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New Data for Answering Old Questions Regarding Employee Stock Options

Kevin F. Hallock and Craig A. Olson

4.1 Background

An employee stock option is the right an employee has to buy a share of stock at a set price at some time in the future, subject to vesting and other provisions. The dramatic growth in the use of stock options in the past decade (Hall and Murphy 2003), new Financial Accounting Standards Board (FASB 2004) standards on how to account for stock options in firm balance sheets, new disclosure requirements for highly paid executives in U.S. firms, and a growing debate over how to handle stock options in national accounts (in the United States and elsewhere) have sparked considerable interest in the study of stock options in recent years.

In keeping with the tradition of the National Bureau of Economic Research (NBER) Conference on Research in Income and Wealth (CRIW), this chapter aims to provide a review and update on some important questions in stock options research and practice, explore a variety of new and interesting data sets for the careful and credible study of employee stock options, discuss implications of options in the national accounts, and pro-

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vide some new empirical evidence on the value of options to employees using a decade of data from a large U.S. firm.

There are a host of reasons why learning more about stock options is important for firms, employees, and public policymakers. First, over the past twenty years, there has been dramatic growth in the use of stock options for senior-level executives and, beginning in the mid-1990s, substantial growth in the use of options for nonexecutive employees that was only partially dampened by the market adjustment in 2001. For example, among publicly traded firms, Hall and Murphy (2003) report that option grants to managers and employees who are not among the top five highest paid in the firm has grown from less than 85 percent of the total options granted to employees in the mid-1990s to over 90 percent by 2002. While there is some evidence that options to nonexecutives have become less common in recent years, they clearly remain an important dimension of compensation in many firms. Research on options may both help researchers understand why firms grant options and inform firms about how they should evaluate their employee stock option policies and practices. Whenever a firm decides to grant options, it must decide whether it is better off granting the options or some alternative form of compensation. In order to do this appropriately a firm must know (a) how employees value the options relative to other forms of compensation, (b) the costs of the options to the firm, and (c) the relative incentive effects of the options (e.g., do they influence the employees to work harder)? Even if the options "cost" the firm more than other forms of pay, the firm may still want to provide them if incentive effects or other benefits are sufficiently large.

A second reason research on options is important is that it may provide insight into the widespread debate about the appropriate method of estimating the cost and value of options to firms. Although there are many strongly held opinions and new FASB regulations on how firms should expense options, there is no consensus on a theoretical model and empirical method for estimating employee stock option costs to the firm. Black and Scholes (1973) and Merton (1973) developed a widely accepted model used for pricing market traded options for risk-neutral, diversified investors that has been used (with modifications) successfully for more than three decades. While the same techniques have been extended to consider the value of options to employees and their cost to the firm, many have pointed out that the value of an option to an employee, and its cost to the firm may be considerably different than the value to an outside investor (e.g., Lambert, Larcker, and Verecchia 1991). Using this idea, Hall and Murphy (2002) have run simulations of option values to risk averse senior managers that show employees value options at a level that is substantially less than the Black-Scholes value and the cost of the option to the firm.

Understanding the cost of options to the firm may also provide insight into how employee stock options should be treated in national accounts and

estimates of employee compensation. Proper measurement of stock options is important for the valid measurement of the national accounts since, as of March 2003, "8 percent of private industry workers had access to stock options" (Schildkraut 2004,1). Current work on this topic by the Bureau of Economic Analysis (BEA) is investigating major data collection, conceptual and practical measurement, and timing issues (Moylan 2007).

Stock option data are not carefully collected in many common data sources in the United States. For example, the National Compensation Survey (NCS) considered the incidence and provisions of stock option plans in a 1999 pilot survey, perhaps with intent to further collect the information (Bureau of Labor Statistics [BLS] 2000; Crimmel and Schildkraut 1999; Crimmel and Schildkraut 2001). But the BLS has not further pursued this path, in part given that there is not a standard costing method that would allow employers to report costs at an occupational level. The NCS does collect information on access to stock options (BLS 2007).

The first section of this chapter briefly describes a typical stock option grant and the famous Black-Scholes option pricing formula for valuing publicly traded stock options. We then discuss why the value of *employee* (nonmarket tradable) options may differ from the valuation of market tradable options. We will also discuss how these alternative valuations relate to the controversy regarding the treatment of stock options in the national accounts. The second section details a set of data sources on stock options within the United States and internationally. We also consider how newer data could improve what we know in the national accounts. The chapter concludes with a case study of employee valuation of stock options in a large nonmanufacturing firm. We examine the value employees place on stock options using data from multiple large grants of stock options to a large set of managerial and professional employees in a multibillion dollar U.S. nonmanufacturing firm. We show that employee exercise decisions are broadly consistent with employee risk aversion and inconsistent with the risk neutral valuation of market-traded options that is predicted by the Black-Scholes model for market-traded options. Our hope is that our work is a useful guide to researchers, policymakers, and practitioners interested in stock options.

4.2 Theoretical Perspective

This section has four main goals. First, we define an employee stock option grant and provide some context. Second, we describe the Black-Scholes method for valuing publicly traded options. Third, we describe why the value employees place on stock options may differ from the well-known Black-Scholes value. Fundamental to this discussion are the differences between market tradable options, for which the Black-Scholes option pricing formula was created, and employee stock options. Finally we discuss implications of alternative valuations for the national accounts.

4.2.1 Defining Stock Options

An option to buy a share of stock at a set price (the strike or exercise price) can be executed by an employee after the option is held for a period of time known as the vesting period. Employee stock options typically vest within one to three years, are forfeited if the employee leaves the firm, and expire (typically) ten years after the grant date. Shorter vesting periods and option terms are common among high-technology firms, and, on some occasions, they gradually vest (e.g., one-third of the options vest at the end of year one, one-third vest at the end of year two, and one-third vest at the end of year three). Finally, employees cannot sell their options to a third party. This limitation ensures that until the options are exercised, the options continue to tie worker compensation to firm outcomes.

4.2.2 Black-Scholes Method of Valuing Publicly Traded Options

A discussion about the value of options to employees begins with the pioneering work of Black and Scholes (1973) and Merton (1973), who describe the value to diversified investors of market traded stock options. The famous diagram shown in figure 4.1 summarizes the basic relationship between the Black-Scholes value (BSV) of an option to buy a share of stock at a fixed price in the future (a call option), the firm's stock price, and the option's exercise price. The kinked *intrinsic value* line equals $\max([SP_t - EP], 0)$, where SP_t is the price of the firm's stock in period t, and EP is the strike or exercise price of the stock option and corresponds to the payoff that could be made by immediately exercising the option and then selling the acquired share at the firm's stock price. The curved line in the figure is the BSV and is the predicted price that an unexercised option could be bought or sold for based on the Black-Scholes theory. The BSV is a function of six variables—the risk-free interest rate, the expiration date of the option, the variance in the firm's stock returns, the firm's dividend rate, the option exercise price, and the current stock price. Figure 4.2 shows the BSV values for an option with an exercise price of \$10 that expires in 10, 5, and 0.5 years for a "typical" firm.[1] When the stock price is \$10 and the option expires in ten years, the BSV estimate of the market value of the option is \$5.57. Thus, even though a profit cannot be made by immediately exercising the option on the grant date, it has significant value because of the expectations of investors that at the end of the ten-year period a significant profit is expected (but not guaranteed) because of the expected positive per-period returns over the option's term. The market value of the option on the option grant increases as the duration of the option increases because the distribution of returns on the expiration date have a larger mean and variance as the

1. The standard deviation of the firm's returns over a year is .3, no dividends are paid by the firm, and the risk-free interest rate is 6 percent.

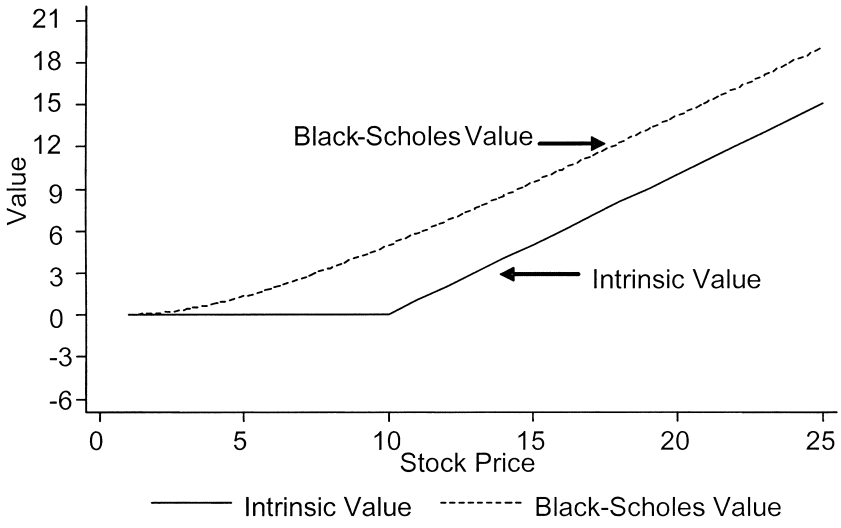

Fig. 4.1 Black-Scholes value and the intrinsic value of an option

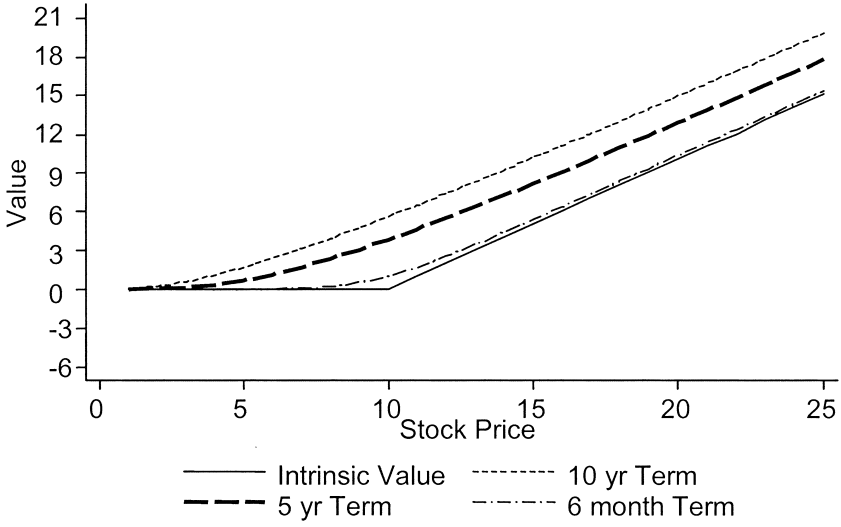

Fig. 4.2 Black-Scholes value and the intrinsic value of an option and the value of options with different terms

option's duration increases.[2] If the option shown in figure 4.2 expires in five years, its value at a $10 stock price is $3.80, and, if the option expires in six months, its market value is $.99 at a $10 stock price. The relationship between the stock price and BSV for options with these terms is shown in figure 4.2.

An important result shown by Black, Scholes, and Merton is that the market value of an option depends on the riskless rate of return and does not depend on the firm's expected return, which includes a firm-specific risk premium. The prediction that owners of market traded options can only expect to earn the riskless rate of return by holding the option is because investors can eliminate the risk that the option will be worthless when it expires because the stock price is less than the exercise price with a hedging strategy. For example, an investor could buy a "put" option that gives the owner the right to *sell* a share of stock at $10 per share in period T. This put option will pay a profit to its owner if the call option is "underwater" ($SP_T < EP$). Owning this put ensures the investor will make a profit at time T no matter what the stock price happens to be on the expiration day. While firms discourage employees from owning put options because these options are a "bet against the company" and earn money only if the firm's stock price falls, for outside investors this example illustrates a simple way of eliminating the risk associated from owning a call option. The ability of investors to hedge risk means competitive market pressures cause options prices to converge to a price that earns only a riskless rate of return.

More formally, the Black-Scholes option pricing formula is

$$\mathrm{BSV} = (\mathrm{SP})\Phi\left[\frac{\ln(\mathrm{SP/EP}) + (r_f + \sigma^2/2)t}{\sigma\sqrt{t}}\right] - (\mathrm{EP})e^{(-r_f t)}\,\Phi\left[\frac{\ln(\mathrm{SP/EP}) + (r_f + \sigma^2/2)t - 1}{\sigma\sqrt{t}}\right],$$

where r_f is the risk-free rate of interest, σ is the standard deviation of returns for the underlying stock, t is time in years until the option expires, and Φ is the cumulative standard normal distribution function. The model assumes the firm's stock returns are normally distributed and uncorrelated from one period to the next. The assumption that returns are normally distributed means the price of a riskless asset in T periods is drawn from a log-normal price distribution. As the option expiration date approaches, the Black-Scholes line shifts toward the intrinsic value line because the chance of drawing a "large" positive return from the return distribution on the expiration date declines.

2. Because the terminal stock price distribution is log-normally distributed, the expected price at the expiration date is a function of both the mean and variance of the per-period return. As we explain shortly, the per-period return investors of market traded options expect to earn equals the risk-free interest rate.

4.2.3 Why the Value of Employee Options May Diverge from the Black-Scholes Value

An important prediction of the Black-Scholes model is that a diversified investor will never exercise the right to buy a share of stock until the moment before it expires because, as figure 4.2 shows, at any earlier date the expected gain from holding the option until the expiration date is greater than the profit that can be made by immediately exercising it. The expectation of a positive return between now and the expiration date means the Black-Scholes value is greater than the profit that could be made by immediately exercising the option and receiving the option's intrinsic value, (SP_t – EP). Therefore, the Black-Scholes model predicts that prior to the expiration date, an investor will sell an option rather than exercise it if they wish to convert an option to cash because the BSV, the sale price, is greater than (SP_t – EP).

The Black-Scholes model predicts that market traded options held by diversified investors will rarely be exercised early because options can almost always be sold for more than the option's intrinsic value (stock price – exercise price).[3] The Black-Scholes model makes no prediction at all about how long the owner of a market traded option will own an option; it only predicts an option will be sold rather than exercised if its owner wants to liquidate his or her position prior to the expiration date. "Early" exercise behavior by employees occurs because they cannot sell their options, and their only choice during the term of the option is between exercising the option or holding the option for another period.

For some time, researchers have noted that the value employees place on employee stock options is likely to be different from the value diversified investors place on market tradable options. The major piece of empirical evidence cited to support this conclusion is the observation that employees frequently exercise employee stock options "early" or well before the option's expiration date (Huddart and Lang 1996; Carpenter 1998). In the firm we study in section 4.4, 86 percent of employees exercised their options prior to the month before the options expired, and half of the sample exercised some of their options at least twenty-seven months prior to the option's expiration date.[4] Lambert, Larcker, and Verecchia (1991) who, among others, argue that because employees are not risk neutral, are heavily invested in their firm (firm-specific human capital and deferred compensation), and may face liquidity constraints, they are likely to value employee options in their firm at a level lower than the Black-Scholes value and may also exercise their options earlier than predicted by Black-Scholes. Simulation work by

3. If firm dividends are sufficiently high, there may be a date prior to the option's expiration date when it is optimal to exercise an option early. This explanation cannot account for widespread exercise behavior over the term of the option and after the vesting date.

4. These data are for the first large employee stock option grant awards made to the middle-level managers included in this study.

Hall and Murphy (2002) shows that, conditional on a set of assumptions about risk aversion and the wealth they hold in firm stock, executives valued options at a level significantly less than the Black-Scholes value for market tradable options and exercised "early" to lock in gains from large stock price increases and diversify their portfolio. Contrary to Black-Scholes, Heath, Huddart, and Lang (1999) find that employees tend to exercise options when the firm's stock price exceeds a target or referent price based on recent stock price highs.[5]

It must certainly be true that for those employees who exercise their options prior to the expiration date, the value they place on holding the option is less than the option's BSV. Because the BSV of an option is greater than the option's intrinsic value and an employee will exercise an option when the profit from exercising early (the option's intrinsic value) is greater than the value of holding the option, then the value of holding the option must be less than BSV when employees exercise their options. This result, however, does not say anything about the value of the options held by employees who have not yet exercised their options. While the differences between market traded options and employee stock options discussed earlier predicts the value of options held by employees is less than BSV, evidence of early exercise behavior by employees only shows employees who do not exercise their options value the options at an amount greater than the option's intrinsic value. The decision by an employee to continue to hold their options does not say anything about the value of the options relative to their BSV. Because employees cannot sell their options or use the options as collateral to borrow money, they have no market signals that could inform them of the value outside investors would place on their options.

The observation that employees frequently exercise employee stock options "early" compared to the Black-Scholes prediction for market traded options reflects the fact that employees cannot sell the options they receive from their employer and must exercise the options if they wish to liquidate their position to diversify their portfolio or meet a household demand for cash. This feature of employee stock options implies information about an option's value to an employee is revealed each period by observing whether a vested option is exercised. If an option is not exercised in a period, then the value to the employee of holding the option and reserving the right to exercise it in a later period is greater than the value from immediately exercising the option and receiving the option's intrinsic value. On the other hand, when an employee exercises an option, we know the value of holding the option another period is less than what is gained by exercising the option and receiving a payment equal to the stock price minus the exercise price. Thus, the decision to exercise immediately or hold an option for at least another

5. Because an employee must typically forfeit her options if she leaves the firm, early exercise decisions may also be caused by voluntary or involuntary employee turnover (Carpenter 1998).

period is an indicator of the current value to an employee of holding the option relative to the option's intrinsic value.

One important implication of the preceding prediction is that variation in the length of time until employees exercise their options reflects heterogeneity in the value employees place on holding their options for another period. This heterogeneity in the value of an employee stock option could reflect differences in turnover intentions because employees must typically forfeit their employee stock options when they leave the firm. It may also reflect differences in household risk aversion, the effects of binding liquidity constraints, or different predictions about the future stock price of the firm. More risk-averse employees may exercise early to "lock in" profits (Hall and Murphy 2002), and the inability of employees to borrow against their employee stock options may cause some employees to exercise options to meet family financial commitments (buying a house, college tuition, or unanticipated health care expenditures). While these same sources of heterogeneity also characterize owners of market traded options, because Black-Scholes predicts owners of market traded options can sell and hedge their options, market traded options are identically valued (conditional on the six variables identified in the preceding), regardless of the risk preferences and liquidity constraints of their owners. Thus, heterogeneity in exercise times is strong evidence that Black-Scholes does not measure the value of employee stock options to employees.

4.2.4 Stock Options, National Accounts, and How Valuation Matters

Accounting for stock options in the United States, National Economic Accounts poses a variety of difficult issues.[6] One problem is that there are, in fact, two types of employee stock options; incentive stock options (ISO) and nonqualified stock options (NSO). Incentive stock options are not deductible for the employer or to the employee. However, when the stock is sold, the difference between the exercise price and the stock price is taxed as a capital gain for the individual (Moylan 2007). The NSOs are much more common and have different tax implications for employees and firms. When an employee exercises an NSO, he or she must pay income tax on the difference between the stock price and the exercise price just as if that compensation had been paid in cash. The firm can count a tax deduction of the same magnitude at the same time.

Collecting options data for the national accounts is very difficult.[7] Given recent advances in the disclosure of employee equity awards, including stock and employee stock options, through the Securities and Exchange Commission Web site, we could imagine that collecting timely data is now easier than

6. As pointed out in Lequiller (n.d.), this is also a problem is many other countries.

7. The Employment Cost Index, another important government statistic, does not include compensation in the form of stock options (Ruser 2001).

at any time in the past. However, there are a series of barriers in considering the valuation of options in the national accounts, even with access to better data. Carol Moylan carefully outlines many of the important issues with the treatment of employee stock options in the U.S. national accounts (Moylan 2007).

One of the issues is that of timing. Cynthia Glassman, undersecretary for economic affairs in the economic and statistics administration of the commerce department, noted (in a paper from the 2008 Allied Social Sciences Association [ASSA] meetings), "proceeds from the exercise of stock options are included in compensation estimates for the quarter in which exercise occurs, and the proceeds are excluded from corporate profits for the same quarter. This means that stock option compensation is not recognized for some time—possibly years after employees actually receive the option grants . . . It also means that any divergence between accounting and tax profits creates a headache for BEA . . ." (Glassmam 2008, 65). Note also that the BEA does not produce a single quarterly Gross Domestic Income (GDI) estimate but many "vintages" of GDI estimates for each quarter. This "reflects a compromise between providing timely estimates based on less-than-complete data and providing increasingly accurate estimates with lags that reflect the availability of better and more complete data" (Glassman 2008). Another issue discussed by Moylan (2007) is that it is unclear when to count the compensation as earnings—at the time of the grant or the time of the exercise of the option.

Moylan (2007) carefully describes that stock options do have value and should be treated as a form of compensation. One problem is *when* to count the compensation. Some argue that options should be counted as compensation at the time of the *grant* and not at the time of *exercise* as they are currently counted in the national accounts.[8] A difficulty with this view as pointed out by many is that employee options are subject to vesting, and, in a sense, the compensation is not earned until after vesting has occurred. So, therefore, perhaps the options should count as compensation at the time of vesting or some time between the grant date and vesting. After vesting, the gains from options could be thought of as a type of capital gain and, therefore, may no longer be considered compensation but as investment income. (Eurostat n.d.; Australian Bureau of Statistics 2002). Therefore, there is difficulty, from a theoretical point of view, about whether stock options are a form of pay, an investment, or a combination of the two.

Moylan (2008) notes that "under most UI laws, wages and salaries include bonuses, tips, the cash value of meals and lodging provided by the employer,

8. The discussion in the text is focused on options in the national accounts. This should not be confused with recent Financial Accounting Standards Board changes that now require firms to expense (and disclose in financial statements) options at the time they are granted. This differs from the tax treatment of options and from the national accounts practice of recognizing options as compensation when they are exercised.

the gain on the employee exercise of certain stock options, and employee contributions to certain deferred compensation plans" (9). She and others (e.g., McIntosh n.d.) note that in calculating compensation for the national accounts, the BEA assumes that compensation includes the exercise of NSOs but not ISOs. One problem, however, is that "there is evidence that some states are inconsistent in their coverage" (Moylan 2007, 2). Also, and as noted by Glassman (2008), the BLS quarterly census of employment and wages (QCEW) are reported with a lag of five months.

One reason properly accounting for options in the National Accounts is extremely difficult is the difference in accounting and tax treatment of stock options in the United States. For many years, there was a "disconnect" between the valuation of options for tax purposes and for purposes of reporting profits in company financial reports. Given the recent FASB change and the requirement for firms to "expense" options in their balance sheet, one would think that it may be easier to account for options in the national accounts.

4.3 Sources of Data on Stock Options

Along with the explosion in the past few decades in the use of stock options by firms in the United States, there has been a dramatic increase in research on employee stock options. In this section, we provide a general review of data sources on stock options and how these data can be useful for answering different questions about their incentive effects, their value to firms and employees, and data that could potentially be useful in the treatment of stock options in the national accounts. We will also try to address whether there are gaps in the set of data sources.

4.3.1 General Review of Sources of Data and How They Can Help Answer Questions

We have categorized the types of data on stock options into seven types: (a) commercial executive-level and firm-level sources, (b) individual firm financial records at the firm level, (c) individual firm financial records at the person level, (d) consulting firm data, (e) employee perception data from surveys, (f) government and nonprofit sources, and (g) international sources. Table 4.1 outlines the data and lists a set of sources that have used each. The set of sources listed in table 4.1 is by no means exhaustive. In each section, we briefly describe the types of data and mention ways that the data have been or could be used.

4.3.2 Commercial Executive-Level and Firm-Level Data Sources

There are at least three available commercial data sources on executive pay at the person level and firm level that are now relatively widely used. The first, ExecuComp (Executive Compensation data base) is produced by

Table 4.1 **Types of data sources (and examples of each) on employee stock options**

Type	Authors	Comments
Commercial sources		
Execucomp	Bergman and Jenter (2007)	1,500 firms, details on options of top 5 execs from 1992–2003
	Chidambaran and Nagpurnanand (2003)	Focus on repricing
	Mehran and Tracy (2001)	Review
Equilar, salary.com		
Individual firm financial records (firm-level)	Aboody (1996)	National Automation Accounting Research System (NAARS) library of financial statement footnotes
	Carpenter (1998)	Average exercise times by firm
	Core and Guay (2001)	Nonexec option holdings, grants, and exercises from 756 firms from 1994–1997
Individual firm detailed case study (person-level)	Armstrong, Jagolinzer, and Larcker (2006)	10 publicly traded firms
	Bajaj et al. (2006)	Two firms, enormous number of option grants
	Hallock and Olson (2007b)	Large firm outside of manufacturing, 13 grants to 2000 middle managers over a decade
	Hallock and Olson (2007a)	Data from a different firm on pay mix, including options
	Heath, Huddart, and Lang (1999) and Huddart and Lang (1996)	Individual grant and exercise data from seven firms
Consulting firm data	Farrell, Krische, and Sedatole (2006)	Training data from equity compensation planning firm
	Heron and Lie (2007)	7.2 million stock and options transactions
	Landsman et al. (2006)	1,354 firm-year observations from S&P500 from 1997–2001
Perception data from surveys	Farrell, Krische, and Sedatole (2006)	Training data from equity compensation planning firm
	Hodge, Rajgopal, and Shevlin (2006)	Executives in class
Government and nonprofit sources	Kroumova and Sesil (2006) and Oyer and Schaefer (2006)	National Center for Employee Ownership (NCEO) survey sent to plan administrators with plans in place—firm-level data for 600 firms
	Oyer and Schaefer (2006)	Bureau of Labor Statistics establishment-level data from 1,437 establishments
International data	Ikäheimo, Kuosa, and Puttonen (2006)	14 plans, 6 firms, 27,808 transactions in Finland
	Jones, Kalmi, and Makinen (2006)	Option plans in all firms in Finland from 1900–2002
	Kato et al. (2005) and Pendleton (2006)	644 stock option plan adoptions in Japan following 1997 rule change

Standard and Poor's Corporation and is likely the most widely used source of data for research on executive pay, including stock options. This source has available data from 1992—present on the compensation of the top-five highest paid employees of U.S. publicly traded firms who have managerial control in roughly 1,500 firms per year. These firms include those listed in the Standard and Poor's (S&P) 500, the S&P SmallCap 600, and the S&P MidCap 400. The data source starts in 1992, which was (until four years ago) the last major change in executive pay disclosure rules. A wide variety of questions can be answered with these data including issues of pay for performance for corporate managers, studies of corporate ownership, and research on the composition (salary, bonus, options, stock, etc.) of executive pay. This data set is perhaps the most popular among academic researchers. Examples of work using these data that are mentioned in table 4.1 include Bergman and Jenter (2007), who examine employee optimism; Chidambaran and Nagpurnanand (2003), who study repricings; and Mehran and Tracy (2001), who provide a summary of some executive pay research using data from ExecuComp.

Two other commercial executive pay sources are Equilar and salary.com. Each also provides comprehensive data sets of executive compensation but have a larger focus on marketing to the for-profit firm and compensation consulting market. These sources are frequently used by compensation design practitioners and consultants to help design executive pay plans (and to set comparison groups), including detailed equity and employee stock option plans.

One problem with all three of these sources is that they only focus on the most senior executives with managerial control over the firm. If one is interested in the compensation of any employee who is not in the top-five highest paid, these data sources are not particularly useful. They do, however, reveal the fraction of options given to the sum of the top-five highest-paid officers so that one can calculate the fraction granted to the rest of the employees in the firm. Another drawback of these data is that they only cover publicly traded firms. Finally, ExecuComp is for a limited set of firms. Data from Equilar and salary.com are more expensive but include information from a wider variety of firms.

4.3.3 Individual Firm Financial Records (Firm Level)

A host of scholars have also considered firm financial records at the firm level but have not used the well-known ExecuComp and related sources; rather, they have dug deeper for more unique sources of information. We will discuss a selection of these examples here. Examples of this include Aboody (1996), who used the National Automation Accounting Research System (NAARS) library on Lexis/Nexis in 1988 in a study of the relationship between outstanding options and stock; Core and Guay (2001), who study the determinants of nonexecutive employee stock option holdings, grants,

and exercises; and Carpenter (1998), who collected information on average time to exercise, stock prices at the time of exercise, and vesting periods using data from 10-Ks, proxies, and S-8 forms (the option plan prospectus).

The latter is an example of a study that required the use of significant "digging" beyond what was easily available in machine-readable form. This kind of work is expensive and time consuming but can open doors to many interesting findings.

4.3.4 Individual Firm Detailed Case Study Data (Person-Level)

There have been an increasing number of individual firm case studies over the past decade that have greatly enriched our understanding of employee stock options. Although these kinds of studies have the obvious drawback that the results may apply to one (or a small number of) firm(s), they are often extraordinarily rich in detail about the firm and individual. Too often, economic and financial scholars are interested in discovering things such as the "incentive effects" of a particular pay policy. In fact, the viability of a particular pay plan may depend quite a bit on the type of workers the firm employs and the strategy and objectives of the firm. That is to say, a particular pay practice may work more effectively in one firm than another, even when firms are in similar industries and employ observably similar workers.

Armstrong, Jagolinzer, and Larcker (2006) study "option-exercise-timing-adjusted" employee option valuation models using detailed data from ten publicly traded U.S. firms including information on strike price, maximum term, and vesting schedule for each option grant to each employee. Their sample includes several tens of thousands of options. In some of our own work (Hallock and Olson 2007a,b), we examine data from two separate firms to consider the value of options to employees and employees' choice of mix of pay. Two very important and early papers that use unique data from firms are Heath, Huddart, and Lang (1999) and Huddart and Lang (1996). The authors use individual-by-individual option grant and exercise data from 50,000 individuals at seven corporations. Bajaj et al. (2006) use data from two firms to consider the valuation of employee stock options and find that employee stock option valuation methods suggested by Financial Accounting Standard (FAS) 123R, such as adjusting the expected life of the employee stock options and making adjustments to the Black-Scholes value, lead to substantial biases in option valuation.

Again, each of these papers makes a unique contribution and shows the details that can be learned from extraordinarily specific data. However, each study also suffers from the drawback that they are studying a very small nonrandom sample of firms.

4.3.5 Consulting Firm Data

An increasing number of scholars have made connections with consulting firms to use data from a variety of firms at once in one study. These have the obvious advantage that more firms are included. In some cases, there are

fewer details than in some of the case studies previously discussed. Heron and Lie (2007) investigated whether stock option backdating explained price patterns around executive stock option grants. The authors use data on stock options grants from Thomson Financial, which collects information from insider transactions of stock and derivative grants and exercises from Securities and Exchange Commission (SEC) forms 3, 4, 5, and 144. Landsman et al. (2006) consider which approach to accounting for stock options best reflects market pricing. They use 1,354 firm-year observations drawn from the S&P 500 from 1997 to 2001. Relationships with data providers are very hard to establish but the payoff from such data collection can be great.

4.3.6 Employee Perception Data from Surveys

One way to estimate the value employees place on stock options is to ask employees. Farrell, Krische, and Sedatole (2006) use "confidential training data files" of New Worth Strategies, Inc. (NWSI), a national leader in equity compensation planning services to investigate this issue. They examine how a training program may help employees understand their employee stock options better. Hodge, Rajgopal, and Shevlin (2006) investigate individual perceptions of the value of stock options and restricted stock. This is an alternative to observing actual exercise behavior and is complementary to the work of others (including that described in section 4.4). A benefit of this method is that the data are easily collected. A disadvantage is that respondents may not take the questions as seriously as they would if they were faced with an actual financial decision. The obvious problems with perception data still exist. It may be possible to try to elicit employee perception or utility by actually offering them choice and observing their behavior. A recent example of this is Hallock and Olson (2007a).

4.3.7 Government and Nonprofit Sources

There are also a set of government and nonprofit data sources that contain different types of information on employee stock options. Kroumova and Sesil (2006) consider the predictors of the use of employee stock option plans using data from the National Center for Employee Ownership (NCEO) in 1998 on 600 public and private firms sponsoring some form of broad-based stock option plan merged with information from Compustat. Oyer and Schaefer (2005a, 2006) have two papers that use these types of sources. Other government sources on stock options include the data from Unemployment Insurance (UI) records that are used in calculating the national accounts and the 1999 special survey conducted by the NCS.

4.3.8 International Data

Although the focus of this chapter is on employee stock options in the United States (and rules on grant, exercise, and taxation of options vary widely) international data on employee options are also available. Ikäheimo, Kuosa, and Puttonen (2006) examine the "most actively traded employee

stock option companies (14 plans of 6 companies), which represents 98.7 percent of total value of employee stock option trades on the Helsinki Stock Exchange (HEX)" (353). In another study using Finnish data, Jones, Kalmi, and Makinen (2006) use firm-level data on option plans from all Finnish firms from 1990 to 2002. Kato et al. (2005) investigate 644 adoptions of stock option plans announced by Japanese firms following the amendment of the Japanese commercial code in May 1997. Pendleton (2006) investigated the behavior of participants in the United Kingdom's Save as You Earn (SAYE) stock option programs.

Data from different countries certainly add to the richness of what we know about employee stock options. At the same time, we need to be careful in interpreting results across countries due to the quite different reporting and tax rules on stock and employee stock options across country boundaries. These differences, of course, provide a potential source of exogenous variation that can be used to understand the adoption of employee stock option plans and the behavior of firms and individuals covered by these plans. There is also substantial international interest in the national accounts measurement and timing issues we discussed previously, including as described in Lequiller (2002).

4.3.9 Gaps in the Set of Option Data and What to Do

Although there are many excellent data sources on stock options, there are significant gaps. These include the difficulties with trying to gain access to firm financial records, difficulty in collecting publicly available data, problems in reporting and understanding by individuals, and the issues of timing and measurement with the national accounts.

Many significant advances in the literature on stock options have been made because of researcher access to data from individual firms or data from consulting companies. The obvious problem is that the firms may have little to "gain" by providing their data to researchers. In one of our recent experiences (Hallock and Olson 2007b), we were turned down by as many as five companies (it could have been much worse) before we got access to the kinds of data we needed. In another (Hallock and Olson 2007a), we had a personal connection and an executive with a keen intellectual interest that helped us out. These types of data collection are very time consuming. In the end, we hope that firms will continue to share their data with researchers so more can be learned about options.

A second problem is that there are many publicly available data sources but the data are not yet "machine readable." This is a substantial barrier to researchers. However, there have been considerable improvements in the kinds of data being collected. For example, all "Form 4" data on stock and option transactions by senior executives in publicly traded firms are posted on the SEC Web site, and commercial sources (such as Thomson Financial) are publishing these data as well.

All is not bad news, however. An example is new requirements for firm reporting of executive pay packages. The changes in the recent proxy seasons (relative to the years before) are extraordinary. Included among these changes is amazing detail on each individual option grant given to each individual executive. These kinds of changes and easy to use machine-readable sources will hopefully contribute to our further understanding of employee stock options.

4.4 Case Study of Employee Exercise Decisions

In this section, we investigate the value of options to employees using a case study of option exercise decisions by over 2,000 middle-level managers and professionals in a large nonmanufacturing firm. The data we have include the entire ten-year exercise history for a sample of employees in the firm holding options that were granted on a common set of exercise dates. All the options from a single grant had the same strike price, expired ten years from the grant date, and vested after two years.[9] These common features mean that on each day in the ninety-six month exercise window the same profit could be earned by exercising an option from a common grant date, but the profit varies from grant to grant because of different exercise prices. Regardless of the option grant date, all option holders faced the same public information about the firm and the same exogenous macroeconomic environment on each calendar day in the exercise window. We also focused only on the exercise behavior of the 1,735 option holders who remained with the firm for the entire ten-year term of the option. This largely eliminates heterogeneity in option valuation because of anticipated turnover.

Daily data on employee exercise decisions for one large option grant were aggregated into calendar months, and figure 4.3 shows the distribution of first exercise times over the ninety-six-month exercise window. Evidence from this grant provides the strongest and simplest evidence of substantial heterogeneity in the value of stock options to employees unrelated to turnover intentions. This figure shows options were exercised over almost the entire ninety-six months with about 1 percent of the sample exercising options each month after about two years except for the final months when exercise activity increased.

Is the variation in exercise time in figure 4.3 substantial? As noted earlier, if employees valued options based on Black-Scholes and they could sell their options, the distribution of exercise times would have a single mass point equal to 1.0 in month ninety-six; all the options would be exercised in month ninety-six. Or, if employees identically valued options at another value, all

9. Two-year vesting means the options could not be exercised until twenty-four months after the grant date.

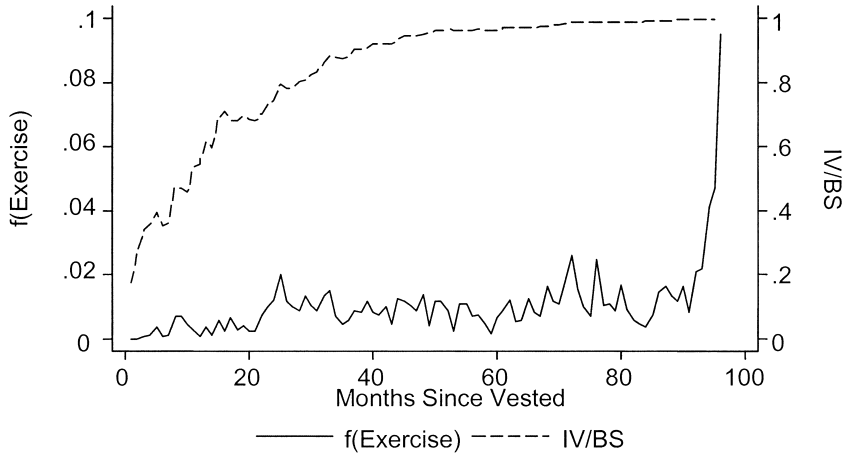

Fig. 4.3 Distribution of exercise times and intrinsic value/Black-Scholes value

of the exercise activity would have occurred in another month. The data clearly reject the prediction of a single exercise date.

The variation in exercise times implies substantial heterogeneity in the value employees place on holding their options. What more can be said? First, the upward sloping dotted line and the right vertical scale in figure 4.3 shows the profit an employee could have made by exercising an option divided by the option's BSV (i.e., $[SP_k - EP]/BSV^T_{t=k}$, $k = 1, 2 \ldots 96$). This ratio approximates the portion of the option's market value that is captured by exercising in any particular month rather than holding the option until the expiration date. One minus this ratio also indexes the penalty employees incur because they cannot sell their options. For example, for this option grant in month twenty, an employee lost about 30 percent of the option's value by immediately exercising the option. The variation in the potential value of the option sacrificed by "early" decisions indexes the substantial variation in the value of options to employees.

While much of the exercise activity summarized in figure 4.3 is "early" relative to what would be expected if employee stock options could be sold, the exercise pattern may be optimal for risk-averse employees who cannot sell their options and who also have their careers, human capital, and retirement income tied to the company. The different value employees place on options with identical terms may reflect differences in employee risk aversion with the least risk-averse employees holding options until the end of the exercise window. This hypothesis can be investigated by focusing on the 18.3 percent of the sample in figure 4.3 that held their options until close to the end of the exercise window and exercised their options in months ninety-four, ninety-five, or ninety-six. For this option grant, the intrinsic value of the option at the start of month ninety-four was about $240 per option, and

the average option holder owned about 200 options. Thus, almost 20 percent of the sample were willing to forego the $240 profit per option at the start of month ninety-four for the opportunity to capture the expected gain from holding the option for, at most, an additional three months. What could employees expect to gain over this three-month period, and what does their behavior imply about their risk aversion?

Assuming the stock price at the beginning of month ninety-four equals $280, and the exercise price equals $40,[10] the Black-Scholes value of an option expiring in three months is $240.70 using reasonable values for the other Black-Scholes parameters.[11] Thus, a diversified, risk-neutral investor would be willing to hold their option for the remaining three months to collect the expected gain of about $.70 per option or a return of 0.29 percent above what could be earned by immediately exercising the option.

The Black-Scholes value of the option at the end of month ninety-four can also be compared with the value from holding the option until month ninety-six for a risk-averse employee who predicts the firm's stock price at the end of month ninety-six using the firm's expected risk adjusted return and the variance in these returns. Following the Hall and Murphy (2002) methodology, the dollar value to a risk-averse employee from holding the option until the end of month ninety-six is the certainty-equivalent dollar value of the uncertain payoffs from holding the options another three months. In these calculations, we follow Hall and Murphy (2002) and define the utility of w dollars to a risk-averse employee to be $(w^{(1-RA)})/(1 - RA)$, where RA is a risk aversion parameter.[12] At the start of month ninety-four, we assume the stock price at the end of month ninety-six is defined by a stock return drawn from a normal distribution of annual returns ($\sigma = .30$) centered on the risk-free return (6 percent) plus the risk premium investors expect to earn by holding this firm's stock (14 percent).[13] The utility function and the ending stock price distribution is used to calculate the certain cash payment employees would be willing to receive at the end of month ninety-three that would make these employees indifferent between exercising the option and holding the option until the expiration day. Because the average number of options or grants that employees received in our sample is about 200, the certainty-equivalent values were calculated by assuming an employee

10. Again, we do not report the precise values because we are unable to disclose the name of the firm. The stock and exercise prices are the prices unadjusted for stock splits that occurred after the option grant date. Therefore, these calculations show the payoff from exercising one of the original options that were granted to the employee and not an option that reflects the effects of the stock splits.

11. This assumes the short-term risk-free interest rate equals 6 percent per year and the standard deviation of yearly firm returns equals .30. These numbers are roughly representative of the firm and time period for this option grant.

12. If RA = 1, then $U(w) = \ln(w)$.

13. The certainty-equivalent values are computed by approximating the log-normal price distribution at the end of month ninety-six using a binomial price tree with 121 terminal prices.

was deciding when to exercise 200 options in the final three months of the option's term.

Table 4.2 shows the results from this exercise for different levels of risk aversion. The first row of numbers are based on the Black-Scholes model and report the expected value of the options at the end of month ninety-six assuming risk-free returns are earned on the options. These calculations give a value of $244.23 per option or $48,846 for 200 options. Discounting this value back to the end of month ninety-three gives the BSV of $48,140 in column two. The remaining rows of the table give the certainty equivalent values for different levels of risk aversion where the final stock price is based on a draw from an annual return distribution centered on the firm's expected risk-adjusted return ($N[.20, .3^2]$). The second row reports the risk-neutral evaluation of the options. This value is greater than the BSV in row one because the BSV assumes market traded options earn an expected rate of return equal to the risk-free interest rate (6 percent), while an employee owning an option that cannot be sold predicts the firm's stock price will increase at an expected rate that includes the firm's risk premium (.06 + .14). For the risk-neutral employee, this difference produces an expected gain larger than the BSV. For a risk-neutral employee, the dollar value at the end of month ninety-three of holding the option until the expiration date is $50,136. This risk-neutral employee would hold their options because this value is greater than the $48,000 profit that could be earned by exercising the options at the end of month ninety-three. The value at the end of month ninety-three of holding the options until the expiration date is also almost $2,000 greater than the BSV of $48,140 for market traded options. This example illustrates the point that risk-neutral employees could value employee

Table 4.2 **Certainty equivalent dollar values of 200 three-month options with an exercise price of $40 and a current stock price of $280**

	Assuming no discounting ($)	Discounted at risk-free interest rate ($)
Black-Scholes value	48,846.40	48,140.00
	Certainty-equivalent values	
Risk aversion parameter[a]		
Risk-neutral	50,871.20	50,135.60
1.0	50,107.60	49,383.00
1.5	49,727.60	49,008.60
2.0	49,348.80	48,635.20
2.5	48,971.20	48,263.00
3.0	48,594.80	47,892.00
3.5	48,219.60	47,522.20

Note: The risk-neutral interest rate is 6 percent, the firm's risk premium is 14 percent, and the standard deviation of firm returns is .30.

[a] $U(x) = W^{(1\text{-RA})}/(1\text{-RA})$ for RA $\neq$ 1 and $U(x)=\ln(x)$ for RA = 1.

stock options at more than their BSV even when they are prohibited from selling their options.

Economists generally believe that individuals are risk averse, and there is no reason to believe the midlevel managers and professionals in this sample have different preferences. Therefore, the remaining rows in table 4.2 report more plausible certainty equivalent values for different levels of risk aversion. Hall and Murphy's evaluation of past research leads them to conclude that a risk-aversion parameter between two and three is a reasonable range for senior executives who are substantially wealthier than the sample of employees included in this analysis. The third row of table 4.2 shows that for a risk aversion parameter of 1.0, the certainty-equivalent value at the end of month ninety-three for the 200 options is $49,383, or $1,383 more than the $48,000 profit that could be earned by immediately exercising the options. The remaining rows show the certainty equivalents for other levels of risk aversion. At RA equal to 2.0, the value at the end of month ninety-three of holding these options to the end of month ninety-six is $635 more than the profit earned by immediately exercising them. When RA equals 3.0, the certainty equivalent value is $47,892, or $108 less than the value from immediately exercising the options. Rational option holders who have a value of risk aversion of 3.0 would be expected to exercise their 200 options at the end of month ninety-three. A risk-aversion parameter of 2.85 gives a certainty-equivalent value exactly equal to $48,000. Thus, individuals less risk averse than this value are predicted to hold their options, and those more risk averse are predicted to exercise their options. Because almost 20 percent of the sample held their options into month ninety-four, these calculations suggest a substantial minority of individuals owning options from this grant had a risk aversion parameter less than 2.85.

The calculations in table 4.2 show that moderately risk averse employees could form rational expectations about the firm's future stock price, decide to hold their options past the 93rd month, and place a value on the options greater than the options' BSV. Employee valuation of options that exceed the option's BSV and could not be sustained if employees could sell their options. If employees holding options at the end of month ninety-three with a risk-aversion parameter < 2.8 were allowed to sell their options, they would discover they had overvalued their options because the market would pay no more than the BSV. This leads to the prediction that the heterogeneity in valuations implied by the dispersed exercise times in figure 4.3 would disappear if options were tradable because employee valuations would converge to the BSV. When employees cannot sell their options, their valuations can exceed BSV because they cannot observe market prices for options with comparably long terms (ten years), and they can't borrow money from a bank using the options as collateral. Market information on options with terms comparable to employee stock options or borrowing terms from lenders might cause employees to value options closer to BSV.

Because employees lack these market signals, these calculations and their exercise behavior suggest they overvalue employee stock options compared to the BSV because they forecast the firm's future stock price distribution using the observed, risk-adjusted return earned by the firm's shareholders and not the risk-free return earned by owners of market traded options. Firms, of course, don't allow employees to sell their options or use them as collateral because they want employees to hold the options to encourage worker commitment to the firm and its objectives.

4.4.1 Inferring the Value of Options to Employees from Their Exercise Decisions

The basic ideas used to construct table 4.2 can be used in a statistical analysis of the exercise behavior for the entire sample of employees. This analysis can provide an estimate of employee risk aversion and the value of stock options to employees. We define the Employee Value Function ($EVF_{k,j,t}$) to be equal the value or utility (in dollars) to person j in month t from holding an option from grant k another time period t measures the months since the option vested and ranges from one to ninety-six because we study ten-year option grants with a two-year vesting period. In each month after vesting, we assume the employee decides between holding the option another period or exercising the option by comparing the profit from exercising the option (the intrinsic value) with the value of holding the option at least another period. Because the stock price minus the exercise price equals the certain cash payment the employee receives from exercising the option, the option will be exercised if this cash payment is greater than the monetary value to the employee of holding the option. In other words, the option is exercised in month t if

$$(1) \qquad (SP_t - EP_{k,j}) > EVF_{k,j,t}$$

and the option is held another period if

$$(1') \qquad (SP_t - EP_{k,j}) \leq EVF_{k,j,t}.$$

The left side of equation (1) is observed and equals the intrinsic value of the option or the profit that is made by exercising the option in month t. The key parameter we wish to estimate is the risk-aversion parameter employees use to discount the uncertain future payoffs from holding the option. Thus, the variable we focus on is the certainty equivalent value from holding the option implied by different levels of risk aversion. The model underlying the calculations in table 4.2 imply an option is held another period if

$$(1'') \qquad (SP_t - EP_{k,j}) \leq CE[RA, f(SP_{96} - EP_{k,j}), rf_t, rm_t, \sigma^2]_{k,j,t},$$

where CE(.) is the certainty-equivalent value of holding the option until it expires. This depends on risk aversion (RA), the distribution of the option's intrinsic value on the option's expiration date, the risk-free interest rate (rf_t), the firm's risk premium (rm_t), and the variance in the firm's returns

(σ_t^2). Equation (1″) could form the basis for estimating a probit model of employee exercise decisions. However, experimentation with different empirical specifications showed that this model fits the data poorly compared to specifications that included other covariates. Therefore, the estimates we report are based on a model where the probability an option is exercised in period t equals

$$\begin{aligned}(2)\quad \Pr(\text{Exercised in } t) = \Pr(\text{SP}_t - \text{EP}_{k,j}) > \beta_0 \\ + \beta_1 \text{CE}[\text{RA}, f(\text{SP}_{96} - \text{EP}_{k,j}), rf_t, rm_t, \sigma^2]_{k,j,t} \\ + XC + v_{k,j,t}, \text{ where } v_{k,j,t} \sim N(0,\sigma_v^2).\end{aligned}$$

The variables included in the X matrix included a set of dummy variables indicating whether period t was within two months of a stock split, a dummy variable indicating whether the stock price surpassed the high price in the past twelve months, the differential between the stock price in month t and the high price in the previous twelve months, and average firm returns in the previous three months and the next six months. Using data from all the option grants in the data set and not just the one grant used in table 4.2 permits us to estimate a random effects probit model because most individuals in the sample held options from grants made on different dates in the early to mid 1990s.

One other problem had to be addressed before the exercise decision model described by equation (2) could be estimated using standard statistical software. The certainty-equivalent value of holding the option until expiration is a nonlinear combination of the parameter RA and the variables $f(\text{SP}_{96,i} - \text{EP}_{k,j})$, rf_t, rm_t and σ_t^2. Using the utility function described in the preceding, the certainty-equivalent value of holding the option until it expires equals $\exp[1/(1 - \text{RA}) \times \ln(\text{E}(\text{utility of holding option until expiration}) \times (1 - \text{RA}))]$ discounted to the current period (t) at the risk-free interest rate. The E(utility of holding option until expiration) $\sim \Sigma f(\text{SP}_{96,i} - \text{EP}_{k,j})$ $U(\text{SP}_{96,i} - \text{EP}_{k,j})$, where $f(\text{SP}_{96,i} - \text{EP}_{k,j})$ is calculated from a discrete estimate of the log-normal stock price distribution at the end of month ninety-six using a twenty-step binomial price tree and $U(\text{SP}_{96,i} - \text{EP}_{k,j}) = (\text{SP}_{96,i} - \text{EP}_{k,j})^{(1-\text{RA})}/(1 - \text{RA})$. These steps mean RA cannot be directly estimated in a standard linear-in-the-parameters probit or linear probability model of exercise decisions because CE(.) is a highly nonlinear function of the risk aversion parameter we wish to estimate. Therefore, we estimate the risk-aversion parameter indirectly by selecting different values of RA and then calculate the certainty-equivalent values implied by each risk aversion value for each observation in the data. A random effects probit model was then fit for each risk aversion value and the log-likelihood values for models computed using different values of RA were compared. The risk-aversion value that best fits the exercise decisions comes from the model with the maximum log-likelihood value.

Before describing the results, we briefly describe the sample and data. We

have data for a sample of 2,180 middle managers and professionals who received multiple option grants at different exercise prices and at different points in calendar time from the studied firm. The firm is a large, long-established firm outside of manufacturing that has many tens of thousands of employees, billions of dollars in sales, and locations throughout the United States.[14] The employees in the sample received options at thirteen different exercise prices on thirteen different days in the 1990s with the majority of the grants occurring on two calendar dates where one exercise price was almost twice the magnitude of the other exercise price.[15] The research summarized here uses data on the exercise decisions made by employees for options received in the first two grants an employee participated in during the 1990s, where the options from the grants had vested before the fall of 2003.

Table 4.3 contains descriptive statistics on the sample of option grants. A total of 3,712 options grants were received by the 2,180 employees, and all but 1,127 of these grants were exercised during the study period (e.g., were not right-censored). Twenty-five percent of the grants are exercised by the 34th month following vesting, the median exercise time is sixty-nine months and the 75th percentile of the exercise distribution is ninety months. The exercise hazard rate is relatively low and stable during the first seventy-two months and then increases sharply in the final year as unexercised options are exercised before they expire. Consistent with the results for the one grant shown in figure 4.3, over the first seventy-two months of the exercise window, an average of 1.11 percent of unexercised option grants were exercised for the first time in each month.

An interesting feature of the experience in this firm is that not all options from a grant were exercised in the same month. In about 42 percent of the option grants where we observe the first exercise date (e.g., the exercise time is not right-censored), the employee did not exercise all of the options in the grant. On the other hand, overall 77 percent of the total options from the grants were exercised by employees on their first exercise date for a grant. For this reason only, the time until the first option from a grant is exercised is analyzed.

A final important feature of the sample is that it excludes managers who joined the firm during the 1990s or managers who received options during the 1990s but left the firm before the fall of 2003. Thus, these results describe the exercise decisions of long-tenured, stable employees who did not exercise options in anticipation of leaving the firm. Excluding option recipients who left the firm during the study period simplifies the analysis because

14. A condition for obtaining data from the firm included a promise that we would not reveal the identity of the firm. Therefore, we cannot provide a more detailed description of the firm or make the data available to other researchers.

15. In all cases, the options were granted "at the money." That is, the exercise price was equal to the firm's stock price on the day of the grant.

Table 4.3 Summary statistics on exercise decisions

No. of employees receiving options	2,180
No. of option grants	3,712
No. of option grants where time to first exercise date is censored	1,127
Mean options/grant	1,302
Mean hazard rate/month	0.0128
25th percentile of time to first exercise date (months)	34
Median time to first exercise date (months)	69
75th percentile of time to first exercise date (months)	90
Options exercised on first exercise date as fraction of options in the grant	0.765
Fraction of first exercise decisions where 100% of options in grant were exercised	0.576

we don't have to jointly model employee turnover and option exercise decisions.[16]

4.4.2 Estimates of Employee Risk Aversion

Table 4.4 reports the log-likelihood values for models that include the certainty-equivalent values of holding an option calculated from different risk-aversion values. For each RA value, the log-likelihood values are shown for two models; one model that includes only CE(.) and the option's intrinsic value and a second model that also includes the other covariates.[17] Across all the values of RA, a comparison of the likelihood values for the two specifications show the model that includes CE(.) and the other covariates does a much better job of predicting exercise decisions than a model with just CE(.) and the option's intrinsic value. Therefore, the discussion focuses on the results in the second column of table 4.4.

The results in column (2) show a clear pattern. For the values shown in the table, the log-likelihood value is maximized at –12,409.44 in the model where RA equals 2.20 and deviations from 2.20 in either direction produce results with smaller log-likelihood values. Additional models were estimated for RA values around 2.20, and a RA value of 2.21 produced a maximum log-likelihood value of –12,409.437. This method of inferring RA does not produce an estimated standard error. Note, however, the risk-neutral specification implies RA = 0, and for this model the log likelihood value is –12,455.24. A likelihood ratio test comparing RA = 0 and RA = 2.21 clearly rejects the hypothesis that these employees were risk neutral in their option

16. Firms often report that they provide options to improve employee retention. Modeling option exercise decisions and turnover is difficult. While options might reduce turnover, employees that are planning to leave the firm can be expected to exercise vested options before their departure. This creates a positive correlation between exercise decisions and the probability of turnover in the "near term." Modeling exercise decisions and turnover behavior jointly would require a more elaborate competing risk framework and data on employees who did not receive options.

17. The log-likelihood value for the model that includes the option's intrinsic value and the *X* variables but not CE(.) is –12,475.29.

Table 4.4 **Log-likelihood values for models that include certainty-equivalent values of holding an option for different levels of risk aversion**

	Model includes:	
Risk aversion	Intrinsic value, CE(.)	Intrinsic value, CE(.), X
Risk-neutral	–12,488.67	–12,455.240
0.50	–12,484.42	–12,452.822
1.00	–12,473.70	–12,443.847
1.50	–12,461.13	–12,433.029
1.75	–12,451.98	–12,424.170
2.00	–12,442.12	–12,413.851
2.20	–12,437.94	–12,409.443
2.25	–12,438.13	–12,409.661
2.30	–12,438.95	–12,410.499
2.50	–12,447.87	–12,419.073
3.00	–12,487.56	–12,453.232
3.50	–12,520.71	–12,475.175

Notes: A model with just the option Intrinsic Value (IV) and the X variables has a log-likelihood value of –12,475.29. The six variables in the **X** matrix include the differential between the stock price in the month and the twelve-month stock price high, the average firm stock return over the previous three months, the average stock return over the next six months, and separate dummy variables indicating whether the stock price in the month exceeds the twelve-month price high, and indicators for two months prior to a stock split and two months after a stock split. The log-likelihood value is maximized (–12,409.437) for a model where RA = 2.21.

evaluations. In addition, the results are consistent with the model described by equation (2) because any of the specifications that include CE(.) fit the data better than a model without CE(.) ($\log L = -12{,}475.3$).

The estimates summarized in the preceding imply all employees in the sample have identical risk preferences. This is unlikely to be true. Indeed, heterogeneity in risk aversion may be an important variable explaining the variability in exercise times observed in the data. One variable we have that may be negatively correlated with risk aversion is an employee's earnings in the firm. Although this sample is a fairly homogeneous sample along earnings relative to the earnings distribution for the entire firm or for the U.S. labor force, the variation in wages in the sample may be sufficient to identify variation in risk aversion.

The sample of employees was divided into wage quartiles based on real earnings in the first month an option held by an individual vested. The empirical method used in the preceding for the entire sample was then replicated for each subsample to identify the value of RA that maximized the log-likelihood value for each subsample. The results are consistent with the hypothesis that lower-wage workers are more risk averse than higher-wage workers. For workers in the first quartile, the best fitting model had an RA value of 2.34; the value for the second quartile was 2.18; 2.15 for the third

quartile; and 2.09 for the highest wage quartile. Although we cannot statistically test whether these values are different from one another, the point estimates suggest variation in risk aversion in the predicted direction.

The values of RA for models that best predict exercise decisions for the entire sample and each wage quartile can be used to calculate the certainty-equivalent value to an employee of holding an option until the expiration date. These option values to employees can be compared to the value the market would place on the same options using Black-Scholes. Figure 4.4 shows these values for thirty-six to eighty-four months after the option vests for a ten-year option with an exercise price of $15 and a current stock price of $50. The figure shows BSV and the certainty-equivalent values of the option for RA = 2.34, 2.21, and 2.09. As expected, the uncertain payoff from holding the option means the option's value declines as risk aversion increases. For example, at sixty months after vesting or seven years since the option was received, the value of holding the option is $38.61 when RA = 2.34, $41.14 when RA = 2.21, and $43.41 when RA = 2.09.

The other key point shown in this figure is that for these three risk-aversion parameters, an employee places a higher value on holding the option than what Black-Scholes predicts the option could be sold for in the market. As discussed earlier, this finding supports the point made from table 4.2 that the exercise behavior of these employees implies they value their options at values in excess of the option's BSV because of fundamental differences

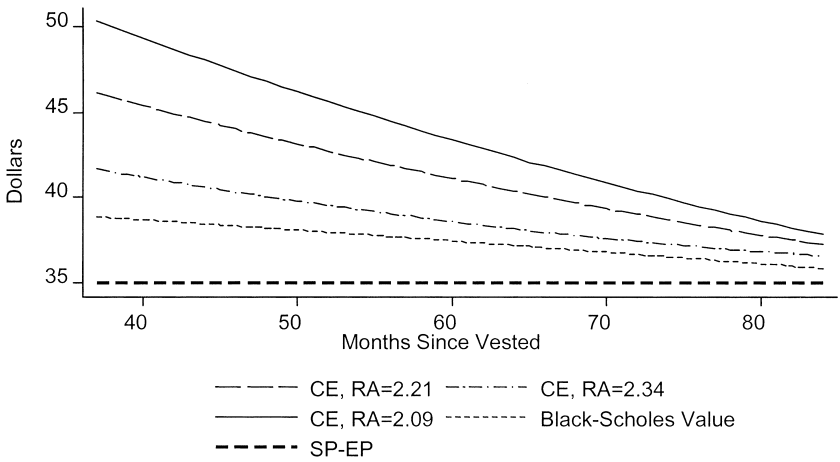

Fig. 4.4 Certainty equivalent and Black-Scholes values 36–84 months after vesting for a 10-year option where SP = 50, EP = 15

Notes: Expected firm return = .2, risk free return = .06, SD returns = .3. Each period the certainty equivalent (CE) values are computed from a terminal stock price distribution estimated from a forty-step binomial price tree. See text for description of the utility function. The CE lines are smoothed estimates through the CE values. SP = stock price. EP = exercise price.

between employee stock options and market traded options. Because employees cannot sell their options or use them as collateral to borrow money, they have no market signals to evaluate their worth to outside investors. The estimates suggest that employees value their options based on the firm's expected returns rather than the risk-free return the market uses to value options. The constraints that prohibit employees from selling their options or using them as collateral are imposed by the firm to further the firm's objectives. For senior managers who have substantial impact on the success of the firm, these features encourage executives to hold onto their options and make decisions that are beneficial to shareholders. In the firm studied here, the employees are not at a sufficiently high level in the firm to individually have a large impact on profitability. However, the firm may gain a more committed management workforce by providing options and encouraging employees to hold on to them.

This section focuses on how employee exercise decisions can be used to infer the risk aversion of employees and the value employees place on employee stock options. These results have implications for many of the research and policy questions summarized in earlier sections of the chapter. For example, the cost of options to the firm depend on when employees exercise their options and the sensitivity of their exercise decisions to changes in the firm's stock price. Using Black-Scholes to cost options assumes options are held until the expiration date and the stock price at expiration is drawn from a log-normal distribution. Because these assumptions do not describe the option grants studied here, the BSV provides a poor estimate of the cost of these options to the firm. However, the empirical model of exercise decisions estimated here can be used to predict when employees exercise their options and the sensitivity of their exercise decisions to the firm's stock price.

4.5 Open Questions and Conclusion

In the past few years, there have been dramatic shifts in public perceptions of and government regulations over how executives and other employees are paid in the United States. Until just recently, firms in the United States were not required to "expense" stock options in their balance sheets. Now that U.S. firms have to report options as an expense in the balance sheet and not just in footnotes to financial statements, decisions to grant options to employees are likely to be subject to greater scrutiny. While much has been learned about employee stock options over the past ten to fifteen years, numerous issues important to firms, policymakers, and employees remain unresolved. In this chapter, we highlight some of these issues, discuss recent policy shifts affecting options, and summarize the data sources on options available in the United States and elsewhere. In the last section, we present some of our own work on options that explore the value employees place on options that, in turn, has implications for the cost of options to the firm.

There are several new and continuing regulatory issues on the horizon that deal with compensation and stock options. One that is interesting is the way that firms have been required to report on executive compensation. Even though there has been considerable reform, there is still confusion about the way firms report options in the "summary compensation table." Firms are given wide leeway in the assumptions they can make about certain forms of compensation and how they report. We anticipate more reforms and changes along these lines in the future.

Another is how to explicitly deal with employee stock options in the national accounts. As is it today, ISOs are not counted at all and the much more prevalent NSOs are, but as discussed previously, there are considerable problems with how and when these data are reported. Recent attempts by the BEA to examine this have been fruitful, but there are still unresolved conceptual and data issues to be addressed.

There is a series of other interesting questions on options where some progress has been made but more is to be done. Some of these questions have been answered, but many have solutions that are not yet known. The questions include why do firms grant options (Hall and Murphy 2003), do options retain employees (Hall and Murphy 2003), do they motivate employees (Hall and Murphy 2003), do they attract employees (Oyer and Schafer 2005b), why are they granted (in some cases) throughout the firm (Oyer and Schafer 2005b), will the recent FASB changes alter the way employees are paid (Bodie, Kalpan, and Merton 2003), how well do options work, why don't more firms use indexed options (e.g., relative performance evaluation work by Antle and Smith 1986; and Gibbons and Murphy 1990), are options efficient, what is the value employees place on options (Hall and Murphy 2003; Hallock and Olson 2007b), what is the cost of options to the firm (Hallock and Olson 2007b), and what are issues surrounding options backdating (Lie 2005, 2007; Yermack 1997)?

New work on stock options has the potential to have a practical impact on firms and the national accounts. If firms do not have a credible estimate of how employees value stock options or other forms of compensation and firms alter the mix of pay, there could be consequences related to employee attraction, retention, and turnover and problems reconciling the national accounts. We hope that our work is a useful step in the right direction of understanding more about compensation and employee stock options.

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Comment

Chris Riddell

Stock options and, in particular, equity awards broadly defined, remain an area with many unanswered questions. Why do companies use stock options (or other equity awards)? do they motivate employees; lead to greater retention? What value do employees place on equity awards? We still know relatively little about these fundamental questions. Further, in light of recent changes in accounting practices for stock options where firms are now required to recognize compensation expense at the time of the grant, as well as international generally accepted accounting principles (GAAP) standards likely coming to the United States, there are many policy issues still to be addressed such as what types of option pricing models may or should be mandated in the future.

A key reason why our knowledge is so limited in the area of equity compensation is data availability: to think deeply about issues such as those in the preceding, we require detailed information on the contractual parameters of a stock grant coupled with personnel records for a reasonable time period (e.g., long enough to examine such behavior as turnover or exercising and so forth). Locating such data is, unfortunately, far from straightforward! Hallock and Olson have done an admirable job in finding several sources of such data resulting in a series of exciting papers (also see Hallock and Olson 2007a,b).

In this chapter, the authors focus primarily on how employees value stock

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