# Uncertainty and Risk

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Trade and Investment Strategy

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# Introduction

## Discounting for risk and delay

- At the beginning of the previous lecture we argued that a good definition of an intrinsic valuation incorporates the twin notions that:
  - the asset might have use over several periods, or throughout time.
  - the returns from the asset might be uncertain.
- This lecture analyzes *risk*, loosely speaking the expected loss from uncertainty, concentrating on two fundamental features:
  1. People generally view mean preserving speads in their own consumption less favorably.
  2. People with different objectives:
     - do not necessarily share everything they know about a situation
     - might behave noncooperatively if their actions are hidden from each other.

# Preferences over Uncertainty

## Individuals do not maximize EPV

- If traders only cared about the mean return of an asset, it is hard to justify why assets would have different mean returns.
- There is abundant evidence that assets have different mean returns, suggesting that traders care about other moments of the probability distribution apart from the first.
- For example AAA bonds have lower mean returns than those on mining and oil stocks, but the latter experience much higher volatility.
- The differential in mean returns is inconsistent with EMH, and suggests that investors require a risk premium to buy stocks whose returns exhibit greater variance.
- To understand why, we need a framework that is more general than EPV maximization, which only values mean return.

# Preferences over Uncertainty

## Expected utility

- Let $(c_1, \ldots, c_J)$ denote the *consumption prizes* associated for a *lottery* over $J$ outcomes that occur with probabilities $(p_1, \ldots, p_J)$.
- These prizes could also be indexed by date, so the formulation is quite general
- Let $\succsim$ denote a *preference ordering* satisfying:
  1. Every prize pair $(c_i, c_j)$ is ranked; $c_i \succsim c_j$ and/or $c_j \succsim c_i$.
  2. There are no contradictions ranking triplets; $c_i \succsim c_j \succsim c_k \Rightarrow c_i \succsim c_k$.
  3. If $c_i \succsim c_j$ then a lottery involving $c_i$ is preferred to substituting $c_i$ with $c_j$ in that lottery; $(p, c_i; 1-p, c_k) \succsim (p, c_j; 1-p, c_k)$.
- These axioms imply that for some function $u(c)$ the preference ordering can be represented by the *expected utility* function:

$$\sum_{j=1}^{J} p_j u(c_j) \equiv E[u(c)]$$

- All three axioms have been challenged, especially the third, but almost all economics and finance takes them as a unquestioned premise.

# Preferences over Uncertainty

## Risk tolerance

- Naturally $u(c)$ is increasing in consumption $c$, implying $u'(c) > 0$.
- Let $c_0$ denote the *certainty equivalent* of a given lottery, measuring how much the person would pay to play, or to avoid, a lottery:
- An individual is risk averse if and only if:

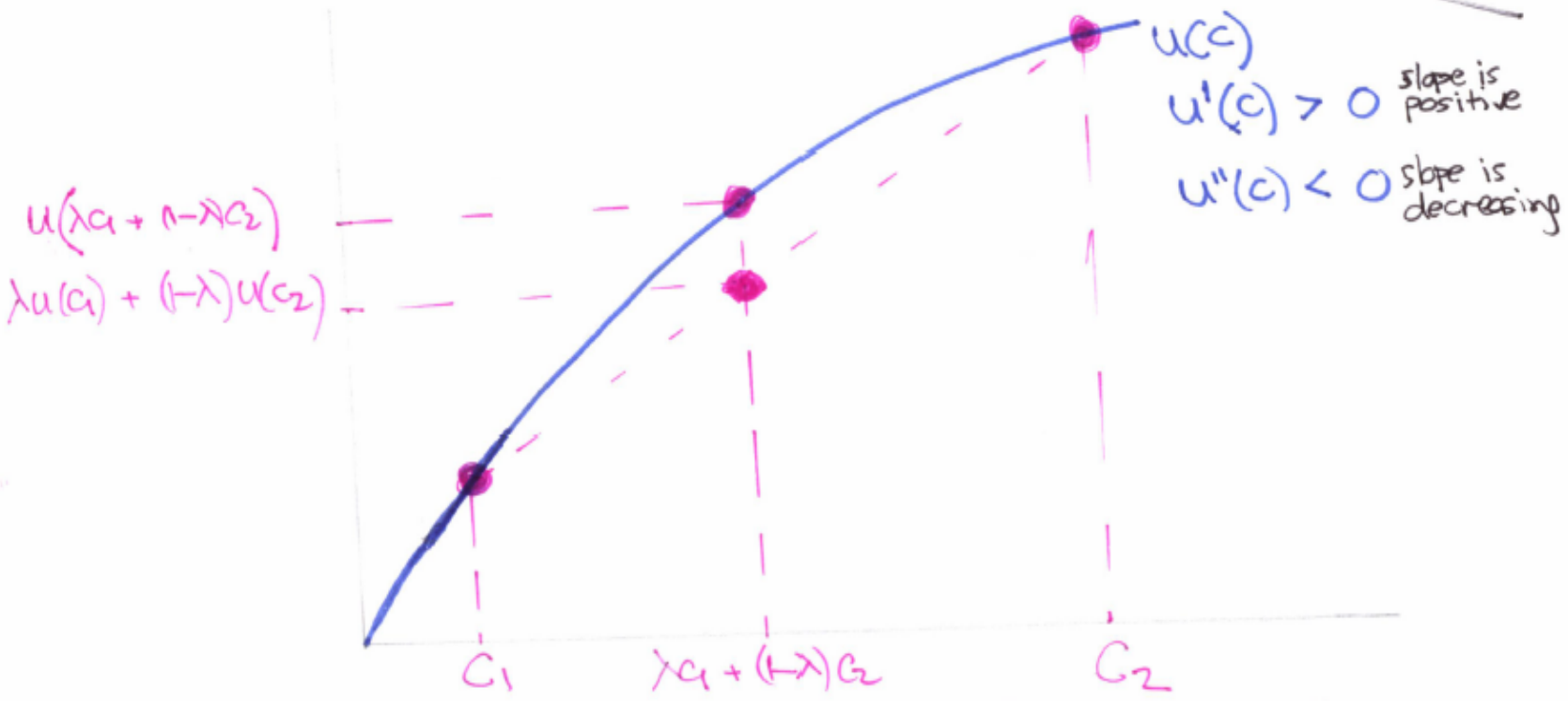
$$\begin{aligned} \sum_{j=1}^{J} p_j c_j &> c_0 \\ \Longrightarrow u\left(\sum_{j=1}^{J} p_j c_j\right) &> u(c_0) = \sum_{j=1}^{J} p_j u(c_j) \end{aligned}$$

  which implies that $u''(c) < 0$ (by Jensen's inequality).
- Similarly an individual is:
  - risk loving if $c_0 > \sum_{j=1}^{J} p_j c_j$ implying $u''(c) > 0$.
  - risk neutral or an expected value maximizer if $c_0 = \sum_{j=1}^{J} p_j c_j$.

# Preferences over Uncertainty

## How risk tolerance affects the shape of the utility function

Why a risk averse consumer has a concave utility function




A risk averter prefers the utility of a combination to the combination of utilities!

# Preferences over Uncertainty

## Indifference curve analysis

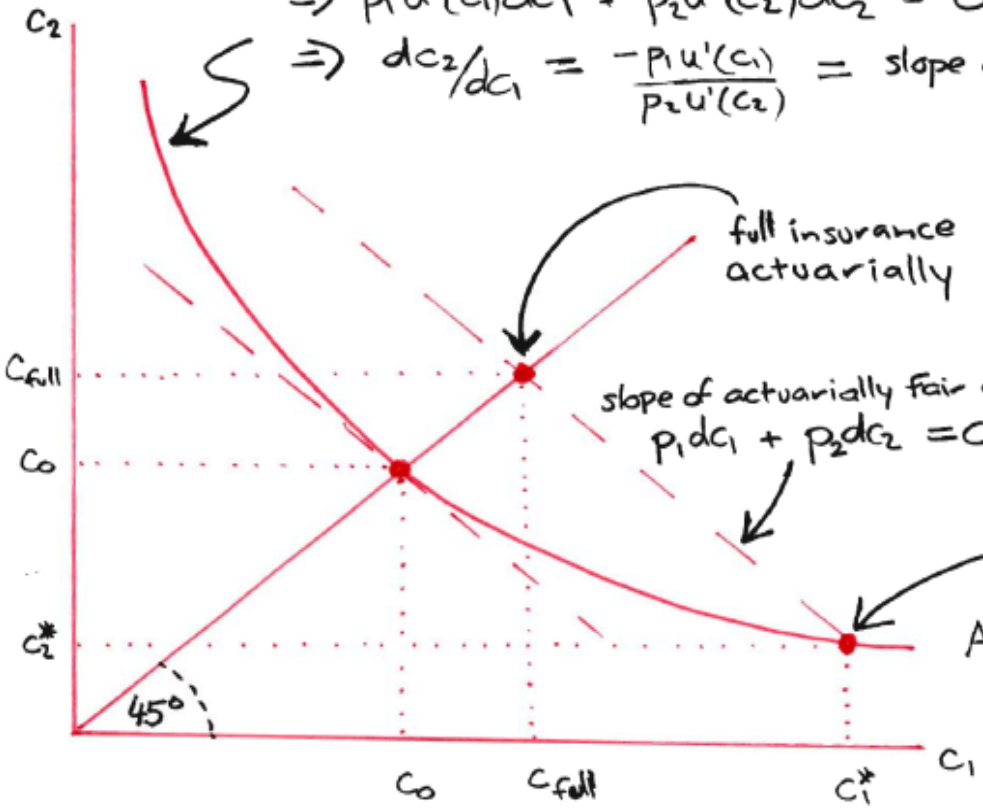
Risk Aversion Illustrated

slope of indifference curve:

$$p_1 u(c_1) + p_2 u(c_2) = u(c_0)$$

$$\Rightarrow p_1 u'(c_1) dc_1 + p_2 u'(c_2) dc_2 = 0$$

$$\Rightarrow dc_2/dc_1 = \frac{-p_1 u'(c_1)}{p_2 u'(c_2)} = \text{slope of indifference curve}$$




full insurance $(c_{full}, c_{full})$ at actuarially fair rates

slope of actuarially fair odds line found from:

$$p_1 dc_1 + p_2 dc_2 = 0 \Rightarrow \frac{dc_2}{dc_1} = \frac{-p_1}{p_2}$$

At $(c_1^*, c_2^*)$, the initial allocation point:

$$\frac{p_1 u'(c_1)}{p_2 u'(c_2)} < \frac{p_1}{p_2}$$

because $u'(c_1) < u'(c_2)$.

$(c_{full} - c_0)$ are potential gains to firm offering insurance if risk is idiosyncratic, that is unpriced.

# Preferences over Uncertainty

## Constant relative risk aversion

- One common specification: the constant relative risk aversion (CRRA) utility function is defined by:

$$u(c) = \frac{c^{1-\alpha}}{1-\alpha}$$

- If $\alpha > 0$ then the consumer who maximizes expected utility is risk averse, and if $\alpha < 0$ then the consumer is risk loving.
- As $\alpha \to 0$ it converges to the risk neutral preferences:

$$u(c) = c$$

- As $\alpha \to 1$ this utility function converges to (natural) log utility:

$$u(c) = \ln(c)$$

# Measuring Risk Preferences

## Measuring risk tolerance

- Professionals draw upon three sources to estimates of $u(c)$:
  1. empirical analysis of *field data* (scholarly research).
  2. *experimental data* from low risk gambles (pedagogical).
  3. *introspection* about hypothetical situations (retail finance marketing).
- From their on-show choices, economists have estimated the risk attitudes of contestants on *Who Wants to be a Millionaire*, *Jeopardy!*, *Illinois Instant Riches*, *Card Sharks* and other lesser known shows.
- My work with Profs Gayle and Golan estimates that:
  - executive officers in publicly traded firms are willing to pay about \$200,000 to avoid an even money bet of losing or gaining \$1 million.
  - (The average annual compensation of these executives across the ranks lies between about \$1.5 million and \$4.5 million.)

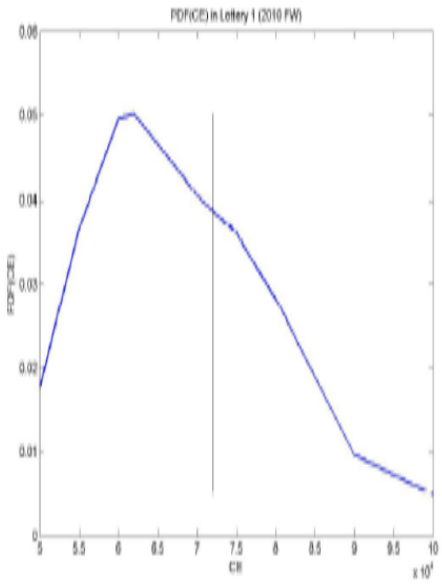
# Measuring Risk Preferences

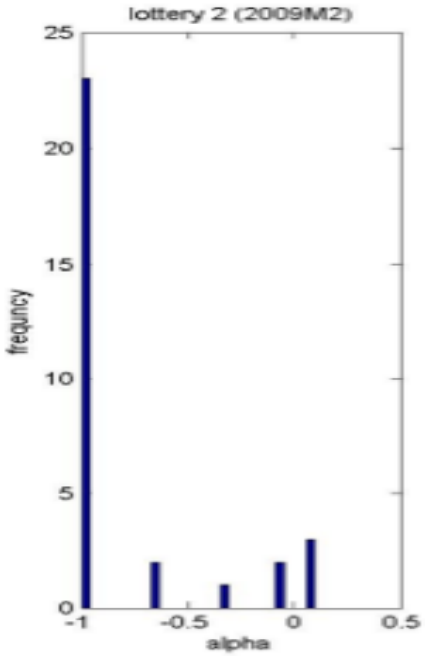
## Introspection

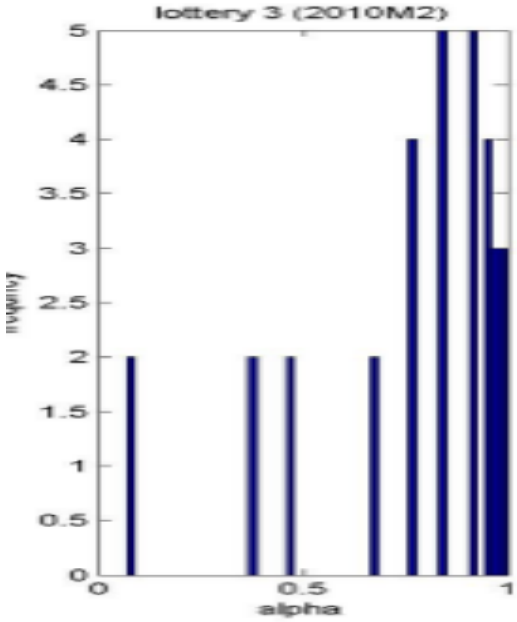
- The main drawback of introspection it focuses on what people say or think or write what they would do, rather than what they actually do.
- But it is relatively cheap to pose questions and paint hypothetical scenes to help them imagine what they might do.
- We consider the following thought experiments.
  1. first job
  2. stay at home versus work
  3. opportunity to earn very high compensation

# Measuring Risk Preferences

## Previous class results




- First lottery exhibits risk aversion.
- Second lottery shows risk loving behavior (anchoring?)
- Third lottery shows risk averse behavior.

# The Agency Problem

## An additional complication

- Uncertainty about the value of a firm's assets is compounded by *asymmetric information* between management and shareholders.
- Top management know more than shareholders about:
  1. the state of the firm and its future prospects (insider information)
  2. their own activities and the effects on firm profitability (moral hazard)
- Asymmetric information lies at the heart of this *principal agent problem*.
  - The principal (shareholders) would like the agent (management) to honestly declare the state of the firm to the principal and act in its interests, but the agent could withhold information and follow her lifestyle objectives instead.
- For these reasons the value of the firm's assets are less than if shareholders were as informed as management.

# The Agency Problem

## Insider information and performance pay (Gayle and Miller, 2009)

- Insider trading is illegal.
- Nevertheless my research with Professor Gayle (formerly at Tepper) on the S&P 1500 composite shows that:
  1. Changes in the stock components of the manager's compensation is a significant predictor of future financial returns, executives opting for more stock and less cash and bonus when the firms they manage subsequently do well.
  2. Retrospectively replicating the manager's compensation strategies and forming a simple investment strategy, we would have earned 20 percent return per year over the 9 year panel for the 1500 firms, instead of the market return of about 9 percent.
- Notice that the strategy fully diversifies firm idiosyncratic risk.
- Why do shareholders allow this?

# The Agency Problem

## Moral hazard

- Compensation committees incentivize managers by paying a risk premium that:
  - gears compensation to firm performance
  - recognizes that managers only partly control profits with a compensating differential for uncertainty.
- Their compensation should be geared to their activities, not to form performance measures they can hardly affect.
- The board of directors only meets several times a year, so is no position to monitor and control day-to-day affairs.
- A shareholder only holding a small percentage of the firm is not motivated to follow the firm's activities either.
- The burden of running the firm mainly falls upon managers.

# The Agency Problem

## Compensation and hierarchy in the C-suite (Figure 1 in Gayle, Golan and Miller, 2015)

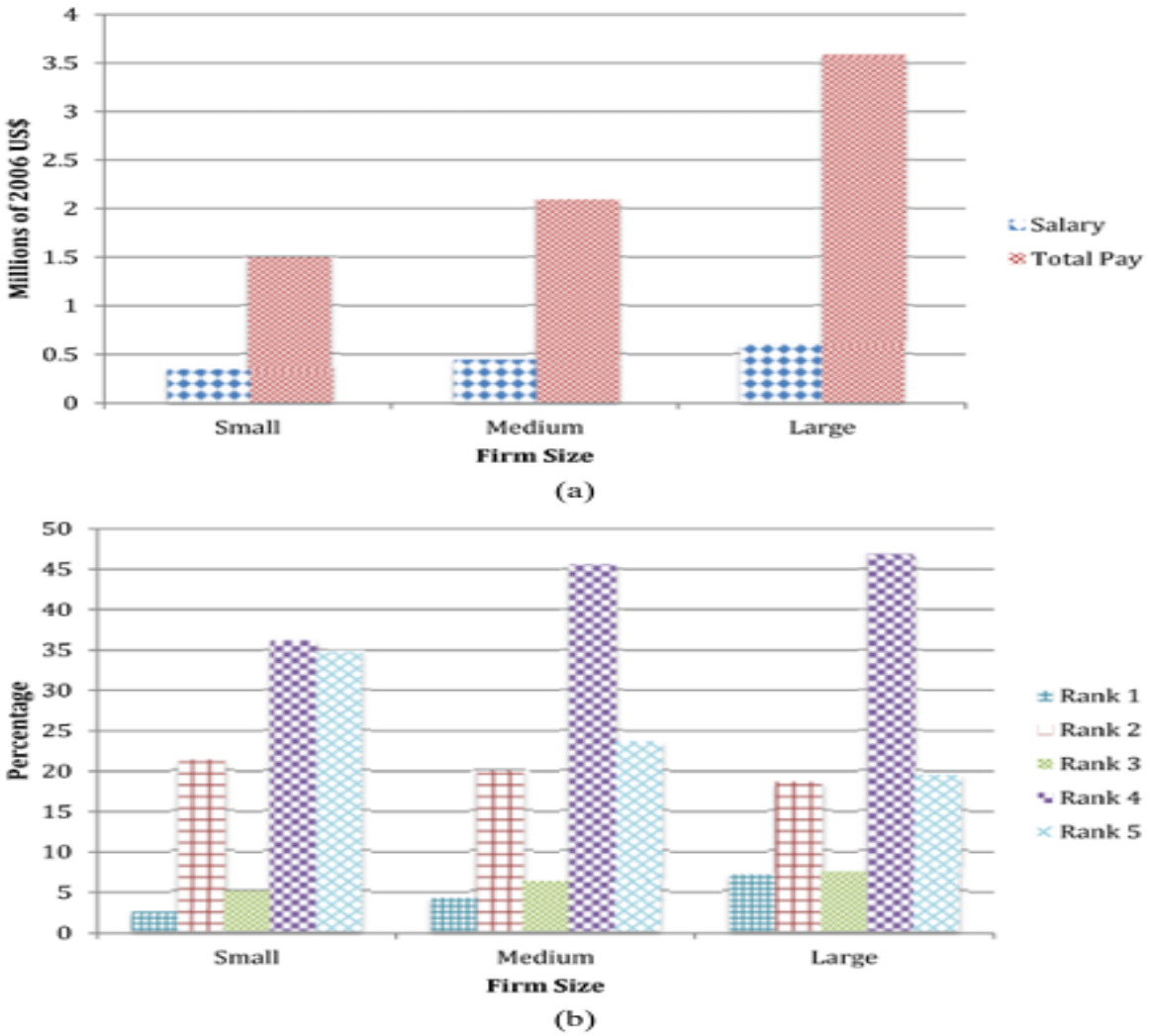



FIGURE 1.—Pay and hierarchy by firm size. (a) Firm size pay premium, (b) hierarchy by firm size.

# The Agency Problem

Pay decomposition by rank and firm size (Figure 3 in Gayle, Golan and Miller, 2015)

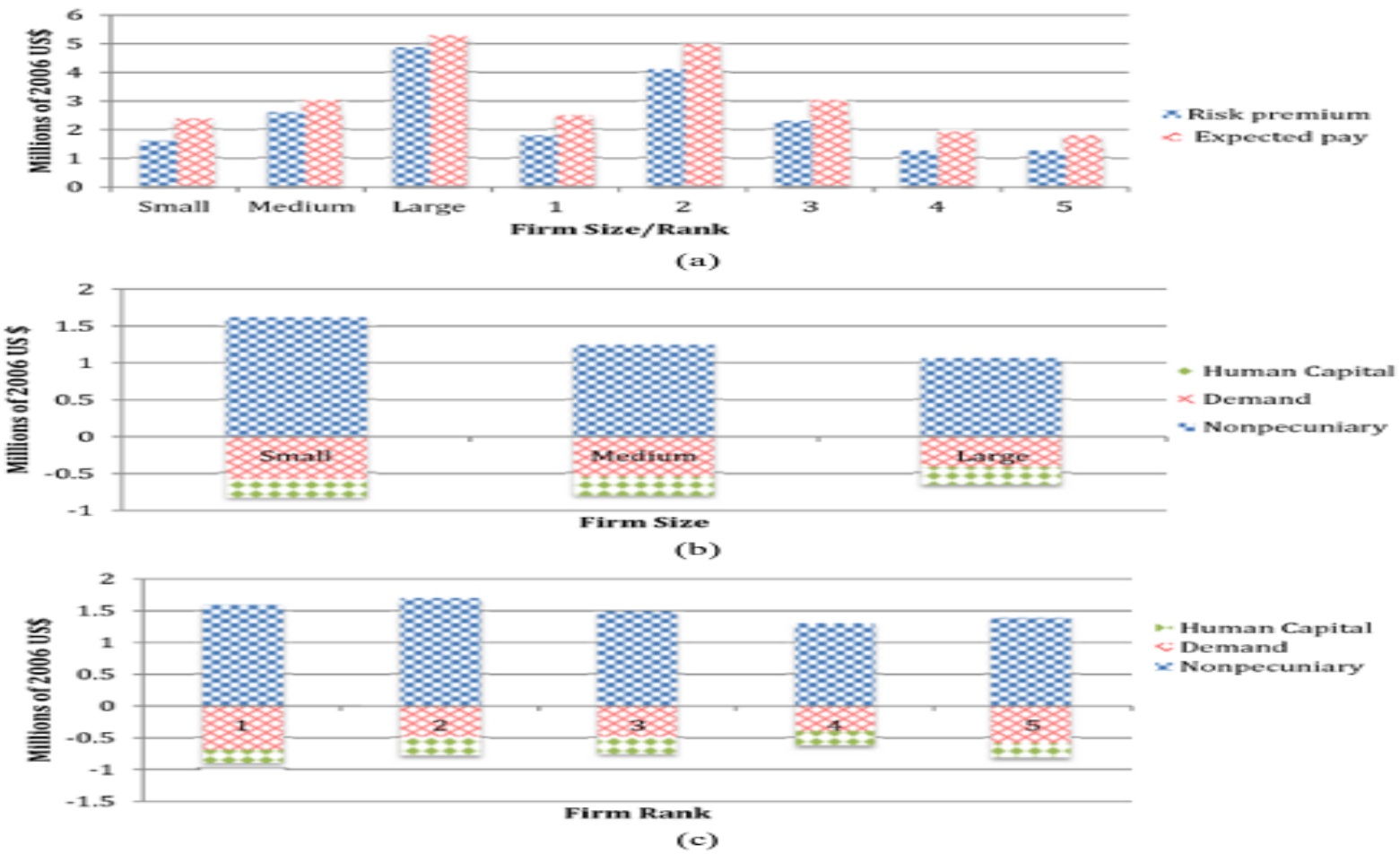



FIGURE 3.—Rank and firm-size pay decomposition. (a) Risk premium, (b) decomposition of certainty-equivalent pay, (c) decomposition of certainty-equivalent pay. *Note*: The certainty equivalent is the sum of human capital, demand, and nonpecuniary compensating differentials.

# Top Management

## Agency cost decomposition (Figure 4 in Gayle, Golan and Miller, 2015)

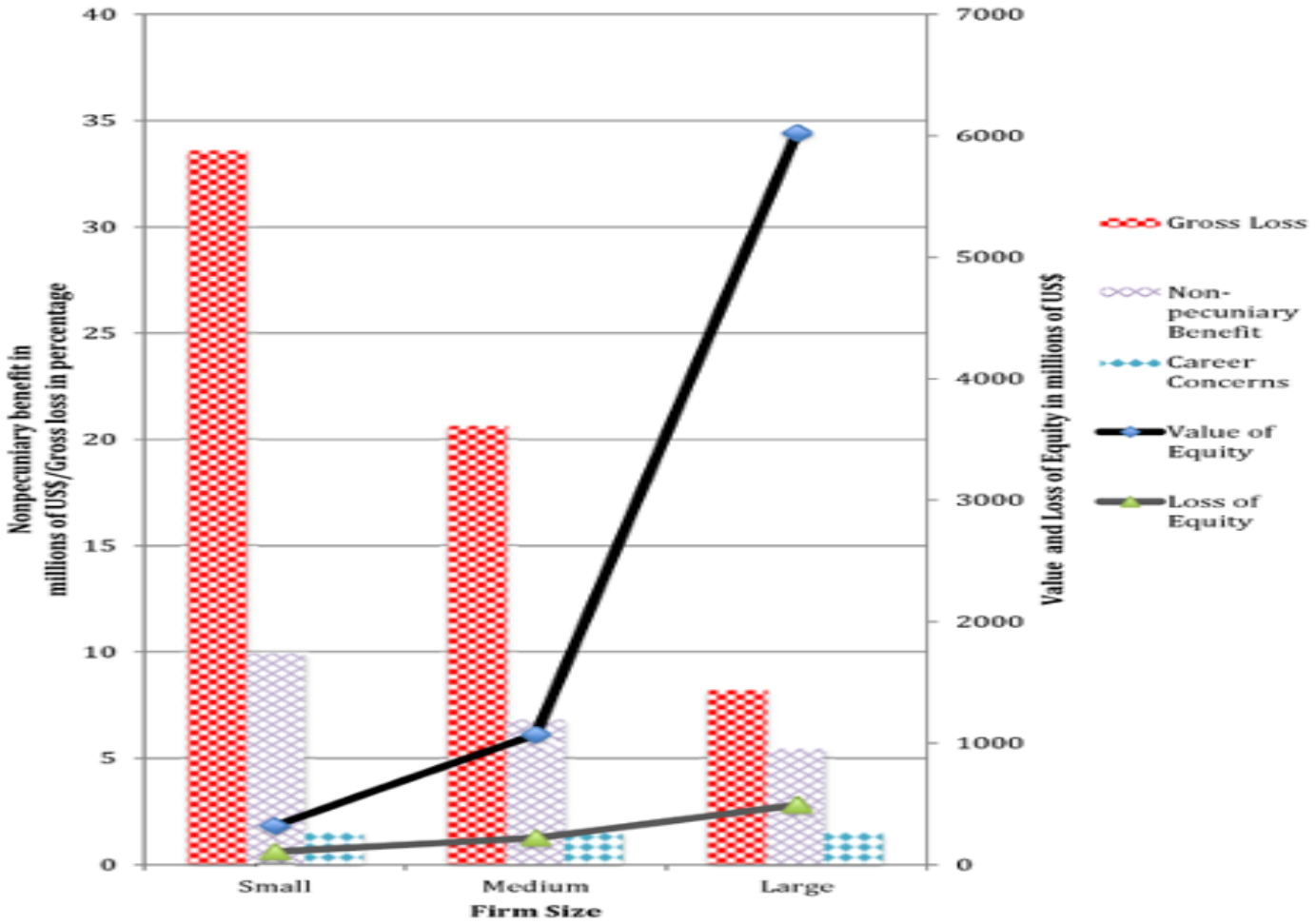



FIGURE 4.—Agency cost decomposition. Sources of agency cost by firm size. *Note*: Gross loss is the percentage of the firm value lost if an executive shirks instead of working. Loss of equity is the firm value lost if an executive shirks instead of working. Nonpecuniary benefit is the value to an executive of shirking relative to working. Career concerns measures the extent to which career concerns ameliorate the agency problem.

# Governance

## Can owners solve the principal-agent problem?

- The board of directors:
  - is elected to represent shareholder interests.
  - signs off on the compensation plan for top management.
  - in principle monitors management.
- Similarly a shareholder confers benefits on the other shareholders by:
  - voting inelections for board members and on managerial pay
  - reporting evidence of malfeasance by management.
- To what extent is the board motivated to serve shareholder interests?
  - They meet several times a year.
  - They are not necessarily heavily invested in the firm.
- These activities are examples of *an information externality*:
  - The costs are borne by the investigator.
  - Yet the benefits are realized by all shareholders.

# Governance

## A free rider problem

- Consider a firm owned by many shareholders, each holding a tiny fraction of the enterprise.
- In this case, any shareholder doing *due diligence* to is essentially performing a public service on behalf of all shareholders.
- Hence the corporate benefit from undertaking activities far outweighs the individual cost.
- Consequently a shareholder holding a tiny proportion of the firm does not commit any (substantial) effort to improving firm performance.
- Generally a firm with a dispersed ownership structure abdicates the operation and organization of the firm to (the perils of) management and organized labor.
- Such firms resemble nonprofit organizations, where market value is a residual reflecting the goals of *insider stakeholders*.

# Governance

## Concentrated ownership solves the free rider problem

- The polar opposite of dispersed ownership is a sole proprietorship.
- In this case the single owner's interest is almost identical to his or her firm's (especially if liability is unlimited).
- Concentrating ownership ameliorates the free rider problem of negligent governance.
- For if a single individual entity:
  1. controlled the firm
  2. and also received (almost) all its dividends and capital gains (upon liquidating or selling the firm)

then the costs of governance could be balanced against its benefits.

# Governance

## Concentrated ownership reduces diversification

- Two important negative factors weigh against buying and holding a large specialized portfolio:
  1. Concentrating an individual's asset portfolio in a small number of firm's exposes risk that could otherwise be reduced through diversification.
  2. Limit order markets penalize shareholders seeking to use their market intelligence:
     - selling a large share in the firm reduces the bid price.
     - buying a large share in the firm increases the ask price.
- High frequency trading (HFT) and algorithms that detect large purchases and sales have exacerbated this problem in recent years.

# Governance

## Alternatives trading mechanism to limit order markets

- Obvious alternatives to ownership turnover within a limit order market are:
  1. Not going through with an IPO, and reach (successive) agreements about ownership through contracts. (About half the GDP is generated by private companies. Many of them are small sole proprietorships or partnerships.)
  2. Turn a public firm private by acquiring its shares
- To sustain these activities the return on investment must be higher than portfolio investment, given scale of agglomeration required and the difficulty with diversification.
- There are several vehicles for achieving this:
  - management buyouts
  - hedge funds
  - holding companies

# Governance

## Dark pools

- Alternatively shares of a public firm could be traded within a *dark pool*, a generic term for a private financial forum or exchange for trading securities, mostly used by institutional investors for block trades involving a large number of securities.
- There are several different types of dark pools:
  - broker or dealer-owned exchanges
  - independently owned exchanges offering private trading to their clients
  - private exchange markets operated by public exchanges
- Trading in dark pools facilitates a stable ownership structure and good governance:
  - Transacting a block of shares from one owner to another preserves the ownership structure.
  - everyone sees the ownership structure has not fragmented.
  - everyone understands that the due diligence exercised by the previous block owner will continue.

# Summary

## The ubiquitous role of uncertainty

- Overall households exhibit risk averse behavior.
- Uncertainty is costly for risk averters.
- Shareholders diversify their portfolios to hedge against risk.
- Individual shareholders monitoring the activities of management creates an information externality.
- This leads to a free rider problem: shareholders are reluctant to monitor managers for the benefit of other shareholders.
- The absence of optimal monitoring exposes all shareholders to malfeasance by managers.
- This cost is ameliorated by compensation schemes, a tool for inducing managers to act in the interests of shareholders
- This resolves the principal agent problem, albeit at a (much smaller) cost of paying management a risk premium.
- An alternative is to hold a specialized portfolio and benefit from monitoring, but be exposed to more firm idiosyncratic risk.

# Summary

## The conflicting objectives of good governance and portfolio diversification

- Owners, typically acting through the board of directors, bera ultimate responsibility for putting in place an organization and a system of incentives that makes the firm valuable.
- To accomplish this collectively shareholders must overcome a free-rider problem: the cost of due diligence is born by the investigative shareholder, but the benefits (of higher firm returns) are reaped by all shareholders
- This leads to an underinvestment in governance of firms with a fragmented ownership structure.
- A concentrated ownership structure (such as each shareholder owning her own firm) is at odds with the principle of portfolio diversification.

# Summary

## Dark pools and the threat of large investment firms improve governance

- Thus firms are only reorganized when an investor anticipates making above market returns to compensate for the cost of acquiring market intelligence.
- Acquiring a controlling interest on public platforms (such as a limit order market), large enough to the costs of market intelligence, is further complicated by near arbitrageurs engaging in HFT. (The ask price increase as more shares are acquired, and the bid price falls as the takeover firm divests itself.)
- This makes alternative ways of attaining control more attractive.
- Having improved governance structure and reorganized the firm, dark pools facilitate the transfer of a controlling interest from one owner to another (such as an institutional investors) without overly diluting the ownership structure so that the new priorities can be channelled through the management structure.