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Firm Volatility and Stock Option Incidence

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Preliminary and Incomplete

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Abstract

In this paper, I present two models that describe the relationship between stock option incidence and stock price volatility. First, I present an industry-clockspeed human resources (HR) model. Firms in industries where products obsolesce quickly will grant stock options to motivate employees to exert high effort and shorten the product development cycle, which increases volatility of firm performance. In the second approach, I present a model of cash-constrained firms, where firm stock price volatility is positively related to borrowing costs. If borrowing costs increase with performance volatility and risk, firms will offer stock options to conserve cash. Using the IT data, I find that option incidence is positively related to firm volatility, which is consistent with the implications of both models, while the relationship between options incidence and firm size and wages is more consistent with the Clockspeed-HR model.

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1 Introduction

> Why do you think they are so motivated? The answer is because they are shareholders of the company. Why are they willing to stay as late as they're staying? Why do they ride coach everywhere they go? It's because they're spending the money as if it were their own.
>
> –Dennis Powell, Cisco's senior vice president of corporate finance (Baker 2002)

> Very young companies can't afford to attract talent with big salaries, they do it by giving people a piece of the action.
>
> – Jim Jarrett, Intel's vice president of worldwide government affairs (Baker 2002)

Executives at two of the world's leading technology firms identify two key reasons for employee stock option incidence. Properly implemented, stock options can motivate workers to a high-level of effort and can provide financially constrained firms with wage bill flexibility. In this paper, I develop two models of stock option incidence that capture the spirit of the high-tech executives quoted above and relate firm volatility to stock option incidence.

First, I present a model based on the "clockspeed" concept presented in Fine (1998) and the "O-ring" model of production functions (Kremer 1993). Firms in industries where products depreciate quickly will have higher relative returns to reducing product time-to-market than firms in industries where products have longer lives. These conditions lead to a twist on the standard segmented labor market model. If time-to-market is determined by the weakest link on a product development team, firms in some industries will implement a high-innovation strategy that leads to high share price volatility and prevalent employee stock options for project-critical employees. Second, I present a model of financially constrained firms where firm stock price volatility is positively related to borrowing costs. If borrowing costs are sufficiently high and firm owners have diminishing marginal utility of wealth and control substantial equity, the expected cost to firms of paying workers enough in wages to satisfy their reservation utility is greater than the expected cost of compensating workers with equity.

In the Clockspeed-HR model, I develop a human resources model where differences in industry clockspeed lead to differences in share price volatility and to segmented labor markets. I choose to focus on the "industry clockspeed" version of segmented labor market models because the clockspeed approach fits the technology boom of the 1990s and relates segmentation of the labor market to firm stock price volatility. In the presentation of the model, I capture the concept of clockspeed by allowing the obsolescence rate of new products to vary across industries.

In the framework of Fine (1998), industry clockspeed captures the rate of innovation, new product introduction, and the velocity of competition in a given industry. High-clockspeed industries are marked by technology that quickly obsolesces and products that have a short life span. The rate of obsolescence is also positively related to product profit margin. Firms in industries where products depreciate quickly will pursue higher value products to hasten product development cost amortization. If the industry has a high clockspeed, firms in that industry must innovate frequently and introduce new products to the market quickly because competitive advantage is temporary.

The video chip industry is an example of a high-clockspeed industry. The company that puts out the first (glitch-free) chip in each generation has a competitive advantage. The competitive advantage erodes until the next generation of chip is introduced (typically two to three months later), at which point the life of the previous product generation ends. Firms have a large incentive to innovate quickly and be the first to market. If firms do not innovate, they die a quick death.

Stock prices are very volatile in this industry because every generation chip that is released results in a shuffling of the winners and losers, and the difference in outcomes for the winners and losers is large. In this industry, stock price is sensitive to employee effort. If project-critical employees work hard and innovate quickly, then the firm can shorten the product development cycle and gain a temporary competitive advantage. Firm stock price will reflect this market success.

The automobile industry is a low-clockspeed industry. Automobile product generations are infrequent (typically a year between product cycles) and even given a new product generation the older generations retain much of their value. In low-clockspeed industries, stock market volatility is lower than in high-clockspeed industries. It is easier to predict firm competitive advantage and competitive advantage is less fleeting.

In this environment, firms can extract revenues from a product generation for a longer time, thus the push to innovate is less critical. Because time to market is less critical, firms in low-clockspeed industries do not need to motivate an extremely high level of effort.

The primary implication of the Clockspeed-HR model under an "O-ring" production function is firms in high-clockspeed industries will provide efficiency wages and exhibit high stock price volatility.

In the second model, firms have borrowing costs that are positively related to the volatility of their net earnings. Because firm volatility is positively related to borrowing costs and financially constrained firms will offer options when the marginal utility of equity ownership is less than the cost of borrowing cash, highly volatile firms will prefer to compensate employees with stock options instead of cash.

In a start-up company, ownership typically consists of founders, friends and family, and angel investors. These individual investors are likely to exhibit diminishing marginal utility of wealth over the relevant range of pay-offs. For example, for these small investors, the marginal utility of the first $10M of wealth is greater than the marginal utility of the next $10M. These investors are willing to sell their rights to the second $10M for less than market value. For institutional investors, this is not the case.

Assume that the start-up has extreme volatility. In the next period, the company will invest heavily in technology and growth and either hit it big and all investors would become fabulously wealthy, or they will fail and all employees would be without jobs and the investors would lose their investment. If the firm is cash constrained, the firm must either borrow cash or sell equity to cover expenses. If investors' marginal utility of equity is less than the marginal cost of borrowing, then the firm is better off diluting equity to cover expenses.

The diminishing marginal utility of wealth effect is largest when all investors are small and all control a large share of the company. If there are institutional investors, or equity is spread thinly across many investors, then firms should be unlikely to offer stock options. However, if compensation policy is set by executives or board members who control substantial equity in the firm and have diminishing marginal utility of wealth, then even large firms will exhibit the diminishing marginal utility of wealth effect.

If firm owners value equity less than borrowed cash, the firm will be more likely to compensate workers with stock options. Similarly, the firm will be more likely to use stock options to pay for other goods and services. In the Silicon Valley in the 1990s, firms used stock options to pay for many outside services and goods including real estate (Kaplan 2000) and professional services (including legal, recruitment, marketing, and advertising (Maharaj 2000)).

In the 1990s, many observers believed that workers were willing to accept options instead of cash. According to Roger King, the president of a technical recruiting firm in the San Francisco Bay Area, "Everyone wants to work for an IPO and most employees are happy to take a 15 percent to 20 percent pay cut for stock options. (Stinton 1997)". Employees may be willing to accept some options instead of cash because the expected value of holding options is positive, the downside risk of holding options is limited by the foregone compensation, and employees have relatively high marginal utility of wealth.

Employee stock options grant employees the right to buy shares of their employer's stock at some future time at the price at time of award. Stock options are a call option - the employee has the right, but not the obligation, to purchase the stock in the future at the current price. The *strike price*, the price of options at time of award, and the *vesting period*, the time until the options can be exercised, determine the structure of a stock option. At the end of the vesting period, the option holder considers the current stock price and decides whether to exercise the option. If the current price is greater than the strike price, the holder will exercise the option and realize immediate profit[1]. If the current price is less than the strike price, the holder chooses not to exercise the options and receives zero gain.

Because there is a lag between the options grant and the potential exercise of the options, options provide an explicit contract for deferred compensation. Stock options are particularly valuable to employees because stock option have limited downside risk. After the vesting period, if current stock value is below the strike price, the return is zero. If current stock value is above the strike price, the return is the difference between the actual price and the strike price. Returns are non-linear, specifically, they are piecewise linear with a kink at the strike price. Employees may realize profit from their options, but they can not realize a loss[2]. Employees share in all of the upside risk but are limited in their exposure to downside

[1]There are two commonly implemented forms of options: American-style options where the options holder has a window in which to exercise options (typically one year) and European-style options, where options holders must exercise or lose the options on the day that they vest.

[2]There are rare occasions when holders of employee stock options may realize a loss by exercising their options. For instance, officers of firms may be restricted in the number of shares they can sell in a given year. When an officer exercises her options, she is liable for the "alternative minimum tax" - a 28% tax on the paper gains from exercising options. If the stock price drops substantially before the officer can sell all the shares, the tax bill may outweigh the realized gains of the exercised options. The alternative is for the officer to quit her job when the stock price begins to decline, freeing herself of the limitations on the number of shares that can be sold, and then sell all shares and pay taxes on the actual profit (Helft 2001).

risk.

Because stock options are an explicit contract of deferred compensation contingent upon firm performance, employers can use options to accomplish a variety of human resource goals. In this paper, I focus on two goals: stock options can be implemented to have incentive effects and motivate workers to exert high effort (the Clockspeed-HR model), and stock options can provide firms with wage-bill flexibility (the Cash Constrained Firm model).

The paper proceeds as follows: in Section 2, I present an overview of the segmented labor market literature and I discuss the role of firm characteristics on employee compensation. In Section 3, I present two models of stock option incidence. Subsection 3.1 contains a description of the Clockspeed-HR model where stock option incidence is related to the rate of product obsolesce. Subsection 3.2 describes how financially constrained firms may use stock options to defer employee compensation. In Section 4, I present a survey of labor market outcomes for information technology (IT) professionals and I present the industry stock price indices used to create industry volatility measures. I also present data from the Center for Research in Security Prices (CRSP) that I use to calculate firm volatilities. In the empirical section of the paper (Section 5), I consider options incidence for information technology (IT) professionals in the framework of the two models to analyze the relationship of industry volatility and stock option incidence. In Section 6, I discuss alternative explanations for the empirical results, and in Section 7, I discuss the implications of this paper.

2 Segmented Labor Markets

2.1 Stock Options and Segmented Labor Markets

In the theoretical section of this paper, I combine the modeling approaches of Kremer (1993) and Rebitzer and Taylor (1991). Kremer presents a model where segmented labor markets arise from an O-ring production function. When production is limited by the least productive employee on a project, firms will segment employees by ability. Rebitzer and Taylor build on the seminal segmented labor market models of Shapiro and Stiglitz (1984) and Bulow and Summers (1986) by allowing for uncertainty in product demand[3]. When product demand is uncertain and workers may be laid off even though they are not shirking, firms must pay higher efficiency wages to deter shirking than firms with certain product demand.

In my presentation of the model, I relax the assumption that employer-employee relationships last indefinitely. Because employees only have a finite relationship with an employer, there is necessarily a bonus granted upon completion of the contract to deter shirking late in the contract. I also assume that employee effort plays a role in determining product demand.

Akerlof and Katz (1989) address the structure of the contract-end bonus necessary to deter shirking in a finite economy. The implicit bond presented in their work discourages shirking and is observed in the real world in upward sloping wage profiles and pensions, and as I posit, in employee stock option grants.

The Akerlof and Katz bond addresses a concerned raised by Carmichael (1985). Carmichael demonstrates that an up-front bond posted by an employee will discourage shirking. If workers are required to post a sufficiently large bond, firms do not need to pay efficiency wages

[3] For an overview of the foundations of segmented labor market theory, see Yellen (1984).

and markets clear. However, because of imperfect capital markets, employees may not be able to post the full up-front bond, thus, as discussed by Akerlof and Katz, employees "pay" the bond by agreeing to defer compensation in the form of upward-sloping wage profiles, pensions, and stock options. Firms with deferred compensation schemes should have lower turnover, but Levine (1993) demonstrates that firms in a sample of manufacturers in the United States and Japan do not exhibit a positive relation between upward-sloping wage profiles and low turnover.

Recent extensions to the basic dual labor market theory include Beaudry (1994) that builds upon the Shapiro-Stiglitz model by introducing signaling into the model, Albrecht and Vroman (1998) that introduce worker heterogeneity into the shirking model, and Walsh (1999) which extends the shirking model to account for industry heterogeneity. My presentation follows in the same line as Walsh, as I extend the shirking model to account for heterogeneity in the rate of depreciation of new products.

2.2 Testing Segmented Labor Market Models

The traditional segmented labor market models are characterized by "primary" sector jobs that offer high compensation and low turnover rates and demand high levels of employee effort and "contingent" sector jobs that offer low compensation and high turnover and require a low level of effort.

A difficulty with testing the implications of dual labor market models is identifying primary and secondary sector jobs. There are three general methods used in the literature to identify primary and secondary sector jobs. The first method is to divide occupations into sectors based on the characteristics of the workers or of the jobs in the occupation. The second method is to estimate different wage equations for different industries and occupations, and the third method is to sort employees into primary and contingent sector jobs using an endogenous switching model (Dickens and Lang 1985). All of these methods are problematic or require strong structural assumptions.

Another approach to analyzing efficiency wage models is to test their implications directly. Wadhwani and Wall (1991) demonstrate for a sample of UK manufacturers that productivity is positively correlated with relative wages and level of unemployment. Levine (1992) demonstrates similar results for firms in the US. Their findings are consistent with the implications of efficiency wage theory. I follow this approach.

2.3 Compensation and Firm Characteristics

In addition to compensation differences arising from dual labor markets, firm characteristics also will affect compensation patterns.

Rebitzer and Taylor (1995) provide an additional explanation for the firm-size wage premia observed in Brown and Medoff (1989). Rebitzer and Taylor argue that in larger firms, the cost of monitoring effort is higher thus the probability of detecting shirking is lower. Because the probability of detecting shirking is smaller, firms need to pay more to deter shirking, thus a firm-size wage premium is observed. Similarly, Rebitzer and Robinson (1991) use the Dickens-Lang switching regression approach and demonstrate firm-size premia in both the primary and secondary sector, but observe a significantly larger premium in the primary sector.

Variability of firm performance also effects compensation. Garen (1994) presents a principal-agent model of executive compensation. Empirically, he demonstrates that variability in firm returns relative to the rest of the industry is positively related to executive pay sensitivity. Queen and Roll (1997) demonstrate that stock volatility and firm mortality are positively related. Assuming that firm mortality probability and compensation are related yields that stock price volatility and compensation are related.

My addition to the literature consists of two models of stock option incidence that capture the decisions of employers and employees in high-tech firms in the 1990s. Specifically, I present a model where differences in industry product markets lead to segmented labor markets and differences in firm volatility. Additionally, I present a model where firm volatility is related to financial borrowing costs.

3 Two Models of Options Incidence

In this section, I present two structurally similar models that capture the spirit of the high-tech executives' quotes at the beginning of the paper and describe different channels through which stock option incidence and firm share price volatility may be related.

In both models, I present a two-period economy where an employee works in the first two periods, draws a salary in each period and may draw a bonus contingent on firm performance at the end of the contract. In both models, the firm's problem is to structure the optimal employee compensation package.

In the first section, I present an HR model based on the clockspeed framework of Fine (1999). Industries vary by the rate of obsolescence of new products. Firms in industries where products obsolesce quickly will attempt to bring new products to market more quickly than firms in industries with longer technology generations. Firms pursuing a high innovation strategy will have more volatile share price and be more likely to offer a performance bond to motivate high effort. In the second model, I present a model of financially constrained firms. Firms facing financial constraints structure compensation to minimize total compensation costs in the face of high borrowing costs.

Both models start from the same basic assumptions:

1. Employees are risk-neutral with linear utility, $u(w, e) = w - e$.

2. Firms are profit maximizers/cost minimizers.

3. Wage renegotiation is costly.

Basic Time-line:

1. A firm offers a contract including compensation package (w, b) to an employee. Under the contract, the employee is paid w for each period of work and the employee receives the option to claim a share, b, of stock market gains exercisable at the end of the contract.

2. Firm stock market valuation is a positive function of firm profits.

3. The worker works for the first period and receives wage w.

4. The worker works for the second period and again receives wage w.

5. At the end of the second period, firm stock price is revealed. If stock market growth over the duration of the contract is positive, the employee exercises her option and receives a bonus. If stock market growth is negative or zero over the duration of the contract, the employee chooses not to exercise her option and receives no bonus.

6. The economy ends.

In the following sections, I extend the basic assumptions and time-line to allow for differences in firms' rate of product obsolescence (the Clockspeed model) and to allow for differences in firm discount rates (the Financially Constrained Firm Model) .

3.1 Clockspeed Model of HR

Industry clockspeed captures the rate of innovation, new product introduction, and competition within an industry (Fine 1999). If the industry has a high clockspeed, firms in that industry must innovate aggressively and introduce new products frequently. Mendelson and Pillai (1998 and 1999) demonstrate that firms in high-clockspeed industries implement business processes to help deal with the high rate of change and inherent time urgency. In this model, I look at the HR side of the business and discuss compensation strategies that allow the firm to succeed in a time-urgent marketplace.

I present a twist on the Kremer O-ring efficiency wage model by introducing a human resources model where differences in product obsolescence rates lead to differences in share price volatility and to segmented labor markets. I capture the concept of "clockspeed" by introducing variance in the obsolescence rate of new products under the assumption that all new products in an industry depreciate at the same rate. A valuable extension would be to allow the initial revenue and obsolescence rate of a new product to be a function of relative time-to-market. If firms are the first to market, they enjoy a greater competitive advantage than firms who enter the market later.

Assumptions for the Clockspeed-HR model:

1. Workers choose intensity of effort, e. Workers have two levels of effort, high intensity, e_H, and low intensity, e_L where $e_H > e_L$.

2. Assume new product introduction follows an "O-Ring" production function (Kremer 1993) where the product development cycle consists of a series of sequential steps and one weak link can doom the project. In the model, new product introduction is a function of employee effort. If all project-critical employees perform their specific step with high effort then the project is a success and the firm can introduce a new product at the beginning of the next period. If any project-critical employee fails to perform their step at high effort, the project gets behind schedule and the firm and can introduce a new product two periods after the beginning of development. In this model, I focus

only on outcomes for project-critical employees. For a project to succeed, the critical employees must be motivated to high-effort and their effort should be sensitive to profit sharing.

3. Individual employee effort is impossible for the firm to monitor. Of course, if a new product introduction is behind schedule, the firm knows that some critical employee was shirking, but the firm can not identify any shirking individual.

4. Industries vary by the rate of product obsolescence d. Revenue from each product declines at a rate of d units per period until $R - d\, t = 0$, where t is a time trend..

5. Each new product generates initial expected revenue per employee $R \sim N(\mu + \alpha d, \sigma^2)$, where μ is the base return to innovation and the αd term captures the clockspeed premium to innovation. Fine (1996) presents examples to motivate the clockspeed premium. He argues that when Intel builds a billion dollar plant, they expect the plant to be obsolete in four years. When Ford builds a billion dollar plant they expect the plant to generate revenue for twenty years. Firms in high-clockspeed industries must develop higher-return products than firms in low-clockspeed industries, or they will never recoup their investment.

6. Assume stock price at time t is equal to the expected value of the sum of firm profits at the end of the economy conditional on the information set at time t. Stock market value at time t is equal to $\Sigma_{i=0}^{2}\mathrm{E}(\pi_i)$ given the information at time t, where π_i demotes firm profits in period i.

7. Innovation rate depends solely on labor inputs.

Time-line:

1. A firm offers a contract consisting of a wage, w, and the option to claim a share, b, of the firm's increase in stock market value exercisable at the end of the contract.

2. Firms begin the economy with no products on the market and no revenues. Firm profit at the beginning of the economy is $\pi_0 = 0$.

3. Firm stock market value equals the sum of expected profits at the end of the second period.

4. Employees work for the first period and receive wage w given all currently available information.

5. If all project critical employees work at a high level of effort, the firm introduces a new product. The new product has initial return $R \sim N(\mu + \alpha d, \sigma^2)$. The effect of innovation on firm performance is driven entirely by "time-to-market" for new products. Quality and uncertainty of all new products are assumed to be identical within industries.

6. Firm stock market value is adjusted to reflect new product performance in the first period.

7. Employees work for the second period and receives wage w. All firms, both low-innovation and high-innovation firms introduce a new product. Again, the new product has initial return $R \sim N(\mu + \alpha d, \sigma^2)$. Any products introduced in the first period depreciate by d units.

8. At the end of the second period, firm stock market value is known with certainty. Stock market value is $\Sigma_{i=0}^{2}\pi_i$. If the value is greater than the stock market value at the beginning of the economy $\Sigma_{i=0}^{2}\mathrm{E}\pi_i$, employees exercise their options and receive a bonus of $b(\Sigma_{i=0}^{2}\pi_i - \Sigma_{i=0}^{2}\mathrm{E}\pi_i)$. If stock market value decreased over the economy, the employee chooses not to exercise the option and receives no bonus.

9. The economy ends.

I will explore the model in three steps. First, I will demonstrate that firms adopting a high innovation strategy will have a more volatile stock price than low innovation firms. Second, firms in industries where products obsolesce quickly will adopt a high innovation strategy, and third, firms that implement the high innovation strategy will offer their workers a bond contingent on firm performance to motivate effort. I will then discuss the empirical implications of these three results.

First, firm share price volatility is positively related to "speed to market". If the firm implements the low innovation strategy, then firm profit starts at $\pi_0 = 0$. In the first period, the firm pays wages, but does not introduce a new product, so profit drops to $\pi_1 = -w$. In the second period, the firm introduces a new product and pays another period of wages. Profit jumps to $\pi_2 = R_1 - 2w$, where R_n is the realized initial return for the n^{th} product introduced by a firm.

Firm stock market value at time $t = 0$, denoted S_0, is equal to the expected sum of firm profits across the time frame given the information at $t = 0$. Initially, the firm knows only that a new product will be introduced in the second period and the distribution of revenues for the new product. Initial stock price is $S_0 = \mathrm{E}(R_1) - 2w$. By assumption, $R_i \sim N(\mu + \alpha d, \sigma^2)$, so $S_0 = \mu + \alpha d - 2w$. No new information is introduced in period 1, so at the end of the first period, firm stock price is $S_1 = \mu + \alpha d - 2w$. In the second period, the new product is introduced and the actual revenue from that product is realized. At this point, the magnitude of R_1 is revealed and stock price at the end of period 2 is equal to $S_2 = R_1 - 2w$.

The *ex post* variance of the stock market series (S_0, S_1, S_2) for a low-innovation firm is $\mathrm{Var}(S^L) = \frac{2}{3}\sigma^2 + \frac{2}{9}(\mu + \alpha d - R_1)^2$. Similarly, the expected variance of the stock series given the information at time $t = 0$ is:

$$\mathrm{E}(\mathrm{Var}(S^L)) = \frac{8}{9}\sigma^2 \tag{1}$$

If the firm implements a high innovation strategy, profits begin at $\pi_0 = 0$, wages are paid and a new product is introduced in period 1, so profits move to $\pi_1 = R_1 - w$. In the second period, wages are paid, the first product depreciates by d units and the firm introduces a second product, so profits are $\pi_2 = R_1 - d + R_2 - 2w$.

Given the information at time $t = 0$, the expected sum of firm profits at time $t = 2$ is $S_0 = 3(\mu + \alpha d) - d - 2w$. At time $t = 1$, the firm learns the value of R_1, so $S_1 = 2R_1 + (\mu + \alpha d) - d - 2w$. At time $t = 2$, R_2 is revealed and $S_2 = 2R_1 + R_2 - d - 2w$.

For a high-innovation firm, the expected variance of the stock market series (S_0, S_1, S_2) given the information set available at time $t = 0$ is:

$$\mathrm{E}(\mathrm{Var}(S^H)) = \frac{40}{9}\sigma^2 \tag{2}$$

Comparing Equations 1 and 2 demonstrates that the expected variance of stock market valuation for a high-innovation firm is greater than the expected variance of stock market valuation for a low-innovation firm. Thus, firms who successfully adopt the high innovation strategy have, on average, a more volatile stock price.

I now show that firms in industries where products obsolesce quickly will adopt the high innovation strategy. I will compare total profits where firms pay a high wage and receive high effort and high innovation to the strategy where firms pay a low wage and receive low effort and low innovation.

Let w_L be the employee reservation wage and w_H be the total wage-bill necessary to ensure that workers are indifferent between working for a high wage at a high effort and working at a low wage at a low-effort:

$$w_H - e_H = w_L - e_L \tag{3}$$

Total expected profit under a low wage-low innovation strategy given the information at time $t = 0$, Π_L, is the sum of expected revenues in each period less the wage bill. As presented above, total expected profit given the information at time $t = 0$ is the stock market value at $t = 0$:

$$\Pi_L = \mu + \alpha d - 2w_L \tag{4}$$

Total expected profit for high wage bill-high innovation firms given the information at time $t = 0$, Π_H, is:

$$\Pi_H = 3(\mu + \alpha d) - d - 2w_H \tag{5}$$

Firms will pursue the high innovation strategy when $\Pi_H > \Pi_L$. Equations 4 and 5 yield the following condition: $\Pi_H > \Pi_L$ if and only if

$$d > \frac{2(w_H - w_L) - 2\mu}{2\alpha - 1} \tag{6}$$

Given wages w_H, w_L, base return on innovation μ and clockspeed premium α, firms with product depreciation rate, d, sufficiently large will implement the high innovation strategy. The product depreciation rate at which firms are indifferent between the low and high innovation strategies decreases with the base return to a new product, μ, and the clockspeed premium, α, and increases with the gap in compensation. Thus, if the return to a new product is large, even firms in slow clockspeed industries will invest in a fast innovation strategy. If it is very expensive to motivate high effort, then even firms in high clockspeed industries will not implement the fast strategy.

The primary implication is industry clockspeed is positively correlated with innovation. Firms in high clockspeed industries (firms where product returns are high but depreciate quickly) are more likely to implement high innovation strategies.

Next, I demonstrate that firms implementing the high innovation strategy will offer their workers a bond contingent on firm performance. Given that firms choose to pursue the high innovation strategy, the firm problem is to structure a self-enforcing contract that ensures employees will exert high effort. If firms offer only the high wage w_H, workers can increase utility by shirking ($u(w_H, e_L) > u(w_H, e_H)$). However, if firms offer enough deferred compensation contingent on firm performance, firms can motivate a high level of effort. Firm performance-contingent deferred compensation is an effective motivation device for project-critical employees because it aligns employee and firm goals. If the worker shirks and decreases firm stock value, then the worker loses compensation.

Firms offer the cost minimizing wage w and stock price increase share b such that employees' utility of working with high effort is greater than the utility of shirking. Firms set w and b such that given all other employees are working hard, the utility associated with high effort and high firm profits is greater than the utility of shirking and decreasing firm profits:

$$u(w + b\Pi_H, e_H) > u(w + b\Pi_L, e_L) \tag{7}$$

Simplifying Equation 7 yields that workers will prefer to work at the high effort if they share a sufficiently large portion of the firm's increase in stock price. Specifically, if

$$b > \frac{e_H - e_L}{2\mu + 2\alpha d - d} \tag{8}$$

then the employment contract is self-enforcing and no employees will shirk. The condition above states simply that the expected utility from an increase in compensation arising from high effort is greater than the disutility of working at the high effort. Thus, utility maximizing individuals are better off working with high effort if their share of firm stock market gain is sufficiently large. Notice that if the expected return to innovation, $2\mu + 2\alpha d - d$, is large relative to the effort spread, $e_h - e_l$, then b may be quite small and still effectively motivate high effort. If Condition 8 does not hold, then workers are always better off shirking. Also, if firms offer no contract-end bonus, or the contract-end bonus is not contingent on firm performance, employees will shirk.

Given that the return to high innovation is greater than the cost of high innovation (Condition 6 holds), firms will offer compensation (w^*, b^*) where b^* is positive and large enough to motivate workers throughout the contract (Condition 8 is satisfied), and workers will prefer working for the high innovation employer to working for a low innovation employer (Condition 3 holds). There is a range of (w^*, b^*) pairs that satisfy these conditions.

Under the high-innovation HR strategy, $w*$ and $b*$ are negatively related and $U(w^*, b^*) \geq U(w_L, 0)$. If the wage bill gap between the high- and low-innovation strategies, $w_H - w_L$, is sufficiently large, and b^* is sufficiently small, then workers in high innovation firms may receive both stock options and a higher wage than workers in low innovation firms.

There are two key (testable) implications of the Clockspeed-HR model:

1. Option incidence is positively related to firm share price volatility. Firms that implement a high innovation HR system have more volatile share price and are more likely

to offer options than low innovation firms.

2. If I relax the assumption that all firms are the same size then firms with more employees may have multiple teams working on multiple technologies and are more likely than smaller firms to have high innovation. High-innovation firms offer options, thus firm size and options should be positively related.

Assuming a slightly more complex model of clockspeed where the initial revenue and obsolescence rate of a new product is a function of relative time to market, then firms will have both a greater incentive to promote innovation and to offer contingent compensation to motivate effort. Under this extension, the key result is the same: options incidence is positively related to firm share price volatility. I will use a sample of information technology professionals to test the implications of this model.

In the following section, I describe a different model linking firm volatility to stock option incidence. More volatile firms are likely to face higher borrowing costs that less volatile firms. If current borrowing costs are high and firms face capital constraints, then firms will seek to defer expenses to later periods.

3.2 Financially Constrained Firms

In this model, I present the same basic economy detailed in the previous section, except firms no longer design compensation packages in order to elicit high effort, instead firms' borrowing costs are a function of firm volatility.

If firm ownership exhibits diminishing marginal return to wealth, there is some level of equity, over which, owners value their marginal share of ownership at less than market value. If the cost of borrowing cash is expensive, it is Pareto-improving to sell or trade this "excess" ownership.

In this model, I assume firms implement one of two compensation strategies: they can offer a wage and a bonus contingent upon firm performance in the first two periods, or they can offer only a wage. Firms will choose the strategy that allows them to satisfy an employee's reservation wage at the minimum cost.

In addition to the basic assumptions outlined in the beginning of this section, this model requires the following additional assumptions:

1. Employees have no effect on firm profits. Firm profits, Π, are drawn from a normal distribution with mean $\mu > 0$ and variance σ^2.

2. The variance of firm profits, σ^2, varies across firms.

3. Firms' discount rates are a decreasing function of volatility, more volatile firms will place less weight on future costs than on current costs. There are several related reasons for this assumption:

    - If investors have diminishing marginal return to wealth, then paying compensation contingent upon firm success is less costly to the owners than paying compensation in all states.

- More volatile firms are likely to face higher borrowing costs than less volatile firms. Because it is more expensive to borrow to cover their current obligations, firms face a credit constraint, and would prefer to push expenses into a future period.
- As Queen and Roll (1987) demonstrate, firm mortality is positively related to stock volatility. Thus, more volatile firms are less likely to have to pay obligations in the future, so their weight on future expenses is smaller than for firms with less volatile stock price.
- If firms have two complementary inputs (capital and labor), one of which has costs that can be satisfied without going to the credit market (labor), and the potential return from the input is greater for more volatile firms. Then more volatile firms will invest their entire credit line in capital and seek to use other devices to compensate labor.

Denote firms' discount rate $\beta(\sigma)$ with $\beta' < 0$, $\beta(0) \leq 1$, and $\lim_{\sigma\to\infty}\beta(\sigma) = 0$. If a firm has very large variance in profits from period to period then the firm places little weight on future expenses.

4. All employees have reservation wage $\overline{w}$, and discount rate r.

5. All employees expend the same effort, e.

Time-line:

1. The firm offers a compensation package (w, b) to their employees.

2. All workers work for two periods at wage w.

3. At the end of the second period, firm profits, Π are drawn from $N(\mu, \sigma^2)$. If the worker holds $b > 0$ and $\Pi > 0$, the worker exercises her options and receives $b\Pi$.

4. The economy ends.

The expected value of holding b options is b times the expected value of profits conditional on profits being positive:

$$\begin{aligned} E(b\Pi|\Pi > 0) &= b(\mu + \sigma\frac{\phi(\frac{-\mu}{\sigma})}{1 - \Phi(\frac{-\mu}{\sigma})}) \\ &= bg(\mu, \sigma) \end{aligned}$$

It can be demonstrated that $g_\mu > 0$ and $g_\sigma > 0$ if $\mu > 0$, thus the expected value of holding options increases with both the mean of the profit draw and the variance of the profit draw.

For a firm with volatility σ, the expected cost of offering the contract (w, b) is:

$$c(w, b) = w + \beta(\sigma)(w + bg(\mu, \sigma)) \tag{9}$$

The firm will choose w and b to minimize costs, while satisfying the employee's reservation wage. The employee's participation condition is satisfied when the utility of the wage and option share is greater than or equal to the utility of receiving just the reservation wage:

$$\begin{aligned} EU(w,b) &\geq EU(\overline{w},0) \\ w + r(w + bg(\mu,\sigma)) - e &\geq \overline{w} + r\overline{w} - e \end{aligned}$$

This inequality is satisfied when:

$$w \geq \overline{w} - \frac{rbg(\mu,\sigma)}{1+r} \tag{10}$$

Because the firm minimizes costs, the inequality in Condition 10 will bind at the optimum, let w^* denote the wage where the Condition binds. Substituting Condition 10 into Equation 9 yields the cost of offering compensation package (w^*, b) under the condition that the employee's participation constraint binds:

$$c(w^*, b) = (1 + \beta(\sigma))(\overline{w} - \frac{rbg(\mu,\sigma)}{1+r}) + \beta(\sigma)bg(\mu,\sigma) \tag{11}$$

Taking the derivative of the cost function with respect to b:

$$\frac{dc}{db} = -(1 + \beta(\sigma))\frac{rg(\mu,\sigma)}{1+r} + \beta(\sigma)g(\mu,\sigma) \tag{12}$$

It can be shown that $\frac{dc}{db}$ is negative if and only if the firm's discount rate, $\beta(\sigma)$ is less than the employee discount rate r. However, $\lim_{\sigma\to\infty}\beta(\sigma) = 0$, so for σ sufficiently large, $\frac{dc}{db} < 0$. Consequently, volatile firms will have lower costs if they offer stock options in lieu of cash. Similarly, for σ small, costs increase with options, so the optimal option share b is zero for firms with low volatility.

Testable implications of the capital constraint model for stock option incidence include:

1. Option incidence increases with firm volatility. As demonstrated, there exists a threshold such that all firms with volatility greater than the threshold will offer options, and all firms less volatile than the threshold do not offer options.

2. Option incidence and salary are negatively correlated. This is a direct implication of Equation 10. If an employee does not hold options, her wage is $\overline{w}$, if the employee does hold options, her wage is strictly less than $\overline{w}$.

3. Wages decreases with firm volatility. This is a result of the previous two implications. For firms with volatility greater than the options-granting threshold, wages are less than those at non-options granting firms.

4. Assuming smaller firms are more likely to face cash constraints, stock option incidence are negatively related to firm size.

If employees are risk averse, employees will demand more options in lieu of the same amount of wages to account for the necessary risk premium. Firms will only offer options if the firm discount factor $\beta(\sigma)$ is less than the employee discount factor times the risk premium of the option package. The employee risk premium of holding options increases with volatility, but if the firm discount rate decreases faster than the risk premium increases, there exists some level of volatility such that all firms with more volatile returns will offer options.

In the empirical section, I examine the testable implications from both models using a sample of information technology professionals. First, I present the data.

4 Data

4.1 Information Technology Professionals Salary Survey

I have acquired exclusive access to a survey of labor market outcomes of Information Technology (IT) professionals administered by Dice, Inc. Dice, Inc. is a service of Earthweb, Inc - "the leading provider of career development resources and technical expertise to the world's Information Technology (IT) professionals."[4] Dice Inc, provides career services assisting in the hiring, retention, and training of IT professionals and runs the leading IT professional job board ("as ranked by Media Metrix and IDC, and MeasureUp, a leading provider of preparation products for IT professional certification."[5])

Traffic at Dice.com consists of IT professionals utilizing the site's career assistance tools. One of the tools is a salary benchmarking tool. Respondents answer a variety of questions about their demographics and current labor market outcomes and receive salary benchmarking based upon their responses. The benchmarking is only valuable if the respondent responds accurately and honestly. Dice.com has allowed me access to the raw data collected through the tool.

There are 28,401 observations and the key variables for this paper include salary, options status, occupation, industry, age, years of technical experience, sex, firm size, location size, employment type, state and telephone area code. Because of the voluntary, on-line nature of the survey there is a certain amount of noise in the sample. In order to minimize the impact of the noise, observations are trimmed on the basis of age, salary, occupation and geographical consistency between area code and state. After trimming, 18,182 observations remain in the sample. Because Dice.com offers career management tools, the dice sample may be biased towards IT professionals who are more mobile. For more detail on the sample, see Campbell (2003).

Table 1 contains summary statistics of the variables of interest. The first column contains the summary statistics for employees who receive stock options, the second column contains the summary statistics for those who do not. Respondents who receive options earn about \$69,000 per year, while those who do not receive stock options earn \$57,000 per year. Options holders are marginally more female (20% compared to 18% of non options holders), and younger (36.8 years of age compared to 38 years of age) and have slightly more technical

[4]http://about.dice.com
[5]http://about.dice.com

experience (8.2 years versus 8.05 years). I re-weight the data to match tabulations from the March 2000 Current Population Survey.

Options holders are more likely to work in very large firms and less likely to work in very small firms. Employees who receive options are more likely to be employed as software engineers and project managers, and less likely to be employed as network managers and PC technicians. Industries that are likely to employ options holders include Internet Services, Computer Software and Telecommunications.

4.2 Industry Stock Indices

In the salary survey, respondents were given a list of industries and asked to indicate their industry of employment. This list is idiosyncratic which confounds comparison to other studies.

For each industry, I identify a stock market index that represents the industry. Indices were selected on the basis of breadth of coverage of the industry (i.e. match to the salary survey industry categories) and data availability[6]. To calculate the industry volatility measures, I focus on the time period from 1995-2001. See Table 2 for the indices and mapping.

There are several problems with these series. For several industry classification I was unable to find a bijective mapping that existed in the relevant time period. Specifically, the problematic classifications are "Automation", "Distributor/Wholesale", "Manufacturing", "Publishing", and "Other". For these industries, I assigned them all to the "Dow Jones Industrial Average". Two indices are good matches, but have limited data availability: "Defense" and "Entertainment". For these industries I used only the limited data available. In the following analysis, they do not appear to generate outliers. For the industry classification "Retail/Mail-Order/E-Commerce", the index (S&P Retail Index) is not a good fit. Employees in the salary survey are more likely to be employed in "E-Commerce", while the index is heavily weighted toward traditional retail. The estimated volatility of the "Retail/Mail-Order/E-Commerce" classification is likely to be biased downward relative to the volatility actually facing the survey respondents.

I assume that stock prices move according to the Scholes-Black (1973) model. Under the Scholes-Black assumptions, stocks move according to geometric Brownian motion:

$$\frac{dS}{S} = \mu dt + \sigma dX \tag{13}$$

where $S(t)$ is the stock price at time t, μ is the average growth rate of the stock, dt is change in time, σ is the volatility of the stock, and dX is a Wiener process with mean 0, and standard deviation dt.

I can test the Scholes-Black assumptions by estimating the following equation:

$$S_t = \alpha S_{t-1} + c + \epsilon_t \tag{14}$$

If the index prices move according to geometric Brownian motion with no drift, α will equal 1, and $c = 0$, and ϵ will be normally distributed.

[6] This is, unfortunately, a subjective exercise. I tried to compile indices that that were a bijective mapping onto the industry categories and spanned a long time period. This was not always possible.

In Table 3, I present estimates from Equation 14 on each industry index. For all industries with sufficient observations (i.e. all industries other than "Defense", I am unable to reject the hypotheses that $\alpha = 1$ and $c = 0$, thus I am confident assuming that the indices move as a random walk.

However, the third condition of the Scholes-Black model is that ϵ will be normally distributed. After performing the Shapiro-Francia test for normality on each series of error terms, I reject the hypothesis that the error terms are normal (results not shown). The indices, typical of most stock prices, exhibit leptokurtosis - the series tails are too fat. However, for the basis of the rest of the research, I will continue to make the simplifying assumption that the error terms are distributed normally. See Figure 1 for a plot of the disturbances from the "Internet Services" industry with superimposed normal distribution. Although the series exhibits leptokurtosis, normality is still a reasonable simplification.

4.3 Firm and Industry Data

As mentioned previously, matching existing industry indices to the idiosyncratic industry classifications in the survey instrument proved imprecise. Because of problems matching industries to existing industry indices, I use firm data from the Center for Research in Security Prices (CRSP) and Compustat to develop new indices of publicly traded firms by industry and firm size.

I randomly assigned every Dice observation that was not employed in "Government" or "Non-Profits" to a publicly trade firm in the Compustat database. The assignment was within Industry-Firm Size cells (14 industries, 6 firm size categories). Using monthly firm stock price from CRSP for up to the past 10 years, I calculated the Scholes-Black volatility for every firm in the sample (see section 5.1 below). I use this measure of firm volatility as an independent variable in options incidence regressions.

As a second specification, I create stock indices for every industry-firm size cell. Using the Compustat and CRSP data, I calculate the volatility of aggregate stock prices within each industry-firm size cell. I calculate the Scholes-Black volatility for each index.

5 Empirical Analysis

The focus of the empirical analysis is to examine the relationship of firm volatility on stock option incidence. First, I will detail my methodology for estimating firm volatility.

5.1 Measuring Volatility

To measure the volatility of the industries and industry-firm size cells in my samples, I calculate the variation of the compounded rate of return in one year.

In the discrete version of the Scholes-Black specification, stock prices move according to the following process:

$$\frac{S_t - S_{t-1}}{S_{t-1}} = \mu + \sigma\epsilon_t \tag{15}$$

First, I estimate the standard deviation of the compounded rate of return in one day, σ and then scale σ to cover a full year of trading.

Equation 15 can be estimated with ordinary least squares, where σ^2 is the mean square error.

Equivalently,

$$\sigma^2 = \text{Var}(\frac{S_t - S_{t-1}}{S_{t-1}})$$

Here, σ^2 is a measure of the variance of the compounded rate of return in one day. Industry volatility, *vol* is typically measured as the standard deviation of rate of return for one year, so:

$$\text{vol} = \sqrt{\tau * \sigma^2}$$

where τ denotes the number of daily observations per year.

I use this method to estimate the volatility of all the industries reported in the salary survey and for all of the firms and industry-firm size indices from the CRSP/Compustat.

In Table 4, I present the estimated volatility for each industry. In the table, I also include the percent of respondents in each industry that report receiving stock options. I plot the log of the square of the volatility measures versus options incidence for all for-profit industries in Figure 2. Figure 3 presents the same relationship, but includes weighting by observation.

Internet Services, Computer Hardware, and Computer Software have the most volatile indices. Defense, Agriculture, and Utilities are the least volatile, excluding Government and Non-Profits. The industries with the highest options incidence are Internet Services, Telecommunications, and Computer Hardware. Excluding Government and Non-Profits, Agriculture, Distribution, and Defense exhibit the lowest options incidence.

The figures depict a strong positive relation between volatility and options incidence.

Volatility measures are sensitive to the time period selected. In Table 5, I present volatility measures calculated for each year in the time sample. The late 1990s marked an era of increasing volatility in the returns in the technology-related sectors, specifically "Banking", "Computer Hardware", "Computer Software", "Internet Services" and "Telecommunications". Despite the increase in volatility, the series tend to keep the same relative positions.

Because volatility measures fluctuate over time, the preliminary results may not be robust to the time frame used to calculate the volatilities. In Table 6, I present a series of regressions where each industry is one observation, the dependent variable is the percent of workers receiving options in the industry and the independent variable is the volatility measure of the industry. For all years except 1995, the coefficient on industry volatility is strongly positive (significant at the 0.1% level). The size of the coefficient on industry volatility decreases in later years, as is expected from the increase in average volatility.

5.2 Options Incidence and Industry Volatility

In this section, I present several different specifications of an options incidence estimation. Table 7 presents the results from a probit specification of option incidence with Industry Volatility and various individual controls on the right-hand side. The individual controls include gender, age, age^2, technical experience, technical experience^2, location size, occupation dummies and region dummies. In Specification I, each observation has volatility measure calculated from a randomly assigned firm within firm size-industry cell. Specification II uses the firm size-industry cell average volatility, and Specification III uses the existing industry indices volatility.

The coefficient on Industry Volatility is significant at the 1% in all specifications. As the columns move to the right, the scale of the volatility measure decreases which explains the increase in the point estimate.

Women are more likely to receive options. In support of the segmented labor market model, experience and establishment size is positively related to option incidence. The establishment size coefficient may be biased upward if small firms are more likely to be privately held and can not offer options.

Both the Clockspeed-HR model and the Financial Constraint model imply that industry volatility is positively related to options incidence - which this specification supports. However, the Clockspeed model implies that establishment size and stock options should be positively related, while the Financial Constraint model implies that establishment size and stock options should be negatively related.

I present a linear regression of log annual salary on industry volatility and assorted controls in Table 8. Industry volatility is positive and significantly related to wages. Experience has a larger effect on wages than age, but the the wage-experience profile is sharply concave. Smaller locations tend to pay less than larger locations. Both specifications suggest that firm size and wages are positively related.

Women earn about 8% less than men, even controlling for differences in occupation and industry. Neither model implies any gender differences in outcomes.

Under certain conditions, wages and volatility are positively related in the Clock speed-HR model but they are always negatively related in the Financial Constraint model. The empirical results are not consistent with the Financial Constraint model.

Table 9 presents a wage regression with option interaction terms. The Industry Volatility term is -.742 and significant, while Industry Volatility interacted with options is 1.682 and significant. This implies that workers who do not receive options earn lower wages in more volatile firms, while workers who do receive options earn higher wages in more volatile firms. This is consistent with outcomes in a labor market segmented by compensation that reflects clockspeed and stock price volatility.

6 Alternative Explanations

In this paper, I focus on two models of stock option incidence. There are a variety of other candidate explanations for stock option incidence. Other reasons for stock option incidence:

- Insulating local labor markets from industry shocks - stock options can be used to index workers' wages to alternative wages in a region. Observe that stock options are relatively more prevalent in regions where employment is more sensitive to industry shocks (Campbell 2002).

- Sorting - when worker quality is difficult to observe performance pay can be used to attract workers who will thrive in the company (Lazear 2000). Options and base salary are negative related.

- Asymmetric information - when workers have better information on the future performance of the firm than outsiders, stock options can be used to reassure outside investors on the prospects of the firm (Lazear 1999). Options and base salary are negative related, options are more likely in volatile (uncertain) firms, options are more likely in smaller (younger) firms.
- Asymmetric valuation - if employees place a greater value on stock options than owners, owners will be more likely offer options instead of salary. A "wedge" in stock option valuation may occur due to differences in marginal utility of wealth, different information on the firm's future. Options and base salary are negative related, options are more likely in volatile (uncertain) firms.
- Compensating differential for risk - if it is more costly for employees to work at risky firms, options can be implemented as a compensating differential to offset the cost of risk. Options are positively related to volatility.

These explanations all focus on the labor supply side, the models presented in this paper focus on the demand side. Of course, both supply side and demand side forces operate in the real world, so in actuality, all of the forces presented may be affecting labor market outcomes. I emphasize the factors that explicitly link labor market segmentation to firm performance and firm volatility. I choose to focus on the two models detailed in this paper because the models are consistent with the conventional wisdom of the IT sector during the time frame of the data. The late 1990s IT sector was marked by frantic innovation and firms trying to grow faster than their credit limits would allow.

7 Discussion

In this paper, I present two models of the relationship between firm volatility and employee stock option incidence. The first model, based on a "clockspeed" framework with "O-ring" production function, leads to a segmented labor market. In the "high-innovation" sector, jobs come with stock options and demand high effort. In an economy of finite duration, firms offer stock options as a bond to prevent shirking. Firms in high-clockspeed industries that have a high rate of innovation will have a highly volatile firm share price. The key result of the Clockspeed-HR model is that option incidence and firm volatility are positively related.

In the second model, firm discount rates decrease with the volatility of firm performance. This occurs because investors have diminishing marginal returns to firm equity. If firms are cash constrained, as firm volatility increases firms are able to minimize costs by deferring compensation into later periods. Stock options provide a device to defer employee compensation.

Using a sample of Information Technology professionals matched to firm and industry data in the CRSP and Compustat, I test the implications of the two models. For IT professionals, industry volatility and option incidence are positively related and industry volatility and wages are positively related. Also, establishment size and options and establishment size and wages are positively related. The wages for workers with options increase with industry volatility, while the wages for workers without options decrease with volatility.

The findings are consistent with the primary implication of both models: stock option incidence and firm share price volatility are positively related. However the findings contradict several secondary implications of the Financial Constraint model, but do not contradict the implications of the Clockspeed-HR model.

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Table 1: Summary of Dice.com Data

		Options = 1	Options = 0	Difference
Demographics	Salary ($1,000s)	68.89	57.06	11.82
	Female (%)	0.20	0.18	0.01
	Age	36.79	38.09	-1.30
	Technical Experience	8.20	8.05	0.15
Firm Size	less than 50	7.48	11.62	-4.14
	50-99	3.37	4.71	-1.34
	100-499	20.67	17.33	3.34
	500-999	9.10	10.36	-1.26
	1000-4999	18.00	20.45	-2.45
	5000+	41.38	35.52	5.86
Occupation	Computer Analyst	10.56	11.76	-1.20
	Business Analyst	2.34	2.66	-0.32
	Database Administrator	4.79	4.13	0.66
	Desktop Support Specialist	3.51	3.80	-0.29
	Developer: Applications	8.20	9.46	-1.26
	Developer: Client/Server	4.27	3.83	0.44
	Developer: Database	1.80	1.99	-0.19
	Developer: Systems	2.18	1.47	0.71
	Graphic Designer	0.70	0.75	-0.05
	Strategist or Architect (IT Management)	5.49	3.17	2.32
	Mainframe Systems Analyst	0.75	1.39	-0.64
	Mainframe Systems Programmer	0.85	1.24	-0.39
	MIS Manager	3.28	4.85	-1.57
	Multimedia Designer	0.35	0.19	0.16
	Multimedia Manager	0.10	0.18	-0.08
	Network Design	0.80	0.28	0.52
	Network Engineer	7.94	8.83	-0.89
	Network Manager	2.71	5.15	-2.44
	PC Technician	2.33	4.45	-2.12
	Project Manager	7.79	5.41	2.38
	Quality Assurance (QA) Tester	2.99	1.69	1.30
	Security Analyst	0.71	0.85	-0.14
	Software Engineers	7.16	4.27	2.89
	Telecommunications Engineer	1.11	0.98	0.13
	WAN Specialist	0.26	0.35	-0.09
	Web Administrator	0.56	0.81	-0.25
	Web Designer	1.47	1.37	0.10
	Web Developer/Programmer	6.31	4.28	2.03
	Systems Administrator	8.66	10.40	-1.74
Industry	Agriculture	0.65	1.69	-1.04
	Bank / Financial / Insurance	10.06	11.60	-1.54
	Computer Hardware	7.48	8.49	-1.01
	Computer Software	27.26	19.58	7.68
	Defense	1.21	2.44	-1.23
	Distributor / Wholesale	0.78	2.04	-1.26
	Entertainment (movies, games)	0.86	0.92	-0.06
	Internet Services	18.04	6.32	11.72
	Manufacturing	6.60	11.57	-4.97
	Medical / Pharmaceutical	2.75	6.13	-3.38
	Publishing	0.66	1.52	-0.86
	Retail / Mail Order / E-Commerce	3.41	3.18	0.23
	Telecommunications	12.29	5.35	6.94
	Transportation	1.09	2.57	-1.48
	Utilities (gas, electricity)	1.27	2.11	-0.84
	Other	5.61	14.50	-8.89
N		5959	8664	

Summary statistics are from the Dice IT Professional Salary Survey. ”Options” is an indicator variable of employee stock options incidence. In the “Demographics” category, sample means are reported. In all other categories, the distribution within the category is reported.

Table 2: Industry - Stock Market Index Mapping

Reported Industry	Index	Period
Agriculture	Goldman Sachs Commodity Index - Agriculture (IOM:^GKX)	1/1/1995-12/31/2001
Automation	Dow Jones Industrial Average (CBT:^DJI)	1/1/1995-12/31/2001
Bank/Finance/Insurance	Philadelphia Stock Exchange Bank Index (Philadelphia:^BKX)	1/1/1995-12/31/2001
Computer Hardware	Goldman Sachs Technology Index - Hardware (WCB:^GHA)	7/1/1996-12/31/2001
Computer Software	Goldman Sachs Technology Index - Software (WCB:^GSO)	7/1/1996-12/31/2001
Defense	Philadelphia Stock Exchange - Defense Index (Philadelphia:^DFX)	12/6/2001-12/31/2001
Distributor/Wholesale	Dow Jones Industrial Average (CBT:^DJI)	1/1/1995-12/31/2001
Entertainment	Dow Jones Entertainment Index (CBT:^DJUSET)	2/1/2000-12/31/2001
Government	None	
Internet Services	Goldman Sachs Technology Index - Internet (WCB:^GIN)	7/1/1996-12/31/2001
Manufacturing	Dow Jones Industrial Average (CBT:^DJI)	1/1/1995-12/31/2001
Medical/Pharmaceutical	American Stock Exchange Pharmaceuticals Index (AMEX:^DRG)	1/1/1995-12/31/2001
Non-Profit	None	
Publishing	Dow Jones Industrial Average (CBT:^DJI)	1/1/1995-12/31/2001
Retail/Mail-Order/E-Commerce	S&P Retail Index (WCB:^RLX)	1/1/1995-12/31/2001
Telecommunications	Nasdaq Telecom Index (NasdaqSC:^IXUT)	5/1/1996-12/31/2001
Transportation	New York Stock Exchange Transportation Index (NYSE:^NHZ)	1/1/1995-12/31/2001
Utilities	New York Stock Exchange Utility Index (NYSE:^NNA)	1/1/1995-12/31/2001
Other	Dow Jones Industrial Average (CBT:^DJI)	1/1/1995-12/31/2001

Table 3: Industry Index Price Movement

	Lag Term			Constant		R^2	N	H: Coef on Lag Term = 1 F(1, N-2)	 Prob > F
Agriculture	0.999	***	(0.001)	0.125	(0.239)	0.998	1756	0.56	0.454
Automation	0.998	***	(0.001)	18.026	(8.813)	0.998	1753	2.94	0.087
Bank / Financial / Insurance	0.997	***	(0.002)	2.345	(1.072)	0.996	1753	3.82	0.051
Computer Software	0.997	***	(0.002)	0.891	(0.560)	0.996	1377	2.38	0.123
Computer Hardware	0.997	***	(0.002)	0.748	(0.511)	0.995	1377	2.31	0.129
Defense	1.009	***	(0.105)	-1.086	(16.875)	0.867	16	0.01	0.935
Distributor / Wholesale	0.998	***	(0.001)	18.026	(8.813)	0.998	1753	2.94	0.087
Entertainment (movies, games)	0.987	***	(0.007)	5.924	(3.683)	0.975	467	2.87	0.091
Internet Services	0.998	***	(0.002)	0.605	(0.588)	0.995	1377	1.63	0.202
Manufacturing	0.998	***	(0.001)	18.026	(8.813)	0.998	1753	2.94	0.087
Medical / Pharmaceutical	0.998	***	(0.001)	0.604	(0.309)	0.998	1753	2.33	0.127
Publishing	0.998	***	(0.001)	18.026	(8.813)	0.998	1753	2.94	0.087
Retail / Mail Order / E-Commerce	0.999	***	(0.001)	0.396	(0.834)	0.997	1756	0.94	0.332
Telecommunications	0.998	***	(0.001)	0.742	(0.778)	0.997	1418	1.15	0.283
Transportation	0.996	***	(0.002)	1.599	(0.672)	0.995	1753	5.01	0.025
Utilities (gas, electricity)	0.998	***	(0.001)	0.610	(0.359)	0.998	1756	2.37	0.124
Other	0.998	***	(0.001)	18.026	(8.813)	0.998	1753	2.94	0.087

Standard Errors in Parentheses. *** denotes significance at the 0.1% level

Table 4: Industry Volatility and Options Incidence

Industry	Volatility	Options Incidence (x100)
Agriculture	0.037	17
Automation	0.044	30
Bank / Financial / Insurance	0.068	37
Computer Software	0.106	38
Computer Hardware	0.117	45
Defense	0.029	22
Distributor / Wholesale	0.044	21
Entertainment (movies, games)	0.101	37
Internet Services	0.148	68
Manufacturing	0.044	25
Medical / Pharmaceutical	0.056	28
Publishing	0.044	24
Retail / Mail Order / E-Commerce	0.064	46
Telecommunications	0.092	60
Transportation	0.052	24
Utilities (gas, electricity)	0.040	29
Other	0.044	23

Volatility Tabulations use the Scholes-Black Model. Volatility data are tabulated from Stock Market Indices. Option Incidence rates tabulated from Dice.com IT Salary Survey.

Table 5: Industry Volatility by Year

Industry	1995	1996	1997	1998	1999	2000	2001
Agriculture	0.031	0.044	0.038	0.033	0.040	0.037	0.036
Automation	0.022	0.030	0.047	0.050	0.041	0.052	0.053
Bank/Financial/Insurance	0.037	0.044	0.061	0.081	0.074	0.091	0.068
Computer Software	.	0.074	0.082	0.087	0.089	0.119	0.152
Computer Hardware	.	0.072	0.075	0.089	0.096	0.155	0.161
Defense	.	.	.	.	.	.	0.029
Distributor/Wholesale	0.022	0.030	0.047	0.050	0.041	0.052	0.053
Entertainment (movies, games)						0.091	0.109
Internet Services	.	0.095	0.100	0.128	0.166	0.180	0.172
Manufacturing	0.022	0.030	0.047	0.050	0.041	0.052	0.053
Medical/Pharmaceutical	0.030	0.041	0.059	0.061	0.062	0.074	0.051
Publishing	0.022	0.030	0.047	0.050	0.041	0.052	0.053
Retail/Mail Order/E-Commerce	0.032	0.045	0.046	0.070	0.065	0.094	0.073
Telecommunications	.	0.042	0.045	0.074	0.080	0.134	0.123
Transportation	0.033	0.033	0.039	0.060	0.051	0.062	0.071
Utilities (gas, electricity)	0.022	0.029	0.035	0.042	0.043	0.054	0.047
Other	0.022	0.030	0.047	0.050	0.041	0.052	0.053

Volatility Tabulations use the Scholes-Black Model. Volatility data are tabulated from Stock Market Indices.

Table 6: Options Prevalence-Industry Volatility Regressions (by year)

	Industry Volatility			Constant			R^2	N
All	361.50	***	(56.15)	9.79	*	(4.17)	0.734	17
1995	558.95		(433.05)	12.66		(11.86)	0.156	11
1996	536.95	**	(142.94)	10.46		(6.95)	0.521	15
1997	528.05	**	(173.49)	5.72		(9.91)	0.416	15
1998	533.11	***	(87.54)	-0.24		(6.04)	0.740	15
1999	380.07	***	(60.30)	9.81	*	(4.38)	0.754	15
2000	313.40	***	(35.24)	8.12	*	(3.31)	0.850	16
2001	257.35	***	(46.43)	13.27	**	(4.24)	0.672	17

*** denotes significance at the 0.1% level, ** denotes significance at the 1% level, * denotes significance at the 0.1% level, Standard Errors in Parentheses.

Table 7: Options Incidence on Industry Volatility

Options: 1=Yes, 0=No	Means	I		II		III	
Mean of the Volatility Measure		.065		.054		.021	
Industry Volatility		0.402	**	3.091	***	13.400	***
		(3.089)		(5.749)		(8.574)	
Female	0.187	0.018		0.022	*	0.038	**
		(1.867)		(2.113)		(2.652)	
Age	37.419	-0.008		-0.006		-0.005	
		(-1.629)		(-1.248)		(-1.151)	
Age^2 (x100)	14.990	0.004		0.003		0.004	
		(0.626)		(0.437)		(0.547)	
Tech Exp	8.016	0.014	***	0.016	***	0.015	**
		(4.071)		(4.281)		(3.478)	
Tech Exp^2 (x100)	0.981	-0.050	*	-0.054	**	-0.049	*
		(-2.583)		(-2.765)		(-2.151)	
Establishment size: < 50	0.243	-0.044	*	-0.084	***	-0.069	**
		(-2.175)		(-3.991)		(-3.453)	
Establishment size: 50-99	0.144	-0.004		-0.026		-0.010	
		(-0.100)		(-0.935)		(-0.502)	
Establishment size: 500-999	0.102	0.004		0.031		0.024	
		(0.524)		(1.666)		(1.149)	
Establishment size: 1000-4999	0.134	0.008		0.035		0.022	
		(0.176)		(1.118)		(0.738)	
Establishment size: 5000+	0.059	0.056		0.084		0.068	
		(1.048)		(1.788)		(1.533)	
Occupation Controls?		Y		Y		Y	
Region Controls?		Y		Y		Y	
N		14623		13626		13676	
R^2		0.0744		0.0676		0.0855	

Model uses a probit specification on options incidence. Specification I uses industry volatility calculated from firms in the CRSP and Compustat that are randomly assigned to Dice observation within Industry-Firm Size cells (Source: CRSP, Center for Research in Security Prices. Graduate School of Business, The University of Chicago [2002]. Used with permission. All rights reserved. www.crsp.uchicago.edu). Specification II uses volatilities calculated Industry-Firm Size indexes calculated from CRSP and Compustat data. Specification III uses industry volatility calculated from standard industry indices. Reported coefficients are marginal effects. T-stats in parentheses - errors are adjusted for industry clustering. *** significant at 0.1%, ** significant at 1%, * significant at 5%.

Table 8: Wage Regression

	I		II		III	
Industry Volatility	0.137	*	0.477	*	5.038	***
	(0.064)		(0.191)		(0.608)	
Female	-0.083	***	-0.083	***	-0.079	***
	(0.010)		(0.010)		(0.010)	
Age	0.022	***	0.022	***	0.023	***
	(0.002)		(0.002)		(0.002)	
Age^2 (x100)	-0.027	***	-0.028	***	-0.028	***
	(0.003)		(0.003)		(0.003)	
Tech Exp	0.058	***	0.058	***	0.057	***
	(0.003)		(0.003)		(0.003)	
Tech Exp^2 (x100)	-0.190	***	-0.190	***	-0.185	***
	(0.016)		(0.016)		(0.016)	
Establishment size: < 50	-0.057	***	-0.062	***	-0.062	***
	(0.012)		(0.013)		(0.013)	
Establishment size: 50-99	-0.043	**	-0.046	***	-0.046	***
	(0.013)		(0.012)		(0.011)	
Establishment size: 500-999	0.024		0.027	*	0.027	*
	(0.014)		(0.013)		(0.012)	
Establishment size: 1000-4999	0.051	***	0.055	***	0.057	***
	(0.013)		(0.013)		(0.013)	
Establishment size: 5000+	0.079	***	0.083	***	0.084	***
	(0.017)		(0.016)		(0.017)	
Occupation Controls?	Y		Y		Y	
Region Controls?	Y		Y		Y	
N	13579		13626		13626	
R^2	0.4323		0.4333		0.4445	

Dependent Variable is log(annual salary). Specification I uses industry-size volatility calculated from firms in the CRSP and Compustat that are randomly assigned to Dice observation within Industry-Firm Size cells (Source: CRSP, Center for Research in Security Prices. Graduate School of Business, The University of Chicago [2002]. Used with permission. All rights reserved. www.crsp.uchicago.edu). Specification II uses volatilities calculated Industry-Firm Size indexes calculated from CRSP and Compustat data. Specification III uses industry volatility calculated from standard industry indices. Standard errors in parentheses - errors are adjusted for industry-size clustering. *** significant at 0.1%, ** significant at 1%, * significant at 5%.

Table 9: Wage Regression with Option Interactions

	Log(Annual Salary)	
Industry Volatility	-0.742	**
	(0.265)	
Industry Volatility x Options	1.682	***
	(0.373)	
Female	-0.080	***
	(0.014)	
Female x Options	-0.014	
	(0.020)	
Age	0.023	***
	(0.003)	
Age x Options	-0.063	
	(0.502)	
Age^2	-0.028	***
	(0.005)	
Age^2 x Options	0.000	
	(0.007)	
Tech Exp	0.058	***
	(0.004)	
Tech Exp x Options	-0.007	
	(0.005)	
Tech Exp^2	-0.195	***
	(0.020)	
Tech Exp^2 x Options	0.039	
	(0.027)	
Occupation Controls	Y	
Occupation x Options Interactions	Y	
Establishment Size Dummies	Y	
Regional Dummies	Y	
N	13626	
R^2	0.4635	

Dependent Variable is log(annual salary). Standard errors in parentheses - errors are adjusted for industry-size clustering. *** significant at 0.1%, ** significant at 1%, * significant at 5%.

Figure 1: Distribution of Internet Services Disturbances

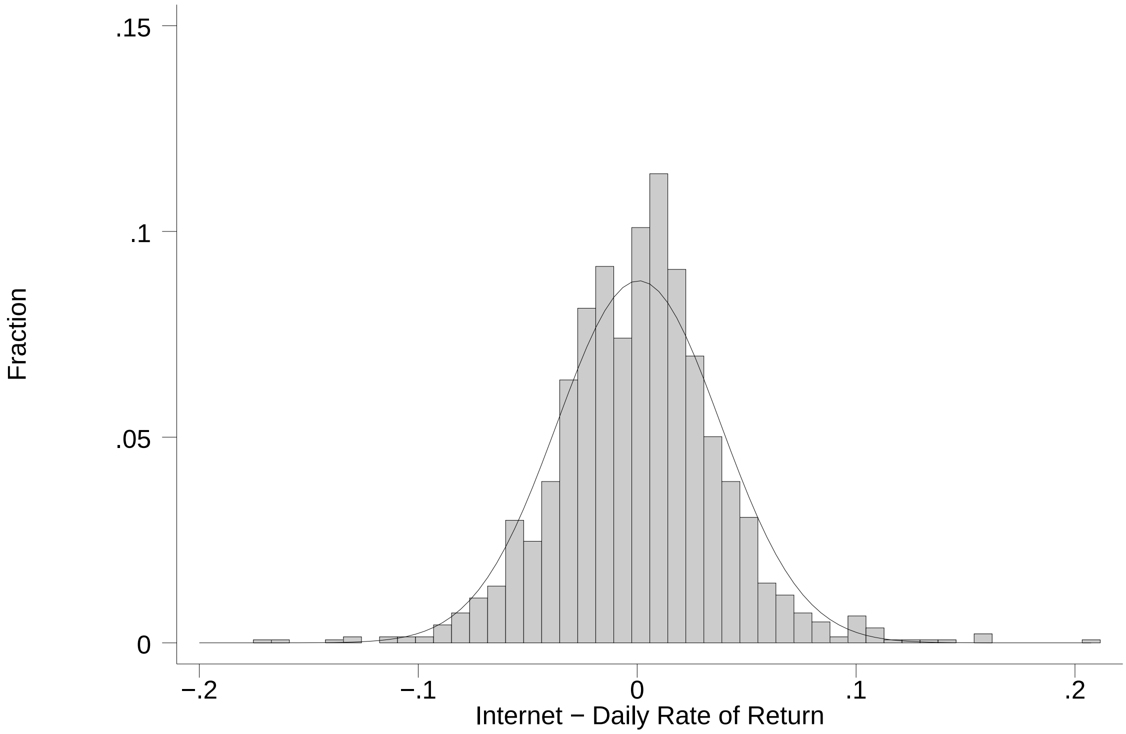

Figure 2: Industry Volatility vs. Industry options Incidence

Industry codes are available in Table 2.

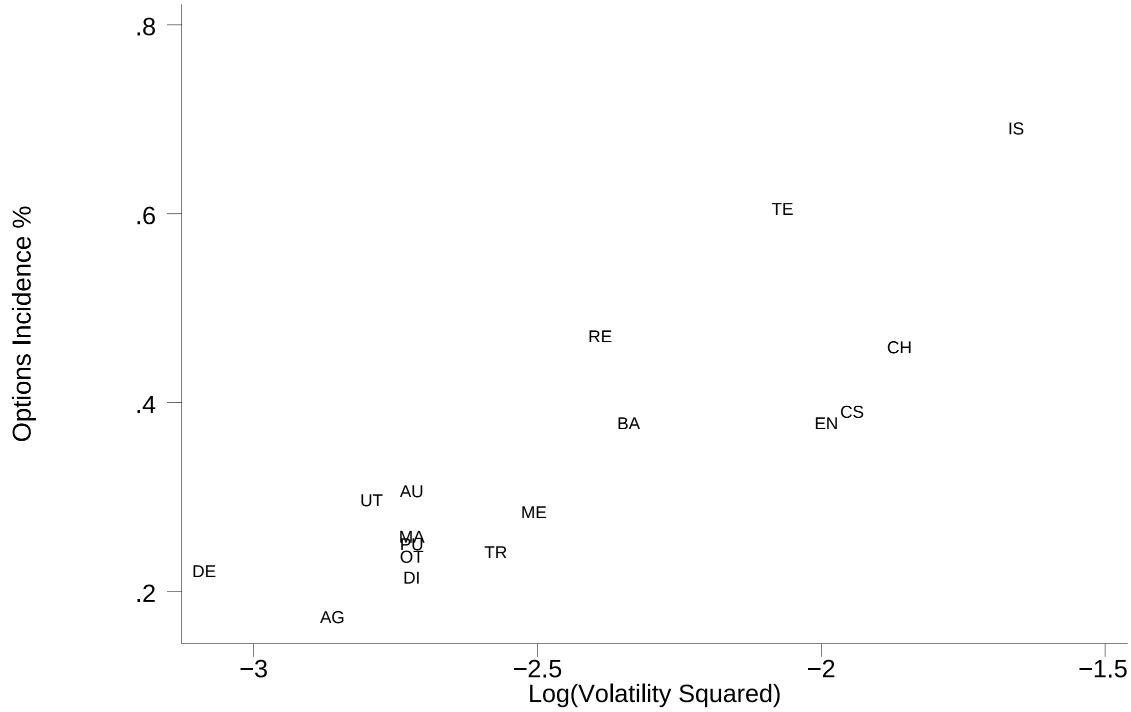

Figure 3: Industry Volatility vs. Industry options Incidence - Weighted