Incentives, Targeting, and Firm Performance: An Analysis of Non-executive Stock Options

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We examine whether options granted to non-executive employees affect firm performance. Using new data on option programs, we explore the link between broad-based option programs, option portfolio implied incentives, and firm operating performance, utilizing an instrumental variables approach to identify causal effects. Firms whose employee option portfolios have higher implied incentives exhibit higher subsequent operating performance. Intuitively, the implied incentive-performance relation is concentrated in firms with fewer employees and in firms with higher growth opportunities. Additionally, the effect is concentrated in firms that grant options broadly to non-executive employees, consistent with theories of cooperation and mutual monitoring among co-workers. (*JEL* J33, D23, G30, G39, J41, M40, M52, M54)

Stock option grants to non-executive employees have become an important component of compensation policy in recent decades (Mehran and Tracy 2001; Murphy 2003). While there is no firm consensus in the literature as to why options are granted to non-executives, many economic studies of non-executive option programs argue that free-riding among employees will outweigh any incentive effects provided by option compensation. Indeed, non-executive employee options have been referred to as "incentives that have no incentive effects" (Oyer 2004), and several studies of non-executive option programs argue that pay-for-performance is unlikely to be the primary motivation behind these option grants.

The authors thank Anup Agrarwal, Ilona Babenko, Sudheer Chava, Jeff Coles, Alex Edmans, Carola Frydman, Stuart Gillan, Yaniv Grinstein, Camelia Kuhnen, Spencer Martin, Lalitha Naveen, Mark Nelson, Paul Oyer, Nagpurnanand Prabhala, Michael Roberts, Antoinette Schoar, Michael Waldman, Michael Weisbach (the editor), and seminar participants at Arizona State University, Case Western Reserve University, Hong Kong University of Science and Technology, National University of Singapore, Texas A&M University, the London Business School Next Generation Conference, the 18th Annual FEA Conference at NYU, and the FIRS Conference in Anchorage for helpful discussions and comments. Brian Young and Soohyung Kim provided excellent research assistance. The authors are grateful for financial support from the Financial Services Exchange and from the Searle Center at Northwestern University Law School. All errors are our own. Send correspondence to Yael V. Hochberg, Kellogg School of Management, Northwestern University, 2001 Sheridan Road, Evanston, IL 60208-2001; telephone: (847) 467-4574. E-mail: y-hochberg@kellogg.northwestern.edu; Laura Lindsey, W. P. Carey School of Business, Arizona State University, P.O. Box 873906, Tempe, AZ 85207-3906; telephone: (480) 965-0523. E-mail: laura.lindsey@asu.edu.

doi:10.1093/rfs/hhq093 Advance Access publication October 7, 2010

In this study, we shift focus away from the question of why stock options are granted to consider the question of evaluating their effects empirically. Though non-executive option programs may be motivated by reasons other than or in addition to effort enhancement, we ask whether option compensation for non-executive employees, and more specifically, the pay for (firm) performance incentives implied by these programs, affect firm performance. Is it indeed the case that free-riding outweighs any possible provision of incentives in this setting?

Whether stock options enhance firm performance is a question with important implications for corporate decisions regarding workforce compensation, as well as for the financial regulatory environment. There is a common belief among practitioners that reducing the attractiveness of options as a form of compensation for non-executive employees (e.g., expensing stock options in financial statements) will derail an important form of incentive compensation. For example, John Doerr, a partner of venture capital firm Kleiner, Perkins, Caufield, and Byers, noted in 2004 that “If the Financial Accounting Standards Board is allowed to mandate expensing of broad-based options, they’re going to basically go away for 14 million Americans who use them . . . whose companies use them as a way to create a powerful ownership incentive.”[1]

Many academic treatments of non-executive option programs, however, consider grants to company rank-and-file too diffuse to create incentive effects, in contrast to option grants provided to CEOs or other top executives. Stock option grants align the incentives of the worker with increasing the value of the whole firm, rather than with his individual performance (Core and Guay 2001; Oyer 2004; Oyer and Schaefer 2005). Much of the academic literature, following the intuition set forth in Alchian and Demsetz (1972), argues that because these stock options compensate employees for joint performance improvements, employees must share the rewards from higher effort, resulting in dilution of worker incentives and mitigation of additional effort.

Alternative literatures, however, suggest that non-executive options may increase cooperation or induce mutual monitoring among co-workers (Baker, Jensen, and Murphy 1988; Drago and Garvey 1998). In particular, if employees collusively agree to exert high effort and then monitor and sanction their colleagues to enforce the group decision, incentives to exert effort will increase.[2] Group incentive schemes may encourage monitoring and sanctioning because each employee’s actions affect payments to other members of the group. While employees in large groups are often unable to observe each other’s efforts, and theoretical work has argued that they therefore may be less willing to incur the

1 Quoted in *Silicon Beat*, 11/13/2004.

2 Theories of collective action based on sub-game perfection suggest that costly punishment is not credible and will not deter free-riding, regardless of the size or structure of groups. However, evolutionary game theory models have demonstrated that punishing strategies often survive (Sethi 1996; Carpenter and Matthews 2004; Carpenter, Matthews, and Ongonga 2004).

costs of monitoring and sanctioning their colleagues (e.g., Heckathorn 1988; and Kandel and Lazear 1992), recent experimental evidence has found that people will punish free riders even at considerable cost and that punishment does not fall appreciably in large groups (Fehr and Gaechter 2000; Bochet, Page, and Putterman 2006; Carpenter, Bowles, Gintis, and Hwang 2009; and Carpenter 2007). Furthermore, case studies of large organizations employing incentive schemes based on firm-wide performance goals have shown that these schemes can raise employee performance despite the apparent threat of free-riding (Knez and Simester 2001). Under a mutual monitoring framework, therefore, stock options could have a direct incentive effect on firm performance.[3]

Examining the direct effect of implied incentives from option compensation on performance, however, is not straightforward. A firm's past and anticipated performance likely affects the nature of its compensation packages. For example, well-performing firms may enjoy higher market valuations and use non-executive options as a way to take advantage of employee optimism (Liang and Weisbenner 2001; Bergman and Jenter 2007). Poorly performing or research-intensive firms may be more cash constrained, and thus may be more likely to offer options to non-executive employees or offer a greater portion of worker compensation in the form of options (Core and Guay 2001). To isolate the effect of non-executive stock options on firm performance, therefore, we employ an instrumental variables (IV) approach that centers on labor market determinants of option plans and implied incentives.

We examine the relation of non-executive options to subsequent firm operating performance, as measured by the firm's return on assets (ROA). We compute ROA in both the traditional manner, and adjusted to reflect the cost of option compensation as per financial statement footnotes. Because recent work on non-executive option plans has focused primarily on broad-based plans (i.e., plans wherein options are granted to a majority of firm employees), we define an indicator measure for broad-based option compensation following Oyer and Schaefer (2005). As our measure of implied rank-and-file incentives from outstanding options, we calculate the sensitivity of employee wealth to an increase in the underlying value of a firm's stock (i.e., the per-employee delta of the firm's outstanding non-executive option portfolio). One of the constraints in the prior literature in this area has been that ExecuComp, a typical source for option data, allows the researcher to infer only annual grants to non-executive employees, rather than characteristics of the entire portfolio of outstanding options. Using data from the Investor Responsibility Research Center (IRRC) Dilution Database, we are able to observe the characteristics of the

[3] Implied incentives from stock options can affect firm performance through channels other than the provision of effort (see Prendergast 1999 for a review of the literature on incentive pay); alternatives, including sorting and retention, are discussed in Sections 3 and 4. We use the term "implied incentives" to mean the average delta of the option portfolio, and reserve the term "incentive effect" to refer to increased effort provision.

outstanding option portfolio for a broad panel of firms, which allows us to obtain a measure of implied incentives from outstanding rank-and-file employee options.

Controlling for the endogeneity of non-executive stock option compensation, we find that both the existence of a broad-based option plan and the implied incentives of an option plan exert a positive effect on firm performance. While the positive effect of the existence of a broad-based plan could stem from a number of factors, including loyalty or morale, the positive effect of the implied *incentives* on subsequent firm performance suggests that free-riding stemming from an individual employee's inability to substantially affect firm value or profits himself may not fully supersede the direct incentive effects provided by stock options in this setting.

Our findings are not uniform across firms, however, offering some support for the notion of free-riding. Free-riding theories predict that in firms with fewer employees, workers share the rewards for their efforts with fewer colleagues, reducing the free-riding problem. Similarly, we might also expect that the incentives provided by option grants should be most effective in firms where increased employee effort is more likely to have a significant effect on creating real value. When we segment the incentive measure by firms with fewer or greater numbers of workers, we find that the relation between incentives and performance is confined to smaller firms, consistent with the notion that free-riding may counteract the incentive effect in larger firms. We also segment the incentive measure by high- and low-growth opportunities per employee (Core and Guay 2001), and repeat our analysis. We find that non-executive option incentives exert a significant positive influence on performance only in firms with higher individual growth opportunities.

Finally, we examine differences in the implied incentive-performance relation across the distribution of incentives in the firm. In many firms, options are granted broadly, to most if not all employees (Oyer and Schaefer 2005).[4] In other firms, option grants to non-executive employees are targeted toward specific workers or groups. Broadly distributed options may foster cooperation in firms for which knowledge sharing is important, or reinforce mutual monitoring in cases where workers who share similar incentives jointly decide to maximize gains, exerting effort and sanctioning those who shirk. If cooperation and monitoring are important in fostering effort provision, we expect to see a stronger relationship between option incentives and performance in firms that broadly grant options than in those who target options to smaller groups within the firm. When we interact the option portfolio incentives measure with an indicator for broad-based grants to non-executive employees, we find that option incentives are significantly and positively related to performance only

4 The National Center for Employee Ownership (NCEO) estimates that as of 2005, 4,000 U.S. companies had broad-based stock option plans, defined as plans that grant options to 50% or more of company employees.

for the group of firms with broad-based plans. These results provide further evidence consistent with mutual monitoring and cooperation.

A caveat to our analysis is that our data do not allow us to fully distinguish the mechanism through which implied option incentives affect subsequent performance. Improved performance from higher implied option incentives could result through several channels. While better performance may be the result of greater effort, it may also be the case that a greater sensitivity of employee wealth to performance attracts higher-quality workers (Lazear 1986). Further, if the firm's stock price performance is linked to employees' outside employment alternatives, this automatic compensation adjustment would serve to retain employees who might otherwise pursue opportunities outside the firm (Oyer 2004). Our results provide some indication, however, that sorting and retention channels are not likely to be the *sole* mechanisms behind the relation between implied incentives and performance. Under the sorting argument, if greater implied incentives attract higher-quality workers, who provide improved performance regardless of effort, one would expect higher incentives to result in improved industry-adjusted performance across both small and large firms.[5] Moreover, while one could argue that broadly granting firms may be attracting a greater number of high-quality workers or automatically adjusting wages for a greater number of employees, resulting in better retention (and thus better performance), our findings regarding the effect of *aggregate* option portfolio incentives on performance for broad- and non-broad-based plans run counter to this logic. Given at least the same amount of wage sensitivity in a firm with a broad-based option plan and a firm that instead targets those options, the performance effect is present only if the incentives are broadly distributed. That the performance effect differs based on factors that are likely to exacerbate free-riding or encourage cooperation and mutual monitoring suggests that the incentive-performance relation we document is likely to occur at least *partially* through an effort mechanism.

We run a variety of robustness checks to ensure the validity of our findings. Since we do not observe wage compensation directly, one concern is that firms that do not employ stock option plans, or that grant fewer options, utilize cash bonuses as a substitute form of incentive compensation. Since cash bonuses are counted as a wage expense, firms with lower option incentives might then have mechanically lower ROA. While the cost-adjusted measure of ROA controls for option expenses, and therefore addresses this concern to some extent, we also find a positive effect of implied incentives on performance if we examine measures of performance that are not affected mechanically by the use of a particular type of compensation method, such as sales growth.

A second concern may be that prior stock price performance influences option compensation policy and also correctly anticipates future operating

[5] For our results to be consistent with the idea of sorting, one would have to extend the idea to include the efficacy of sorting based on free-riding concerns.

performance. Though this is precisely the type of endogeneity our estimation strategy is designed to address, we repeat our analysis on subsamples based on prior stock price performance to further verify that this is not likely to be the case. When we re-estimate our models on subsamples based on positive or negative prior-year stock price performance or on above- or below-median prior-year stock price performance, we observe a positive and significant coefficient on the incentive measure across all four subsamples. Therefore, it is unlikely that the results we present are merely a result of options being employed primarily in firms with strong stock price performance.

Third, because defining non-executive option delta for all employees other than the top five might overstate non-executive compensation in large firms, we recompute our measure using the same calibration used in Oyer and Schaefer (2005). Specifically, we adjust our measure of non-executive incentives assuming that the top 10% of employees hold a portfolio one tenth as large as the portfolios of the second through fifth most highly paid employees. The relation between implied incentives and firm performance that we document is robust to this second measure of average non-executive delta, ensuring that compensation to lower-level executives is not driving our results.

Finally, we conduct a variety of additional robustness tests to address alternative explanations for our results. We address concerns that our findings could be driven by firms with very few employees, by correlated local shocks to performance, or by management style. Additionally, we confirm robustness to auxiliary performance measures.

Our findings provide new insights into this important form of non-executive compensation. To the best of our knowledge, these findings represent the first evidence of a positive effect on firm performance from implied employee stock option incentives. While causal incentive effects in compensation have been documented to some extent for top executives (see Baker, Jensen, and Murphy 1988 or Murphy 1999 for an overview), and for piece-rate labor (Foster and Rosenzweig 1994; Paarsch and Shearer 1999; and Lazear 2000), our study has broad implications for overall workforce compensation. Importantly, we show that free-riding is likely not the sole operant force in this setting, as some theoretical treatments of the topic suggest.

Our study provides additional support for theories of mutual monitoring and cooperation among co-workers. Previous work on group-based incentive pay has produced mixed results. In an experimental setting, Nalbantian and Schotter (1997) find that participants facing group-based incentives converge to the shirking equilibrium in repeated play. In contrast, Fitzroy and Kraft (1986) note that free-rider arguments neglect the idea of cooperation and group optimization, and find positive effects on productivity in firms using profit sharing plans.[6] Weiss (1987) and Hansen (1997) find that group incentives can

[6] See also Fitzroy and Kraft (1987), Kraft (1991), Fitzroy and Kraft (1995), and Kraft and Ugarkovic (2006).

increase productivity over individual incentive schemes for less productive workers. Hamilton, Nickerson, and Owan (2003) link moves to group-based incentives from individual-based plans to increased productivity, but find productivity diminishes as more workers engage. The finding that option incentives positively affect performance only in firms where the options are granted broadly adds to evidence consistent with cooperation and mutual monitoring among co-workers in a related yet different setting.

Our results are also consistent with general findings in the economics literature about the prevalence of cooperative outcomes. In addition to the team-based compensation studies noted above, which show that free-riding does not always appear as dominant as theory may suggest, the economics literature has repeatedly documented deviations from theoretical predictions in non-cooperative game theory in short horizon games and in managing common resource pools (e.g., Marwell and Ames 1981; Selten and Stoecker 1986; Ochs and Roth 1989; Ostrom 1990; and Ostrom, Gardner, and Walker 1994).

Our work adds a number of new dimensions to research on non-executive option plans. Previous studies that have evaluated performance aspects of non-executive option plans treat the existence of the stock option plan as given. Sesil, Kroumova, Blasi, and Kruse (2002) study differences in financial outcomes for companies that do and do not grant stock options broadly, noting that profitability levels rise as plans are adopted. Hillegeist and Penalva (2003) find a positive link between option-based compensation and performance when option grants are unexpectedly high. In contrast to these studies, our work accounts for the endogenous nature of stock option plans. Other studies, such as Kedia and Mozumdar (2002), examine the relation between the total level of firm stock option grants and firm stock market performance. Our study focuses instead on the operating performance of the firm, thus eliminating concerns about market pricing of these plans. Further, unlike the majority of studies on performance in this area, our data allow us to focus on the effect of stock option implied incentives, rather than granting behavior alone.

Our work also relates to the literature on non-executive stock options that focuses on the rationales for the use of these options in the workplace. Core and Guay (2001) present evidence that firms grant options due to cash and other financial constraints in addition to incentive rationales.[7] Oyer and Schaefer (2005) consider several possible economic justifications for broad-based option programs and conclude that sorting and retention motivations, rather than incentive provision, appear to be most consistent with empirical data. Their framework, however, does not consider the possibility of externalities such as increased cooperation or monitoring. Liang and Weisbenner (2001) and Bergman and Jenter (2007) suggest stock market valuations and employee

[7] Jones, Kalmi, and Makinen (2006) find that smaller firms and those with higher measures of intellectual capital are more likely to have broad-based plans, but find the liquidity constraint evidence mixed.

optimism as rationales for the increased use of non-executive options.[8] Ittner and Lambert (2003) study the determinants of grants in a sample of companies that employ option plans and measure the success of these plans against the company's stated objectives. Hand (2005), using a sample of private firms, argues that compensating too few employees with options may more negatively affect performance than granting too deeply. Our work underscores the idea that implied incentives provided by rank-and-file employee option plans are an important feature of these plans for certain types of firms, even if incentives are not the *primary* motivation for granting options in the first place.

The remainder of the article is organized as follows. Section 1 describes the data and empirical approach used in the study. In Section 2, we present our empirical analysis of the relation of both broad plans and average implied incentives of non-executive stock option portfolios to firm performance. Section 3 considers these effects in relation to factors more likely to accommodate free-riding. In Section 4, we evaluate the relative importance of mutual monitoring by examining the implied incentive-performance relationship for targeted and broad-based option plans. Section 5 discusses alternative explanations and robustness, and Section 6 concludes.

1. Data and Methodology

Our primary data source is the Investors Responsibility Research Center (IRRC) Dilution Database. This database contains company option plan information collected from public filings for firms in the S&P Super 1500, composed of the S&P 500, S&P midcap 400, and S&P small cap 600. Coverage begins in 1997 and extends through 2004, with each year of coverage providing information on the prior year's stock option plans.[9] The IRRC collects information on year-end outstanding grants, weighted average exercise price of options outstanding, and weighted average contractual life of outstanding options, as well as information on new grants and option exercises.[10]

To isolate information on the option portfolios of non-executive employees, we match the data from the IRRC with information on grants and options

[8] Additional rationales for incentive pay include the ability to minimize wages when productivity falls (Inderst and Mueller 2005) and also to motivate employees to invest in themselves (Banker, Lee, Potter, and Srinivasan 2000). See also Oyer and Schaefer (2006) and Babenko and Tserlukevich (2009), who consider tax-based explanations for the granting of non-executive stock options; Landsman, Lang, and Yeh (2005), who examine the role of governance in determining the split of options between executive and non-executive employees; and Babenko, Lemmon, and Tserlukevich (forthcoming), who argue that revenue from option exercises can relax financing constraints.

[9] Because each year of data from IRRC contains two years of lagged data when available for variables of interest, we purchase each third year of data beginning in 1997. As such, our sample approximates the S&P 1500, which is subject to additions and deletions.

[10] There were no major changes in requirements for the accounting of stock options during our sample period, though the debate about expensing did intensify around the passage of the Sarbanes-Oxley Act of 2002. A small number of companies began voluntarily expensing stock options later in the sample, though FASB had issued FAS 123, the recommendation to expense options at fair value, in 1995 (Hall and Murphy 2003).

outstanding for top executives from the Compustat ExecuComp database. Previous studies of non-executive options have employed either small samples of hand-collected data or data from ExecuComp. ExecuComp, however, only provides information on option grants to executives and the percentage of total grants to all employees that are represented by these executive option grants, and does not provide data on the outstanding option portfolio for the whole firm. The IRRC Dilution Database, in contrast, allows us to track the characteristics of the portfolio of outstanding options.[11]

We obtain data on firm operating performance and other financial characteristics from Compustat and use CRSP data to obtain risk-free rate approximations for use in Black-Scholes calculations.

1.1 Variable definitions

Our primary measure of firm performance is operating return on assets before depreciation. Barber and Lyon (1996) argue that this measure is the preferred measure of operating performance because it is unaffected by leverage, extraordinary items, discretionary expenditures, or depreciation policy. For each firm, we compute industry-adjusted ROA, defined as the difference between the firm's ROA in a given year and the median ROA for all sample firms in its Fama-French 30 industry classification.[12] A natural concern might be that these measures are mechanically higher for firms employing option compensation given the accounting treatment of such plans. We therefore additionally recalculate ROA to reflect the cost of options by subtracting the Black-Scholes value of the firm's option grants from net income before dividing by assets. We estimate the Black-Scholes value by taking the total cost of grants as reported in the financial statement footnotes.[13] We make the same adjustment to the rest of the sample when calculating industry and cost-adjusted ROA.

To determine if a firm's non-executive stock option program is broad-based (i.e., grants options to over 50% of employees), we follow the criterion described in Oyer and Schaefer (2005). Because many firms have more than five very-high-ranking employees, which is the required threshold for detailed option compensation reporting, defining non-executive options as all options granted to employees other than the five most highly compensated executives can overstate the level of option grants and incentives for non-executive employees, particularly those in large firms. Oyer and Schaefer (2005), calibrating from a dataset where they can observe option program eligibility directly,

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[11] We find that approximately half (50.2%) of the estimated delta can be attributed to current grants versus previous grants in the portfolio.

[12] Following common convention in the accounting literature, we winsorize our measure of ROA at the 1% level. Our results are robust to other reasonable cutoffs, as well as unwinsorized ROA measures.

[13] We note that this estimate may overstate true costs to the firm since corporate insiders have been shown to exercise options early and also because these options are often illiquid (Huddart 1994; Hemmer, Matsunaga, and Shevlin 1996; Bettis, Bizjak, and Lemmon 2005). We also performed the analysis subtracting only the value of non-executive options to compute adjusted ROA. Results are similar.

assume that the top 10% of employees receive an option grant one-tenth as large as the grants received by the 2nd through 5th most highly paid employees in the firm. They classify a program as broad-based if the residual grants to employees after this adjustment exceed 0.5% of the shares outstanding. We define an indicator variable for the existence of a broad-based plan accordingly.

As a measure of the incentives implied by a firm's portfolio of non-executive stock options, we compute the cumulative option delta, the change in employee wealth for a 1% change in stock price, for each firm, for the firm's non-executive option portfolio outstanding at the end of the year. We use the one-year estimation method for portfolio incentives outlined in Core and Guay (2002).[14] We calculate the incentive measure for the total portfolio of options for all employees using the aggregate number of options outstanding and their associated characteristics at the end of each year. Similarly, we calculate the incentive measure for the portfolio of options held by the top five executives. We subtract the executive incentives measure from the total incentives measure to obtain the portfolio incentives measure for the option portfolio of non-executive employees. We then compute our main measure of incentives averaged on a per-employee basis by dividing the aggregate measure described above by the number of employees (in thousands) for the firm.[15] Because the distribution of incentives may be unequal, we also use the aggregate measure for robustness and further tests. In our models, we are interested in segmenting this incentive measure along dimensions related to the likelihood of free-riding. We use the number of employees to measure labor force size. We also calculate growth options per employee as in Core and Guay (2001), defined as the market value of equity minus the book value of equity divided by the number of employees.

To isolate the performance effects of non-executive stock options, we must control for a variety of firm characteristics that may affect the operating performance of the firm, and in some cases, the granting of options as well. Larger firms and older firms may have different operating performance characteristics than smaller or younger firms, and ROA may differ with firm productivity. We control for firm size using the natural log of the market value of assets, defined as the market value of equity plus the book value of debt.[16] We control for the

14 Core and Guay's (2002) "One-year Approximation" (OA) method values stock options using the Black-Scholes (1973) model, as modified by Merton (1973) to account for dividend payouts. Our data source does not separate aggregate options information by exercisable and non-exercisable options. In essence, we assume all are exercisable at the average time to expiration.

15 We compute two such measures for portfolio incentives: one that is the cumulative incentives for all employees other than the top five executive officers, and one allowing an adjustment for other executives beyond the top five following the logic described in Oyer and Oyer and Schaefer (2005). We assume the top 10% of employees hold a portfolio one-tenth as large as the portfolios of the second through fifth most highly paid employees. For brevity, we report results using only the first measure; however, we obtain similar results using the second measure as well.

16 Our results are robust to employing alternative measures of firm size, such as firm sales.

age of a firm using the natural log of the number of years the firm has been publicly traded and productivity using sales per employee.

Marginal corporate tax rates may also affect the tendency to grant options (Yermack 1995; Dechow, Hutton, and Sloan 1996; Hall and Liebman 2000). Option compensation should be more costly for firms with high marginal tax rates. Firms receive an immediate tax deduction for cash compensation, as opposed to the future tax deduction from deferred compensation instruments such as options. We define indicator variables for firms facing high (HMT) or low (LMT) marginal tax rates as in Core and Guay (2001). HMT takes the value of one if the firm has positive income and no net operating loss carry-forwards in any of the previous three years, and zero otherwise; LMT takes the value of one if the firm has negative taxable income and net operating loss carry-forwards in each of the previous three years, and zero otherwise. We also include an indicator variable for the existence of long-term debt to capture the effects of the tax shields provided by debt.

Option grants may be a preferred method of compensation in companies that are cash constrained, and cash constraints relate to operating performance as well. We include a measure of cash flow shortfall as per Core and Guay (2001), defined as the three-year average of common and preferred dividends plus cash flow used in investing activities less cash flow from operations, all divided by total assets. Additionally, option programs and performance are both influenced by a company's research intensity. We therefore include the three-year average of R&D expenditures, both as a proportion of assets and per employee, as controls. Bushman, Indjejikian, and Smith (1995) suggest that interdependencies among operating units, and therefore aggregate performance measures, increase with firm inter-segment sales, and decrease with greater product market and geographic diversification. We control for the ratio of inter-segment sales to total net sales for the firm. Using data from the Compustat segments file, we define diversification using entropy measures designed to capture dispersion across multiple dimensions. Specifically, product diversification is defined as $\sum_i P_i * ln(1/P_i)$, where P_i is the dollar sales of product i divided by total firm sales. Geographic diversification is similarly defined as $\sum_i G_i * ln(1/G_i)$, where G_i is the dollar value of sales for geographic region i divided by total firm sales.[17]

While it is unlikely that non-executive employees can effectively shift the risk profile of the firm, recent studies suggest that executive incentive contracts may have such an effect in addition to providing incentives (Guay 1999; Coles, Daniel, and Naveen 2008). We therefore include the portfolio delta (the sensitivity of executive wealth to changes in stock price) and vega (the sensitivity of executive wealth to changes in stock price volatility) for the top

17 While physical dispersion of employees across firm locations may play a role in strengthening or weakening mutual monitoring, the Compustat segment data only provides information about sales, rather than physical dispersion, and we are thus unable to explore the physical dispersion of employees.

five company executives, transformed by the natural log. Finally, we include year and industry fixed effects, with industries based on the Fama-French 30 classification.

An important aspect of our research design is that we do not ask whether broad-based plans or non-executive option portfolio incentives are priced. Instead, we focus on the question of how these option plan characteristics affect the operating performance of the firm. Accordingly, we do not include stock-performance-related variables as controls in our analysis. If we were to include such variables, which may already incorporate market pricing of these instruments, we may not discern a performance effect simply because it is already priced into market-related controls.

1.2 Identification

To build an instrumental variables model that will allow us to properly identify the effects of option incentives on firm performance, we require instruments that are correlated with the extent of option grants to non-executive employees and their implied incentives but are uncorrelated with the structural residual of performance. Our goal is not to catalog (nor do we econometrically require) all of the factors that may influence the broad granting of options or option portfolio incentives.

Economic theory suggests that option-granting practices in the local geographic region might affect an individual firm's option usage, through local labor market competition or the influence of fixed-agent peers (e.g., Glaeser, Sacerdote, and Sheinkman 1996). Empirical evidence supports this idea; Kedia and Rajgopal (2009) find that firms grant options more broadly when a higher fraction of firms in the local area grant options broadly. Following this intuition, we construct geography-based measures of non-executive option plan characteristics using the option-granting behavior of local peer firms. A natural concern with such an approach is the possibility of the existence of correlated local shocks to performance. As shown in Engelberg, Ozoguz, and Wang (2010), there is significant correlation in firm fundamentals for industry cluster firms; firm fundamentals exhibit correlation with the fundamentals of other local firms in their industry, and these effects appear to be driven by firms located in an industry cluster. Thus, if our instrumentation strategy were to rely on same-industry peer behavior within the local geographic area, it is possible that the exclusion restriction would be violated. Instead, we rely on the behavior of local *other*-industry firms to construct an instrument for firm option policies. Specifically, for each firm-year in our sample, we calculate the average non-executive option portfolio delta per employee for all companies in the firm's two-digit ZIP code that are *not* within the firm's industry (as defined by 3-digit SIC code).[18] We use this measure as an instrument in

[18] Our results are robust to employing other criteria to define same-industry firms, including 2-digit SIC codes and the Fama-French 30 classification.

specifications involving the per-employee measure of non-executive delta and for the broad-based plan indicator. We also calculate the average cumulative non-executive option portfolio delta for proximate firms (again defined by two-digit ZIP code) outside a firm's industry for use as an instrument in specifications involving the firm's aggregate option incentive measure.

To further ensure that our results are not driven by industry cluster or otherwise correlated geographic performance, we conduct a variety of additional tests. First, our results are robust to excluding all firms located in industry clusters, whether defined as in Kedia and Rajgopal (2009), Engelberg, Ozoguz, and Wang (2010), or Almazan, de Motta, Titman, and Uysal (2010).[19] Second, an additional concern might be that local economic shocks extend beyond the industry cluster. We find that our results are robust to excluding geographic areas where operating performance may be correlated. Furthermore, our results are also robust to the use of alternative identification strategies that omit the geographic portfolio delta instrument. We discuss these robustness tests in detail in Section 5.

As a second instrument, we take the natural log of the number of employees, measured in thousands, at the firm level. Zenger (1994) offers support that smaller firms are more likely to provide incentives to exert effort. It is important to note that this labor force measure is included after controlling for size as measured by the value of assets, so that the well-documented relation between size and performance is held constant. Further, insofar as firms with fewer employees achieve higher levels of performance due to the nature of assets at the firm, for example, the inclusion of initial productivity as measured by sales per employee and the firm's past performance controls for these types of effects.

As an additional instrument, we also add the number of shares outstanding for the firm (in thousands). While companies with large option programs may have a higher number of shares outstanding due to option exercises, Babenko (2009) shows that companies with a large pool of employee options are more likely to make share repurchases, which reduces the number of shares outstanding.[20] While the number of shares outstanding and our option delta measures should be correlated, the number of shares outstanding for a firm should have no relation to operating performance.

In specifications with multiple endogenous regressors, we expand our instrument set to achieve stronger identification. In these specifications, the

[19] Almazan, de Motta, Titman, and Uysal (2010) define clusters based on a 10% market share threshold with at least three firms in the industry and also a 3% market share threshold with at least ten firms in the industry, where industry is defined by 3-digit SIC code. Engelberg, Ozoguz, and Wang (2010), also using 3-digit SIC codes, define a cluster as more than ten firms in an industry in the same MSA. Kedia and Rajgopal (2009) use 2-digit SIC codes and require both that firms within an MSA have greater than 10% of industry market share and that the industry have 10% market share within the MSA.

[20] Because companies might make share repurchases in anticipation of improved performance, we re-estimate our models for the subsamples of firm-years with increasing shares outstanding and decreasing shares outstanding. Results are qualitatively similar, suggesting our results are not an artifact of share repurchases in anticipation of future high performance.

non-executive delta measure is split according to labor force size and growth options per employee. For these specifications, we construct additional geography-based instruments split along the same dimensions. For firms with smaller labor forces, an additional average near-firm delta is computed for proximate firms with less than the median number of employees; for firms with larger labor forces, this new instrument is computed for proximate firms with above-median numbers of employees. We construct a similar near-firm cohort delta based on above- and below-median growth options per employee.[21]

To achieve greater confidence in the exclusion restriction required for identification, we over-identify each specification in the article. While there exists no true test of exogeneity (since instruments would need to be orthogonal to the inherently unobservable structural residual), over-identification tests such as the Hansen-J statistic allow for tests of *statistical* exogeneity. The over-identification tests are tests of the joint null hypothesis that the model is correctly specified and that the set of instruments is valid (i.e., the instruments offer no additional explanatory power beyond the included controls and are therefore uncorrelated with the error) (see Davidson and McKinnon 1993, p. 235).

In addition to the exclusion restriction, consistency of an instrumental variables approach in finite samples requires that instruments correlate “strongly” with the endogenous first-stage variable(s) (Staiger and Stock 1997). As noted by Stock and Yogo (2002), different estimators have different properties when instruments are weak, such that the bounds for establishing sufficiently strong instruments for identification vary with the estimation method. We therefore estimate our models using limited information maximum likelihood (LIML), wherein maximal relative bias (worst-case asymptotic bias greater than some threshold value) is zero, offering more attractive finite sample properties than traditional estimators such as two-stage least squares or the more efficient 2-step GMM.[22] Our tests for instrument strength rely on thresholds for maximal size bias (a worst-case rejection rate for the null of the coefficient equaling zero). Importantly, our estimates of coefficients of interest and statistical significance levels do not vary substantially across estimation methods, rendering a formal comparison of estimation methods unnecessary.

1.3 Descriptive statistics

Table 1 presents the number of observations, mean, median, and standard deviation of each of the above variables for the sample. Data are reported in

21 For specifications where incentives are segmented by the breadth of the option program, we cannot construct an instrument analogously since option program breadth is an endogenous choice. We can include as an instrument a measure for the proportion of the firms in the area with broad-based plans and obtain similar results to those reported, but this instrument does not aid in identification.

22 We additionally considered only single-equation estimation methods. Full system methods such as FIML are more sensitive to specification, in that any misspecification will lead to inconsistent estimates across all equations. Further, in a system for which only a single equation is overidentified, FIML degenerates to LIML (see Davidson and McKinnon 1993, pp. 644, 660).

thousands, where applicable, except for the non-executive delta measure, which is reported in tens of millions of dollars (in order to produce readable coefficients in the tables). Of the 9,650 firm-year observations with complete data from Compustat and ExecuComp, 44.1% are from firms that grant options

Table 1
Descriptive Statistics

Panel A: Summary Statistics

Variable	*N*	Mean	Median	Std. Dev.
BROADPLAN	9650	0.4412	0	0.4966
NONEXEC DELTA PER EMPLOYEE	6315	0.0761	0.0141	0.5706
NONEXEC DELTA (AGGREGATE)	6354	0.6039	0.0978	2.8668
IND. ADJUSTED ROA	9647	0.0024	0.0006	0.0946
BS & IND. ADJUSTED ROA	9646	0.0009	0.0006	0.0968
R&D	9650	0.0339	0.0000	0.0678
CASH FLOW SHORTFALL	9650	−0.0877	−0.0782	0.0952
LONG-TERM DEBT	9650	0.8570	1	0.3501
MARKET VALUE ASSETS (LN)	9516	7.6031	7.3792	1.5711
SALES PER EMPLOYEE	9567	0.3081	0.1985	0.7005
R&D PER EMPLOYEE	9345	0.0110	0	0.0280
PRODUCT DIV	9650	0.3621	0	0.4671
GEOGRAPHIC DIV	9650	0.4054	0.2381	0.4609
INTERSEGMENT REL	9650	0.0054	0	0.0335
LMT	9650	0.0343	0	0.1820
HMT	9650	0.3102	0	0.4626
TOP5 DELTA	9650	9.4076	11.620	5.2747
TOP5 VEGA	9650	8.3236	10.233	4.7927
AGE	9650	22.166	15	19.547
NEAR FIRM NON-IND. AVG DELTA	6369	0.0694	0.0353	0.1377
NEAR FIRM NON-IND. AGG DELTA	6405	0.5925	0.3398	0.8994
SHARES OUTSTANDING	9645	157.65	43.103	505.01
NUMBER OF EMPLOYEES	9567	17.832	4.9510	44.140
GROWTH OPTIONS / EMPLOYEE	9434	424.14	110.95	1365.2

Panel B: Differences in Means

Variable	Mean BROAD Sample	Mean NON-BROAD Sample	*P*-value For Difference
BROADPLAN	1	0	N/A
NONEXEC DELTA PER EMPLOYEE	0.1131	0.0175	0.0000
NONEXEC DELTA (AGGREGATE)	0.5791	0.6426	0.3411
IND. ADJUSTED ROA	0.0062	−0.0006	0.0004
BS & IND. ADJUSTED ROA	0.0043	−0.0018	0.0024
R&D	0.0376	0.0309	0.0000
CASH FLOW SHORTFALL	−0.0857	−0.0893	0.0580
LONG-TERM DEBT	0.8347	0.8746	0.0000
MARKET VALUE ASSETS (LN)	7.4076	7.7575	0.0000
SALES PER EMPLOYEE	0.3531	0.2720	0.0000
R&D PER EMPLOYEE	0.0136	0.0090	0.0000
PRODUCT DIV	0.3409	0.3788	0.0001
GEOGRAPHIC DIV	0.4443	0.3747	0.0000
INTERSEGMENT REL	0.0060	0.0049	0.1162
LMT	0.0348	0.0339	0.8265
HMT	0.3175	0.3043	0.1652
TOP5 DELTA	9.2980	9.4942	0.0686
TOP5 VEGA	8.3816	8.2778	0.2904
AGE	20.386	23.572	0.0000

Continued

Table 1
Continued

Panel B: Differences in Means

Variable	Mean BROAD Sample	Mean NON-BROAD Sample	*P*-value For Difference
NEAR FIRM NON-IND. AVG DELTA	0.0751	0.0605	0.0000
NEAR FIRM NON-IND AGG DELTA	0.6031	0.5759	0.2523
SHARES OUTSTANDING	129.40	179.98	0.0000
NUMBER OF EMPLOYEES	8.3936	25.401	0.0000
GROWTH OPTIONS / EMPLOYEE	511.50	354.06	0.0000

The unit of analysis is a firm-year. Panel A presents summary statistics for the full sample. Panel B presents means and *p*-values for differences in means for subsamples based on firms with and without broad-based option plans. *BROADPLAN* is an indicator variable that takes the value 1 if the company had a broad-based employee option plan, 0 otherwise; *NONEXEC DELTA PER EMPLOYEE* is the estimated wealth increase for the employees other than the top five executives from a 1% change in stock price divided by the number of employees; *NONEXEC DELTA* is the estimated wealth increase for the employees other than the top five executives from a 1% change in stock price; *IND. ADJUSTED ROA* is industry adjusted return on assets before depreciation; *BS & IND. ADJUSTED ROA* is the industry- and Black-Scholes expense-adjusted return on assets before depreciation; *R&D* is the three-year average for R&D expenses; *CASH FLOW SHORTFALL* is the three-year average of common and preferred dividends plus cash flow used in investing activities less cash flow from operations, divided by total assets; *LONG-TERM DEBT* is an indicator variable equal to 1 if the company had long-term debt, 0 otherwise; *MARKET VALUE ASSETS* is the natural log of the market capitalization of the firm's equity plus the book value of debt; *SALES PER EMPLOYEE* is the ratio of sales to number of employees; *R&D PER EMPLOYEE* is the three-year average of the ratio of R&D expenses to the number of employees; *PRODUCT DIV* measures product diversification using the number of firm segments; *GEOGRAPHIC DIV* measures geographic diversification using the number of geographic segments; *INTERSEGMENT REL* measures the relatedness of the firm's segments; *LMT* is an indicator variable that takes the value 1 if the company had a low marginal tax rate, 0 otherwise; *HMT* is an indicator variable that takes the value 1 if the company had a high marginal tax rate, 0 otherwise; *TOP5 DELTA* is the estimated wealth increase for the top five executives from a 1% change in stock price; *TOP5 VEGA* measures the sensitivity of compensation of the top five executives to volatility; AGE is the number of years the firm has been public; *NEAR FIRM NON-IND AVG DELTA* is the per-employee non-executive incentive averaged across firms in the same two-digit ZIP code excluding the firm itself and others in its industry; *NEAR FIRM NON-IND AGG DELTA* is the aggregate non-executive incentive averaged across firms in the same two-digit ZIP code excluding the firm itself and others in its industry; *SHARES OUTSTANDING* is the number of common shares; *NUMBER OF EMPLOYEES* is the number of employees; *GROWTH OPTIONS / EMPLOYEE* is market of assets value less book value of assets divided by the number of employees.

broadly to employees. We can calculate the per-employee non-executive option portfolio incentives measure for 6,315 firm-year observations (6,354 for the aggregate measure), and the measure of other-industry near-firm portfolio incentives is available for 6,369 (6,405) observations.

In Panel B of Table 1, we segment the sample according to whether a firm's plan is broad-based, presenting the means and *p*-values for the differences in means for each variable across subsamples. Firms with broad-based plans have higher per-employee incentives, on average, but, strikingly, there is no statistical difference in the average aggregate employee incentives between firms with broad plans and firms that target their options to a smaller fraction of the workforce.[23] Firms with more extensive option plans have intuitive

23 Differences in median tests indicate that firms that do not grant broadly have higher pay for performance sensitivities.

characteristics: they are smaller, younger, more productive, have higher research intensities, greater cash flow shortfalls, and a lower incidence of long-term debt. These firms also tend to have less diverse product lines, more diversity in firm geographic segments, and marginally more interdependencies among segments. Interestingly, the top five executives of such firms have a lower pay-to-performance sensitivity, though such differences could be driven by size effects. There is no statistical difference in the high and low marginal tax rate indicators or in the average executive option portfolio vega across the subsamples. Notably, in the univariate, industry-adjusted ROA is higher for firms with broad-based plans, as is cost and industry-adjusted ROA.

1.4 Naïve OLS

For comparison with later models, we present results from OLS regressions of firm performance on our non-executive option plan measures and control variables in Table 2. The dependent variable is industry-adjusted ROA, both with and without a cost of options adjustment.[24] In Columns 1 and 2, the option plan variable of interest is the indicator for BROADPLAN from the prior year. Results for the average employee incentives implied by the non-executive stock option portfolio are reported in Columns 3 and 4. As controls, we include prior-year firm operating performance, 3-year average R&D expenditures, 3-year average R&D expenditures per employee, 3-year average cash flow shortfall, a long-term debt indicator, firm product diversification, firm geographic diversification, firm inter-segment relatedness, the indicator for low marginal tax rate, the indicator for high marginal tax rate, and the delta and vega of the option portfolio of the top five executives in the firm.[25] We also include controls for firm size as measured by market value of assets, productivity as measured by sales per employee, age, and industry and year fixed effects. Our dataset is an unbalanced panel. Standard errors are White (1980) heteroskedastic-consistent, clustered at the firm level.

In the naïve OLS specifications, there is either an insignificant or weakly positive coefficient on the indicator for having a broad-based plan, and neither of the coefficients on the non-executive implied incentive measures are statistically significant.[26] Intuitively, higher R&D expenditures are associated with

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24 We specify ROA as the dependent variable with lagged ROA as an independent variable rather than specify change in ROA as the dependent variable, which constrains the coefficient on the lagged measure to one. To alleviate concerns about potential simultaneity with the lagged value, we note that our specifications are robust to substituting the second lag, which is predetermined, as well as to defining changes in ROA over this time period as the dependent variable and omitting the lag as a control.

25 We note that the coefficients on the last two variables should be regarded as correlations throughout the analysis. In the instrumental variable specifications, inclusion of additional variables that may be endogenous potentially biases coefficients on the variables of interest. Our results are robust to excluding executive delta and vega as controls from both equations, as well as including them in the performance equation only. We therefore do not believe their inclusion to be a concern.

26 The significant coefficient in the industry and cost-adjusted ROA specification for broad-based plans is driven primarily by the negative relation between top five executive compensation and broad-based plans. When we cost-adjust for non-executive options only, for example, the coefficient is not significantly different from zero.

Table 2
Non-executive Option Plans and Firm Performance: Ordinary Least Squares

Dependent Variable	1 IND ADJUSTED ROA	2 BS & IND ADJUSTED ROA	3 IND ADJUSTED ROA	4 BS & IND ADJUSTED ROA
BROADPLAN	0.0018	0.0021*	N/A	N/A
	(1.50)	(1.69)		
NONEXEC DELTA PER EMPLOYEE	N/A	N/A	0.0015	−0.0009
			(1.25)	(−0.66)
LAGGED PERFORMANCE	0.7558***	0.7444***	0.7714***	0.7621***
	(47.89)	(46.31)	(52.06)	(51.33)
R&D	−0.0418	−0.0509*	−0.0577*	−0.0880**
	(−1.45)	(−1.74)	(−1.66)	(−2.37)
CASH FLOW SHORTFALL	−0.0031	−0.0054	0.0030	0.0009
	(−0.32)	(−0.54)	(0.26)	(0.08)
LONG-TERM DEBT	0.0008	0.0005	−0.0023	−0.0029
	(0.32)	(0.18)	(−0.88)	(−1.07)
MKT VALUE ASSETS	0.0020***	0.0019***	0.0027***	0.0025***
	(3.71)	(3.56)	(5.02)	(4.45)
SALES PER EMPLOYEE	−0.0032***	−0.0031***	−0.0036***	−0.0036***
	(−2.88)	(−2.75)	(−4.37)	(−4.42)
R&D PER EMPLOYEE	−0.2383***	−0.2590***	−0.0920	−0.0491
	(−3.66)	(−3.93)	(−1.29)	(−0.62)
PRODUCT DIV	−0.0354***	−0.0033**	−0.0026**	−0.0024*
	(−2.68)	(−2.44)	(−2.01)	(−1.79)
GEOGRAPHIC DIV	0.0009	0.0007	0.0007	0.0004
	(0.55)	(0.43)	(0.39)	(0.24)
INTERSEGMENT REL	0.0016	−0.0013	−0.0082	−0.0111
	(0.15)	(−0.11)	(−0.81)	(−1.07)
LMT	0.0080	0.0102	0.0000	0.0007
	(1.09)	(1.29)	(0.01)	(0.08)
HMT	0.0015	0.0022	0.0012	0.0018
	(1.10)	(1.52)	(0.86)	(1.18)
TOP5 DELTA	0.0025***	0.0014**	0.0021***	0.0012**
	(4.53)	(2.46)	(3.54)	(2.04)
TOP5 VEGA	−0.0029***	−0.0018***	−0.0024***	−0.0016**
	(−4.82)	(−2.94)	(−3.82)	(−2.45)
LNAGE	−0.0011	−0.0011	−0.0007	−0.0005
	(−1.49)	(−1.51)	(−0.91)	(−0.56)
Intercept	−0.0037	−0.0011	−0.0148**	−0.0028
	(−0.74)	(−0.22)	(−2.20)	(−0.15)
N	9188	9188	6159	6160
F(51,1233-1472)	107.03	100.84	110.87	101.52
Prob > F	0.0000	0.0000	0.0000	0.0000

This table presents the results of OLS estimations of operating performance on two measures of a firm's non-executive option plan. The unit of analysis is a firm-year. Variables are defined as in Table 1; year and industry controls are included but not reported. Standard errors are White heteroskedasticity-adjusted and are clustered for the same company (Rogers 1993). We report *t*-statistics in parentheses. *, **, or *** mean the coefficient is significant at the 10%, 5%, or 1% level, respectively.

lower levels of performance. Larger firms and firms with higher previous performance tend to perform better, as do firms with larger implied incentives for top executives. Higher pay sensitivity to increased volatility among the top executives, however, is associated with lower levels of performance, as are firms with higher sales per employee and greater product diversification. The general lack of significance of non-executive option plans and their incentives in the naïve model, at first glance, is consistent with the commonly held view that these plans do not have a significant performance effect. Of course, the OLS specifications are also consistent with firms optimally setting option plans and incentives to balance benefits and costs. As noted by Demsetz and Lehn (1985), if a naïve empirical specification (OLS, for example) adequately captures the effects of all relevant exogenous variables (i.e., those structural parameters that drive both option portfolio incentives and performance), that specification would be unlikely to detect any relation between the jointly determined endogenous variables for value-maximizing firms.

2. Broad-based Plans, Implied Incentives, and Firm Performance

To examine the effect of broad-based plans and option incentives implied by the total outstanding non-executive employee option portfolio on realized firm operating performance, we allow for the endogeneity of the option plan measures using an IV approach. We first analyze the effect of a broad-based plan on firm performance, followed by analysis of the effects of implied incentives on firm performance.

2.1 Broad-based plans and firm performance

We begin by examining the effect of the existence of a broad-based option plan on firm performance. The "first-stage" model is a linear probability model predicting the presence of a broad-based option plan using the exogenous instruments and all explanatory variables from the performance equation, while the "second-stage" model predicts firm performance.[27] We use two measures of performance: industry-adjusted ROA and cost and industry-adjusted ROA. As excluded instruments, we employ the first three instruments described in Section 1.2: the mean non-executive option portfolio delta for firms in the company's geographic region that are not in the firm's industry, the natural logarithm of the number of employees at the company, and the number of shares outstanding. The control variables are as described in Section 1.4. Once again, our dataset is an unbalanced panel and standard errors are White (1980) heteroskedastic-consistent, clustered at the firm level. We estimate both stages of the model jointly using limited information maximum likelihood (LIML).

Results of the estimations are presented in Table 3, with the system for industry-adjusted ROA reported in Columns 1 and 2 and the system for cost- and industry-adjusted ROA reported in Columns 3 and 4. The Hansen-J test statistics for over-identification fail to reject the null of valid instruments,

[27] Qualitatively similar results obtain when estimating the performance equation with a fitted value from a first-stage probit. Though the indicator variable for having a broad-based plan is binary, consistency of instrumental variables estimation does not depend on the functional form of the "first-stage" equation; moreover, estimating the first stage as a probit requires the stronger assumption that the first stage is correctly specified (Angrist and Krueger 2001).

Table 3
Broad Plan and Firm Performance: Instrumental Variables Approach

Dependent Variable	1 BROADPLAN	2 IND ADJUSTED ROA	3 BROADPLAN	4 BS & IND ADJUSTED ROA
BROADPLAN	N/A	0.0259***	N/A	0.0225***
		(4.20)		(3.49)
LAG PERFORMANCE	0.3260***	0.7541***	0.2796***	0.7473***
	(3.68)	(47.33)	(3.23)	(47.70)
R&D	0.2112	−0.0717**	0.2118	−0.0973***
	(1.28)	(−2.07)	(1.27)	(−2.63)
CASH FLOW SHORTFALL	−0.0551	0.0050	−0.0650	0.0024
	(−0.57)	(0.41)	(−0.68)	(0.19)
LONG-TERM DEBT	0.0155	−0.0009	0.0135	−0.0016
	(0.72)	(−0.35)	(0.63)	(−0.58)
MKT VALUE ASSETS	0.0225**	0.0056***	0.0236**	0.0050***
	(2.19)	(6.05)	(2.30)	(5.29)
SALES PER EMPLOYEE	−0.0216**	−0.0042***	−0.0216**	−0.0041***
	(−2.56)	(−9.21)	(−2.55)	(−8.62)
R&D PER EMPLOYEE	−0.1872	−0.1486*	−0.1965	−0.1115
	(−0.52)	(−1.90)	(−0.53)	(−1.29)
PRODUCT DIV	−0.0197	−0.0013	−0.0201	−0.0015
	(−1.23)	(−0.90)	(−1.26)	(−1.02)
GEOGRAPHIC DIV	0.0419**	−0.0006	0.0420**	−0.0008
	(2.42)	(−0.35)	(2.42)	(−0.42)
INTERSEGMENT REL	0.3337*	−0.0127	0.3308*	−0.0161
	(1.66)	(−1.17)	(1.65)	(−1.50)
LMT	−0.0307	0.0006	−0.0357	0.0011
	(−0.99)	(0.08)	(−1.14)	(0.12)
HMT	0.0309*	−0.0000	0.0325*	0.0007
	(1.86)	−(0.01)	(1.95)	(0.45)
TOP5 DELTA	−0.0629***	0.0035***	−0.0630***	0.0024***
	(−9.01)	(5.05)	(−9.00)	(3.42)
TOP5 VEGA	0.0526***	−0.0036***	0.0526***	−0.0026***
	(6.95)	(−4.98)	(6.94)	(−3.55)
LNAGE	−0.0234**	0.0006	−0.0236**	0.0009
	(−2.34)	(0.67)	(−2.37)	(0.96)
NEAR FIRM NON-IND.	0.0840**	N/A	0.0835**	N/A
DELTA	(2.15)		(2.13)	
LN NUMBER	−0.1851***	N/A	−0.1858***	N/A
EMPLOYEES	(−16.24)		(−16.33)	
SHARES OUT	0.0047***	N/A	0.0048***	N/A
	(3.52)		(3.58)	
Intercept	1.0276***	−0.0750***	1.0198***	−0.0650***
	(8.51)	(−4.70)	(8.50)	(−3.99)
N	6209		6208	
Joint Test of excluded instruments /	F(3,1235) = 93.95	Prob > F = 0.00	F(3,1235) = 94.82	Prob > F = 0.00
Hansen J Chi2∼(1)	1.090	p-val = 0.5799	2.085	p-val = 0.3526
	F(53,1235) = 38.85 Prob > F = 0.00	F(51,1235) = 103.86 Prob > F = 0.00	F(53,1235) = 38.63 Prob > F = 0.00	F(51,1235) = 96.96 Prob > F = 0.00

This table presents the results of LIML estimation of industry-adjusted performance and an indicator variable for a broad-based option plan. The unit of analysis is a firm-year. Columns I and III present the results of the first equation linear probability model, where the dependent variable is *BROADPLAN*. Columns II and IV present the estimates of the main model with *BROADPLAN* endogenized. The excluded instruments are *NEAR FIRM NON-INDUSTRY DELTA*, defined as the per-employee non-executive incentive averaged across firms in the same two-digit ZIP code excluding the firm itself and others in its industry; *EMPLOYEES*, defined as the natural log of the number of employees; and *SHARES OUT*, the number of common shares outstanding. Additional variables are defined as in Table 1; year and industry controls are included but not reported. Standard errors are White heteroskedasticity-adjusted and are clustered for the same company (Rogers 1993). We report *Z*-scores in parentheses. *, **, or *** mean the coefficient is significant at the 10%, 5%, or 1% level, respectively.

increasing confidence that the instruments are exogenous. Staiger and Stock (1997) note, however, that having valid instruments that meet the exclusion restriction is not sufficient to ensure consistent two-stage estimators in finite samples. The instruments also have to be "strong" in the sense that they correlate "strongly" with the endogenous first-stage variable.[28] In our model, the joint test of significance for the excluded instruments far exceeds critical values for 10% maximal size distortion, indicating that weak identification is unlikely to be a concern.

Columns 1 and 3 in Table 3 present the estimates for the first-stage model obtained from LIML estimation of the combined system of first- and second-stage equations using each of the two operating performance measures. In both columns, we observe that the number of employees is highly negatively correlated with the presence of a broad-based option plan while other-industry near-firm average per-employee delta and shares outstanding are significantly positively related to the existence of such plans. Larger firms, as measured by assets, and firms with better prior operating performance are positively associated with such plans. Younger firms, less productive firms, firms with greater geographic diversification, firms with more related operating segments, and firms with higher tax rates are also associated with having a broad-based option program. Interestingly, a higher pay-to-performance sensitivity for the top five executives is negatively related to having a broad-based plan, and a higher sensitivity to volatility for the top executives is positively related to having a broad-based plan.

Columns 2 and 4 in Table 3 present estimates for the second-stage performance equations. For both measures of operating performance, we find a strong, positive, and statistically significant relationship between the presence of a broad-based stock option plan for rank-and-file employees and subsequent firm operating performance. Having a broad-based plan is associated with a subsequent 2.59-percentage-point increase in industry-adjusted ROA, and a 2.25-percentage-point increase in cost- and industry-adjusted ROA.[29] The coefficients on the control variables are intuitive. Average R&D expenditure is significantly and negatively related to firm operating performance, and larger firms are positively associated with performance. Productivity leads to lower ROA after controlling for size and past performance, which may reflect that more productive firms, as measured by sales per employee, are often more physical-capital-intensive than human-capital-intensive firms. The delta of the top five executives' option portfolio is positively related to performance, while

[28] The recommended "rule of thumb" critical value of 10 for an F-test of joint instrument significance in the first stage has since been shown to correspond to bias and size distortion of no greater than 10%. Moreover, appropriate critical values vary according to the number of endogenous regressors, number of excluded instruments, and the estimation method (Stock and Yogo 2002).

[29] While this total effect may seem large, the coefficient on the indicator for broad-based plans would encompass all benefits associated with such plans, including incentive, retention, sorting, and behavioral explanations. Further, the magnitude reflects a binary change, though the indicator is calculated from a continuous variable.

the vega is negatively related to performance. Other controls, such as geographic market diversification, intersegment relationships, cash flow shortfall, long-term debt, marginal tax rates, and the age of the firm, exhibit no significant relationship to performance in the models.

The estimates from the models in Table 3 thus imply that the existence of a broad-based plan positively affects firm performance. There is a growing literature on employee loyalty and satisfaction, the ideas from which would be consistent with a positive effect from broad-based plans regardless of incentives (e.g., Benabou and Tirole 2003; Carlin and Gervais 2007; Cohen 2007; or Edmans 2010). These interpretations, however, have limited applicability to relating pay-for-performance sensitivity itself to improved operating performance. We therefore proceed to examine precisely such a relationship.

2.2 Implied incentives from non-executive options and firm performance

If option plans effectively increase effort provision, we would expect a causal relation between implied incentives and performance as well. Our next specification, therefore, endogenizes the implied per-employee incentives (delta) of the non-executive stock option portfolio. The "first-stage" model predicts the implied option incentive measure from the year prior using the exogenous instruments and all explanatory variables from the performance equation, while the "second-stage" model predicts firm performance. Excluded instruments and controls are the same as in the broad-based specification reported above. Results are reported in Table 4.

As can be seen from the estimates of the first-stage model presented in Columns 1 and 3 of Table 4, the natural logarithm of the number of employees in the firm is significantly and negatively related to the incentive measure, and the average option portfolio delta for other-industry firms in the near geographic region is positively related to per-employee incentives.[30] The F-statistic for the joint significance of the instruments exceeds the Stock-Yogo threshold for 10% maximal size (Stock and Yogo 2002), suggesting our instruments are collectively strong. Once again, as was the case for the models employing the broad plan indicator, Hansen-J test statistics for over-identification fail to reject the null of valid instruments.

The estimates from the second-stage models, presented in Columns 2 and 4 of Table 4, support the hypothesis that the implied incentives of the option portfolio positively affect firm operating performance. The coefficient on the non-executive option portfolio delta is positive and statistically significant at the 95% confidence level. The economic effect is non-negligible: Holding all other variables constant, a move from the 25th percentile of per-employee delta

30 Though the *p*-value (11.6%) on the coefficient indicates borderline statistical significance, instrument redundancy tests show that the model is overidentified: we can reject with 95% confidence that the instrument is redundant. The shares outstanding instrument offers no additional power in identifying this specification, though we include it for consistency with later models. Similar results obtain when excluding this instrument from the specification.

Table 4
Implied Incentives and Firm Performance: Instrumental Variables Approach

Dependent Variable	1 AVG NON EXEC DELTA	2 IND ADJUSTED ROA	3 AVG NON EXEC DELTA	4 BS & IND ADJUSTED ROA
AVERAGE NON EXEC DELTA	N/A	0.0439***	N/A	0.0383**
		(2.84)		(2.54)
LAG PERFORMANCE	−0.0241	0.7658***	−0.248	0.7566***
	(−0.16)	(47.20)	(−0.17)	(47.41)
R&D	−0.8464***	−0.0281	−0.8468***	−0.0594
	(−3.53)	(−0.75)	(−3.52)	(−1.47)
CASH FLOW SHORTFALL	−0.2653	0.0163	−0.2650	0.0121
	(−1.42)	(1.19)	(−1.43)	(0.87)
LONG-TERM DEBT	−0.0328	0.0001	−0.0327	−0.0000
	(−1.03)	(0.28)	(−1.02)	(−0.00)
MKT VALUE ASSETS	0.0901***	0.0023***	0.0901***	0.0022***
	(3.49)	(3.86)	(3.50)	(3.55)
SALES PER EMPLOYEE	−0.0044	−0.0045***	−0.0044	−0.0045***
	(−0.65)	(−11.61)	(−0.65)	(−10.74)
R&D PER EMPLOYEE	2.3470***	−0.2536**	2.3432***	−0.2024*
	(3.83)	(−2.46)	(3.78)	(−1.84)
PRODUCT DIV	0.0005	−0.0017	0.0005	−0.0018
	(0.03)	(−1.14)	(0.03)	(−1.23)
GEOGRAPHIC DIV	−0.0065	0.0008	−0.0065	0.0004
	(−0.40)	(0.43)	(−0.41)	(0.23)
INTERSEGMENT REL	0.0525	−0.0045	0.0525	−0.0092
	(0.99)	(−0.45)	(0.99)	(−0.88)
LMT	−0.0499	0.0021	−0.0501	0.0023
	(−1.19)	(0.28)	(−1.20)	(0.25)
HMT	−0.0279**	0.0023	−0.0279**	0.0027*
	(−2.00)	(1.46)	(−1.99)	(1.68)
TOP5 DELTA	0.0032	0.0017***	0.0032	0.0008
	(0.60)	(2.63)	(0.62)	(1.24)
TOP5 VEGA	−0.0023	−0.0021***	−0.0023	−0.0012*
	(−0.36)	(−3.00)	(−0.37)	(−1.79)
LNAGE	0.0002	0.0000	0.0002	0.0004
	(0.04)	(0.04)	(0.04)	(0.44)
NEAR FIRM NON-IND. DELTA	0.0670	N/A	0.0669	N/A
	(1.57)		(1.57)	
LN NUMBER EMPLOYEES	−0.1098***	N/A	−0.1098***	N/A
	(−3.62)		(−3.63)	
SHARES OUT	0.0010	N/A	0.0010	N/A
	(0.61)		(0.60)	
Intercept	−0.6173***	−0.0219**	−0.6174***	−0.0189**
	(−2.64)	(−2.53)	(−2.49)	(−2.16)
N	6160		6159	
Joint Test of excluded instruments /	F(3,1233) = 6.85	Prob > F = 0.00	F(3,1233) = 6.96	Prob > F = 0.00
Hansen J Chi2∼(1)	1.19	p-val = 0.5515	2.34	Pval = 0.3100
	F(53,1233) = 7.77 Prob > F = 0.00	F(51,1233) = 96.26 Prob > F = 0.00	F(52,1233) = 7.78 Prob > F = 0.00	F(51, 1233) = 88.93 Prob > F = 0.00

This table presents the results of LIML estimation of industry-adjusted performance and average non-executive delta. The unit of analysis is a firm-year. Columns I and III present the results of the first equation estimation, where the dependent variable is the measure of incentives. Columns II and IV present the estimates of the main model with measures of incentives endogenized. The excluded instruments are *NEAR FIRM NON-INDUSTRY DELTA*, defined as the per-employee non-executive incentive averaged across firms in the same two-digit ZIP code excluding the firm itself and others in its industry; *EMPLOYEES*, defined as the natural log of the number of employees; and *SHARES OUT*, the number of common shares outstanding. Additional variables are defined as in Table 1; year and industry controls are included but not reported. Standard errors are White heteroskedasticity-adjusted and are clustered for the same company (Rogers 1993). We report Z-scores in parentheses. *, **, or *** mean the coefficient is significant at the 10%, 5%, or 1% level, respectively.

to the 75th percentile of per-employee delta implies an increase of 0.17% in ROA and a 0.15% increase in cost-adjusted ROA. One can also consider the economic magnitude of the effect in terms of the impact of dollar changes in per-employee delta. The effect we estimate is approximately a 0.4-percentage-point change in industry-adjusted ROA for every $1,000 increase in per-employee delta. Since the average per-employee delta in our sample is about $760, a $1,000 increase represents a little over a doubling of pay-to-performance sensitivity. The signs of the coefficients on the control variables remain similar to those observed in the previous estimations, with the exception of the high marginal tax rate control in the first stage, which is negatively associated with per-employee delta. The estimates in Table 4 are consistent with a positive effect of per-employee implied option portfolio incentives on firm operating performance. Note that the causal estimates we find do not necessarily imply that a firm can improve performance by increasing implied incentives, but rather that implied incentives improve performance for firms in which they are employed.

3. Free-riding Effects

The fact that the implied incentives of the non-executive option portfolio positively affect firm operating performance could be considered surprising. Non-executive stock options may be granted to hundreds or thousands of employees, each of whom is likely to have a negligible impact on overall firm performance. In accepted economic wisdom, such conditions are generally expected to favor free-riding. While free-riding may not be the dominant force, we might expect it to have some effect on the strength of the relation between incentives and performance. To further explore this issue, we segment our incentive measure on firm characteristics that are likely to be related to the predominance of free-riding, specifically the number of employees in the firm and the growth options per employee at the firm. We then examine whether the incentive-performance effect we document is stronger in firms where free-riding incentives are weaker.

In general, the incremental likelihood that an individual worker's wealth will increase through his option compensation if he exerts effort is expected to be a decreasing function of labor force size, since overall performance is less sensitive to the actions of individual workers in larger firms. Therefore, the more employees at the firm, the greater the free-rider problem is likely to be. Because the free-rider problem is greater in larger organizations, we may expect the incentive-performance effect documented in the previous section to be concentrated in smaller firms. To test this hypothesis, we segment our incentive measure at the median number of employees, and re-estimate our models, allowing the coefficient on our measure of non-executive delta to differ for firms with above- and below-median labor force size. The performance measures are industry-adjusted ROA and cost- and industry-adjusted

ROA, with two endogenous regressors per specification: the per-employee delta for firms with above-median number of employees, zero otherwise; and the per-employee delta for firms with below-median number of employees, zero otherwise. For better identification of the model, we add the cohort-based geography instrument, for which we compute near-firm per-employee delta for firms with above- or below-median number of employees.[31]

In similar fashion, one might expect that free-riding would be weaker in firms where the ability of any individual worker to influence the overall success of the firm is higher, and therefore, where individual effort may have a more significant effect on creating real value. To explore this hypothesis, we also segment our sample based on high- and low-growth options per employee (Core and Guay 2001). We allow the coefficient on our measure of implied incentives to differ for firms with above- and below-median growth options per employee, and re-estimate our models. We again add a cohort-based instrument, for which the near-firm per-employee delta is averaged for firms with above- or below-median growth options per employee.

The results from our estimations are reported in Table 5. All estimates are taken from Instrumental Variables (IV) models, with the first-stage models for each per-employee incentive variable unreported for brevity. Once again, the regression diagnostics support our choice of instruments. Hansen-J test statistics for over-identification of all instruments fail to reject the null of valid instruments in both sets of models. For models with more than one endogenous regressor, the test statistic for instrument strength no longer corresponds to the joint F-test of significance from the first-stage model. Kleibergen and Paap (2006) suggest a rank test that provides a Wald test of weak identification in the case of multiple endogenous variables and heteroskedasticity, as in our case with errors clustered for observations on the same firm. The rank F-statistic is 3.735 for the specification relating the labor-force size interaction to ROA (3.754 for cost-adjusted ROA) and 5.886 for the specification relating the growth option per employee interaction to ROA (5.851 for cost-adjusted ROA), in both cases exceeding the threshold for the Stock-Yogo 10% maximal size distortion critical value of 3.39.[32]

The results in each specification we estimate are similar: The option incentive measure has a positive, statistically significant effect in firms with fewer employees and higher growth options per employee, but is not statistically significant in firms with more employees or limited growth options per

[31] We add the cohort instrument in the subsample analysis because in systems with more than one endogenous variable, strong identification depends on cross-correlations of the instruments. The motivation is primarily statistical, rather than deriving from a belief that firms compete for labor only with their cohorts.

[32] Because critical values are derived under assumptions of homoskedasticity, Baum, Schaffer, and Stillman (2007) suggest that while using the rank Wald statistic as the robust analog of the Cragg-Donald statistic is sensible, comparison to critical values should be made with some caution.

Table 5
Differential Effects by Number of Employees and Growth Option Per Employee

	Number of Employees (X = Below Median)		Growth Options per Employee (X = Above median)	
Dependent Variable	1 IND ADJUSTED ROA	2 BS & IND ADJUSTED ROA	3 IND ADJUSTED ROA	4 BS & IND ADJUSTED ROA
AVG NON EXEC DELTA (X = 1)	0.0441***	0.0386**	0.0413***	0.0380**
	(2.75)	(2.47)	(2.72)	(2.47)
AVG NON EXEC DELTA (X = 0)	0.0405	0.0340	−0.2386	0.0117
	(1.08)	(0.85)	(−0.73)	(0.03)
LAG PERFORMANCE	0.7662***	0.7572***	0.7598***	0.7560***
	(45.88)	(45.77)	(42.23)	(40.72)
R&D	−0.0283	−0.0596	−0.0331	−0.0599
	(−0.75)	(−1.48)	(−0.86)	(−1.46)
CASH FLOW SHORTFALL	0.0162	0.0120	0.0230	0.0128
	(1.17)	(0.85)	(1.49)	(0.80)
LONG-TERM DEBT	0.0008	−0.0001	0.0009	−0.0000
	(0.27)	(−0.03)	(0.30)	(−0.00)
MKT VALUE ASSETS	0.0023***	0.0023**	0.0013	0.0021
	(2.56)	(2.41)	(1.03)	(1.38)
SALES PER EMPLOYEE	−0.0046***	−0.0045***	−0.0047***	−0.0045***
	(−11.09)	(−10.37)	(−11.48)	(−9.74)
R&D PER EMPLOYEE	−0.2515**	−0.1998*	−0.2414**	−0.2012*
	(−2.37)	(−1.74)	(−2.34)	(−1.81)
PRODUCT DIV	−0.0017	−0.0019	−0.0004	−0.0017
	(−1.13)	(−1.22)	(−0.16)	(−0.72)
GEOGRAPHIC DIV	0.0008	0.0004	0.0007	0.0004
	(0.42)	(0.22)	(0.38)	(0.23)
INTERSEGMENT REL	−0.0043	−0.0089	−0.0088	−0.0096
	(−0.42)	(−0.84)	(−0.74)	(−0.80)
LMT	0.0021	0.0024	0.0002	0.0021
	(0.29)	(0.26)	(0.03)	(0.22)
HMT	0.0023	0.0027*	0.0023	0.0027*
	(1.47)	(1.69)	(1.48)	(1.68)
TOP5 DELTA	0.0017***	0.0008	0.0019***	0.0008
	(2.64)	(1.25)	(2.65)	(1.15)
TOP5 VEGA	−0.0021***	−0.0013*	−0.0022***	−0.0013*
	(−3.01)	(−1.79)	(−3.02)	(−1.68)
LNAGE	0.0000	0.0004	−0.0003	0.0004
	(0.03)	(0.42)	(−0.30)	(0.37)
Intercept	−0.0224**	−0.0195*	−0.0110	−0.0179
	(−2.10)	(−1.84)	(−0.73)	(−1.02)
N	6160	6159	6160	6159
Hansen J	1.322	2.329	1.273	2.270
Prob > Chi-sq	0.516	0.312	0.529	0.322
F(52,1233)	95.41	88.18	96.42	88.21
Prob > F	0.00	0.00	0.00	0.00

This table presents the results of LIML estimations of the performance equation in IV-style regressions of industry-adjusted performance on the delta of the outstanding non-executive option portfolio, split at the median value of number of employees and growth options per employee. The unit of analysis is a firm-year. The excluded instruments are *NEAR FIRM NON-INDUSTRY DELTA*, defined as the per-employee non-executive incentive averaged across firms in the same two-digit ZIP code excluding the firm itself and others in its industry; *EMPLOYEES*, defined as the natural log of the number of employees; *NEAR COHORT FIRM DELTA*, defined as the Near Firm Delta Averaged over Firms in the same cohort of number of employees or growth options per employee; and *SHARES OUT*, the number of common shares outstanding. We calculate growth options per employee as the difference between market value of assets and book value of assets divided by the number of employees as in Core and Guay (2001). Additional variables are defined as in Table 1; year and industry controls are included but not reported. Standard errors are White heteroskedasticity-adjusted and are clustered for the same company (Rogers 1993). We report Z-scores in parentheses. *, **, or *** mean the coefficient is significant at the 10%, 5%, or 1% level, respectively.

employee.[33] A move from the 25th percentile to the 75th percentile of implied incentives for small firms produces a 0.38% increase in industry-adjusted ROA and a 0.33% increase in cost- and industry-adjusted ROA, and a move from the 25th percentile to the 75th percentile of incentives for firms with high growth options per employee implies a 0.33% increase in industry-adjusted ROA and a 0.31% increase in cost- and industry-adjusted ROA.

A natural concern might be that small-growth firms, precisely those firms with fewer employees and higher individual growth opportunities, would be the same types of firms where there is increased use of stock options in order to take advantage of positive employee sentiment. If performance is persistent, previous stock price performance could drive both increased use of options and future performance. We note that our IV estimation technique should control for this type of endogeneity, and that such theory does not necessarily imply that the firm average delta should be related to performance. For robustness, however, we test directly for the effects of prior stock price performance. In unreported results, we divide our data into subsamples based on whether prior stock price performance was positive or negative and also whether it was above or below the median for the sample. In all four subsamples, we find a positive and significant incentive-performance effect, indicating that it is unlikely that our results arise from a tendency toward greater use of options in firms with better stock price performance.

Overall, the results from these estimations suggest the relative strength of the implied incentive-performance relation is consistent with the presence of free-riding, though it does not appear that free-riding is the dominant force overall. While alternative explanations to increased effort, such as higher incentives attracting or retaining a higher-quality worker, are consistent with the first set of results in Table 4, these explanations are less likely to be the *sole* drivers of the effect in light of the results presented in Table 5. If greater implied incentives attract and retain higher-quality workers who provide improved performance regardless of effort, one would expect higher incentives to result in improved industry-adjusted performance across small and large firms. The fact that the incentive-performance effect depends on factors that are likely to exacerbate free-riding suggests that the relationship we document is likely to occur at least *partially* through an effort mechanism.

4. Mutual Monitoring Effects

Compensation based on firm-wide performance introduces externalities between the efforts of individual workers and the welfare of their colleagues.

[33] The unreported first-stage estimations reveal an interesting economic phenomenon: Small firms tend to follow the policies of larger local firms. For the first-stage equation predicting small firm implied incentives, the coefficient on the near-firm delta instrument is positive with a *p*-value of .15, while the coefficient on the cohort near-firm delta is negative and significant. A similar phenomenon occurs with low-growth option firms following neighbors with high-growth options per employee.

If a worker exerts low effort, he reduces not only the likelihood that he will receive an increase in his wealth from his options, but also the likelihood that other employees will receive a wealth increase. This creates incentives for employees to monitor their colleagues and encourage them to exert more effort. Mutual monitoring can be implemented in a number of ways: Workers may employ peer pressure by direct sanctioning of co-workers or by inducing feelings of shame for those who do not exert sufficient effort (Kandel and Lazear 1992). Alternatively, employees may sanction a co-worker by reporting low effort to management or a supervisor. In either form, mutual monitoring is a penalty imposed on co-workers that exert effort below group norms.

If mutual monitoring among co-workers is important in limiting free-riding and leading to the incentive-performance effect observed above, we expect that this relation will be concentrated in firms that grant options broadly. Mutual monitoring is more likely to occur when workers know all have similar incentives, and therefore can jointly decide to maximize total gains by exerting effort and sanctioning those who deviate from the group agreement. We therefore turn to the interaction of option portfolio incentives and broad-based grants.

To explore this hypothesis, we allow the coefficient on our measure of option portfolio incentives to differ for firms with and without broad-based option plans, and re-estimate our models. Our models again have two endogenous regressors and employ the first three instruments described in Section 1.2. The estimates for the performance equations from our models are presented in the first two columns of Table 6. Once again, the Hansen-J test statistics for model over-identification fail to reject the null of valid instruments. The Kleibergen and Paap (2006) rank F-statistic is 3.540 for the industry-adjusted ROA specification (3.528 for cost-adjusted ROA), placing maximal size distortion at no more than 15%, indicating that identification is slightly weaker for this specification. We note, however, that test statistics for robust inference under weak instruments such as the Stock-Wright S statistic (Stock and Wright 2000), which generalizes the Anderson-Rubin test and allows for error clustering, is significant at 99% for both models, indicating valid inference even in the presence of weak instruments.

For both performance measures, the coefficient on option incentives for firms with broad-based option plans is positive and statistically significant. In contrast, the coefficient on incentives for firms without broad-based plans is insignificant. These results suggest that incentive effects are significantly and positively related to performance only for the group of firms with broad-based plans, consistent with mutual monitoring. A move from the 25^{th} percentile of per-employee delta to the 75^{th} percentile of per-employee delta for firms with broad-based plans implies an increase of 0.29% in ROA and a 0.25% increase in cost-adjusted ROA.

An immediate concern is that these estimates are also consistent with a performance effect resulting from having a greater fraction of higher-quality

Table 6
Differential Effects by Targeted versus Broad Plans

	NON EXEC DELTA PER EMPL		NON EXEC DELTA	
	1	2	3	4
Dependent Variable	IND ADJUSTED ROA	BS & IND ADJUSTED ROA	IND ADJUSTED ROA	BS & IND ADJUSTED ROA
NON-EXEC INCENTIVE (BROAD PLAN = 1)	0.0441***	0.0381**	0.0180***	0.0155**
	(2.76)	(2.46)	(2.57)	(2.35)
NON-EXEC INCENTIVE (BROAD PLAN = 0)	0.0340	0.0528	−0.0471**	−0.0404**
	(0.20)	(0.29)	(−2.53)	(−2.31)
LAGGED PERFORMANCE	0.7658***	0.7565***	0.7368***	0.7364***
	(47.19)	(47.37)	(32.62)	(36.66)
R&D	−0.0278	−0.0599	0.0218	−0.0167
	(−0.74)	(−1.47)	(0.40)	(−0.31)
CASH FLOW SHORTFALL	0.0164	0.0120	0.0353	0.0293
	(1.21)	(0.86)	(1.26)	(1.14)
LONG-TERM DEBT	0.0009	−0.0001	0.0031	0.0021
	(0.28)	(−0.00)	(0.54)	(0.40)
MKT VALUE ASSETS	0.0023**	0.0021**	0.0083***	0.0072***
	(2.34)	(2.06)	(3.06)	(2.90)
SALES PER EMPLOYEE	−0.0045***	−0.0044***	−0.0035***	−0.0036***
	(−11.54)	(−10.71)	(−4.17)	(−4.42)
R&D PER EMPLOYEE	−0.2537**	−0.2023*	−0.4326**	−0.3545*
	(−2.47)	(−1.84)	(−2.19)	(−1.87)
PRODUCT DIV	−0.0017	−0.0019	0.0009	0.0004
	(−1.14)	(−1.27)	(0.23)	(0.12)
GEOGRAPHIC DIV	0.0008	0.0004	0.0048	0.0039
	(0.43)	(0.23)	(1.29)	(1.13)
INTERSEGMENT REL	−0.0044	−0.0092	−0.0131	−0.0163
	(−0.44)	(−0.88)	(−0.59)	(−0.86)
LMT	0.0021	0.0023	0.0039	0.0044
	(0.28)	(0.24)	(0.48)	(0.49)
HMT	0.0023	0.0027*	−0.0015	−0.0007
	(1.46)	(1.67)	(−0.48)	(−0.26)
TOP5 DELTA	0.0017**	0.0007	0.0062**	0.0047**
	(2.07)	(0.87)	(2.35)	(2.01)
TOP5 VEGA	−0.0021**	−0.0012	−0.0062**	−0.0048**
	(−2.42)	(−1.32)	(−2.38)	(−2.09)
LNAGE	0.0000	0.0004	0.0013	0.0015
	(0.04)	(0.45)	(0.65)	(0.84)
Intercept	−0.0222**	−0.0184*	−0.0826**	−0.0703**
	(−1.98)	(−1.65)	(−2.51)	(−2.34)
Number of observations	6160	6159	6160	6159
Hansen J	1.184	2.337	0.278	0.559
p-val	0.277	0.126	0.598	0.455
F(52,1233)	94.27	87.37	64.44	66.17
Prob > F	0.000	0.0000	0.0000	0.0000

This table presents the results of LIML estimations of the performance equation in IV-style regressions of industry-adjusted performance on the delta of the outstanding non-executive option portfolio for firms with and without broad-based option plans. The unit of analysis is a firm-year. The excluded instruments are *NEAR FIRM NON-INDUSTRY DELTA*, defined as the per-employee non-executive incentive averaged across firms in the same two-digit ZIP code excluding the firm itself and others in its industry; *EMPLOYEES*, defined as the natural log of the number of employees; and *SHARES OUT*, the number of common shares outstanding. Additional variables are defined as in Table 1; year and industry controls are included but not reported. Standard errors are White heteroskedasticity-adjusted and are clustered for the same company (Rogers 1993). We report Z-scores in parentheses. *, **, or *** mean the coefficient is significant at the 10%, 5%, or 1% level, respectively.

workers or from better worker retention. Under these alternative explanations, the positive effect of option incentives on performance could stem either from sorting effects for a greater percentage of the workforce or from worker compensation better adjusting to outside opportunities for a larger set of employees. The likelihood of these alternatives is diminished, however, by examining implied incentives for the *aggregate* non-executive option portfolio. To illustrate, consider two firms of the same size, both granting similar option incentives to employees in aggregate. In Firm A, these incentives are spread across all employees, while in Firm B, they are concentrated to a targeted subset of employees. If option incentives have an effect on performance solely through sorting or retention, we would not expect a differential effect between the firm that grants broadly and the firm that targets its grants, since we expect that firms are distributing incentives in a manner that maximizes value. If, on the other hand, we observe that the incentive-performance relationship at the *aggregate* level is concentrated in the firm that grants broadly, this implies that if the firm that targets the option grants to a particular subset of employees does so to either attract higher-quality workers for those positions or retain workers in those positions, there is no commensurate performance effect for this targeted group. It is difficult to imagine that a firm would not be able to correctly identify key positions for which it needed higher-quality workers or which employees would be most valuable to retain. In contrast, an *aggregate* incentive-performance effect that is concentrated in firms that grant options broadly is consistent with firms granting options to provide incentives for greater effort, with mutual monitoring outweighing free-riding at those firms where the majority of employees receive the option incentives, but not at firms where only a subset receives them. Note that this does not necessarily imply that firms are behaving suboptimally; there may be other benefits to option usage not captured by the pay-to-performance sensitivity.

In examining the summary statistics for option incentives for firms with and without broad plans, we observe no significant difference in the mean of aggregate portfolio delta for firms with and without broad-based plans. Tests of medians indicate firms without broad-based plans exhibit *higher* pay-for-performance sensitivity. This suggests that there exist at least similar amounts of wage sensitivity in *aggregate* across firms that grant options broadly versus those that do not. We can therefore test for differences in the aggregate incentive—performance effect between firms that grant options broadly and those that target in the presence of similar amounts of aggregate option incentives for the two groups. We re-estimate our models using the interaction of broad plans with the *aggregate* incentive measures for the firm. Results are reported in Columns 3 and 4 of Table 6. If positive performance effects of option incentives at the *aggregate* level are concentrated among firms that grant broadly, it suggests either that broad-based grants play a role in the performance effect, presumably through a channel such as mutual monitoring, or that firms that pursue a more targeted strategy for sorting or incentives are doing so ineffectively.

For both performance measures, the coefficient on aggregate option incentives for firms with broad-based option plans is positive and statistically significant and the coefficient on incentives for firms without broad-based plans is negative. Further, a test for differences in coefficients finds the coefficients on the incentives measure for firms with broad-based plans to be significantly different than for firms with targeted plans at 99% confidence for both specifications. A move from the 25^{th} percentile to the 75^{th} percentile of aggregate non-executive employee delta for firms with broad-based plans implies an increase of 0.37% in ROA and a 0.32% increase in cost-adjusted ROA. Regression diagnostics are similar to the per-employee specifications, with the Hansen-J test statistics failing to reject the null of valid instruments, and the Kleibergen-Paap rank F-statistics exceeding the threshold for 10% maximal size distortion for both specifications. Again, the Stock-Wright S statistic is significant at greater than 99% confidence. This finding adds to the evidence suggesting that the sorting and retention channels are likely not the *sole* source of incentive-performance relationship we document. Our results appear to be consistent with the notion that broad-based plans are more likely to induce monitoring among co-workers, and suggest that, while we cannot definitively rule out sorting and retention as possible explanations for the incentive-performance relationship, mutual monitoring may serve to govern the detrimental effects of free-riding in the provision of incentives.

5. Alternative Explanations and Robustness

We consider a number of additional tests to confirm the robustness of the implied incentive-performance relationship. First, a possible concern with our analysis is that the per-employee incentive effects associated with having a broad-based plan may merely be a function of such firms having fewer employees. While there is actually substantial variation in the number of employees for firms that grant broad-based plans, we address this concern more directly in Table 7, where we re-estimate the specifications presented in Table 6 on the subsample of firms that have higher than the median number of employees. We obtain similar results in this subsample as we do in the full sample of firms. The coefficient on implied incentives for firms with broad-based plans is positive and significant, and the implied incentives coefficient is insignificant or negative for firms without broad-based plans. That we observe the same incentive-performance relation in the subsample of firms with above-median numbers of employees suggests that the effect we document is not merely capturing a “few employees” effect.

Second, a potential concern is that local correlation in option programs occurs in areas where firm operating performance is correlated at the local level even with the operating performance of firms outside the firm’s industry,

Table 7
Differential Effects by Targeted versus Broad Plans: Large Firm Subsample

	NON EXEC DELTA PER EMPL		NON EXEC DELTA	
	1	2	3	4
Dependent Variable	IND ADJUSTED ROA	BS & IND ADJUSTED ROA	IND ADJUSTED ROA	BS & IND ADJUSTED ROA
NON-EXEC INCENTIVE	0.1933**	0.1761**	0.0078**	0.0074**
(BROAD PLAN = 1)	(2.42)	(2.16)	(2.39)	(2.34)
NON-EXEC INCENTIVE	0.3806	0.3934	−0.0176***	−0.161***
(BROAD PLAN = 0)	(0.95)	(1.00)	(−3.02)	(−2.80)
LAGGED PERFORMANCE	0.7732***	0.7747***	0.7915***	0.7947***
	(29.09)	(28.97)	(39.48)	(41.36)
R&D	0.2245	0.2026	0.1975	0.1833
	(1.63)	(1.42)	(1.48)	(1.38)
CASH FLOW SHORTFALL	0.0373**	0.0357*	0.0401*	0.0393*
	(1.96)	(1.89)	(1.78)	(1.81)
LONG-TERM DEBT	0.0189**	0.0182**	0.0120*	0.0121*
	(2.37)	(2.33)	(1.71)	(1.77)
MKT VALUE ASSETS	−0.0002	−0.0002	0.0065***	0.0060***
	(−0.11)	(−0.12)	(3.11)	(2.91)
SALES PER EMPLOYEE	−0.0091**	−0.0096**	−0.0113***	−0.0114***
	(−2.29)	(−2.48)	(−2.88)	(−3.09)
R&D PER EMPLOYEE	−1.5401**	−1.4546**	−0.8960	−0.8798
	(−2.28)	(−2.09)	(−1.58)	(−1.59)
PRODUCT DIV	0.0005	0.0004	0.0012	0.0010
	(0.33)	(0.26)	(0.51)	(0.47)
GEOGRAPHIC DIV	0.0023	0.0017	0.0023	0.0017
	(0.81)	(0.60)	(0.69)	(0.55)
INTERSEGMENT REL	−0.0254**	−0.0290**	−0.0160	−0.0203
	(−2.05)	(−2.21)	(−1.06)	(−1.43)
LMT	−0.0121	−0.0193	0.0075	−0.0005
	(−0.47)	(−0.62)	(0.98)	(−0.03)
HMT	0.0001	0.0003	−0.0016	−0.0014
	(0.03)	(0.15)	(−0.63)	(−0.56)
TOP5 DELTA	0.0006	−0.0001	0.0044***	0.0036**
	(0.35)	(0.04)	(2.72)	(2.40)
TOP5 VEGA	−0.0008	−0.0003	−0.0046***	−0.0038**
	(−0.50)	(−0.17)	(−2.78)	(−2.53)
LNAGE	0.0008	0.0010	−0.0007	−0.0004
	(0.69)	(0.91)	(−0.65)	(−0.34)
Intercept	−0.0196	−0.0173	−0.0696***	−0.0639***
	(−1.35)	(−1.19)	(−3.01)	(−2.82)
N	3800	3799	3800	3799
Hansen J	0.044	0.058	0.013	0.027
p-val	0.833	0.810	0.910	0.871
F(52,730)	59.56	61.85	76.69	86.12
Prob > F	0.0000	0.0000	0.0000	0.0000

This table presents the results of LIML estimations of the performance equation in IV-style regressions of industry-adjusted performance on the delta of the outstanding non-executive option portfolio for firms with and without broad-based option plans, restricted to the subsample of firms with a higher than median number of employees. The unit of analysis is a firm-year. The excluded instruments are *NEAR FIRM NON-INDUSTRY DELTA*, defined as the per-employee non-executive incentive averaged across firms in the same two-digit ZIP code excluding the firm itself and others in its industry; *EMPLOYEES*, defined as the natural log of the number of employees; and *SHARES OUT*, the number of common shares outstanding. Additional variables are defined as in Table 1; year and industry controls are included but not reported. Standard errors are White heteroskedasticity-adjusted and are clustered for the same company (Rogers 1993). We report Z-scores in parentheses. *, **, or *** mean the coefficient is significant at the 10%, 5%, or 1% level, respectively.

thus causing our instrument, other-industry near-firm delta, to violate the exclusion restriction. To address this concern, we conduct a number of robustness tests.

First, we construct a test designed to eliminate geographic areas where correlated local shocks could be contributing to the results. To do so, we estimate a simple OLS regression of our performance equation, excluding the endogenous option incentive measure and augmented with fixed effects for each two-digit ZIP code geographic region. We then eliminate observations for all the geographic areas where the fixed effect is statistically significant at greater than 90% confidence, including observations for Silicon Valley firms. We then re-estimate the specifications in our original analysis on this subsample, and find our results (untabulated) to be robust to the exclusion of geographic regions that may experience correlated local shocks. This removes concerns related to a time-invariant local performance effect.

Second, as we have multiple instruments that allow us to over-identify the model, we can eliminate our main geography-based instrument from the first-stage models in order to determine whether our results are driven by its inclusion. Our results are robust to the exclusion of the non-industry geography-based instrument.

Finally, we employ an additional instrumentation strategy based on the lagged idiosyncratic component of other firms' stock returns, as in Leary and Roberts (2009). We employ firm-specific, rolling regressions of returns on both the usual asset-pricing factors and *industry* and *geography* factors to obtain the idiosyncratic shock to the returns of peer firms.[34] The specification for the idiosyncratic shock to other firms' stock returns ensures that the estimated residual (i.e., instrument) is orthogonal to local and industry shocks. To alleviate the concern that peer idiosyncratic shocks might be correlated with the firm's own shock, we include lagged own-firm idiosyncratic return as a regressor in both equations. As noted in Leary and Roberts (2009), this variable violates the exclusion restriction only if one argues that the idiosyncratic component of other firms' stock returns is a better proxy for firm i's operating performance than firm i's characteristics. Our results are robust to augmenting our first stage model with idiosyncratic shocks averaged over 3-digit SIC codes or 2-digit ZIP codes, with the shock constructed removing common industry and/or geographic components in addition to a standard 4-factor model. Thus, our results are robust to a variety of alternative specifications for identification, alleviating concerns that the effect we document is driven by firm operating performance exhibiting correlation with local firm performance outside its industry.

Third, one may think that the use of option incentives or a broad-based option plan is reflective of a particular "management style" that is geographically

[34] Intuitively, the identifying assumption is that the idiosyncratic shock to the stock price of firm j in period t-1 may affect the option program policies of firm j in period t, and hence through peer effects, also affect the option program policies of firm i as well, but should be unrelated to the operating performance of firm i (except inasmuch as it affects firm i's option policies).

correlated, and that our analysis merely reflects the returns to this particular style of management. For example, perhaps instances of higher pay for performance sensitivity in firms that do not grant broadly are reflective of cronyism in compensation, such that the firms that grant broadly are merely better-governed firms. Or, perhaps managers who attend specific institutions form beliefs about effective compensation, but performance has little to do with these compensation practices, but rather other aspects of the management style. While we cannot capture all facets of management style, our results are robust to re-estimation controlling for a number of variables that may affect management style. First, our results are robust to including controls for corporate governance policies, such as the governance index of Gompers, Ishii, and Metrick (2003) and the entrenchment index of Bebchuk, Cohen, and Ferrell (2009), as well as below- or above-median levels of these indices. Second, we collect education information for the CEOs in our sample firms, including the educational institution and the type of degree.[35] Our results are robust to augmenting our models with controls for whether the CEO holds an MBA or a non-MBA advanced degree. Our results are further robust to including fixed effects for whether the CEO holds an MBA degree from a specific institution.[36] These tests provide some reassurance that the documented relation between implied incentives and performance is unlikely to be due to management style that is related to CEO education, school networks, or governance policies. That said, as is often the case in such empirical studies, we cannot absolutely rule out the possibility that our results are driven by an omitted variable that is simultaneously related to all three of geography, option policies, and performance.

Finally, we note that our results are robust to a wide variety of permutations in variable definitions and specification. Similar results obtain employing alternative measures of performance, including changes in firm ROA, sales growth, and Tobin's Q or alternative measures of firm size, such as the natural log of sales. As mentioned earlier, our results hold for subsamples based on positive or negative prior-year stock price performance and for subsamples based on above- or below-median prior-year stock price performance, indicating that the effects we measure are not a result of positive stock price performance. Finally, alternative estimation methods yield similar results, showing that our findings are not dependent on our choice of estimation.

6. Conclusion

Whether options granted to rank-and-file employees have causal effects on the performance of the firm is an important open question in the existing

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35 Educational information is collected from ZoomInfo, Who's Who, SEC filings, and other Internet resources.

36 We define 13 such fixed effects, one for each school that comprised at least 0.5% of the collected education data. The schools include Columbia University, Cornell University, Dartmouth College, Harvard University, Indiana University, Northwestern University, New York University, Stanford University, University of Chicago, University of Pennsylvania, University of Michigan, University of Texas, and University of Virginia.

literature. This article seeks to inform the issue by exploring the link between option portfolio implied incentives and firm operating performance. To the best of our knowledge, this article is the first to address in depth the question of these programs' effects on objective measures of firm performance while attempting to carefully account for the endogenous nature of these option plans.

Common economic wisdom holds that non-executive stock options are unlikely to affect the performance of the firm due to free-riding. Competing theories argue that mutual monitoring among employees may overcome the free-riding problem. Using a previously unemployed dataset, we obtain a measure of option portfolio incentives that is unobtainable from well-known datasets such as ExecuComp. We examine the sensitivity of the firm's outstanding non-executive options, both per employee and in aggregate, to an increase in the underlying value of a firm's stock. Controlling for other likely determinants of firm operating performance, as well as the endogenous nature of option programs for non-executive employees, we find a positive, causal relationship between the implied per-employee incentives of the portfolio of outstanding non-executive options and subsequent firm operating performance. The magnitude of the relation of implied incentives to performance is economically large, and suggests that free-riding is not the dominant effect in these programs.

Consistent with economic theory, we find that the incentive-performance effect is observed only in smaller firms, and in firms with higher growth options per employee. Finally, we find that that this incentive-performance effect is concentrated solely in firms that grant options broadly to non-executive employees, supporting the argument that options may induce cooperation or monitoring among co-workers, in addition to other known effects such as sorting and retention of employees.

To the best of our knowledge, these findings represent the first evidence of a net benefit from the implied incentives of employee stock options on firm performance, and as a result, our study has broad implications for workforce compensation overall. Importantly, we show that free-riding is not the overriding force that some theoretical treatments of this topic suggest. Rather, our findings suggest that while free-riding may be present to some extent, mutual monitoring by co-workers may be the stronger force.

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