The Other Side of the Tradeoff: The Impact of Risk on Executive Compensation—A Reply

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Abstract: Core and Guay (2001) argue that there is an increasing relation between an executive's pay-performance sensitivity (incentives) and firm risk, in contrast to the findings in Aggarwal and Samwick (1999) and the predictions of principal-agent models such as Holmstrom and Milgrom (1987). They claim that including a control variable for firm size in our regression specification reverses the sign of the coefficient on firm risk. We show that their conclusions are based on errors in their empirical work, not the validity of their claim. We re-examine both our original findings and Core and Guay's findings and show that our original findings are quite robust to changes in specification—the relation between pay-performance sensitivity and firm risk is decreasing as predicted by principal-agent theory.

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I. Introduction

Core and Guay (2001) argue that there is an increasing relation between an executive's pay-performance sensitivity (incentives) and firm risk, in contrast to the findings in Aggarwal and Samwick (1999) and the predictions of principal-agent models such as Holmstrom and Milgrom (1987). Core and Guay focus on the regression results from Table 3, Panel A, Column 1 of our original article. They claim that including a control variable for firm size in our regression specification reverses the sign of the coefficient on firm risk. Their conclusions are based on errors in their empirical work, not the validity of their claim. We re-examine both our original findings and Core and Guay's findings and show that our original findings are quite robust to changes in specification—the relation between pay-performance sensitivity and firm risk is decreasing as predicted by principal-agent theory.

In their comment dated October 2001, which was distributed as forthcoming in the *Journal of Political Economy* but which has now been rejected, Core and Guay made several errors in their empirical work.[1] These errors, not the inclusion of a measure of firm size (market value of equity), generate their finding of a positive coefficient on firm risk. We demonstrate this in two ways. First, Core and Guay use a different sample than the one we used in our original article. In our original sample, we show that including the market value of equity as an explanatory variable does not eliminate the importance of firm risk (as measured by the dollar variance of firm returns) in explaining incentives.

Second, we use the Core and Guay sample and correct their two main errors. Their first error is that, when calculating an executive's change in firm-specific wealth, Core and Guay exclude the value of stock options exercised. This is inconsistent with the prior literature (e.g., Jensen and Murphy (1990)) and our original article. Their second error is that, contrary to what they state in their comment, they do not impose the same sample restrictions that we did in our original article. Specifically, in our original article, we exclude observations for which there are fewer than 48 months of return data, whereas Core and Guay include observations for which there are between 12 and 48 months of return data. When we correct these errors, we find that the coefficient on the firm risk variable is negative and significant, as we argued in our original article. Thus, we conclude that our original results are robust to the inclusion of firm size as measured by the market value of equity.

Even though Core and Guay's findings are not valid as a critique of our original article, it is worth understanding how firm size influences incentives. Core and Guay argue that firm size matters for incentives because it proxies for the marginal product of an executive's effort—larger firms have more productive executives. If this is why firm size matters, then there are better measures of firm size than the market value of equity such as firm sales, assets, capital stock, or number of employees. When these measures are included in our specifications, the relation between incentives and firm risk is again negative and significant. Further, the prediction from this model is that controlling for risk, the effect of firm size on incentives is positive. This prediction is always rejected empirically. Instead, it is more plausible that firm size matters because it proxies for further aspects of risk not fully captured by the variance of dollar returns.

Core and Guay also argue that the correct measure of risk is the percent return variance, not the dollar return variance. Core and Guay base their argument on the model of Schaefer (1998) and Baker and Hall (2002). When we correctly estimate this model, we find a negative relation between risk and incentives over almost the entire range of parameter values, consistent with the results in Schaefer and Baker and Hall. These results provide no support for the Core and Guay claim that including firm size invalidates our original results. We conclude that there is a negative relation between risk and incentives.

II. How robust are our original results?

To examine the robustness of our original results, we estimate both our original specification and Core and Guay's specification using our original sample in Table 1. Our original specification (equation (2) from our 1999 article) is:

$$w_{ijt} = \gamma_0 + \gamma_1 \pi_{jt} + \gamma_2 F(\sigma^2_{jt})\pi_{jt} + \gamma_3 F(\sigma^2_{jt}) + \mu_t + \varepsilon_{it}. \tag{1}$$

[1] Their original comment is available at http://mba.tuck.dartmouth.edu/pages/faculty/raj.aggarwal/CGComment.pdf.

The dependent variable w_{ijt} is the dollar increase in CEO wealth. The independent variables are the dollar change in the market value of the firm π_{jt}, the interaction of this dollar return with the cumulative distribution function (CDF) of the variance of dollar returns calculated over the preceding five years $F(\sigma_{jt}^2)\pi_{jt}$, the CDF of dollar return variance $F(\sigma_{jt}^2)$, and year dummies μ_t. The pay-performance sensitivity is given by $\gamma_1 + \gamma_2 F(\sigma_{jt}^2)$. If γ_2, the coefficient on the interaction of dollar returns with the CDF of the variance of dollar returns, is negative, then the pay-performance sensitivity (incentives) is decreasing in risk. To get Core and Guay's specification (equation (5) from their comment), we add the CDF of the market value of equity interacted with the dollar return $F(V_{jt-1})\pi_{jt}$ and this CDF $F(V_{jt-1})$ alone:

$$w_{ijt} = \beta_0 + \beta_1 \pi_{jt} + \beta_2 F\left(\sigma_{jt}^2\right)\pi_{jt} + \beta_3 F\left(\sigma_{jt}^2\right) + \beta_4 F(V_{jt-1})\pi_{jt} + \beta_5 F(V_{jt-1}) + \mu_t + \varepsilon_{it}. \qquad (2)$$

The first column of Table 1 replicates Table 3, Panel A, Column 1 from our 1999 article and estimates equation (1) above. The second column of Table 1 estimates equation (2) above. This is the specification used by Core and Guay in their Table 2, Column (c). We note that the Core and Guay specification applied to our original sample yields results entirely consistent with our original results and inconsistent with those in their comment. In particular, the coefficient on the interaction of the dollar return and the CDF of dollar return variance, -9.722, is negative and significant even after controlling for the market value of equity. While the market value of equity is correlated with incentives, including it in the regression does not invalidate the importance of the risk variable, the dollar return variance, in our original sample.

The next two columns demonstrate similar results for our original sample of non-CEOs to those in the first two columns for our original sample of CEOs. Even when controlling for the market value of equity, we find a negative and significant coefficient on the interaction of the dollar return and the CDF of the dollar return variance for our original sample.

III. Are the Core and Guay results correct?

Core and Guay begin with a somewhat different sample than the one we used in our original article.[2] In Table 2, we examine the relation between incentives, dollar return variance, and market value of equity using the Core and Guay sample. Columns (1) through (3) transcribe Core and Guay's Table 2, Columns (a), (c), and (e), respectively, for ease of comparison. The dependent variable is the dollar increase in CEO wealth. The independent variables are the dollar change in the market value of the firm, the interaction of this dollar change with the CDF of the variance of dollar returns calculated over the preceding five years, the interaction of the dollar return with the CDF of market value of equity, the interaction of the dollar return with the CDF of the market-to-book ratio, the interaction of the dollar return with the CDF of CEO tenure, the interaction of the dollar return with the CDF of the percent return variance, these CDFs not interacted, and year dummies. Column (1) is their replication of our original specification (equation (1) above) from the first column of Table 1. The key result from the Core and Guay comment is in the second column, estimating equation (2) above. Core and Guay argue that the coefficient on the risk variable (dollar return interacted with the CDF of dollar return variance) becomes positive and significant when a measure of firm size, the market value of equity, is added to the regression. Column (3) shows that this coefficient becomes negative but insignificant when additional control variables are added.[3]

The fourth through sixth columns contain the results when we attempt to replicate Core and Guay's results in Columns (1) through (3) using their sample. In Column (5), our estimate of the coefficient on the dollar return interacted with the CDF of the dollar return variance is negative and significant, as in our original article. In addition, the coefficients are very close to those in the second

[2] We thank Core and Guay for providing us with their programs and data so that we can estimate regressions on their sample. The Core and Guay sample differs from our original article in several respects. First, Core and Guay use a later release of the ExecuComp data (October 1999 versus October 1997 for our original sample). In replicating their results, we use the October 1999 release of the data. Second, Core and Guay use a more precise definition of CEO status than we used in our original sample. In replicating their results, we use their definition. This reduces the number of CEOs relative to our original sample. These two differences turn out to be minor.

[3] Core and Guay attach special meaning to the percent return variance. We return to this issue in Section V below. Core and Guay's coefficient on the interaction of dollar return and the CDF of percent return variance in Column (3) is an order of magnitude larger than ours in Column (6), presumably due to a transcription mistake.

column of Table 1. Column (6) shows that adding the other covariates increases the magnitude and significance of the coefficient on the dollar return interacted with the CDF of dollar return variance. Market-to-book and CEO tenure were provided by Core and Guay; all other variables are defined as in our original article.

What accounts for the dramatic difference between Core and Guay's results in the first three columns of Table 2 and our attempt to replicate their results in the last three columns of Table 2? There are two major differences and one minor difference between Core and Guay's empirical work and ours. The minor difference is that Core and Guay use 26 observations for which some aspect of compensation data is missing in ExecuComp (e.g., ExecuComp's calculation of the Black Scholes value of options granted). These observations were entered as having values of zero in Core and Guay's empirical work. We drop these observations.

The first major difference is that, in our original article, we use only observations for which a minimum of 48 months of return data are available to calculate variances of returns (see footnote five in our original article). In their comment, Core and Guay claim that they follow this same sample restriction: "To create our sample, we use the same data restriction as A&S (1999), and compute compensation variables consistent with the A&S measures . . . To compute the variance of monthly dollar returns (i.e., A&S's measure of firm risk), we use a time series of no less than 48 months and no more than 60 months of returns . . ." (page 7-8; also see the notes to Table 2 in their comment). However, our inspection of observations in their sample revealed numerous cases of firms that were not even publicly traded for 48 months (e.g., America Online went public on March 19, 1992, but Stephen Case, AOL's CEO, appears in Core and Guay's sample from 1994 to 1996). In a subsequent examination of their programs, we found that Core and Guay restricted their sample to observations for which a minimum of 12 months of return data are available, not 48 as they claimed in their comment. By our calculations, Core and Guay include 624 observations that do not pass our original sample selection criteria. This issue, along with the minor issue noted above, accounts for the differences in sample size between Core and Guay's results in the first three columns of Table 2 and our results in the last three columns of Table 2 (4,162 + 624 + 26 = 4,812 observations).

Why does this sample selection issue matter? Our original criterion was designed to ensure that we had enough return data to accurately calculate variances of returns, as is typically done in the asset pricing literature. However, there is a deeper issue as well. The 624 observations that Core and Guay mistakenly include in their sample consist primarily of newly listed companies in the form of recent initial public offerings. In these specifications, a minimum of 12 months of trading data is insufficient to accurately characterize the variance of returns for newly traded companies. Moreover, recent IPOs have the feature that their top managers have large positions of company stock and options. These large positions are typically not due to optimal contracting in a principal-agent setting (such as the one we tested in our original article), but instead are due to the fact that many of the managers are owner-founders of their firms. These owner-founders take their firms public to achieve liquidity but trade out of their undiversified positions fairly slowly. For example, Field and Hanka (2001) show that executives' ownership positions remain very high one year after the IPO, falling from 27.5% at the time of the IPO to 25.3% one year later, in part due to lockup provisions. At the same time, these companies have high variances of returns. Thus, it is not surprising that on this subsample one would find a positive relation between incentives and the variance of returns.

The second major difference is that Core and Guay define their dependent variable differently than we did. In our original article, we defined the dependent variable, the change in firm-specific wealth, as the sum of total flow compensation, the change in the value of stock holdings, and the change in the value of option holdings. Core and Guay have the same definition as we do for total flow compensation and the change in the value of stock holdings. However, their definition of the change in the value of option holdings differs from ours. Core and Guay define the change in the value of option holdings as the difference between the value of unexercised options from the beginning of the year to the end of the year. Core and Guay do not include the value of any options exercised during the year. As in Jensen and Murphy (1990), we define the change in the value of option holdings as the difference between the value of unexercised options from the beginning of the year to the end of the year plus the value of any options exercised during the year.

Core and Guay's failure to include the value of options exercised during the year is flawed. To see this, suppose that an executive has 100 options at the beginning of the year, each in the money with an intrinsic value of 5. For simplicity, ignore the time value of the options. Then the executive's beginning of year value of option holdings is 500. Suppose that the stock price does not change over the course of the year and the executive exercises 20 options during the year. The value of these options that are exercised is 100. At the end of the year, the executive has 80 options each with an intrinsic value of 5, so the end of year value of option holdings is 400. Core and Guay would treat this as the executive's change in firm specific wealth from options is 400 – 500 = - 100. However, the executive's exercise decision is still firm-specific wealth and so we would treat the executive's change in firm-specific wealth from options as 400 + 100 – 500 = 0.

Our approach is not only consistent with the previous literature, it is also consistent with how we treat the change in the value of stock holdings. Specifically, the change in the value of stock holdings multiplies the value of the shares held by the executive at the beginning of the year by the total return to shareholders over the course of the year. Thus, any stock that is sold during the year is treated as if it were sold at the end of the year. The option calculation that we use also treats any option exercise during the year as occurring at the end of the year. As Core and Guay make the same assumption we do for stock holdings but a different one for option holdings, their treatment of the two is inconsistent.

These differences in empirical work account for the large differences in results between the first three and the last three columns of Table 2.[4] In Core and Guay's results, it is not the inclusion of market value of equity in the regression that reverses the sign on firm risk, but rather errors in their empirical work.

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[4] The first and fourth columns of Table 2 are almost identical. This is because wrongly including the 624 observations with fewer than 48 months of returns data will increase the coefficients relative to those reported in column 4. However, excluding the value of options exercised will decrease the coefficients relative to those

IV. Why does firm size matter?

In the previous two sections, we showed that including the market value of equity does not reverse our original conclusion that there is a negative relation between incentives and firm risk. It is also true that there is a correlation between firm size as measured by the market value of equity and incentives. Why does firm size matter? In their model, Core and Guay argue that firm size matters because it proxies for an executive's marginal product of effort—executives at larger firms have higher marginal products of effort. In the context of this model, however, it is worth considering what would be a good proxy for the marginal product of effort.

There are several reasons why market value of equity may be an inadequate proxy. First, from basic accounting, the market value of equity does not represent the value of all claims on the firm, making it an incomplete measure of firm size. Second, the market value of equity is a highly volatile measure of firm size. This volatility is more likely to be related to noise in financial markets than to changes in productivity.[5] When the market value of equity decreases by 10 percent for random reasons, it seems implausible that the marginal product of the executive's effort is also 10 percent lower. The marginal product of effort is a real, not financial, variable. It is better captured by real operating measures of firm size. Third, in the context of Core and Guay's specifications, the market value of equity is the measure of firm size that is most highly correlated with the measure of firm risk. Core and Guay report that this correlation is 0.92. This multicollinearity will lead to less precise and less stable estimates of the relations between incentives and both risk and size. For these reasons, the market value of equity is not a good measure of firm size for the purpose of capturing the marginal product of effort.

Because of these issues, we consider Core and Guay's model in a more general setting. Similar to their equation (1), the change in market value is given by:

$$\Delta V = \lambda(s)x + \varepsilon, \quad (3)$$

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reported in column 4. These two mistakes roughly offset each other in the specifications in column 1 and 4. They have a large impact on the specifications in Columns 2 and 5 and 3 and 6.

where $\lambda' > 0$. Here λ measures the marginal product of an executive's effort and it is assumed to be increasing in firm size, s. This theoretical specification does not require that firm size is the market value of equity. In particular, we assume that the proxy for the marginal product of effort, firm size s, is uncorrelated with the shock to firm value ε. If the change in market value is given as above, it is straightforward to show that the optimal contract is:

$$\alpha_1^* = \frac{\lambda(s)^2}{\lambda(s)^2 + \rho k \sigma^2}, \tag{4}$$

where ρ is the executive's coefficient of absolute risk aversion and k is the executive's disutility of effort.

In this version of the optimal contract, σ^2 is the dollar return variance as in the Holmstrom and Milgrom (1987) model we tested and the pay-performance sensitivity α_1^* is increasing in the marginal product of effort. As the marginal product of effort is increasing in firm size (by assumption), the pay-performance sensitivity is increasing in firm size, controlling for firm risk. In an empirical test of equation (4), such as equation (2), the coefficient on the interaction of dollar return with firm size s should be positive and the coefficient on the interaction of dollar return and firm risk σ^2 should be negative.

Given the shortcomings in using the market value of equity as a proxy for the marginal product of effort, we consider four additional measures of firm size: log of firm sales, book value of assets, the value of the firm's capital stock (net property, plant, and equipment), and the number of employees at the firm. As the marginal product of effort is a real, not financial, variable, it is better captured by real operating measures of firm size such as revenue brought in, the value of assets utilized in production, and the amount of physical capital or labor directed by the executive. Log of firm sales has been used by a number of authors including Himmelberg, Hubbard, and Palia (1999) and Jin (2002). Schaefer (1998) estimates his model using assets as well as market value of equity. Our last two measures capture capital and labor from a neoclassical production function. These other measures of firm size are far less

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[5] Berk (1995) argues that the market value of equity captures unmeasured risk factors in the context of expected returns. Berk advocates using non-market-value-based measures of firm size to test for size effects independent of risk (see also Jin (2002)).

correlated with the variance of dollar returns than is the market value of equity, making them more appealing econometric proxies for firm size.

Table 3 shows that the coefficient on the interaction of the dollar return with the CDF of the dollar return variance is negative and significant using all four alternative measures of firm size.[6] Further, the coefficient on the dollar return interacted with each of the four measures of firm size is negative and significant. We draw two conclusions from these results. First, regardless of the measure of firm size, our original conclusion that there is a negative and significant relation between incentives and firm risk is unaffected. Second, the prediction of the generalized Core and Guay model that the relation between incentives and firm size is positive, controlling for risk, is rejected in all specifications.

Core and Guay also suggest that the model can be tested using a direct measure of incentives, the executive's ownership share in the firm through holdings of stock and options. This measure of incentives ignores incentives from flow compensation but does capture the bulk of an executive's pay-performance sensitivity. In Table 4, Panel A, we estimate median regressions analogous to those in Core and Guay's Table 3, Panel B. Here the dependent variable is the executive's ownership share through stock and options, which we regress directly on the risk variable and all of the size variables. When we use the market value of equity as the measure of firm size, the coefficient on the CDF of dollar return variance is positive and significant. This is the only case in which we are able to generate a positive coefficient on the risk variable. When we use sales, assets, capital stock, or the number of employees as the measure of firm size, we find that incentives are decreasing in the measure of risk; the coefficient on the CDF of dollar return variance is negative and significant. These results suggest that the positive coefficient on the risk variable when the measure of firm size is the market value of equity is an artifact of the high correlation between market value of equity and dollar return variance.

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[6] While these results are reported for the sample that corrects the errors in the Core and Guay empirical work, it turns out that the results for sales, assets, capital, and labor as the measures of firm size are robust to including the 624 observations for which there is return data of between 12 and 48 months. Details are available from the authors upon request.

In Table 4, Panel B, we estimate the same specification using OLS regressions including an executive fixed effect. Because ownership shares are not as highly skewed in the way that dollar changes in CEO wealth are (the distribution of dollar changes in CEO wealth is determined by the distribution of dollar returns to shareholders in addition to the distribution of CEO ownership shares), there is less need to downweight outliers using a median regression. Moreover, as emphasized by Himmelberg, Hubbard, and Palia (1999), including the fixed effect allows us to control for any time-invariant, executive or firm specific characteristics that determine the level of incentives such as experience, ability, education, etc. In all of the specifications in Table 4, Panel B, we find that incentives are negatively and significantly related to both the CDF of dollar return variance and the CDFs of the measures of firm size (significance for the CDF of the dollar return variance is marginal for assets as the measure of firm size with a p-value of 0.066). Similar results using a variety of specifications and using log(sales) as the measure of firm size are found in Jin (2002) and Aggarwal and Samwick (2002). Our basic conclusion, that risk matters for incentives as predicted by the principal-agent model, is unaffected.[7] Further, in all specifications, firm size has a negative and significant impact on the pay-performance sensitivity, contrary to the prediction of the generalized Core and Guay model.

Given that the primary theoretical argument by Core and Guay for why firm size matters—that it proxies for the marginal product of effort—is rejected in this more general setting, why else might size matter? In the literature that was written prior to our paper, firm size mattered for the pay-performance sensitivity because it was considered to be a proxy for firm risk (Jensen and Murphy (1990)). As we noted in our original article, larger firms by market capitalization have larger dollar return variances, and this is why the dollar return variance is the appropriate variable in a test of the principal-agent model. Holmstrom (1992, p. 214) concurs:

> I view the negative correlation [between size and incentive strength] in the data as broadly supportive of the agency theoretic presumption that risk is traded off against incentives at the margin (limited wealth, which also could explain this relation, is just a version of risk aversion).

[7] We have run the same specifications in Tables 3 and 4 on our original sample. The results, namely the negative and significant coefficients on the CDF of dollar return variance interacted with the dollar return for Table 3 and the CDF of dollar return variance for Table 4, are similar to those reported here.

Thus, the most natural interpretation for why all of the measures of firm size are negatively related to incentives is that they help capture the effect of risk.

To summarize, a more general version of Core and Guay's model predicts that incentives should be negatively associated with firm risk and positively associated with firm size (a proxy for an executive's marginal product of effort). The first prediction is consistent with the Holmstrom and Milgrom (1987) model we originally tested and is supported in almost all specifications. The second prediction is rejected in all specifications. The primary theoretical argument Core and Guay give for why firm size matters *independent of risk* has no empirical support.

V. Is Core and Guay's percent return variance specification valid?

In the previous section, we provide a more general version of Core and Guay's model and examine its implications. Core and Guay use the more restricted version of the model to argue that the percent return variance is a better measure of firm risk than the dollar return variance. We now examine this claim.

In the more restricted version of their model, Core and Guay use the market value of equity as the measure of firm size. Specifically, they set $\lambda(s) = V_{t-1}^{\eta}$. The market value of equity at the beginning of the period is V_{t-1}. The parameter η measures the sensitivity of the marginal product of the executive's effort to the market value of equity. This allows Core and Guay to express the pay-performance sensitivity (see their equation (2)) as:

$$\alpha_1^* = \frac{V_{t-1}^{2\eta}}{V_{t-1}^{2\eta} + \rho k \sigma^2} = \frac{V_{t-1}^{2\eta}}{V_{t-1}^{2\eta} + \rho k \sigma_r^2 V_{t-1}^2}. \quad (5)$$

Core and Guay argue that this equation "shows that the variance of percentage returns [σ_r^2] and market value [V_{t-1}^2] can be substituted for the variance of dollar returns [σ^2] in a test of the dollar returns specification of the agency model."[8] This point is extremely important to the Core and Guay argument

[8] This statement is incorrect. Core and Guay assume that $\sigma^2 = \sigma_r^2 V_{t-1}^2$ so that the market value of equity is measured at the end of the previous year (t-1). This is not equivalent to the variance of dollar returns calculated over the previous five years, which is the measure of risk we used in our original article and in Tables 1 through 4 here. In

that the correct measure of firm risk is percent return variance, not dollar return variance. It allows them to argue that incentives are decreasing in firm size measured by the market value of equity and the percent return variance. However, if we divide the numerator and denominator of equation (5) by $V_{t-1}^{2\eta}$, we obtain:

$$\alpha_1^* = \frac{1}{1+\rho k \sigma_r^2 V_{t-1}^{2-2\eta}} = \frac{1}{1+\rho k\left(\sigma_r V_{t-1}^{1-\eta}\right)^2}. \qquad (6)$$

This expression shows that the correct specification, based on Core and Guay's model, is not two separate variables for market value and the standard deviation of percent returns. It shows that the correct specification includes the interaction of the standard deviation of percent returns and a function of market value, $\sigma_r V_{t-1}^{1-\eta}$. Core and Guay do not estimate this specification.

As discussed by Baker and Hall (2002) and Schaefer (1998), this version of the principal-agent model cannot be tested without knowing the value of η, which must be incorporated along with the standard deviation of percent returns and the market value of equity. As a result, Core and Guay's percent return variance specifications (see their Table 2, columns (d) and (e)) are not valid tests of this model. Schaefer (1998) estimates the parameters of the equation directly. Baker and Hall (2002) assume that observed pay-performance sensitivities are optimal, and use them to infer values of η from the data. Their preferred estimate is 0.4, and they reject the values of 0 and 1. In their comment, Core and Guay, in effect, only use values of η of 0 and 1. Their focus on the percent return variance implies an a priori belief that the correct value of η is 1.

In the absence of independent information about the value of η or any specification in Core and Guay using values of η other than 0 or 1, we estimate a regression of incentives on the CDF of $\sigma_r V_{t-1}^{1-\eta}$ for the entire range of η between 0 and 1. Figure 1 graphs the relation between η and the coefficient on the CDF of $\sigma_r V_{t-1}^{1-\eta}$ using median regression, along with the 95 percent confidence interval bands. If the

order to correspond to the variance of dollar returns, the expression would have to be $\sigma^2 = \sigma_r^2 V^2$, where V is the average market value of equity over the previous five years. Notwithstanding this model misspecification, we follow the Core and Guay assumption for the rest of this section to further demonstrate the robustness of our results.

principal-agent model is valid, implying a tradeoff between risk and incentives, the coefficient should be negative. The coefficient on the extreme left ($\eta = 0$) corresponds to our original dollar return variance specification, and the coefficient on the extreme right ($\eta = 1$) corresponds to the percent return variance specification advocated by Core and Guay. Figure 1 shows that the coefficient is negative and significant for values of η between 0 and 0.69. It is positive and significant for values of η above 0.73.

Figure 2 graphs the relation using OLS regressions with executive fixed effects. The coefficient is negative for the entire range of η between 0.0 and 1.0, and it is significant for η between 0 and 0.95. Note that the negative coefficient for $\eta = 1$ is similar to the results in Himmelberg, Hubbard, and Palia (1999), who find a negative and significant coefficient on percent return variance in a fixed effect regression. These results are also consistent with the results in Schaefer (1998) and Baker and Hall (2002). We conclude that the effect of risk on incentives is negative for values of η between 0 and 0.69 to 0.95, again supporting the basic features of the principal-agent model.

VI. Conclusion

There are four key points that emerge from our analysis. First, when we examine Core and Guay's results in the context of our original sample, we find that the market value of equity does matter for explaining variation in incentives. However, in the context of our original sample, controlling for the market value of equity does not invalidate the importance of firm risk in explaining incentives. There is a negative relation between incentives and firm risk.

Second, when we examine Core and Guay's results in the context of their sample, we find that a number of inconsistencies in their empirical work drive their results. In particular, including firm size in the regression is not why Core and Guay find a positive coefficient on the risk variable—differences in sample restrictions and in the construction of the dependent variable are why Core and Guay find a positive coefficient on the risk variable. When these errors are corrected in the Core and Guay sample, the coefficient on the risk variable is negative and significant, as we found in our original article.

Third, Core and Guay argue that firm size matters for incentives because the marginal product of an executive's effort is correlated with firm size. If so, then there are better measures of firm size than a noisy measure such as the market value of equity. Better measures include sales, assets, capital, and labor, in the sense that they are more plausibly correlated with the marginal product of effort. When we include these measures of firm size in our specifications using Core and Guay's sample, there is a negative and significant relation between risk and incentives in all specifications.

Fourth, Core and Guay argue that the correct measure of risk is the percent return variance. In the context of the models by Schaefer (1998) and Baker and Hall (2002) that Core and Guay use to motivate their claim, there is a tradeoff between greater exposure to risk and greater incentives. In other words, if the model advocated by Core and Guay is tested correctly, for a wide range of parameter values, there is a negative association between risk and incentives.

It is also worth noting that there exists a literature written subsequent to our paper that further tests the relation between the pay-performance sensitivity and firm risk. Himmelberg, Hubbard, and Palia (1999) find, in exactly the econometric setting advocated by Core and Guay using fixed effects, log(sales) to measure firm size, and other control variables for managerial discretion, that there is a negative relation between stock return volatility and managerial ownership. Kraft and Niederprum (1999) find similar results in German data controlling for firm size by using sales. Jin (2002) finds that the relation between pay-performance sensitivity and idiosyncratic risk is negative and that there is essentially no relation between pay-performance sensitivity and systematic risk. Jin controls for firm size directly using log(sales) in his specifications. Garvey and Milbourn (2002) find similar results to Jin, and find that there is further variation by CEO age. Finally, in Aggarwal and Samwick (2002), we find that the relation between pay-performance sensitivities and firm risk for different categories of executives is negative after controlling for aspects of the firm's contracting environment including firm size, as suggested by Himmelberg, Hubbard, and Palia (1999). This result holds quite strongly for CEOs. These results are consistent with our results and inconsistent with the Core and Guay results. We conclude that our original results are robust: there is a negative relation between risk and pay-performance sensitivity.

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Table 1
Median Regressions of Change in Firm-Specific Wealth on Dollar Returns: Original Sample

	CEOs		Non-CEOs	
Dollar Return	27.596 (1.983)	29.903 (1.338)	6.008 (0.140)	6.392 (0.170)
Dollar Return x CDF of Dollar Return Variance	-26.147 (2.093)	-9.722 (4.702)	-5.427 (0.154)	-1.473 (0.461)
Dollar Return x CDF of Market Value		-18.753 (4.558)		-4.360 (0.558)
Pseudo R^2	0.104	0.105	0.175	0.177

Notes: This sample is the one used in our original article. There are 4,506 CEO observations and 14,592 Non-CEO observations. The dependent variables are the annual dollar increase in CEO and non-CEO wealth (total annual compensation plus the change in the value of holdings of stock and options). The independent variables are the dollar change in the market value of the firm ("dollar return"), the interaction of this dollar return with the CDF of the variance of dollar returns calculated over the preceding five years, and the CDF of the market value of equity interacted with the dollar return. As in our original article, all regressions include the CDFs uninteracted and year dummies, but these coefficients are not reported to conserve space. Standard errors, based on 20 bootstrap replications as in our original article, are in parentheses.

Table 2
Median Regressions of CEO Change in Firm-Specific Wealth on Dollar Returns:
Core-Guay Sample Original and with Errors Corrected

	Core-Guay Results from their Table 2, Columns (a), (c), and (e)			Core-Guay Specifications with Errors Corrected		
	(1)	(2)	(3)	(4)	(5)	(6)
Dollar Return	26.75 (34.22) t-stat	30.74 (30.33) t-stat	20.24 (5.85) t-stat	26.725 (1.310)	28.220 (1.036)	17.124 (2.281)
Dollar Return x CDF of Dollar Return Variance	-25.63 (-30.83) t-stat	7.37 (1.91) t-stat	-4.03 (-0.72) t-stat	-25.204 (1.441)	-9.291 (4.290)	-12.195 (3.613)
Dollar Return x CDF of Market Value		-37.15 (-8.17) t-stat	-19.19 (-2.47) t-stat		-17.590 (4.521)	-9.927 (4.369)
Dollar Return x CDF of Market-to-Book Ratio			3.53 (3.14) t-stat			3.810 (1.581)
Dollar Return x CDF of CEO tenure			6.22 (5.71) t-stat			7.021 (1.862)
Dollar Return x CDF of Percent Return Variance			50.94 (2.37) t-stat			6.019 (1.873)
Pseudo R^2	0.0878	0.0934	0.1151	0.1108	0.1132	0.1454
Number of Obs.	4,812	4,812	4,812	4,162	4,162	4,162

Notes: 1) The dependent variable is the annual dollar increase in CEO wealth (total annual compensation plus the change in the value of holdings of stock and options). The independent variables are the dollar change in the market value of the firm ("dollar return"), the interaction of this dollar return with the CDF of the variance of dollar returns calculated over the preceding five years, the CDF of the market value of equity interacted with the dollar return, the CDF of Market-to-Book ratio interacted with the dollar return, the CDF of CEO tenure interacted with the dollar return, and the CDF of the variance of percent returns interacted with the dollar return. All regressions include the relevant CDFs uninteracted and year dummies, but these coefficients are not reported to conserve space.

2) Columns (1) – (3) are transcribed from Core and Guay's Table 2, columns (a), (c), and (e). Note that Core and Guay report t-statistics. Columns (4) – (6) are results based on the corrected Core and Guay sample, with standard errors based on 20 bootstrap replications in parentheses. The corrections are: 1) We exclude observations for which there is missing data in ExecuComp on components of compensation, such as the value of options granted (26 observations). 2) As in our original article, we exclude any observations for which there are fewer than 48 months of stock returns available to compute the variance of returns (624 observations). 3) The dependent variable, change in firm specific wealth, includes the value of stock options exercised during the year, as in our original article. The first two differences account for the difference in sample size between the two sets of results. All other variables in columns (4) – (6) are defined as in our original article.

Table 3
Median Regressions of CEO Change in Firm-Specific Wealth on Dollar Returns on Corrected Core-Guay Sample, Using Alternative Measures of Firm Size

Dollar Return	28.066 (1.132)	28.092 (1.019)	25.980 (1.606)	27.220 (1.153)
Dollar Return x CDF of Dollar Return Variance	-13.555 (2.708)	-11.994 (2.404)	-11.054 (5.098)	-17.457 (1.402)
Dollar Return x CDF of Sales	-13.345 (2.830)			
Dollar Return x CDF of Assets		-15.262 (2.765)		
Dollar Return x CDF of Capital			-13.988 (5.376)	
Dollar Return x CDF of Labor				-8.530 (1.526)
Pseudo R^2	0.116	0.121	0.113	0.115
Number of Obs.	4,160	4,162	3,690	4,088

Notes: This sample is comprised of Core and Guay's executive-year observations, less any observations for which there are missing data in ExecuComp and less any observations for which there are fewer than 48 months of return data. The dependent variable, defined as in our original article, is the annual dollar increase in CEO wealth (total annual compensation plus the change in the value of holdings of stock and options). The independent variables are the dollar change in the market value of the firm ("dollar return"), the interaction of this dollar return with the CDF of the variance of dollar returns calculated over the preceding five years, the CDF of firm sales interacted with the dollar return, the CDF of the book value of assets interacted with the dollar return, the CDF of firm capital stock (net property, plant, and equipment) interacted with the dollar return, and the CDF of firm labor (number of employees) interacted with the dollar return. All regressions include the relevant CDFs uninteracted and year dummies, but these coefficients are not reported to conserve space. Standard errors based on 20 bootstrap replications are in parentheses.

Table 4
Regressions of CEO Incentives on Dollar Return Variance and Firm Size on Corrected Core-Guay Sample

	Panel A: Median Regressions					
CDF of Dollar Return Variance	-2.346 (0.083)	0.870 (0.280)	-1.029 (0.127)	-0.412 (0.100)	-0.341 (0.134)	-1.749 (0.129)
CDF of Market Value		-3.317 (0.298)				
CDF of Sales			-1.543 (0.133)			
CDF of Assets				-2.400 (0.154)		
CDF of Capital					-2.422 (0.149)	
CDF of Labor						-0.758 (0.171)
Pseudo R^2	0.059	0.069	0.066	0.081	0.082	0.060
	Panel B: Fixed Effects Regressions					
CDF of Dollar Return Variance	-2.546 (0.609)	-2.191 (0.627)	-1.752 (0.625)	-1.142 (0.620)	-1.988 (0.643)	-1.875 (0.640)
CDF of Market Value		-0.868 (0.377)				
CDF of Sales			-2.421 (0.817)			
CDF of Assets				-3.679 (1.149)		
CDF of Capital					-3.220 (0.898)	
CDF of Labor						-2.008 (0.759)
R^2 (excluding fixed effects)	0.048	0.052	0.059	0.082	0.081	0.047
Number of Observations	4,147	4,147	4,145	4,147	3,678	4,073

Notes: This sample is comprised of Core and Guay's executive-year observations, less any observations for which there are missing data in ExecuComp and less any observations for which there are fewer than 48 months of return data. The dependent variable is the CEO's ownership share in the firm through holdings of stock and options (a direct measure of incentives). The independent variables are the CDF of the variance of dollar returns calculated over the preceding five years, the CDF of the market value of equity, the CDF of firm sales, the CDF of the book value of assets, the CDF of firm capital stock (net property, plant, and equipment), and the CDF of firm labor (number of employees). All regressions include year dummies (not reported to conserve space). Panel B includes executive fixed effects. In Panel A, standard errors are based on 20 bootstrap replications. In Panel B, standard errors are robust to heteroskedasticity. All standard errors are in parentheses.

Figure 1
Median Regression Slope Coefficients

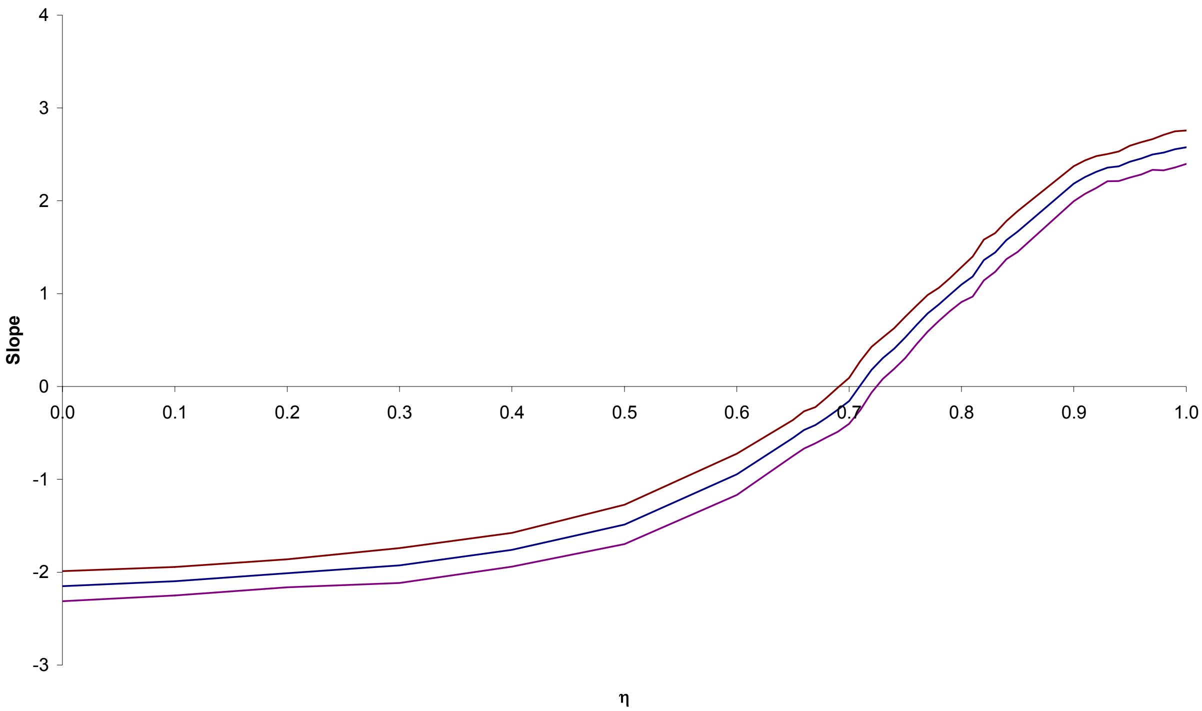

Figure 2
Fixed Effect Regression Slope Coefficients