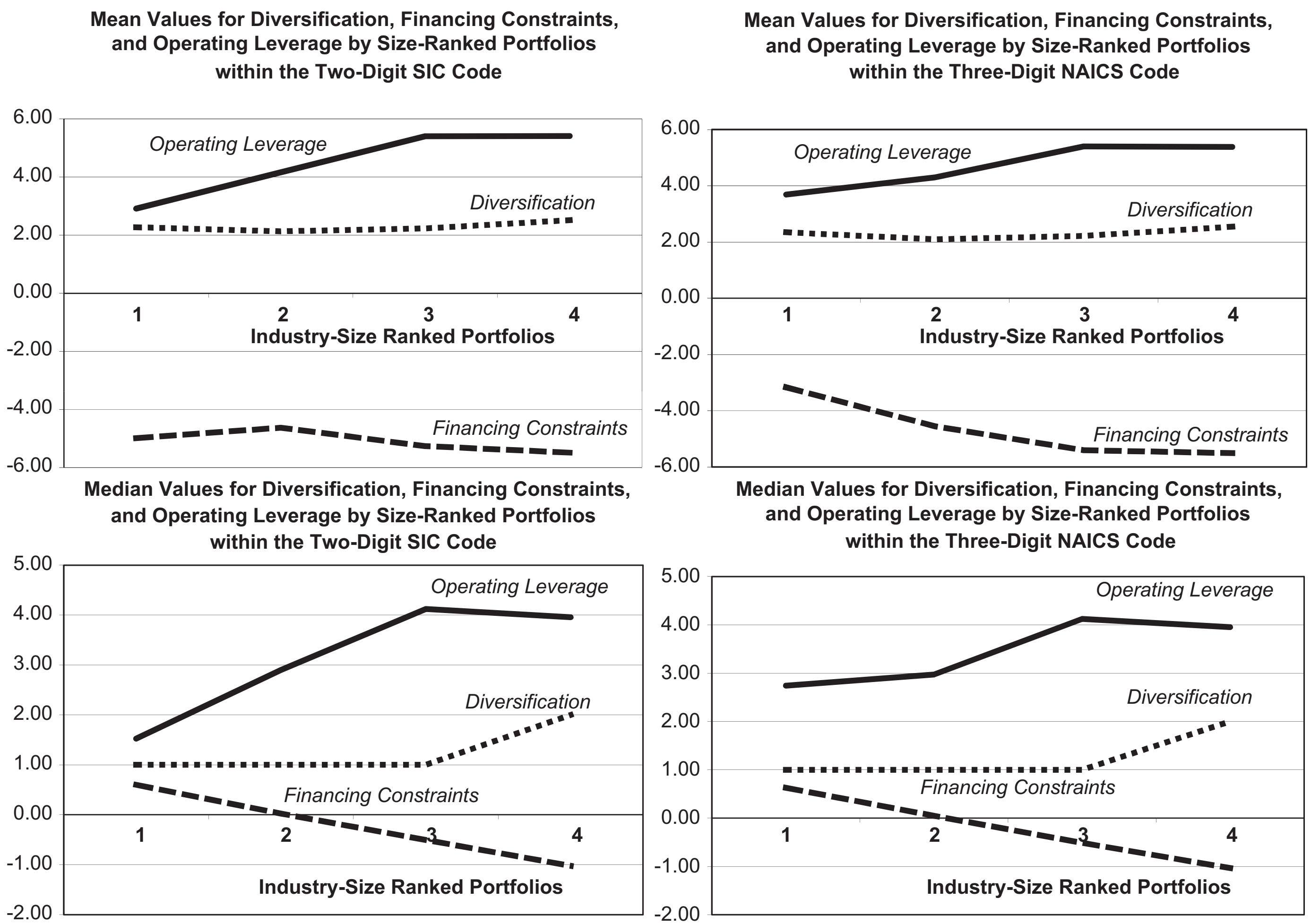

Fig. 1. Levels of diversification, financing constraints, and operating leverage by industry-size-ranked portfolios. These graphs depict the mean and median levels of diversification, financing constraints, and operating leverage against size-ranked portfolios of firms within the industry. Size portfolios are constructed by ranking firms in each industry and year based on their market values of equity at the beginning of the year. Portfolio 1 (4) includes all firms in the bottom (top) quartile of market value of equity in each industry and year. Diversification is defined as the number of business segments in which the firm operates. Financing constraints are constructed following the Kaplan and Zingales (1997) financing constraint index. Operating leverage is defined as the percentage change in operating income for a percentage change in sales revenue and is obtained in two steps. First, I run yearly firm-specific regressions of operating income after depreciation on sales using the last 10 years of observations. Second, I multiply the estimated firm-specific coefficients by the past 10-year mean of sales divided by the past 10-year mean of operating income to obtain the operating leverage measure. I use the lagged sensitivity of operating income to sales as a proxy for operating leverage.

performance than industry-only and S&P 500 peer groups. In addition, below I discuss tests of RPE when peers are formed on industry and other firm characteristics.

3. Empirical model

I estimate the following model:

$$\text{CEOPay}_{it} = c_0 + \alpha_1 \text{FirmPerf}_{it} + \alpha_2 \text{PeerPerf}_{it} + \alpha_3 \text{ControlVariables}_{it} + \varepsilon_{it}. \quad (1)$$

The subscript t indicates time in years and the subscript i indicates a CEO-firm pair. CEOPay_{it} is a measure of the compensation of the CEO. FirmPerf_{it} and PeerPerf_{it} are performance measures for firm i and its peer group, respectively. Control variables capture variation in CEO pay that is not related to firm or industry performance. These variables are discussed in Section 4.

The basic test of RPE is $H_0 : \alpha_2 \geqslant 0$ against the alternative $H_A : \alpha_2 < 0$. Rejecting the null hypothesis constitutes evidence that external shocks are filtered out from own-firm performance in compensation contracts. This test is also called a weak-form test of RPE.[11]

Firm performance can be measured as the percentage change in firm value (i.e., stock return) or as the change in shareholder wealth (i.e., gross stock return multiplied by beginning-of-year market value). The choice depends on what drives CEO incentives. Hall and Liebman (1998) and Baker and Hall (2004) argue that if CEO incentives increase with CEO dollar ownership, then compensation should be specified as a function of stock returns. If, instead, CEO incentives are driven by the CEO's fraction of stock ownership, then performance should be specified in dollar terms. Without favoring any of the specifications, Hall and Liebman (1998) conclude that CEO wealth constraints imply that even small fractional ownership can provide large incentives. I use both in my tests. When the model is specified with stock returns as the performance measure (levels regression), I regress the logarithm of the level of total compensation on stock returns and the other independent variables. When the model is specified with the change in the logarithm of shareholder wealth as the performance measure (changes regression), I difference both left- and right-hand-side variables and regress the change in the logarithm of total compensation on the firm's stock return and on the other independent variables also expressed as changes (see Murphy, 1999, for the algebra of this transformation). When the independent variables have little or no time-series variation, I include them in levels.

4. Data

Standard & Poor's ExecuComp database provides annual CEO compensation as reported by firms in their proxy statements. Financial data are from Compustat. Stock return data are obtained from the Center for Research in Security Price (CRSP) monthly stock files, and inflation data are obtained from CRSP-Indexes-US Treasury and Inflation.

The initial dataset from ExecuComp has approximately 23,000 firm-CEO-year observations for 1992–2005. I delete observations for which there is more than one CEO per firm and year or when the CEO was in the firm for less than a full year. I also drop observations with missing or nonpositive values for total compensation, sales, market value, and common equity. In addition, I exclude observations with no industry classification, stock returns, governance measures, or idiosyncratic variance. Table 2 shows that the final sample contains approximately 16,000 CEO-year observations for 2,374 firms.

CEO compensation is defined as the total annual flow compensation, which is the sum of salary, bonus, other annual compensation, long-term incentive payouts, restricted stock grants, Black and Scholes value of stock option grants, and all other compensation. I do not include in the measure of CEO compensation changes in the value of existing firm options and stock holdings owned by the CEO. The revaluation of these previously granted securities is mechanically related to the firm's own performance and is consequently independent of relative performance (see, e.g., Gibbons and Murphy, 1990; Hall and Liebman, 1998; Aggarwal and Samwick, 1999a).[12] I measure total annual compensation flow in real terms (base January 1992 for the consumer price index, CPI) and deflate compensation by the value of the CPI index of the fiscal month. Panel A of Table 3 presents summary statistics for the measures of compensation. The average (median) CEO receives a real total annual compensation flow of $3.36 million ($1.61 million). I use the logarithm of real total annual compensation flow in the empirical analysis. This mitigates heteroskedasticity resulting from extreme skewness and facilitates comparison of results with previous studies (Murphy, 1999).

[11] An alternative test of RPE uses the ratio α_2/α_1 as opposed to α_2 alone. This alternative test takes into consideration the correlation between firm and peer group performance, which can lead to the insignificance of α_2 and to an improper rejection of the alternative hypothesis. However, one potential problem of the alternative testing procedure is that α_1 could be zero, leading to a misspecified test. Untabulated results show that tests using the ratio α_2/α_1 yield qualitatively similar results to those using α_2.

[12] Excluding the revaluation of firm stock options and stock holdings owned by the CEO is likely to bias the estimated own-firm performance sensitivity (α_1) downward.

Table 2
Sample selection process.

	CEO-years
Initial sample with CEO compensation data from ExecuComp	23,113
Cases with more than one CEO per firm-year or CEO tenure less than a year	3,193
Observations missing compensation data	564
Observations with missing or nonpositive value for sales, market value, and common equity	878
Observations missing industry classification and firm stock returns	926
Observations without portfolio returns, governance measures, or idiosyncratic variance	1,465
Final sample	16,087

The sample covers the time period 1992–2005.

Table 3
Sample summary statistics.

	No. of obs.	Mean	Std. dev.	Percentiles		
				25th	50th	75th
Panel A. Compensation data						
Total flow compensation	16,087	3,359	8,778	827	1,614	3,438
Ln of total flow compensation	16,087	7.25	1.10	6.53	7.20	7.93
Change in flow compensation	13,040	6%	0.77	−22%	5%	36%
Panel B. Performance measures						
Firm stock returns	16,087	0.073	0.436	−0.130	0.094	0.298
Firm ROA	16,073	0.022	0.117	−0.008	0.023	0.066
Change in firm ROA	16,037	0.000	0.113	−0.018	0.001	0.019
Peer return (industry-size)	16,087	0.082	0.256	−0.047	0.092	0.226
Peer return (industry)	16,087	0.117	0.255	−0.020	0.113	0.256
Change in peer ROA (industry-size)	15,259	0.002	0.135	−0.017	0.002	0.022
Change in peer ROA (industry)	15,259	0.000	0.067	−0.016	0.001	0.018
Panel C. Firm and CEO characteristics						
Firm size (real sales) (1992 $MM)	16,087	3,278	9,360	298	820	2,525
Firm size (Ln of real sales)	16,087	6.8	1.6	5.7	6.7	7.8
Firm size (real mkt. value) (1992 $MM)	16,087	4,704	16,022	359	940	2,999
Firm size (Ln of real mkt. value)	16,087	7.0	1.6	5.9	6.8	8.0
Growth options	16,087	2.04	1.81	1.15	1.50	2.21
Regulation dummy	16,087	0.06	0.24	0.00	0.00	0.00
CEO tenure	16,087	8.5	7.5	3.3	6.1	11.0
Ln of CEO tenure	16,087	1.80	0.84	1.18	1.81	2.40
Idiosyncratic variance	16,087	0.01	0.03	0.00	0.01	0.02
CEO chair dummy	16,087	0.72	0.45	0.00	1.00	1.00
Number of meetings dummy	16,087	7	3	5	7	9
CEO equity ownership (%)	16,087	2.8	6.6	0.1	0.4	1.9
Interlock dummy	16,087	0.08	0.27	0.00	0.00	0.00
ρ (industry-size)	16,087	0.78	0.01			
ρ (industry)	16,087	0.74	0.01			
ρ (S&P 500)	16,087	0.64	0.02			

Summary statistics for 16,087 CEO-firm observations for 2,374 (3,589) firms (CEOs) for the fiscal years 1992–2005. The primary dataset is the ExecuComp database released by Standard and Poor's (S&P). This dataset contains data for the S&P 500, the S&P mid-cap 400, and the S&P small-cap 600 firms. Financial data are obtained from Compustat, stock return data are obtained from the CRSP monthly stock files, and inflation data are obtained from CRSP-Indexes-U.S. Treasury and Inflation. All dollar values are in thousands (compensation) or millions (firm characteristics) of constant 1992 dollars. The variable ρ in Panel C is the slope coefficient from a pooled regression of firm stock performance on peer stock performance. Remaining variables are defined in Appendix B.

I measure annual firm performance using both stock returns and return on assets (ROA). The mean real stock return is 7.3% and the mean real ROA is 2.2% (see Panel B of Table 3). Following Lambert and Larcker (1987), Barro and Barro (1990), and Sloan (1993), I use changes in ROA to better approximate the news in the series because ROA exhibits high persistence.

I construct portfolios to calculate peer returns matched on industry at the two-digit standard industry classification (SIC) level and firm size.[13] First, I form annual portfolios based on industry codes using all the firms in the merged

[13] The results are robust to different industry classifications. Tests using the three- and four-digit North American Industry Classification System (NAICS), the three-digit SIC codes, and the Fama and French (1997) industry classification produce qualitatively the same results.

Table 4
Correlation matrix.

	Firm stock return	Change in firm ROA	Peer $return_{ind-size}$	Peer $return_{ind}$	Change in peer $ROA_{ind-size}$			
Panel A. Performance measures								
Change in firm ROA	0.23*							
Peer $return_{ind-size}$	0.45*	0.10*						
Peer $return_{ind}$	0.43*	0.10*	0.89*					
Change in peer $ROA_{ind-size}$	0.05*	0.05*	0.15*	0.20*				
Change in peer ROA_{ind}	0.07*	0.07*	0.19*	0.24*	0.73*			
	Firm size	GO	CEO tenure	Regulation dummy	CEO chair dummy	Number of meetings dummy	CEO ownership dummy	Interlock position dummy
Panel B. Firm and CEO characteristics								
Growth options	−0.17*							
CEO tenure	−0.06*	0.02*						
Regulation dummy	0.10*	−0.09*	−0.07*					
CEO chair dummy	0.20*	−0.04*	0.19*	0.07*				
Number of meetings dummy	−0.17*	0.04*	0.13*	−0.15*	−0.06*			
CEO ownership dummy	0.32*	−0.05*	−0.37*	0.19*	−0.03*	−0.19*		
Interlock position dummy	−0.08*	0.01	0.13*	−0.01	0.06*	0.06*	−0.10*	
Idiosyncratic variance	−0.24*	0.14*	0.00	−0.10*	−0.05*	0.00	−0.09*	0.04*

This table presents Pearson product-moment correlations between performance measures in Panel A and firm and CEO characteristics in Panel B. The sample consists of 16,087 observations covering the period 1992–2005. Variables are defined in Appendix B. * indicates significance at the 5% level.

CRSP-Compustat database.[14] Doing so ensures that relevant peers are included even if they are not in ExecuComp. Second, within an industry, firms are sorted by beginning-of-year market value into size quartiles.[15] Third, I match each firm with an industry-size peer group that excludes the own firm and compute an equal-weighted portfolio return using the firm-specific peer group. Using value-weighted portfolio returns yields qualitatively similar results. I require a minimum of two firms per industry-size group to calculate its return. When the number of firms per industry-size group is less than two, to minimize loss of observations, the portfolio's return is based only on industry and no size portfolio is created. Requiring a minimum of three or five firms per industry-size group, as opposed to two, does not change the results qualitatively. I repeat this procedure for both ROA- and stock returns-based performance. The only difference in the portfolio formation when computing accounting versus stock returns of the peer group is that, in the former, I further require that firms be matched by fiscal year-end month. This is done to ensure that the timing of the performance measures is matched. This problem does not arise for stock returns as the monthly availability of stock return data allows the construction of annual peer group stock returns that exactly match the fiscal year-end month of each firm.

Following the literature, I control for firm size (Smith and Watts, 1992; Rosen, 1982), growth opportunities (Smith and Watts, 1992; Core and Guay, 1999), CEO tenure (Himmelberg and Hubbard, 2000; Bertrand and Mullainathan, 2001), firm-specific stock return variance as a proxy for operating or informational environment risk (Core et al., 1999; Aggarwal and Samwick, 1999a), and several measures of corporate governance (Core et al., 1999). Albuquerque (2006) contains a more detailed justification for using these controls. Appendix B provides a detailed explanation of how the variables are constructed.

In addition to these controls, I include year dummies to capture year-specific differences in the level of compensation, for example, due to business cycles or trends in pay (Murphy, 1999), and industry dummies to account for unobservable variation in the industry level of pay, for example, due to variation in the demand for managerial talent across industries

[14] To mitigate the impact of outliers I exclude firms with assets less than $10 million.

[15] Lys and Sabino (1992) demonstrate that grouping firms by placing 27% of the sample on each of the extreme portfolios produces the most powerful tests. This motivated the selection of quartiles (25% of observations within an industry) to form the industry-size groupings.

(Murphy, 1999). I further control for CEO-fixed effects in the level of CEO pay to capture differences in CEO pay that result from unobservable CEO characteristics such as risk aversion.[16]

Panel C of Table 3 reports the slope coefficient, ρ, from a pooled regression of firm performance on peer performance. According to Holmstrom and Milgrom (1987), peer performance measures with higher ρ constitute better filters for external shocks. When peers are defined as the firms in the same industry-size group, ρ equals 0.78. When peers are defined as the firms in the same industry group, ρ equals 0.74 (the difference in ρ's is statistically significant at the 1% level).

Table 4 shows the correlation matrix of the independent variables. As expected, firm stock returns and changes in ROA display a positive correlation of 0.23. The correlation of firm stock returns with its industry peer is 0.43, lower than the correlation of firm stock returns with its industry-size peer of 0.45. A test of significance of the difference in correlation coefficients (see Cohen and Cohen, 1983) yields a p-value of 0.02. As with ρ above, this is indicative of the ability of size-based peer groups to better filter noise in firm performance measures.

5. Results

In this section, I present the main results of the paper. First, I show that measuring peer performance based on industry-size groups improves the ability to detect firm usage of RPE in contrast to industry or S&P 500 peer groups. Second, the inclusion of accounting performance measures in total compensation does not remove the significance of RPE.

5.1. Peer groups and RPE in stock returns

In this subsection, I test for the presence of RPE in CEO compensation using alternative peer groups (S&P 500 index, industry, and industry-size peers) in stock returns as performance measures. The results are presented in Table 5. Panel A shows the estimation of the levels regression using CEO-fixed effects, and Panel B shows the estimation of the changes regression without CEO-fixed effects.

In Panel A, the coefficient on firm stock performance is positive and statistically significant for each specification with coefficients ranging from 0.21 to 0.24, consistent with CEOs being rewarded for positive firm stock performance. When the peer group consists of the firms in the S&P 500 index, RPE is not rejected as the coefficient on the peer portfolio is negative and significantly different from zero (coefficient of −0.25, and p-value of 0.06). When the peer group is defined as those firms in the same industry, RPE is again not rejected (coefficient of −0.06, and p-value of 0.07). However, when the peer group is defined as those firms in the same industry and size group, the results suggest that external shocks are better filtered through these industry-size groups than with industry groups only. The coefficient on the industry-size peer group is more negative (coefficient of −0.13, and p-value of 0.00). To further test the marginal contribution of each peer group in filtering external shocks from the level of CEO pay, I simultaneously include the S&P 500 index, the industry, and the industry-size peer groups in the level of CEO pay regression. The results in column (4) suggest that common uncertainties are filtered out of executive compensation only through the industry-size peer group (coefficient of −0.29, and p-value of 0.00). The coefficient on the S&P 500 peer group is insignificant (coefficient of −0.20, and p-value of 0.14), and the coefficient on the industry peer group exhibits the opposite sign to that predicted by RPE (coefficient of 0.20, and p-value of 0.00). These results indicate that the level of CEO pay increases with industry stock performance, but that common shocks within the same industry-size portfolio are filtered out from the level of CEO compensation.

Panel B of Table 5 shows the results for the changes regressions. CEO pay growth is tightly linked to firm stock performance (coefficients ranging from 0.37 to 0.39 with p-values of 0.00). Column (1) shows that the coefficient associated with the S&P 500 index return is not statistically significant, suggesting that aggregate market movements are not filtered out from CEO pay growth. Likewise, when the peer group consists of firms in the same industry [column (2)], the performance of these peer firms does not seem to be filtered out from CEO pay growth. In column (3), the peer group is represented by those firms in the same industry and size quartile as that of the firm. The coefficient on this peer group stock return is −0.10 and statistically significant (p-value of 0.02), providing evidence that the stock return performance of peers is filtered out from the growth in CEO pay as predicted by RPE. Column (4) presents the results when all the above-mentioned peer groups are simultaneously included in the regression model. The results show that CEO pay growth increases with industry stock performance (coefficient of 0.24, and p-value of 0.00) and that it decreases with the stock performance of other companies in the same industry and size quartile (coefficient of −0.28, and p-value of 0.00). Overall, the results in the changes regressions suggest that evidence of RPE is observed only using industry-size peers, highlighting the importance of the size breakdown and reinforcing the results obtained in the levels regressions.[17]

The coefficient on industry peer performance switches from negative and statistically significant when included as the sole peer performance measure to positive and statistically significant when the performance of the industry-size peers is

[16] The Black and Scholes value of stock option grants can overestimate the option value for undiversified, risk-averse executives (Hall and Murphy, 2000, 2002; Core and Guay, 2003). Given that both risk aversion and the level of diversification are likely to be CEO-specific, different CEOs might evaluate the same options differently. The CEO-fixed effect can thus capture differences in the valuation of these options by CEOs.

[17] I estimate the same regression model using median regressions to mitigate the impact of outliers. The untabulated results are qualitatively similar.

Table 5
Regressions estimating the sensitivity of CEO compensation to RPE using stock returns performance measures.

Independent variables	Predicted sign	Panel A				Panel B			
		Total compensation (levels regressions)				Change in total compensation (changes regressions)			
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Intercept		**5.20**	**5.34**	**5.36**	**5.35**	**0.23**	**0.21**	**0.21**	**0.11**
		(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.01***)	(***0.00***)	(***0.00***)	(***0.00***)
Firm stock return	+	**0.21**	**0.22**	**0.24**	**0.23**	**0.37**	**0.37**	**0.39**	**0.38**
		(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)
S&P 500 Index	−	**−0.25**			−0.20	−0.13			−0.12
		(***0.06***)			(*0.14*)	(*0.61*)			(0.62)
Peer return (industry)	−		**−0.06**		**0.21**		−0.01		**0.24**
			(***0.07***)		(***0.00***)		(*0.80*)		(***0.00***)
Peer return (Industry/size)	−			**−0.13**	**−0.29**			**−0.10**	**−0.28**
				(***0.00***)	(***0.00***)			(***0.02***)	(***0.00***)
Firm size (sales)	+	**0.23**	**0.23**	**0.23**	**0.23**	0.02	0.02	0.01	0.01
		(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(*0.62*)	(*0.62*)	(*0.65*)	(*0.65*)
Growth options	+	**0.06**	**0.06**	**0.06**	**0.05**	**0.02**	**0.02**	**0.02**	**0.02**
		(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.08***)	(***0.07***)	(***0.08***)	(***0.08***)
CEO Tenure	+	**0.17**	**0.18**	**0.18**	**0.18**	**−0.03**	**−0.03**	**−0.03**	**−0.03**
		(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)
Regulation dummy	−	**−1.42**	**1.92**	**1.94**	**1.99**	**0.04**	0.05	0.05	0.05
		(***0.01***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.07***)	(*0.14*)	(*0.14*)	(*0.14*)
Idiosyncratic	+	**0.33**	**0.39**	**0.33**	**0.37**	0.12	0.19	0.18	0.18
Variance		(***0.04***)	(***0.04***)	(***0.06***)	(***0.05***)	(*0.19*)	(*0.24*)	(*0.28*)	(*0.28*)
Governance measures									
CEO chair dummy	+	0.11	0.00	0.01	0.00	0.01	0.01	0.01	0.01
		(*0.42*)	(*0.99*)	(*0.95*)	(*0.99*)	(*0.19*)	(*0.33*)	(*0.36*)	(*0.36*)
Number of meetings dummy	+	0.01	0.00	0.00	0.00	**−0.02**	**−0.02**	**−0.03**	**−0.03**
		(*0.76*)	(*0.82*)	(*0.88*)	(*0.88*)	(***0.08***)	(***0.04***)	(***0.03***)	(***0.03***)
CEO ownership dummy	+	0.01	0.01	0.01	0.01	−0.02	−0.02	−0.02	−0.02
		(*0.69*)	(*0.79*)	(*0.80*)	(*0.84*)	(*0.11*)	(*0.13*)	(*0.11*)	(*0.11*)
Interlock dummy	+	0.07	0.07	0.08	0.08	0.01	0.02	0.02	0.02
		(*0.19*)	(*0.19*)	(*0.18*)	(*0.18*)	(*0.57*)	(*0.43*)	(*0.42*)	(*0.42*)
Year dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CEO-fixed effects		Yes	Yes	Yes	Yes	No	No	No	No
Adjusted R^2		78.07%	78.06%	78.09%	78.12%	4.45%	4.59%	4.65%	4.73%
Number of observations		16,079	16,087	16,087	16,087	12,998	13,012	13,012	13,012

This table estimates the equation $\text{CEOPay}_{it} = \alpha_0 + \alpha_1 \text{FirmPerf}_{it} + \alpha_2 \text{PeerPerf}_{it} + \alpha_3 \text{ControlVariables}_{it} + u_{it}$. Panel A presents the results from regressing the natural logarithm of real total CEO compensation on the firm performance (measured by the natural logarithm of real annual stock returns including dividends), peer group performance (defined as the natural logarithm of real annual stock returns, excluding own-firm performance), and control variables. Panel B presents the results for the percentage change of real total CEO compensation. The control variables are firm size, growth options, CEO tenure, regulation dummy, idiosyncratic variance, governance measures, and year and industry (defined at two-digit SIC) dummies. The control variables firm size and growth options are defined in changes in the changes regressions. Variables are defined in Appendix B. The table reports estimates from CEO-fixed effects (Panel A) and pooled ordinary least squares (Panel B) regressions. All dollar values are in thousands (compensation) or millions (firm characteristics) of constant 1992 dollars. *p*-Values are reported in parentheses beneath each coefficient estimate. Bold coefficients are significant at least at the 10% significance level. The standard errors are heteroskedasticity-consistent using the Huber–White correction and are clustered by firm. The sample is drawn from the ExecuComp database for the years 1992–2005 merged with Compustat and CRSP data.

also included. A possible explanation for the sign switch of the industry peer performance coefficient is that industry peer performance, when used as the sole measure of peer performance, is capturing two effects. One of the effects is that of RPE: if industry peer performance is used as a filter for external shocks, then its coefficient in the regression should be negative. The other effect is that industry peer performance captures shocks to demand for managerial talent that drive up CEO pay (see Himmelberg and Hubbard, 2000; Oyer, 2004): its coefficient should therefore be positive. If industry-size peer performance is a better proxy to filter external shocks, the inclusion of both industry only peer performance and industry-size peer performance would cause the industry peer performance variable to capture the effect that the demand for managerial talent has on CEO pay.

Regarding the impact of the control variables on the level of CEO pay, and consistent with the previous literature, I show in Panel A that CEOs of larger firms, with longer tenure, more growth options, and more idiosyncratic variance are paid more. Year Dummies (untabulated) are statistically significant at common levels and are consistent with the fact that the level of real pay has increased over the sample period (see also Murphy, 1999). The governance variables are statistically insignificant as a consequence of the high correlation between CEO-fixed effects and firm characteristics that are quasi-fixed over the tenure of the CEO.[18] The regulation dummy switches signs across regression specifications, but in median regressions the sign is always negative so that CEOs of firms in nonregulated industries receive higher total compensation. The impact of the control variables in the growth of CEO pay is shown in Panel B. The results indicate that CEO pay growth is higher for firms that increase growth options, for less experienced CEOs, and for firms with boards that meet more frequently.

Next, I evaluate the economic significance of RPE by calculating the change in total compensation that occurs when peer performance, measured as industry-size peer performance, changes by one standard deviation, while keeping all else equal. In this scenario, the peers are doing well (or poorly) overall and firm performance exhibits no change. I use the results from column (4) in Panel A, due to the slightly higher explanatory power of this model. One standard deviation of peer performance is 25.6% per year (see Table 3) and represents a typical shock to peer performance.[19] An increase (decrease) in peer performance of 0.256 leads to a 7.4% (equal to -0.29×0.256) decrease (increase) in total CEO compensation, all else equal. This is equivalent to a mean decrease in real CEO pay of \$249,372 (equal to 7.4% $\times$ \$3.36 million).[20]

The results in Table 5 are based on regressions with pooled time-series and cross-sectional data that assume constant regression coefficients across time and firms. While this is the common approach in the literature, one could argue that industry-size peer portfolios appear successful because they proxy for differential RPE coefficients across firms or over time.[21] To address the concern that RPE coefficients can vary across firms, I reestimate model (1) using firm-specific regressions for firms with more than 10 observations. As a result of this data requirement, the sample of firms used in this analysis is reduced to approximately 780 firms (representing 33% of the number of firms in the full sample).[22] To conserve degrees of freedom, I drop the control variables and include only a constant and the firm performance and peer performance variables in the regression. Many controls are constant over time, or almost constant, for each firm and dropping them does not affect the estimation.

The small sample in each regression (minimum of 10 observations per regression per firm and a maximum of 14 observations per regression per firm) lowers the power to reject the null hypothesis when it is false. The problem is that the null of no RPE may not be rejected often enough. After all, this is why pooled regressions are used. Therefore, if, in spite of the small sample issue, I still find evidence that industry-size peers act as filters for exogenous shocks (rejecting the null hypothesis of no RPE), then this finding constitutes strong evidence in favor of RPE.

Table 6 presents the mean and median of the estimated coefficients on firm and peer performance across the firm-specific regressions as well as the mean R^2 across the regressions. Table 6 also presents the results on the hypothesis test that the mean coefficient is zero. The results for the levels regressions are reported in Panel A, and the results for the changes regressions are reported in Panel B. Panel A shows that the mean estimated coefficient on the industry-size peer is -0.18 and statistically significant (t-statistic of -3.02). The mean estimated coefficient on the industry peer group is not statistically significant. These results show a bigger discrepancy between industry-only and industry-size peers in the firm-specific regressions than in the pooled regressions, confirming the result that industry-size peers are better filters for external shocks.

The results for the changes regressions show that both the industry peer performance and industry-size peer performance are filtered out from the growth of CEO pay. The mean coefficient is slightly higher when using industry-size peers than when using industry peers only. The results when the peer group is the S&P 500 firms mimic those in Table 5.

Panels C and D of Table 6 allow for all peer groups to potentially act as filters of exogenous shocks from the level and growth of CEO pay, respectively. The regressions in these panels allow different firms to have different sensitivities to different peer performance. For example, the board of directors of a well-diversified firm may find it more appropriate to benchmark the firm's stock performance against the S&P 500 index than against an industry-size grouping, as it can be hard to define the industry to which this firm belongs. The results are similar to those in Table 5 using pooled regressions. The mean coefficient on industry peer performance becomes positive (in both the levels and changes regressions) but is significant only in the levels regressions. The change in sign on industry performance mirrors the result in the pooled regressions. The mean coefficient on industry-size peer performance remains negative and significant in both the levels

[18] The regressions without CEO-fixed effects show that, consistent with evidence in Core et al. (1999), CEOs who are board chairs and have low equity ownership are more highly compensated. I also find that boards that meet relatively less frequently and CEOs with an interlock relationship are compensated less, which is inconsistent with an entrenchment story.

[19] Assuming that peer performance follows a normal distribution, then a one standard deviation shock (up and down) around the mean corresponds to about 68% of all observations.

[20] This lower compensation does not lead to a violation of the CEO's participation constraint in Holmstrom and Milgrom (1987) because the firm is required to meet only an ex ante participation constraint, which implies that, ex post, the wage paid to the CEO can be lower than his outside opportunity.

[21] I thank the Editor for making this point.

[22] These firms are on average larger than in the full sample (the mean real market value and sales of firms in the reduced sample is \$6.65 billion and \$4.38 billion, respectively, versus \$4.71 billion and \$3.28 billion, respectively, in the full sample). I reestimate the regressions presented in Table 5 for a subsample of firms whose firm size is below the median firm size within each industry. The untabulated results (available upon request) are similar to those for the full sample.

Table 6
Firm-specific regressions estimating the sensitivity of CEO compensation to RPE using stock returns performance measures.

Coefficient estimates	Median	Mean	Std. dev.	*N*	*t*-Stat.
Panel A. Summary of estimated coefficients of total compensation on a single portfolio of returns					
Industry-size peers					
Firm stock return	0.13	0.12	1.37	781	2.43
Peer stock return	−0.18	−0.18	1.67	781	(3.02)
R^2	13.9%	19.3%			
Industry peers					
Firm stock return	0.11	0.08	1.16	781	2.04
Peer stock return	−0.06	−0.03	1.33	781	(0.63)
R^2	13.5%	18.3%			
S&P 500 *Peers*					
Firm stock return	0.15	0.15	1.09	787	3.85
Peer stock return	−0.37	−0.39	1.72	787	(6.33)
R^2	17.0%	21.5%			
Panel B. Summary of estimated coefficients of the change in total compensation on a single portfolio of returns					
Industry-size peers					
Firm stock return	0.41	0.45	1.35	781	9.25
Peer stock return	−0.23	−0.26	1.80	781	(4.09)
R^2	25.0%	30.1%			
Industry peers					
Firm stock return	0.38	0.45	1.24	781	10.24
Peer stock return	−0.22	−0.22	1.62	781	(3.76)
R^2	24.8%	29.7%			
S&P 500 *peers*					
Firm stock return	0.31	0.34	1.21	787	7.93
Peer stock return	−0.07	0.03	1.93	787	0.37
R^2	22.4%	27.0%			
Panel C. Estimated coefficients of total compensation on multiple stock return portfolios					
Firm stock return	0.15	0.19	1.59	781	3.30
S&P 500 return	−0.33	−0.31	3.04	781	(2.82)
Peer return (industry)	0.37	0.37	4.01	781	2.55
Peer return (industry-size)	−0.40	−0.46	3.11	781	(4.16)
R^2	39.4%	39.7%			
Panel D. Estimated coefficients of the change in total compensation on multiple stock return portfolios					
Firm stock return	0.40	0.53	2.43	781	6.14
S&P 500 return	0.01	0.07	3.00	781	0.67
Peer return (industry)	0.02	0.07	4.10	781	0.50
Peer return (industry-size)	−0.26	−0.51	4.73	781	(3.04)
R^2	49.7%	50.1%			

This table presents the estimated coefficients obtained from estimating $\text{CEOPay}_{it} = \alpha_0 + \alpha_1 \text{FirmPerf}_{it} + \alpha_2 \text{PeerPerf}_{it} + u_{it}$ by firm. Panel A presents summary statistics for the estimated regression coefficients of the natural logarithm of real total CEO compensation on firm stock performance and peer group stock performance. Panel B presents summary statistics for the estimated regression coefficients of the percentage change of real total CEO compensation on firm stock performance and peer group stock performance. Panels C and D present the results from regressing the natural logarithm and percentage change of total flow compensation, respectively, on firm stock performance and on the performance of the S&P 500, industry, and industry-size peer groups simultaneously. Variables are defined in Appendix B. The sample is drawn from the ExecuComp database for the years 1992–2005 merged with Compustat and CRSP data.

and changes regressions. The results using S&P 500 peer firms show that shocks affecting S&P 500 firms are filtered out from the level of CEO pay, but not from the growth in CEO pay as before.

Although not reported, I also estimate the firm-specific regressions including firm size and growth options as controls in the levels regressions and changes in growth options in the changes regressions. The results that replicate Panels A and B, in which only one peer portfolio is used at a time, are very similar. The results that replicate Panels C and D, in which all peer portfolios are used simultaneously, differ significantly. When the additional controls are included in the regressions only the firm-specific return and the industry-size peer return are significant. In the levels (changes) regression, the mean coefficient on firm stock return is 0.38 (0.57) with a t-statistic of 6.20 (6.32) and the coefficient on peer performance is −0.42 (−0.62) with a t-statistic of 3.84 (2.96).

To address the concern that the coefficients on peer performance may not be constant over time, I reestimate the pooled regressions used in Table 5 adding two interaction variables to capture whether the coefficients on firm and peer performance are different in the second half of the sample (1999–2005) versus those in the first half of the sample (1992–1998). The untabulated results show that the results presented in Table 5 remain qualitatively the same. The coefficient on the interaction between firm performance and a dummy variable for the second half of the sample is insignificant, as is the coefficient on the interaction between peer performance and the same dummy variable. I also run Fama–MacBeth cross-sectional regressions. If the true coefficients are not on average negative over time, then I would expect to reject RPE using this method. The results (untabulated) also support the industry-size peer group definition.

5.2. Accounting returns and RPE

Sloan (1993) argues that accounting measures can be viewed as substitutes to RPE, and vice versa, because the information value of accounting earnings helps filter out the noise in firm stock returns. Hence, ROA can be a useful measure of firm performance, but it can also be a substitute for RPE. As Bushman and Smith (2001) point out, if the signal value of ROA is dominated by the noise filtering effect of ROA, then ROA would receive a negative weight. In this subsection, I include both stock returns and ROA as signals of firm performance and test for RPE in both stock returns and accounting returns. First, I test the informativeness of changes in ROA versus stock returns.[23] Second, I test whether RPE using stock returns survives the inclusion of the ROA signal. Third, I test for RPE in ROA.

Panel A of Table 7 presents the results using the levels regression, and Panel B presents the results using the changes regression. First, ROA is not additionally informative of CEO actions both in the levels and changes regressions. Moreover, the magnitude and significance of the coefficients associated with own-firm stock returns do not change significantly after including ROA. This evidence is consistent with Core et al. (2003), who find that, for most CEOs, stock returns are the dominant component of their incentive packages (see also Baber et al., 1996; Leone et al., 2006). Second, controlling for ROA does not decrease the significance of RPE in stock returns when peer groups are defined by industry-size in both the levels and changes regressions. The results for industry peers remain similar to those in Table 5, showing no statistical significance in the changes regression.

Third, I find no evidence of RPE in ROA for any peer group definition. In fact, the coefficient on the industry or industry-size peer ROA is positive and statistically significant for both the levels and changes regressions. Moreover, in unreported results, I find that the absence of evidence supporting RPE in ROA holds whether stock returns are included in the compensation regressions or not. These results are consistent with the evidence in Gibbons and Murphy (1990), who test RPE using ROA, and Janakiraman et al. (1992), who test RPE using return on equity (ROE). The lack of RPE in ROA could be due to two reasons. First, accounting returns are a less noisy measure of performance, thus mitigating the need for RPE in this measure. ROA numbers are based on conservatism and thus already remove some common shocks by not recognizing unrealized gains. Second, accounting data are available only at an annual or quarterly frequency, with a substantial lag, which precludes firms from using accounting returns to evaluate the performance of CEOs.

5.3. Asymmetric use of RPE

The evidence of RPE in CEO turnover contrasts with prior evidence on the lack of RPE usage in CEO compensation and suggests that RPE can be used more in poor firm performance years. This raises the question of whether the success of the industry-size peer performance comes from being a good filter during periods of poor firm performance only. One possible reason for such an asymmetry is the board's concern with a higher probability of shareholder litigation when the firm performs poorly not only in absolute terms but also relative to its peers. For example, in February 2005, a shareholder lawsuit was filed against Abercrombie & Fitch Co. alleging that the company's poor performance compared with other retailers did not justify the amount of CEO compensation. In this subsection, I test whether the use of RPE is asymmetric in CEO pay.[24]

A firm is said to have performed poorly if its yearly return was among the bottom quartile of returns across all firms in ExecuComp. These constitute periods of significant poorer performance, which I label as poor performance years. I construct a dummy variable that equals one during poor performance periods and zero otherwise. To test for an asymmetric use of RPE, I interact this dummy variable with firm and peer stock returns. If RPE is used asymmetrically, I expect to find a negative coefficient associated with the dummy for poor performance interacted with peer stock returns.

The results are reported in Table 8. First, the sensitivity of compensation to peer stock performance remains significantly negative, regardless of how compensation is measured. The coefficient (p-value) on peer performance during normal

[23] For advantages and disadvantages to using either stock returns or earnings-based measures as performance signals, see Sloan (1993), Watts (2003a, b), Leone et al. (2006), and Lambert and Larcker (1987).

[24] Garvey and Milbourn (2006) show an asymmetric effect in RPE usage in CEO pay. However, Garvey and Milbourn suggest that RPE usage varies with good and bad market or industry performance, in contrast to good and bad firm performance as I do in this paper. Their hypothesis is that weak governance structures imply that RPE is used only when it is in the interest of the CEO to do so, that is, when the market overall displays negative returns.

Table 7
Regressions estimating the sensitivity of CEO compensation to RPE using both stock and accounting returns performance measures.

Independent variables	Predicted sign	Panel A			Panel B		
		Total compensation (levels regressions)			Change in total compensation (changes regressions)		
		(1)	(2)	(3)	(1)	(2)	(3)
Intercept		**5.36**	**5.36**	**5.34**	**0.20**	**0.20**	**0.21**
		(0.00)	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**
Firm stock return	+	**0.22**	**0.24**	**0.24**	**0.36**	**0.38**	**0.37**
		(0.00)	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**
Change in firm ROA	+	−0.01	−0.01	−0.02	0.06	0.05	0.05
		(0.89)	(0.84)	(0.81)	(0.59)	(0.61)	(0.64)
Peer return (industry)	−	**−0.08**		**0.17**	−0.04		**0.20**
		(0.02)		**(0.00)**	(0.47)		**(0.02)**
Peer return (industry-size)	−		**−0.16**	**−0.29**		**−0.13**	**−0.28**
			(0.00)	**(0.00)**		**(0.00)**	**(0.00)**
Change in peer ROA (industry)	−	**0.21**		−0.17	**0.26**		−0.13
		(0.06)		(0.25)	**(0.07)**		(0.56)
Change in peer ROA (industry-size)	−		**0.23**	**0.27**		**0.26**	**0.28**
			(0.00)	**(0.00)**		**(0.02)**	**(0.07)**
Firm size (sales)	+	**0.22**	**0.22**	**0.22**	0.02	0.02	0.02
		(0.00)	**(0.00)**	**(0.00)**	(0.44)	(0.54)	(0.60)
Growth options	+	**0.06**	**0.06**	**0.06**	0.01	0.01	0.01
		(0.00)	**(0.00)**	**(0.00)**	(0.14)	(0.12)	(0.13)
Ln of CEO tenure	+	**0.19**	**0.19**	**0.19**	**−0.03**	**−0.03**	**−0.03**
		(0.00)	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**
Regulation dummy	−	**1.58**	**1.62**	**1.63**	0.06	0.05	0.05
		(0.00)	**(0.00)**	**(0.00)**	(0.12)	(0.13)	(0.14)
Idiosyncratic variance	+	**0.38**	**0.32**	**0.36**	0.20	0.19	0.21
		(0.03)	**(0.05)**	**(0.05)**	(0.24)	(0.27)	(0.25)
Governance measures							
CEO chair dummy	+	0.04	0.03	0.03	0.01	0.01	0.01
		(0.76)	(0.79)	(0.80)	(0.25)	(0.26)	(0.29)
Number of meetings dummy	+	0.01	0.00	0.00	**−0.02**	**−0.02**	**−0.02**
		(0.76)	(0.82)	(0.81)	**(0.07)**	**(0.07)**	**(0.07)**
CEO ownership dummy	+	0.01	0.01	0.01	−0.02	−0.02	**−0.02**
		(0.74)	(0.73)	(0.74)	(0.11)	(0.11)	**(0.09)**
Interlock dummy	+	0.06	0.06	0.06	0.02	0.02	0.02
		(0.28)	(0.28)	(0.27)	(0.40)	(0.40)	(0.40)
Year dummies		Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies		Yes	Yes	Yes	Yes	Yes	Yes
CEO-fixed effects		Yes	Yes	Yes	No	No	No
Adjusted R^2		78.21%	78.30%	78.32%	4.35%	4.55%	4.61%
Number of observations		15,232	15,232	15,232	12,369	12,369	12,369

This table estimates the equation $\text{CEOPay}_{it} = \alpha_0 + \alpha_1 \text{FirmPerf}_{it} + \alpha_2 \text{PeerPerf}_{it} + \alpha_3 \text{ControlVariables}_{it} + u_{it}$.
Panel A presents the results from regressing the natural logarithm of real total CEO compensation on firm performance [measured by the natural logarithm of real annual stock returns including dividends and by the firm percentage change in real return on assets (income before extraordinary items/ beginning-of-year total assets)], peer group performance (defined as the natural logarithm of real annual stock returns, excluding own-firm performance, and as the percentage change in return on assets of the corresponding peer group, also excluding own-firm performance), and control variables. The control variables firm size and growth options are defined in changes in the changes regressions. Panel B presents the results for the percentage change of real total CEO compensation. The control variables are firm size, growth options, CEO tenure, regulation dummy, idiosyncratic variance, governance measures, and year and industry (defined at two-digit SIC) dummies. Variables are defined in Appendix B. The table reports estimates from CEO-fixed effects (Panel A) and pooled ordinary least squares (Panel B) regressions. All dollar values are in thousands (compensation) or millions (firm characteristics) of constant 1992 dollars. p-Values are reported in parentheses beneath each coefficient estimate. Bold coefficients are significant at least at the 10% significance level. The standard errors are heteroskedasticity-consistent using the Huber–White correction and are clustered by firm. The sample is drawn from the ExecuComp database for the years 1992–2005 merged with Compustat and CRSP data.

performance periods is −0.15 (0.00) for the level of compensation and −0.14 (0.01) for the change in compensation. Hence, I cannot reject that industry-size peer performance is a good filter during normal performance periods. Second, the marginal effect from poor performance periods on peer-performance sensitivity is not statistically significant. This result suggests that the level of RPE during poor performance periods is not different from the level of RPE used at other times.

5.4. A strong-form RPE test

In this subsection, I test whether the optimal level of RPE is used as suggested by Holmstrom and Milgrom (1987). This is called a test of the strong-form RPE (e.g., Antle and Smith, 1986; Janakiraman et al., 1992). Finding evidence that

Table 8
Asymmetric sensitivity of RPE during good and bad firm performance.

Independent variables	Predicted sign	Total compensation	Change in total compensation
Firm stock return	+	**0.23**	**0.40**
		(***0.00***)	(***0.00***)
Firm stock return * *D* (poor firm performance)		−0.01	−0.07
		(*0.84*)	(*0.25*)
Change in ROA	+	−0.08	0.08
		(*0.45*)	(*0.53*)
Change in ROA * *D* (poor firm performance)		0.14	−0.06
		(*0.32*)	(*0.74*)
Peer return (industry-size)	−	**−0.15**	**−0.14**
		(***0.00***)	(***0.01***)
Peer return (industry-size) * *D* (poor firm performance)	−	−0.05	0.02
		(*0.53*)	(*0.85*)
Change in peer ROA (industry-size)	−	**0.22**	**0.20**
		(***0.01***)	(***0.10***)
Change in peer ROA (industry-size) * *D* (poor firm performance)	−	0.05	0.15
		(*0.77*)	(*0.51*)
Control variables		Yes	Yes
Year dummies		Yes	Yes
Industry dummies		Yes	Yes
CEO-fixed effects		Yes	No
Adjusted R^2		78.30%	4.55%
Number of observations		15,232	12,369

This table estimates the equation $\text{CEOPay}_{it} = \alpha_0 + \alpha_1 \text{FirmPerf}_{it} + \alpha_2 \text{FirmPerf}_{it} * D_{it} + \alpha_3 \text{PeerPerf}_{it} + \alpha_4 \text{PeerPerf}_{it} * D_{it} + \alpha_5 \text{ControlVariables}_{it} + u_{it}$. In testing for an asymmetric use of RPE, I include two interaction variables that result from the product of a dummy variable (that equals one if the firm exhibits poor performance and zero otherwise) with the firms' stock returns and the peers' stock returns. A firm is said to have performed poorly if its yearly return was among the bottom 25% lowest returns across all firms for the year. Control variables are included (but not shown) in the regressions. Remaining variables are defined in Appendix B. The table reports estimates from pooled ordinary least squares and CEO-fixed effects regressions. All dollar values are in thousands (compensation) or millions (firm characteristics) of constant 1992 dollars. *p*-Values are reported in parentheses beneath each coefficient estimate. Bold coefficients are significant at least at the 10% significance level. The standard errors are heteroskedasticity-consistent using the Huber–White correction and are clustered by firm. The sample is drawn from the ExecuComp database for the years 1992–2005 merged with Compustat and CRSP data.

some noise is removed from compensation, as I do above, is a necessary but not sufficient condition to find evidence of strong-form RPE. In Holmstrom and Milgrom, the optimal amount of RPE suggests that CEOs should be compensated only for unsystematic firm performance. Unsystematic firm performance is firm performance that is unrelated to peer performance and can be estimated as the residual in the regression of firm performance on a constant and on peer performance:

$$\text{UnsystFirmPerf}_{it} = \text{FirmPerf}_{it} - \hat{\gamma} - \hat{\rho}\text{PeerPerf}_{it}. \quad (2)$$

A test of the strong-form RPE, first proposed by Antle and Smith (1986) (see Appendix A), amounts to estimating a modified version of Eq. (1),

$$\text{CEOPay}_{it} = c_0 + \delta_1 \text{UnsystFirmPerf}_{it} + \delta_2 \text{SystFirmPerf}_{it} + \alpha_3 \text{ControlVariables}_{it} + \varepsilon_{it}, \quad (3)$$

where

$$\text{SystFirmPerf}_{it} = \hat{\gamma} + \hat{\rho}\text{PeerPerf}_{it} \quad (4)$$

and testing whether $\delta_2 = 0$. If the optimal amount of noise is filtered in CEO pay and $\delta_2 = 0$, then CEOs are not compensated by performance that appears to be exogenous to the firm.

This test is implemented in two steps. First, I estimate a pooled regression of firm performance on a constant and on peer performance. The estimates, $\hat{\gamma}$ and $\hat{\rho}$, are then used to construct estimates of unsystematic and systematic firm performance. Second, I estimate model (3), including both unsystematic and systematic stock returns and accounting returns. Table 9 presents the results of the test $H_0: \delta_2 = 0$ against the alternative $H_A: \delta_2 \neq 0$. Panel A shows that H_0 cannot be rejected at common significance levels in the levels regressions ($\hat{\delta}_2$ is 0.03 with a *p*-value of 0.32). This evidence provides support for the hypothesis that the optimal amount of noise in stock returns is filtered and that CEOs are not compensated for systematic performance when peers are defined by the firms in the same industry and size quartile. No support is found for the strong-form RPE in either stock returns or accounting returns when industry peers are used.

Table 9
Testing a strong-form of RPE.

Independent variables	Panel A		Panel B	
	Total compensation (levels regressions)		Change in total compensation (changes regressions)	
	Industry	Industry-size	Industry	Industry-size
Systematic firm stock performance	**0.12**	0.03	**0.31**	**0.22**
	(***0.00***)	(*0.32*)	(***0.00***)	(***0.00***)
Unsystematic firm stock performance	**0.22**	**0.24**	**0.36**	**0.38**
	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)
Systematic firm ROA performance	**2.45**	**7.50**	**3.04**	**8.42**
	(***0.06***)	(***0.00***)	(***0.06***)	(***0.02***)
Unsystematic firm ROA performance	−0.01	−0.01	0.06	0.05
	(*0.89*)	(*0.84*)	(*0.59*)	(*0.61*)
Control variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
CEO-fixed effects	Yes	Yes	No	No
Adjusted R^2	78.2%	78.3%	4.4%	4.6%
Number of observations	15,232	15,232	12,369	12,369

This table estimates the equation $\text{CEOPay}_{it} = \alpha_0 + \alpha_1 \text{UnsystFirmPerf}_{it} + \alpha_2 \text{SystFirmPerf}_{it} + \alpha_3 \text{ControlVariables}_{it} + \text{u}_{it}$.
This table presents the results from regressing the natural logarithm of real total CEO compensation flow (Panel A) and the percentage change of real total CEO compensation (Panel B) on unsystematic and systematic firm performance. Control variables are included (but not shown) in the regressions. Remaining variables are defined in Appendix B. Unsystematic firm performance is the error term from regressing firm performance on the average peer group stock performance. The remaining portion of firm performance is systematic performance. The table reports estimates from CEO-fixed effects regressions (Panel A) and pooled ordinary least squares (Panel B). All dollar values are in thousands (compensation) or millions (firm characteristics) of constant 1992 dollars. p-Values are reported in parentheses beneath each coefficient estimate. Bold coefficients are significant at least at the 10% significance level. The standard errors are heteroskedasticity-consistent using the Huber–White correction and are clustered by firm. The sample is drawn from the ExecuComp database for the years 1992–2005 merged with Compustat and CRSP data.

Panel B shows that, in the changes regressions, no evidence exists of strong-form RPE in either stock returns or accounting returns.[25]

6. Peer groups based on other firm characteristics

The success of industry-size peers in identifying RPE peers is subject to the concern that other firm characteristics could better proxy for external shocks. I replicate the regressions in Tables 5 and 7 using peers defined by industry-diversification, industry-financing constraints, and industry-operating leverage (as suggested by the discussion in Section 2.2). The results (untabulated) show no evidence of RPE in either the levels or the changes regressions when each of these peers is used, except in the levels regression using the industry-diversification peers.

Another candidate method to form peers is using a firm's level of growth options. Firms with different growth options can face similar shocks or similar costs in responding to external shocks in a way that is not captured by differences in firm size. For example, exogenous shocks to interest rates can change the value of high-growth options firms differently than the value of low-growth options firms.[26]

To analyze the role of growth options versus that of firm size in constructing peer groups, I create portfolios of firms based on industry and growth options quartiles following the same procedure used for industry-size portfolios. I also create portfolios of firms based on industry and growth options-size quartiles. The latter portfolios were created by ranking the firms in each industry and year into two growth options portfolios and two other independent size portfolios. The result is four portfolios of firms in each industry per year. I then reestimate the compensation models using as peer performance the average returns of these peer groups.

Table 10 presents the results. Using industry-growth options peers, RPE is not rejected in the level of CEO pay (coefficient of −0.13, and p-value of 0.00), but it is rejected in the growth of CEO pay (coefficient of −0.04, and p-value of 0.29). However, when the performance of industry-growth options peers and that of industry-size peers are both included in the regressions, evidence shows that shocks are filtered through industry-size peer performance only in both the level and growth of CEO pay. The industry-size portfolios appear to filter information that subsumes the information filtered through industry-growth options portfolios. Evidence exists of RPE in the level and growth of CEO pay when peers are defined as the firms in the same industry-size-growth options group.

[25] In untabulated results, I find no evidence consistent with strong-from RPE when the peer group is defined as the S&P 500 index.

[26] In the dividend discount model, the intrinsic value of a firm with dividends D, growth g, and discount rate r is $V = D/(r-g)$. The sensitivity of firm value to r is $\partial V/\partial r = -D/(r-g)^2$, which is larger if g is larger.

Table 10
Testing RPE using peer groups formed on firm's size and growth options.

Independent variables	Predicted sign	Panel A				Panel B			
		Total compensation (levels regressions)				Change in total compensation (changes regressions)			
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Firm stock return	+	**0.24**	**0.24**	**0.24**	**0.25**	**0.38**	**0.37**	**0.37**	**0.37**
		(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)	(***0.00***)
Change in firm ROA	+	−0.01	−0.01	−0.01	−0.01	0.05	0.05	0.06	0.05
		(*0.84*)	(*0.94*)	(*0.89*)	(*0.91*)	(*0.61*)	(*0.61*)	(*0.56*)	(*0.63*)
Peer return (industry-size)	–	**−0.16**			**−0.11**	**−0.13**			**−0.12**
		(***0.00***)			(***0.01***)	(***0.00***)			(***0.01***)
Peer return (industry-GO)	–		**−0.12**		−0.06		−0.05		0.03
			(***0.00***)		(*0.16*)		(*0.28*)		(*0.55*)
Peer return (Industry-Size-GO)	–			**−0.14**				**−0.08**	
				(***0.00***)				(***0.07***)	
Change in peer ROA (industry-size)	–	**0.23**			**0.11**	**0.26**			0.12
		(***0.00***)			(***0.09***)	(***0.02***)			(*0.26*)
Change in peer ROA (industry-GO)	–		−0.01		−0.03		0.00		−0.03
			(*0.86*)		(*0.56*)		(*0.96*)		(*0.75*)
Change in peer ROA (industry-size-GO)	–			**0.12**				0.06	
				(***0.08***)				(*0.53*)	
Control variables		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CEO-fixed effects		Yes	Yes	Yes	Yes	No	No	No	No
Adjusted R^2		78.30%	78.43%	78.25%	78.45%	4.55%	4.47%	4.35%	4.53%
Number of observations		15,232	15,197	15,232	15,197	12,369	12,339	12,369	12,339

This table estimates the equation: $\text{CEOPay}_{it} = \alpha_0 + \alpha_1 \text{FirmPerf}_{it} + \alpha_2 \text{PeerPerf}_{it} + \alpha_3 \text{ControlVariables}_{it} + u_{it}$.
Panel A presents the results of regressing the natural logarithm of real total CEO compensation on a set of variable using CEO-fixed effects. Panel B presents the results from regressing the percentage change of real total CEO compensation without CEO-fixed effects. In each panel, the respective compensation component is regressed on firm performance, peer group performance, and some control variables. Refer to previous tables for a description of the control variables included (but not shown) in the regression. Variables are defined in Appendix B. The (1) columns use as peer returns the average return on a portfolio of firms within the same two-digit SIC and size quartile. The (2) columns use as peer returns the average return on a portfolio of firms within the same two-digit SIC and growth quartile. The (3) columns use as peer returns, the average return on a portfolio of firms in the same two-digit SIC and size-growth quartile. The (4) columns use both peer returns, the average return on a portfolio of firms in the same two-digit SIC and Size quartile, and the average return on a portfolio of firms in the same two-digit SIC and growth quartile simultaneously. All dollar values are in thousands (compensation) or millions (firm characteristics) of constant 1992 dollars. p-Values are reported in parentheses beneath each coefficient estimate. Bold coefficients are significant at least at the 10% significance level. The standard errors are heteroskedasticity-consistent using the Huber–White correction and are clustered by firm. The sample is drawn from the ExecuComp database for the years 1992–2005 merged with Compustat and CRSP data.

7. Conclusion

Despite the theoretical motivation for the use of RPE in setting CEO compensation, extant empirical evidence supporting RPE is mixed. This paper contributes to the literature by showing that previous failures to detect RPE can be attributed to the choice of the peer group. An important consideration in identifying peer groups within an industry is a firm's size because both the type of shocks and a firm's ability to respond to shocks are functions of firm size. Using industry-size peer groups and ExecuComp data, I find consistent evidence of RPE in the level and change of CEO pay when performance is measured by stock returns. This stands in contrast with previous papers using ExecuComp data. I find no evidence of RPE when performance is measured using accounting returns.

While industry-size peers is a simple and convenient way of identifying peers, as it allows for more powerful tests of RPE, it is certainly not the only way. For example, geographic location is an important criterion when defining peer firms for banks and utilities. Canandaigua National Bank & Trust National considers other local banks as competitors (e.g., Bank of Geneva) but does not view banks located in Texas as competitors even if they are similar in size. An interesting topic for future research is the development of theories that optimally define firm-specific peer groups allowing empiricists to perform more powerful tests.

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Appendix A. Empirical models of compensation

This appendix presents and compares three alternative empirical models that have been used to test for RPE in executive compensation. One widely used model was proposed by Holmstrom and Milgrom (1987) and takes the form

$$\text{CEOPay}_{it} = \alpha_0 + \alpha_1 \text{FirmPerf}_{it} + \alpha_2 \text{PeerPerf}_{it} + \varepsilon_{it}, \tag{A.1}$$

which appears in the main text in Eq. (1). In this model, Holmstrom and Milgrom define RPE as α_2/α_1. Most of the literature that follows this specification focuses on testing whether α_2 is less than zero, because α_1 is expected to be positive. This is a test of weak-form RPE. There is also a test of strong-form RPE, which examines whether $\alpha_2/\alpha_1 = -\rho$ holds.

An alternative model that has also been widely used in the literature, and was first used in Antle and Smith (1986), assumes the following specification:

$$\text{CEOPay}_{it} = \delta_0 + \delta_1 \text{UnsystFirmPerf}_{it} + \delta_2 \text{SystFirmPerf}_{it} + \varepsilon_{it}. \tag{A.2}$$

This model is estimated using a two-step procedure. First, firm performance is regressed on an industry (peer) group performance measure,

$$\text{FirmPerf}_{it} = \gamma + \rho \text{PeerPerf}_{it} + \upsilon_{it}. \tag{A.3}$$

Using (A.3), firm i's performance is decomposed into its systematic (or predicted) performance component, $\gamma + \rho\text{PeerPerf}_{it}$, and its unsystematic component, υ_{it}. This model yields a strong-form test of RPE, $\delta_2 = 0$, and predicts as before that only the unsystematic component of firm performance affects CEO pay, not the systematic component.

Model (A.1) and model (A.2) are obviously related. Substituting the firm performance Eq. (A.3) into model (A.1) yields

$$\text{CEOPay}_{it} = (\alpha_0 + \alpha_1\gamma) + \alpha_1\upsilon_{it} + (\alpha_1\rho + \alpha_2)\text{PeerPerf}_{it} + \varepsilon_{it}.$$

In summary, this derivation says that testing the presence of RPE in model (A.2) by letting $H_0 : \delta_2 = 0$ (and also $\delta_1 > 0$) is equivalent to testing $H_0 : \alpha_2/\alpha_1 = -\rho$ in model (A.1). The two models (A.1) and (A.2) are exactly equal when (A.3) imposes the condition that the coefficients γ and ρ be constant across firms.

A third model is the one used in Jensen and Murphy (1990). This model is a restricted version of model (A.2) (by imposing $\gamma_i = 0$ and $\rho_i = 1$) and is specified as

$$\text{CEOPay}_{it} = \alpha_0 + \alpha_1 \text{FirmPerf}_{it} + \alpha_2(\text{FirmPerf}_{it} - \text{PeerPerf}_{it}) + \varepsilon_{it}.$$

Appendix B. Variable definitions

B.1. Dependent variables

Total compensation: The logarithm of the real total annual compensation flow. Total annual compensation flow is calculated as the sum of salary, bonus, other annual compensation (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases), long-term incentive payouts, restricted stocks granted during the year (determined as of the date of the grant), the value of stock options granted (estimated using the Black–Scholes formula), and all other compensation (e.g., payouts for cancellation of stock options, 401K contributions, signing bonuses, tax reimbursements). I measure total annual compensation flow in real terms (base January 1992 for the CPI) and deflate compensation by the value of the CPI index of the fiscal month.

Change in total compensation: The change in the variable total compensation.

B.2. Independent variables

Firm stock return: Measured as the continuously compounded gross real rate of return to shareholders assuming that dividends are reinvested. Calculated as the natural logarithm of $[(1 + \text{retann}/100)/(1 + \text{CPIANN})]$, where retann is the annual (compounded) stock return obtained from the CRSP monthly tapes and CPIANN is the annual rate of CPI inflation from CRSP-Indexes-U.S. Treasury and Inflation.

Peer return (*industry-size*): The equal-weighted stock return portfolio of the peer firms in the same two-digit SIC code and size quartile, excluding the own-firm stock return.

Peer return (*industry*): The equal-weighted stock return portfolio of the peer firms in the same two-digit SIC code, excluding the own-firm stock return.

Change in firm ROA: ROA is calculated as the natural logarithm of one plus annual income before extraordinary items divided by beginning-of-year total assets, both adjusted for inflation.

Change in peer ROA (*industry-size*): The equal-weighted change in ROA portfolio of the peer firms in the same two-digit SIC code and size quartile, excluding the own firm.

Change in peer ROA (*Industry*): The equal-weighted change in ROA portfolio of the peer firms in the same two-digit SIC code, excluding the own firm.

Firm size: The natural logarithm of sales, using constant 1992 dollars. I use beginning-of-year values for firm size (and for growth options). This assumes that the parameters of the compensation package are set at the beginning of the year and helps control for the fact that these firm characteristics may not be exogenous variables, but choice variables of the CEO.

Growth options: The beginning-of-year ratio of the market value of the firm to the book value of assets. The market value of the firm is the book value of assets minus the book value of equity plus the market value of equity. Firm market value of equity is calculated as number of shares outstanding multiplied by the closing price at fiscal year-end.

Regulation dummy: Variable equal to one for firms in the gas and electric industries with SIC codes from 4900 to 4939 and zero otherwise.

CEO tenure: The natural logarithm of CEO tenure. Tenure is calculated as the difference between the year and month in which the CEO assumed office (obtained from the variable BECAMECEO, from ExecuComp) and the year and month of the current fiscal year for which the CEO is still in office. I use the log of CEO tenure to account for a possible concave relation between experience, as measured by tenure in the firm, and the level of pay.

Idiosyncratic variance: The firm-specific stock return variance measured relative to the industry's variance, calculate over the previous 36 months.

B.3. Corporate governance variables

For all measures, a high number means greater potential agency conflicts and, presumably, a weaker governance structure.

CEO chair dummy: A dummy that equals one if the CEO is the board chair, as identified by searching the CEO's title and zero otherwise.

Number of meetings dummy: A dummy that takes the value of one if the number of board of directors' meetings held during the year is less than the overall sample median of meetings for that year and zero otherwise.

CEO ownership dummy: A dummy variable that takes the value of one if the CEO ownership share is lower than the median for the year across CEOs in the sample and zero otherwise. The percentage of CEO ownership is calculated as the number of shares (excluding options) owned by the CEO divided by the number of common shares outstanding at the end of the fiscal year.

Interlock dummy: A dummy that takes the value of one if the CEO is involved in an interlock relationship requiring disclosure in the proxy statement and zero otherwise. ExecuComp defines an executive as having an interlock relationship if the executive serves on the board committee that makes his compensation decisions or if he serves on the board (and possibly compensation committee) of a company managed by an officer on the compensation committee of the indicated executive.

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