Lecture 5
Financial Incentives

This lecture is paired with our previous one that discussed employee benefits. Here we focus on the reasons why monetary compensation is not invariably a fixed payment. The argument for not introducing uncertainty about monetary compensation is that exposing the employee to risk is costly to him. The arguments for making payments contingent on worker performance is that this might affect their behavior in two ways, what types of workers accept the job offer in the first place, and how they perform on the job.

Performance and Compensation

Why start at the top?

- In the first lecture we provided several examples showing how employees respond to incentive pay.
- In the last part of this lecture we focus on the performance and pay of executive management.
- There are several good reasons for doing so, relating to how much analysts observe about their:
  1. compensation
  2. job tasks
  3. performance
  4. importance to the firm and their expense

Performance and Compensation

How visible are job assignments and performance measures of employees?

- To measure an employee's performance, we must know his or her job assignments, and how well the person performs in each of the assigned roles.
- With regards to top management:
  1. they are held responsible for the overall profitability of the firm
  2. the process of determining their compensation is also relatively well understood.
  3. there are many public measures of firm performance.
- Turning to the employees they oversee:
  1. often the functions of the employees are not on public record
  2. analysts rarely observe how they are compensated
  3. measures of their output are rarely made available to stockholders and analysts
  4. even in the fairly specific instances when they were available, they typically depend on the performance of other people in the firm from whom they take orders.

- The CEO manages the day-to-day activities of his firm.
- Note that many CEOs also serve as Chairman of the Board of Directors, and in that way direct the board as well.
- Even when they are not actually chairing the board they are very powerful members because they have access to so much information about the firm.
- An M&A typically requires the board's approval, but even in this situation the CEO would have a large influence on the agenda for discussion and the final decision.
- For this reason the CEO is more than anyone else responsible of the financial rate of return of the firm relative to the rate achieved by his competitors in the industry.

Performance and Compensation

How is compensation to executive management determined in publicly held companies?

- Securities and Exchange Commission (SEC) filing requirements mandate that the various components of compensation to top management be placed on public record, seen by shareholders and analysts alike.
- Compensation to top management in large companies is determined by the board of directors who are often advised by a compensation committee. Although these records are not subject to public scrutiny, analysts can often uncover some information about the process of determination.
- A compensation committee meets several times a year and makes recommendations to the Board.

Performance and Compensation

Components of managerial compensation

- Managerial compensation comes in the form of:
  1. Cash and bonus
  2. Stock and option grants
  3. Abnormal return on stocks and options held by the manager
  4. Pension and retirement benefits
  5. Compensation for termination

TABLE 4—CROSS-SECTIONAL INFORMATION ON COMPONENTS OF COMPENSATION
(In thousands of US$ (2000); standard deviations in parentheses)

Variable	Rank	Old	New restricted	New all
Salary and bonus	All	219	838	667
		(114)	(1,066)	(905)
	CEO	261	1,037	1,127
		(115)	(1,365)	(1,282)
	Non-CEO	179	640	552
		(97)	(576)	(738)
Value of options granted	All	79	2,401	903
		(338)	(13,225)	(3,753)
	CEO	111	3,402	1,782
		(439)	(18,172)	(7,169)
	Non-CEO	51	1,401	681
		(198)	(4,237)	(2,106)
Value of restricted stock granted	All	11	187	152
		(95)	(1,633)	(936)
	CEO	8	242	298
		(72)	(2,021)	(1,464)
	Non-CEO	13	133	115
		(112)	(1,118)	(743)
Change in wealth from options held	All	5	785	281
		(134)	(14,636)	(8,710)
	CEO	7	1,667	1,474
		(167)	(17,078)	(13,567)
	Non-CEO	3	−76	−18
		(94)	(11,706)	(6,939)
Change in wealth from stock held	All	−3	−40	125
		(439)	(5,681)	(4,350)
	CEO	0.434	−14	264
		(479)	(6,712)	(6,791)
	Non-CEO	−7	−64	90
		(398)	(4,496)	(3,473)

Performance and Compensation

Striking features of executive pay

- CEO compensation is very sensitive to the firms' financial abnormal return (that is net of return on market portfolio), because of the amount of the firm's (granted but not yet vested) securities he holds.
- Below the very top ranks, compensation does not depend as much on the firm's abnormal returns.
- On the lower rungs, the prospect of promotion is a very important motivator.
- Removing pay incentives at the top level would probably have a negative cascading effect throughout the organization.

Measuring the importance of moral hazard

- There are three basic ways to measure how the goals of shareholders (value maximization) differ from those of their managers (expected utility maximization over career).
- We say a manager "shirks" if he pursues his own goals as if he has a fixed wage. We say a manager "works" if he pursues firm's goals of expected value maximization:

1. Gross expected loss to firm in one year when manager "shirks", instead of "works", (denoted by τ_1).
2. Compensating differential to manager for "working" rather than "shirking" (denoted by τ_2).
3. Maximum amount shareholders would pay to eliminate the moral hazard problem for a perfect monitor to oversee the manager and ensure he "works" (τ_3).

TABLE 7—GROSS LOSSES TO FIRMS FROM SHIRKING IN MILLIONS OF US$ (2000)
(*Standard deviations in parentheses*)

Parameter		Industry	Old	New
τ_1	Per year	Aerospace	13.751	180.212
			(29.522)	(261.294)
	Present value		81.065	1,261.484
			(177.132)	(1,829.058)
	Per year	Chemicals	33.392	160.038
			(73.537)	(240.970)
	Present value		200.352	1,120.266
			(441.222)	(1,686.79)
	Per year	Electronics	16.650	230.566
			(49.182)	(600.607)
	Present value		99.907	1,613.962
			(894.492)	(4,204.249)

TABLE 10—NONPECUNIARY BENEFITS OF SHIRKING AND WELFARE COST
(*In thousands of US$ (2000); standard deviations in parentheses*)

Parameter	Industry	Rank	Old	New
τ_2	Aerospace	CEO	2,380	4,000
			(43)	(92)
		Non-CEO	1,500	3,400
			(72)	(78)
	Chemicals	CEO	920	3,800
			(274)	(209)
		Non-CEO	812	600
			(321)	(451)
	Electronics	CEO	747	3,048
			(432)	(387)
		Non-CEO	436	2,070
			(515)	(366)
τ_3	Aerospace	CEO	500	10,350
			(1,316)	(15,473)
		Non-CEO	330	1,280
			(1,413)	(10,501)
	Chemicals	CEO	490	2,973
			(1,437)	(5,087)
		Non-CEO	299	301
			(206)	(1,678)
	Electronics	CEO	278	4,873
			(1,257)	(17,285)
		Non-CEO	67	1,206
			(188)	(11,159)

Designing an optimal compensation contract

- There are two players in this game, a shareholder board member who is on the compensation committee and a manager.
- The manager's activities cannot be monitored directly.
- The shareholder can only observe a signal about whether the manager is working diligently for them or not.
- The goal of the shareholder is to minimize the expected compensation paid to the manager to make him work diligently (even though the shareholder does not observe whether the manager works or shirks).

The signal

- The signal has two values: “high inventory” of finished goods or “low inventory”.
- Low inventory indicates that shows that the manager has probably been doing a good job matching demand with supply well, whereas high inventory indicates this is probably not true.
- When the manager works, the probability of “high inventory” is $p = 0.3$, and the probability of “low inventory” is $1 - p = 0.7$.
- When the manager shirks, the probability of “high inventory” is $q = 0.8$, and the probability of “low inventory” is $1 - q = 0.2$.

Gross payoff to shareholder

- The gross payoff to the shareholder is 1500 if there is low inventory, but only 1000 if there is high inventory.
- Thus the expected gross payoff to the shareholder if the manager works is:

$$0.7(1500) + 0.3(1000) = 1350$$

- Similarly the expected gross payoff to the shareholder if the manager shirks is:

$$0.2(1500) + 0.8(1000) = 1100$$

- Therefore the gross loss the shareholder incurs from the manager shirking is:

$$\tau_3 = 1350 - 1100 = 250$$

The participation constraint

- The shareholder decides upon a compensation plan, a wage level for each signal.
- We denote by w_L the compensation he receives if inventories are low, and w_H the compensation he receives if inventories are high.
- The manager can reject the offer if he wishes and find employment elsewhere. If he finds employment elsewhere his utility is 10.
- To meet the "participation constraint" the shareholder must offer w_L and w_H such that the expected utility of the manager exceeds 10.

A fixed compensation rate induces shirking

- If the manager accepts the firm's offer of employment, he then decides with to work or shirk.
- He realizes a utility of $2\sqrt{w}$ from shirking but only $\sqrt{w}$ from working.
- Thus if the manager was offered a fixed wage of more than 25 he should definitely accept the offer and then shirk, since:

  $2\sqrt{25} = 10.$

- In other words if the shareholder guarantees a wage of just over 25 the manager will make more by accepting the offer and shirking than taking alternative employment.

Compensating differential for working

- Now suppose, just a moment, that there is a way to perfectly monitor the manager's behavior on the job.
- Aware he will be monitored, the minimal amount the manager would accept an offer to work is 100, because:

  $\sqrt{100} = 10.$

- Therefore the compensating differential to induce working rather than shirking, or the value of the benefits from pursuing his own goals at work instead of trying to maximize the firm's expected profits, is:

  $\tau_2 = 100 - 25 = 75$

Incentive compatibility constraint

- But if compensation varies with inventory level, then the manager's problem is more complicated.
- His expected utility from accepting the offer and working is:

$$0.3\sqrt{w_H} + 0.7\sqrt{w_L}$$

- His expected utility from accepting the offer and shirking is:

$$1.6\sqrt{w_H} + 0.4\sqrt{w_L}$$

- To meet the "incentive compatibility constraint" the shareholder sets w_H and w_L so that:

$$16\sqrt{w_H} + 4\sqrt{w_L} < 3\sqrt{w_H} + 7\sqrt{w_L}$$

Minimizing the cost of inducing work

- To summarize, if the shareholder wants the manager to work, w_L and w_H should be chosen to minimize:

  $0.7[150 - \sqrt{w_L}\,] + 0.3[100 - \sqrt{w_H}\,]$

  subject to the participation constraint:

  $3\sqrt{w_H} + 7\sqrt{w_L} > 100$

  and the incentive compatibility constraint:

  $13\sqrt{w_H} < 3\sqrt{w_L}$

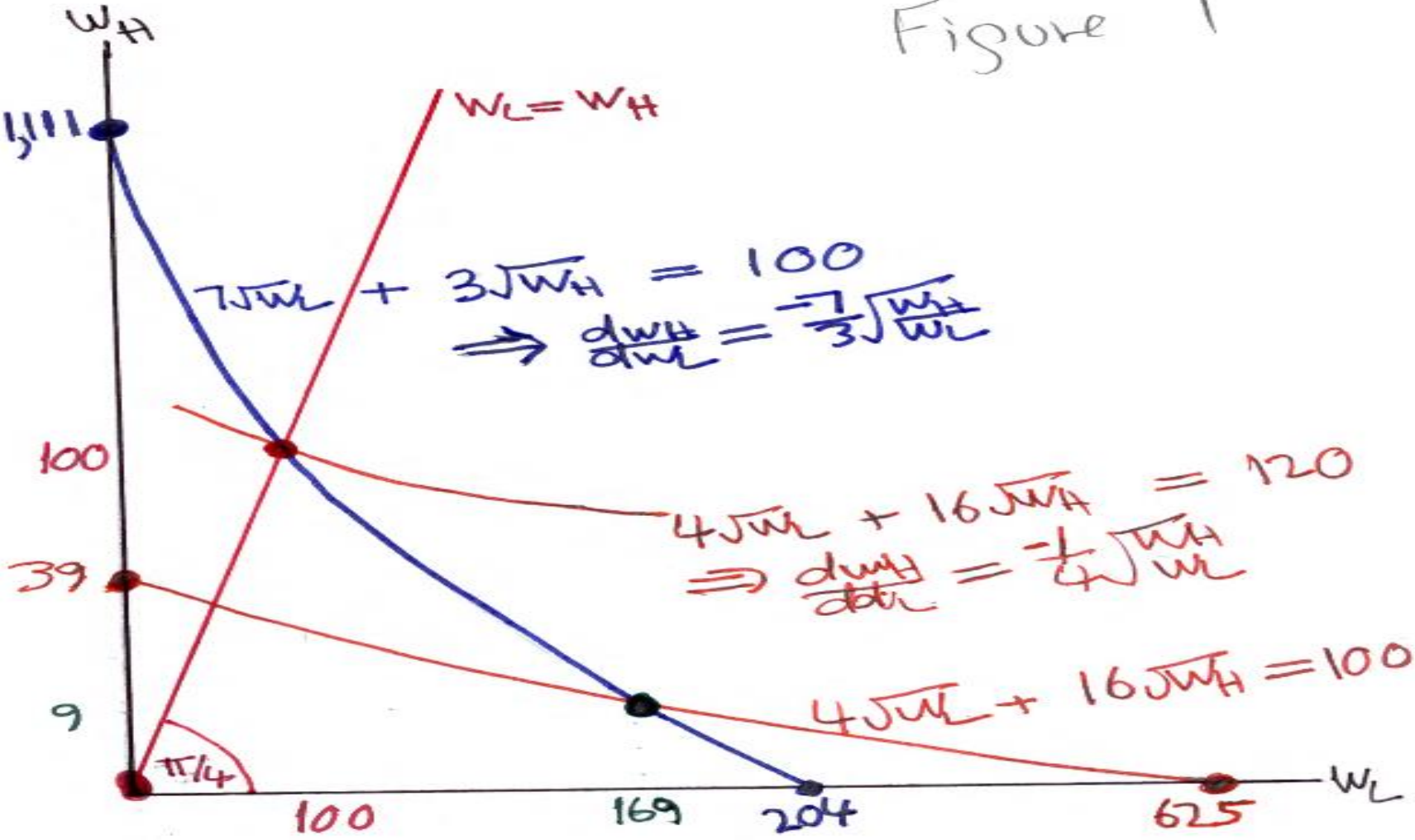
- Solving the two equation system:

  $3\sqrt{w_H} + 7\sqrt{w_L} = 100$

  $13\sqrt{w_H} = 3\sqrt{w_L}$

  gives $w_L = 169$ and $w_H = 9$.

Figure 1



With monitoring, wage cost of working is 100, but with moral hazard, cost is:

$0.7 \times 169 + 0.3 \times 9 = 121$

Value of a perfect monitor

- The previous slides show that the cost minimizing compensation package to induce the manger to work sets $w_L = 169$ and $w_H = 9$.
- Therefore the expected cost of managerial compensation is:

  $$0.7[169] + 0.3[9\ ] = 121.3$$

- From our previous slides, the shareholder would only have to pay a fixed wage of 100 for the manager to work if his behavior could be perfectly monitored.
- Thus the shareholder would be willing to pay:

  $$\tau_3 = 121.3 - 100 = 21.3$$

  for a monitor to resolve the moral hazard problem.

Comparing working with shirking from the firm's perspective

- The expected net benefit to the shareholder from paying the manager to shirk is:

  $$0.2[1500] + 0.8[1000] - 25 = 1075.$$

- The expected net benefit to the shareholder from paying the manager to work is:

  $$0.7[1500 - 169] + 0.3[1000 - 9] = 1228.7$$

- Hence the gain from incentivizing the manager to work rather than shirk is:

  $$\tau_3 - \tau_2 - \tau_1 = 153.7.$$

Employing specialists

- Often the manager knows less about the value of the work to the firm and its difficulty than the employee under him or her doing the work.
- This is particularly true in a research department where the management heading central office may be somewhat out of touch with the latest scientific and technological developments.
- More generally any situation where employees with special expertise that affect the firm's long run performance have strategic leverage in their dealings with upper level management.

Legal advice

- Similarly in legal matters, HR and more generally the firm, relies on lawyers to explain their best course of action.
- There is no guarantee that the in house lawyers, or lawyers outside the firm contracted for the case, will behave in the firms best interests unless they are properly incentivized.
- One response is to pay lawyers only when they win cases fought for the firm.
- This exposes law firms and in-house lawyers to the uncertainty they face about the verdict and the willingness of the counter party to settle.

Research and development

- Consider a firm engaged in the research, discovery and development of new products.
- Scientists are essentially provided with a working environment to facilitate this process.
- Suppose there are two types of discoveries, minor and major, denoted by $j = 1, 2$.
- It is often unreasonable for headquarters to assume they can become as fully informed as their technical experts, without guidance form those very same experts.

Costs and benefits from discoveries

- The expected value of the new product line to the firm from a discovery is:

$$\log(x+1)$$

  where x is an index of product development.

- Major discoveries are associated with lower development costs than minor discoveries.
- The total cost of product development, achieving x, is $c_j x$ where $c_1 \geq c_2$.
- In addition, the research and development group must be paid a fixed cost of at least r even if nothing is discovered to maintain the group.

Product development under full information

- First let us suppose that headquarters can easily verify whether a discovery has been made, and if so whether it is major or minor.
- If no discovery is made there is no reason to pay the R&D division more than r, the reservation budget for maintaining the division.
- In the event of a discovery the firm chooses x to:
  1. maximize the social surplus from the R&D division through its choice of x
  2. compensate the R&D division with a sufficiently large budget, denoted by b, to maintain the group.

Solving the problem under full information

- The net social surplus from the division is:

$$\log(1+x) - c_j x - r$$

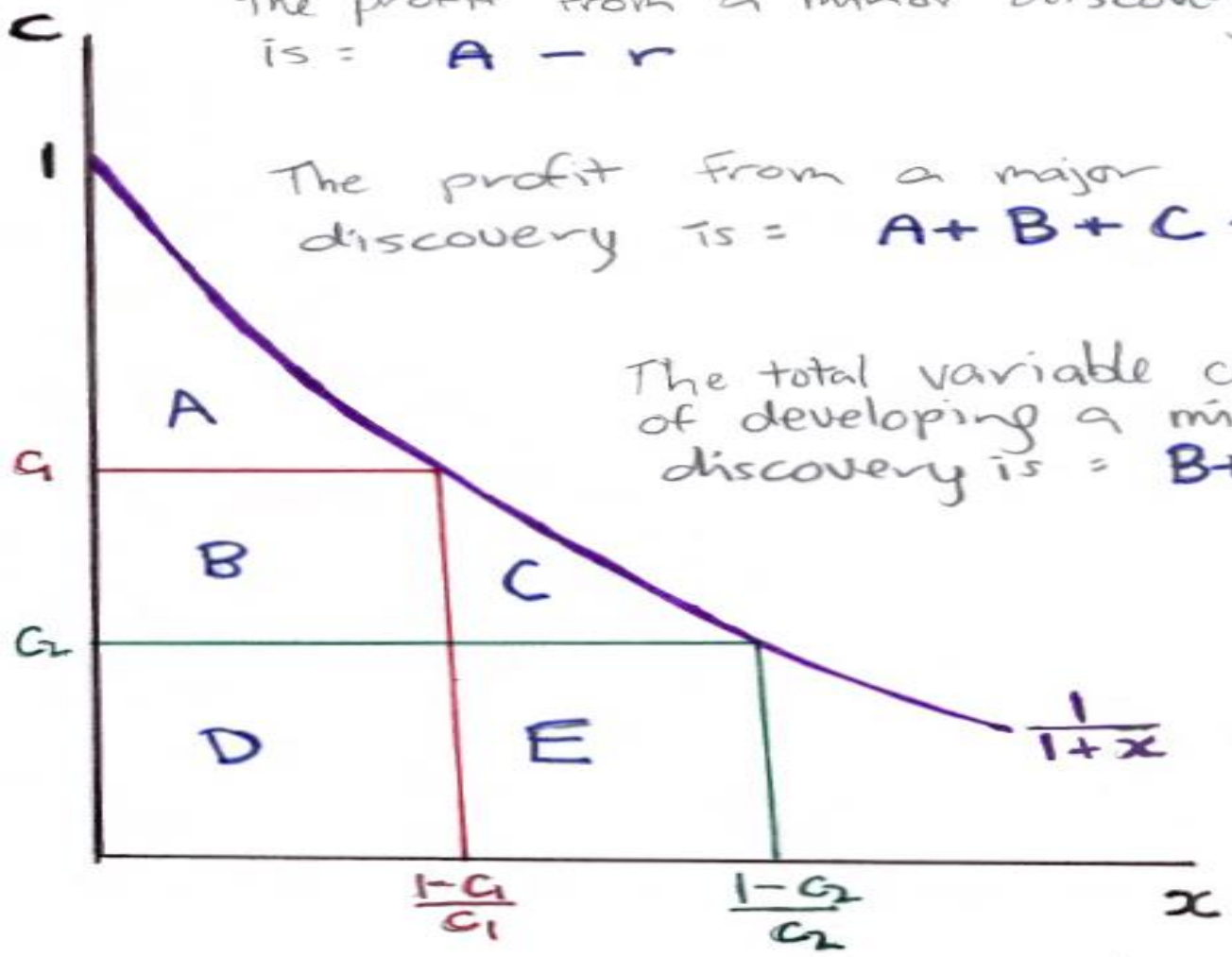
- If the product is developed, then the marginal costs of further development, denoted by c_j, will be equated with its marginal benefits denoted by the inverse of (1+x).
- Solving for b_j and x_j yields:

$$x_j = (1 - c_j)/c_j = 1/c_j - 1$$

$$b_j = r + c_j x_j = r + 1 - c_j$$

- See Figure 2.

Figure 2



The profit from a minor discovery is = $A - r$

The profit from a major discovery is = $A + B + C - r$

The total variable cost of developing a minor discovery is = $B + D$

The total variable cost of developing a major discovery is = $D + E$

Product development with asymmetric information

- Now suppose headquarters cannot observe whether a discovery has occurred, and if informed that there was a discovery, does not know how to evaluate it.
- If the firm cannot distinguish between perks to the division and expenditure and effort on development, how should the firm fund its R&D division?
- It is easy to see that the research division will not falsely claim it has made a discovery. In that case, it would not be able to continue with the product development phase, so its lie would be unmasked.
- But conditional on R&D making a discovery of some type, headquarters does not have a simple way of determining whether the discovery was major or minor.

The probability of a discovery being minor

- We have seen that if the firm knows whether the discovery is a major or a minor one, the probability of it being one or the other does not enter the equation determining optimal development.
- However the solution to the asymmetric problem does involve that probability.
- Supposing a discovery is announced, let p denote the probability it is a minor one ($j = 1$), and $1 - p$ the probability it is a major one ($j = 2$), where $0 < p < 1$.

Two special cases

- If the firm used the same policy but simply relied on R&D to report the type of discovery, then the division would report all discoveries are minor, and pocket a difference equal to area B in Figure 2 whenever it makes a major discovery.
- If p is close to 1, this R&D policy is almost optimal.
- Alternatively the firm could treat every discovery the division reports as major, and require development of $c_2/(1 - c_2)$ in return for $b_2 = 1 - c_2 + r$.
- Then R&D would not report minor discoveries at all, since they would make losses on such developments, so the firm would lose area A for every minor discovery.
- If p is close to zero, this R&D policy is almost optimal.

Outlining optimal R&D funding policy when there is asymmetric information

- Suppose headquarters chooses a policy (b_1,x_1) and (b_2,x_2), and then the division announces whether it has made a major or minor discovery, or no discovery at all.
- Headquarters maximizes the expected value with a policy satisfying two constraints that induce the division to:

1. report all its discoveries, a participation constraint. For each j:

$$b_j - c_j x_j \geq r$$

2. truthfully declare whether the discoveries are major or minor, a truth telling constraint:

$$b_2 - c_2 x_2 \geq b_1 - c_2 x_1$$

and vice versa.

Participation constraint

- The participation constraint should bind for at least one of the policy options policy (b_1,x_1) and/or (b_2,x_2), otherwise headquarters could lower both b_1 and b_2 without affecting how the division reports.
- However the participation constraint does not bind for a major (j = 2) discovery because, by the truth telling constraint:

$$b_2 - c_2x_2 \geq b_1 - c_2x_1 > b_1 - c_1x_1 \geq r$$

- Therefore the participation constraint binds for minor discoveries (j = 1):

$$b_1 - c_1x_1 = r$$

- In other words headquarters pays the R&D division a "bonus" for truthfully reporting "good luck".

Incentive compatibility and truth telling

- Since the participation constraint does not bind for major discoveries, the truth telling constraint must bind for major discoveries (j = 2). Thus:

$$b_2 - c_2 x_2 = b_1 - c_2 x_1$$

- However the truth telling constraint does not bind for the minor discoveries (j = 1).
- The easiest way of showing this is to solve the optimization problem ignoring the constraint in this case, and then showing it is satisfied by default.

Profit maximization for headquarters

- The objective function for headquarters is expected profits:

  $p[\log(1+x_1) - b_1] + (1 - p)\,[\log(1+x_2) - b_2]$

- From the participation constraint and the truth telling constraint we can express b_1 and b_2 as:

  $b_1 = r + c_1 x_1$

  $b_2 = b_1 - c_2 x_1 + c_2 x_2 = r + c_1 x_1 - c_2 x_1 + c_2 x_2$

- Thus headquarters chooses x_1 and x_2 to maximize:

  $p[\log(1+x_1) - r - c_1 x_1]$

  $+ (1 - p)\,[\log(1+x_2) - r - c_2 x_2 + c_2 x_1 - c_1 x_1\,]$

Major discoveries

- The marginal benefit of product development for a major discovery is equated with its marginal cost:

$$1/(1+x_2) = c_2 \qquad \text{or} \qquad x_2 = 1/c_2 - 1$$

- This is the same level of development that pertains to the situation where headquarters can observe the type of discovery directly.
- Note that if x_1 is positive (when minor discoveries are also developed) the division is paid a premium of:

$$b_2 = r + c_1x_1 - c_2x_1 + c_2x_2$$

$$= r + 1 - c_2 + (c_1 - c_2)x_1$$

- This deters the R&D division from pretending that a major discovery is only a minor one.

Ignoring minor discoveries

- Differentiating the firm's maximization problem with respect to x_1 yields:

  $$p[1/(1+x_1) - c_1] + (1 - p)(c_2 - c_1)$$

- If this expression is negative at $x_1 = 0$ the firm should not develop minor discoveries. That occurs whenever:

  $$p(1 - c_1) < (1 - p)(c_1 - c_2)$$

  The left side of the inequality is the expected value from marginally developing a minor discovery.

  The right side is the expected amount the firm gives up to deter the R&D from reporting a minor discovery when they make a major discovery.

Minor discoveries

- When the inequality in the previous slide is not satisfied, the firm should develop both types of discoveries.
- The first order condition for minor discoveries is:

$$p[1/(1+x_1) - c_1] = (1 - p)(c_1 - c_2)$$

- Solving for x_1 yields::

$$x_1 = p/[(1 - p)(c_1 - c_2) + pc_1] - 1$$

$$< 1/c_1 - 1$$

- Notice that under asymmetric information, the firm under-develops minor discoveries to deter R&D from taking rent when it makes a major discovery.

Illustrating the interior solution

- Compared to the situation where the firm instantly recognizes the type of discovery, Figure 3 shows that x_2 is the same as before, but x_1 is lower.
- The green dotted area shows the extra amount the firm pays the R&D division for "lucky" major discovery, if it wants to develop its minor discoveries to a slightly greater degree.
- The red shaded area is the marginal benefit from developing a minor discovery a little more.
- At the optimal policy the firm weights the areas by the probability of their occurrence and offsets the two exactly.

Figure 3

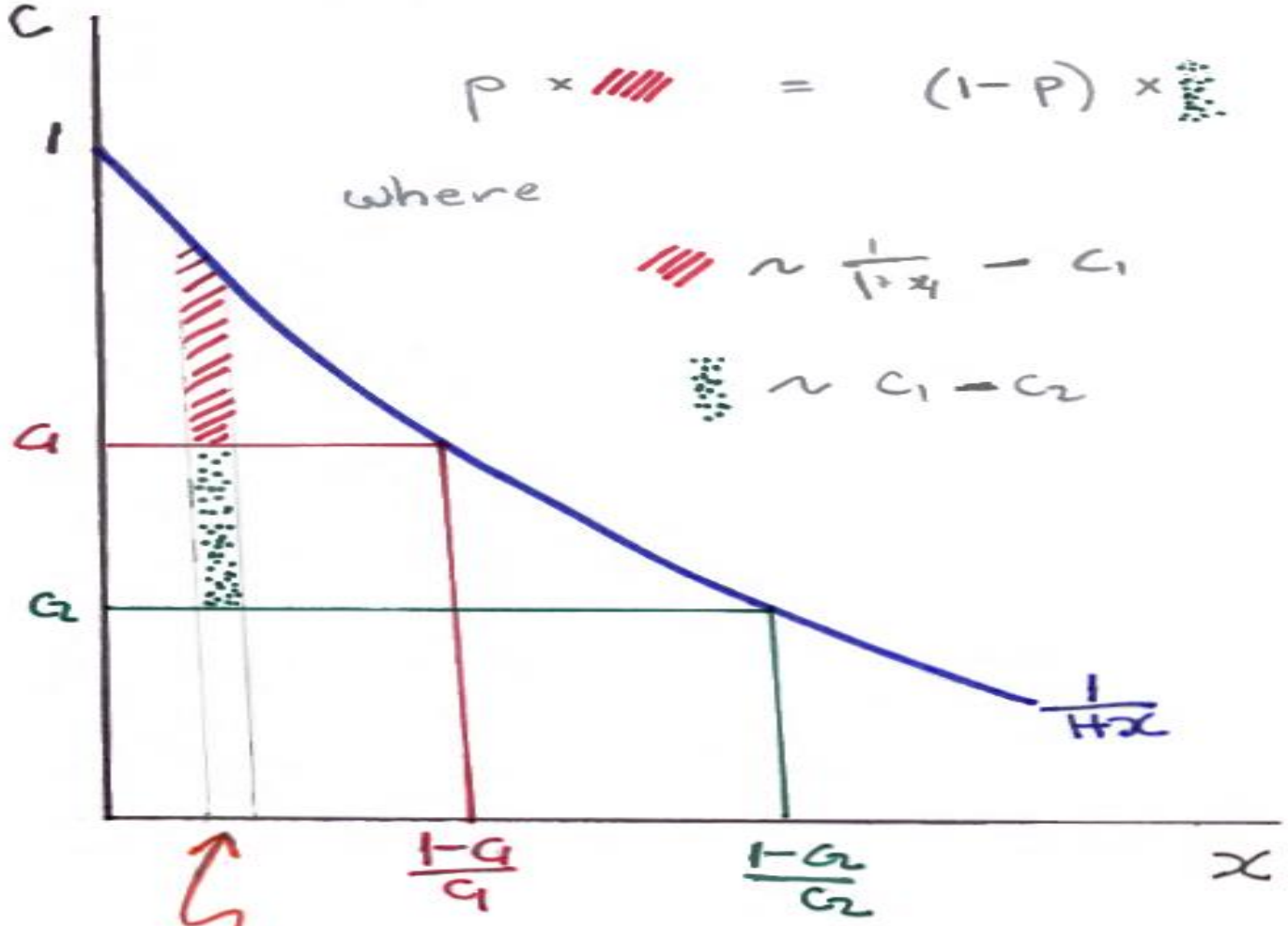
The optimal firm policy is to set

$$p \times \text{////} = (1-p) \times \text{:::}$$

where

$$\text{////} \sim \frac{1}{1+x} - c_1$$

$$\text{:::} \sim c_1 - c_2$$



$$x_1 = \frac{p}{(1-p)(c_1-c_2)+pc_1} - 1$$

Summary

- Financial incentives are used to:
  1. hire the most valuable job candidates
  2. incentivize managers to reveal their knowledge
  3. induce managers to take decisions in the firm's best interests.
- Exposing managers to signals that are imperfect requires the firm to compensate them for the risk. This reflects the cost of acquiring knowledge.
- Similarly, when managers and specialists are privy to valuable information, the firm pays them to reveal it.