Advanced Topics in Labor Economics

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Monday-Thursday: 11:30 am - 12:50 pm

Webpage: http://web.uvic.ca/~pcourty/labor.htm
Course Objectives

We covers modern topics in labor economics such as moral hazard, adverse selection, matching, and intrinsic motivation.

In each session, we investigate how micro-theory has been applied to address specific labor issues, review the predictions of the theory, and assess how these predictions have been tested.

This course teaches new researchers how to write a paper by following an incremental three-step approach: (a) read research papers and assess each paper’s contribution, (b) write, present, and defend a research proposal, (c) write a preliminary research paper.
Readings (books)


Lecture 0: Course Introduction

Modern micro-theory offers many tools useful to labor economists. For example, the moral hazard model is a starting point to investigate issues of compensation and the adverse selection model explains how workers sort across careers, occupations, firms... These models, however, are difficult to bring to the data.

**Example:** Choice of risk-sharing in a tenant-landlord relationship. Theoretical prediction on trade-off between incentives and risk sharing.

**Prediction:** Under the assumption that risk is exogenous (e.g. weather), more likely to use sharecropping in less risky environments.
This prediction is correct “everything else equal”. Assume, however, that tenants vary in risk attitude. Risk neutral agents will choose to work in risky environments and will prefer high powered incentives (less risk sharing). Would reject the theory!

**Conclusion:** Sometimes difficult to draw inference on causality from correlation between contracts and environment
**Identification problem 1**: Contracts are endogenous. Need to control for all exogenous variables that influence contract choice (see above sharecropping example)

**Identification problem 2**: Different theories may be consistent with the evidence. Say that you find that people who face more comprehensive coverage exhibit a larger accident probability. This is consistent both with pure adverse selection and pure moral hazard or a combination of both!
Policy Implications

Example 2: Conducting a before-after estimation of the switch from fixed salary to piece rate, one finds that a dramatic increase in productivity (e.g. Lazear, 2000). If this is driven by incentive responses, then the introduction of piece rates may be welfare improving. If this is driven by self-selection, then the introduction of piece rates is a zero-sum game between employers.

Example 1: In cross sectional data, one finds that better health coverage is correlated with higher expenditure level (e.g. Rand Health Insurance Experiment). If this is driven by moral hazard then the policy implication would be to introduce deductible to reduce over-expenditure. If this is driven by adverse selection then introducing deductible would reduce welfare as it would increase risk without any effect on expenditures.
Empirical questions

Do the departing assumptions of the theory hold? Moral Hazard: Agents respond to incentives, but do they? Adverse Selection: Some agents are privately informed, but are they?

Are contracts designed optimally? Do firms design contracts consistent with incentive theory? Predictions on how contracts should vary as a function of the environment?

Equilibrium and welfare predictions? Tests regarding market outcomes and efficiency properties
Tests of micro-based labor theories often require information on:

Contracts but the information needs to be somewhat standardized to apply econometric tools

Information available to all parties: what is privately and publicly observed?

Behavioral choice variables: action/effort taken, contract selected...

Outcomes: payments and compensation

Structural versus non-structural approaches
Lecture 1: Moral Hazard (MGW 14-B)

Introduction to the principal-agent paradigm

Two effort levels and two outcomes model

Two efforts and continuous outcome model

Linear-Normal-Exponential Moral Hazard Model

Principal Agent Paradigm

Under an agency relationship, one party, the principal, hires another party, the agent, to perform some task.

Agency problems occur when the agent does not have the same preferences as the principal.

The agent faces a moral hazard problem because she is confronted with the dilemma of doing what's best for her or what's best for the principal. Economists put moral issues aside and assume that the agent does what’s best for her.

What can the principal do to address the problem? (a) Find a perfect agent: Selection or screening. (b) Get the right behavior: Incentive provision.
Short-Term Incentives: Piece Rates and Bonuses

Piece rates pay workers based on the amount of output they produce regardless of the amount of time actually worked.

Bonuses are lump-sum payments (made in addition to other forms of compensation) usually conditional on some kind of performance evaluation.

The common point to piece rate and bonus is that they provide short term performance incentives.
Short-Term Incentives: How does it work?

The principal (e.g. firm) cannot observe the agent’s (e.g. worker) effort or true contribution

The firm observes only an imperfect measure of effort (e.g. profits, sales...)

The performance measure is a function of the worker’s effort and also some random noise

For example, a CEO’s performance depends on the level of industry competition, a sales person performance depends on the product sold, a farmer’s output depends on the weather...
Two effort levels and two outcomes model

The worker can either supply high \((e_H)\) or low effort \((e_L)\) and this decision is not observed by the principal. The cost of effort \(e\) is \(g(e)\) such that \(g(e_H) > g(e_L)\) and we denote the incremental cost of effort \(c = g(e_H) - g(e_L)\). The worker has reservation utility \(u\).

The principal observes a performance outcome that can be either high or low. \(p_H\) and \(p_L\) are the probability of high performance under high and low efforts respectively. High effort is more likely to generate high performance \(p_H > p_L\). Perfect performance measure has \(p_H = 1\) and \(p_L = 0\).

The principal makes an offer which consists in a fixed salary \(s\) plus a bonus \(b\) if performance is high.
Timing of events:

1. Firm sets the compensation policy

2. Worker chooses effort level

3. Nature draws performance according to probability conditional on effort

4. Worker gets compensated
Analysis

Assume there is no performance bonus \((b = 0)\)

Since \(s - c < s\) the worker prefers to supply low effort

The worker will not supply effort unless \(s + p_H b - c > s + p_L b\).

The lowest bonus such that \(e_H\) is incentive compatible is,

\[
b = \frac{c}{p_H - p_L}
\]

The incremental benefit of supplying effort has to be greater than (or equal to) the incremental cost of doing so

Under perfect performance measure \((p_H = 1, p_L = 0)\) the bonus is equal to the cost of effort \(b = c\)
The more noisy the performance measure ($p_H - p_L$ low) the greater the bonus $\frac{\partial b}{\partial (p_H-p_L)} < 0$

The worker earns $s + b$ with probability $p_H$ and $s$ with probability $1 - p_H$. The principal sets the fixed salary $s$ such that the worker is indifferent between working under contract $(s, b)$ and the outside option $u = p_H(s + b) + (1 - p_H)s - g(e_H)$ or

$$s = u + g(e_H) - p_H b$$

A risk averse worker gets disutility from incentive compatible compensation since pay is variable.
Two efforts and continuous outcome model

e \in \{ e_L, e_H \}

\pi \in [\underline{\pi}, \bar{\pi}]$, and \( f(\pi|e) \) represent the conditional density function of profits given effort

\( F(\pi|e_L) \geq F(\pi|e_H) \) for \( \pi \in [\underline{\pi}, \bar{\pi}] \) with strict inequality for some interval \( \Pi \)

**Agent:** \( u(w, e) = v(w) - g(e) \) with \( v' > 0, v'' \leq 0 \), and \( g(e_H) > g(e_l) \geq 0 \). Reservation utility \( u \)

**Principal:** \( E(\pi - w) \) (risk neutral)
**Game:** Principal makes a take-it-or-leave-it contract offer to the agent. The contract can be conditional on effort level under symmetric information, $w(\pi, e)$ but not under asymmetric information $w(\pi)$

Let $e^* = e_L$ if $\int \pi f(\pi|e_L) d\pi - v^{-1}(u + g(e_L)) \geq \int \pi f(\pi|e_H) d\pi - v^{-1}(u + g(e_H))$ and $e^* = e_H$ if the opposite (strict) inequality holds.

**Efficient outcome:** set $e = e^*$ and pay the agent a fix wage.

Joint surplus $E(\pi|e^*) - u - g(e^*)$
Discussion

Stylized model of an employment relationship: the assumption that the agent has a reservation utility gives all bargaining power to principal

In a market with many agents and many principals the surplus may be shared differently but this is beyond the point since our focus here is on the nature of the contract that maximizes constrained efficiency and not on the division of surplus

The principal agent framework is a starting point to model incentive problems in organizations
Market outcomes to be determined:

Wage schedule

Worker’s effort

Possible scenarios:

Observable effort $w(e, \pi)$

Unobservable effort $w(\pi)$ and risk neutral agent

Unobservable effort $w(\pi)$ and risk averse agent
Economic questions of interest:

1. What is the optimal compensation contract?

2. Is the contracting outcome efficient? Efficient level of effort? Efficient risk sharing?

3. Is the equilibrium contract consistent with observed compensation policies (i.e. fixed salary, piece rate)?
Case 1: Symmetric information (Benchmark 1)

Under a take-it-or-leave-it offer the principal must satisfy the agent’s participation constraint:

$$\int v(w(e, \pi))f(\pi | e)d\pi - g(e) \geq u \quad PC$$

The principal sets the level of effort $e$ and wage schedule $w(e, \pi)$ to maximize $\int (\pi - w(e, \pi))f(\pi | e)d\pi$ subject to $PC$

Solve the problem in two steps: (a) set the optimal compensation conditional on effort, (b) set the optimal level of effort

**Lemma 1:** Wage schedule $w(e, \pi) = v^{-1}(u + g(e))$ and $w(e', \pi) < v^{-1}(u)$ for $e' \neq e$ implements effort level $e$
The principal binds the participation constraint and pays the agent only if the requested level of effort is observed.

**Lemma 2**: The optimal level of effort is $e^*$.

The principal selects the efficient level of effort because she captures all the surplus from effort ending up with a surplus of $E\pi - v^{-1}(u + g(e^*))$.

**Conclusions**: (a) Full insurance if the agent is risk averse. (b) The optimal contract implements the efficient level of effort.
Case 2: Asymmetric information and risk neutral worker
(Benchmark 2)

Assume the agent's utility is $u(w, e) = w - g(e)$

Consider the contract $w(\pi) = \pi - E(\pi|e^*) + u + g(e^*)$

This contract implements the first best level of effort since (a) The agent chooses $e^*$ because she receives all the surplus from effort. (b) The agent accepts the contract since she is indifferent with the outside option.

The principal earns $E(\pi|e^*) - u - g(e^*)$ which is identical to the symmetric information profits (under the assumption that $v(w) = w$). Since $w(\pi)$ maximizes total surplus and gives the agent
exactly her outside option, this contract has to be an optimal contract

The agent faces risk (level of utility varies) while the principal faces no risk (receives a fixed payment)

In a context where the principal owns a productive asset (e.g. firm, land), this contract can be interpreted as the principal selling the project to the agent at price $E\pi - u - g(e^*)$. The agent supplies the efficient level of effort because she fully appropriates the marginal benefit of effort

This can be interpreted as a transfer of ownership. The agent is the residual claimant to firm’s return
Remark: The contract $w(\pi)$ is not the only contract that implements the optimal profits for the principal. Any contract that varies wage enough to satisfy the incentive constraint that the agent chooses the high action when it is optimal to do so and leaves no surplus to the agent is also optimal.
Case 3: Asymmetric information and risk aversion

The wage schedule under asymmetric information and risk neutrality (benchmark 2) $w(\pi)$ is no more first best because the agent faces some risk

The wage schedule under symmetric information (benchmark 1) $w(e, \pi)$ is not implementable because the wage cannot depend directly on the level of effort

If $e^* = e_H$ and the principal pays the agent $w(e_H, \pi)$ then the agent will accept the contract and select $e_L$ since $\int v(w(e_H, \pi)) f(\pi|e_H) d\pi - g(e_H) = v(w(e_H, \pi)) - g(e_H) = u < u + g(e_H) - g(e_L) = \int v(w(e_H, \pi)) f(\pi|e_L) - g(e_L)$
The full-insurance contract is not incentive compatible!

Contract $w(\pi)$ is incentive compatible for effort $e_H$ if

$$\int v(w(\pi))f(\pi|e_H)d\pi - g(e_H) \geq \int v(w(\pi))f(\pi|e_L)d\pi - g(e_L) \quad IC(e_H)$$

Contract $w(\pi)$ is incentive compatible for effort $e_L$ if

$$\int v(w(\pi))f(\pi|e_L)d\pi - g(e_L) \geq \int v(w(\pi))f(\pi|e_H)d\pi - g(e_H) \quad IC(e_L)$$

The principal chooses $e \in \{e_L, e_H\}$ and $w(\pi)$ to maximize $E(\pi - w(\pi))$ subject to PC and IC(e)

**Case 1:** $e^* = e_L$
Assume for now that it is efficient for the agent to supply low effort

**Lemma 3**: $IC(e_L)$ always hold when the wage is constant

In fact, for any non increasing compensation rule, the agent always prefers to supply low effort

If $e^* = e_L$, the optimal contract sets $w(\pi) = v^{-1}(u + g(e_L))$ and implements the first best outcome

**Case 2**: $e^* = e_H$

Assume now that $e^* = e_H$. Let $\lambda$ and $\mu$ the Lagrange multipliers on $PC$ and $IC(e_H)$
Assume the principal chooses the function $w()$ point by point. The first order condition for $w(\pi)$ is

$$\frac{1}{v'(w(\pi))} = \lambda + \mu \left(1 - \frac{f(\pi|e_L)}{f(\pi|e_H)}\right) \quad FOC(\pi)$$

**Lemma 4**: $e^* = e_H$ implies $\lambda > 0$ and $\mu > 0$

The optimal contract is defined by a set of $\lambda > 0$, $\mu > 0$, and $w(\pi)$ such that $PC$ and $IC(e_H)$ bind and $FOC(\pi)$
Discussion

There is a statistical interpretation to the optimal compensation rule: Let \( \hat{w} \) such that \( \frac{1}{v'(\hat{w})} = \lambda \). For any \( \pi \) such that \( w(\pi) > \hat{w} \) we have \( \frac{f(\pi|e_L)}{f(\pi|e_H)} < 1 \) and the opposite inequality holds for any \( \pi \) such that \( w(\pi) < \hat{w} \). The fraction \( \frac{f(\pi|e_L)}{f(\pi|e_H)} \) is the likelihood ratio. For a given outcome \( \pi \) the likelihood ratio is high if the chance that this outcome could have occurred is high under effort \( e_L \) and/or low under effort \( e_H \). Stated differently, conditional on \( \pi \), \( e_L \) is more likely than \( e_H \) if the likelihood ratio is high.

The principal pays the agent more in those states of the world where, an outsider who would observe only the outcome realization \( \pi \) and would know nothing about which action \( e \) the agent
has taken, would conclude that it is more likely that the agent has taken the high action. This is just an interpretation since there is no inference to be made here: given the incentives in place, the principal knows that the agent takes the high action 

\( w(\pi) \) is not necessarily linear as in a piece rate. More problematically, \( w(\pi) \) is not necessarily increasing in \( \pi \). In fact, taking full derivative of \( FOC(\pi) \) with respect to \( \pi \)

\[
\frac{d}{d\pi} w(\pi) = \mu \left( \frac{v'(w(\pi))}{v''(w(\pi))} \right)^2 \frac{d}{d\pi} \left[ \frac{f(\pi|e_L)}{f(\pi|e_H)} \right]
\]

The wage schedule increases if and only if the likelihood ratio is decreasing in \( \pi \) and this is known as the monotone likelihood ratio condition. More surprisingly, the wage can decrease with profits and this happens over intervals where the likelihood ratio increases with \( \pi \)!
More costly to implement the high effort under asymmetric information since $E w(\pi) > v^{-1}(u + g(e_H))$. The increase in utility cost is called risk premium

Inefficiency necessarily occur when $e_H$ is the first best level of effort because either the principal settle for $e_L$ (when the risk premium is too high) or the agent faces some residual risk (which is an inefficient risk allocation given that the principal is risk neutral)

Assume the principal observes an additional measure $y$ in addition to $\pi$. In the landlord/farmer application, the landlord may observe the crop and also the weather. Should the principal use this new measure in the compensation contract. To answer
this question define $f(\pi, y|e)$ as the joint distribution of $y$ and $\pi$ conditional on $e$. One can write

$$f(\pi, y|e) = f_1(\pi|e)f_2(y|\pi, e)$$

If $f_2(y|\pi, e)$ does not depend on $e$ then $\frac{f_2(y|\pi, e_L)}{f_2(y|\pi, e_H)}$ cancels out in the FOC and $y$ does not enter the FOC. Therefore, the optimal wage does not depend on $y$. In statistical terms, one says that $\pi$ is a sufficient statistic for $y$ with respect to $e$ when $f_2(y|\pi, e)$ does not depend on $e$.
Linear-Normal-Exponential Moral Hazard Model

Basic Setup (Holmstrom and Milgrom 1991, BD 4.2)

Agent chooses effort $e \geq 0$ at cost $c(e)$ such that $c(e) = \frac{ce^2}{2}$. The agent has utility over effort $e$ and wage $w$, $U(e, w) = -\exp[-r(w - c(e))]$ and reservation utility $U$. (The coefficient of absolute risk aversion, CARA, $r = -\frac{u''}{u'}$, is constant)

The principal observes performance outcome $s = e + \epsilon_s$, where $\epsilon_s \sim N(0, \sigma^2_s)$

The principal uses linear compensation contracts (Holmstrom and Milgrom 1987), i.e. $w = \beta_0 + \beta s$, where $\beta_0$ is the agent’s fixed salary and $\beta$ is the “piece rate” on signal $s$. 
The Principal is risk neutral and maximizes expected profits, assumed to be equal to the effort expensed by the agent, minus compensation, $E(e - w)$

**Lemma**: If variable $x$ is normal, $x \sim N(\mu, \sigma^2)$, then $E[\exp(x)] = \exp(\mu + \frac{\sigma^2}{2})$

**Issues**:

1. Compute the agent’s effort choice given incentive scheme $(\beta_0, \beta)$

2. Compute the optimal incentive scheme $(\beta_0, \beta)$
3. Comparative static: how does the piece rate $\beta$ vary with $r$, $c$, and $\sigma_s^2$?
The Agent’s Problem

\[ \max E \left\{ -\exp \left[ -r \left( \beta_0 + \beta \left( e + e_s \right) - \frac{ce^2}{2} \right) \right] \right\} \]

The above Lemma simplifies this expression to,

\[ \max -\exp \left[ -r \left( \beta_0 + \beta e - \frac{ce^2}{2} \right) + \frac{(r\beta\sigma_s)^2}{2} \right] \]

The expression in brackets (minus) is called the certainty equivalent. This corresponds to the level of riskless compensation that gives the agent the same level utility as under the risky compensation contract \((\beta_0, \beta)\). \(\frac{(r\beta\sigma_s)^2}{2}\) is the risk premium the principal has to give the agent to face risk. The agent maximizes her certainty equivalent

\[ \max e \left\{ r \left( \beta_0 + \beta e - \frac{ce^2}{2} \right) - \frac{(r\beta\sigma_s)^2}{2} \right\} \]
taking first order condition and solving for $e$ gives

$$e = \frac{\beta}{c}$$

The Principal’s Problem

Max\(\underbrace{E \left[ e - (\beta_0 + \beta s) \right]}_{\beta_0, \beta}

s.t.\(E(U) \geq U_{PC}

e = \frac{\beta}{c} \quad IC

The principal’s objective simplifies to $e - (\beta_0 + \beta e)$. Assuming that the participation constraint binds, this constraint can be written as

$$- \exp \left[ -r \left( \beta_0 + \beta e - \frac{c e^2}{2} \right) + \frac{(r \beta \sigma_s)^2}{2} \right] = U$$
\[-r \left( \beta_0 + \beta_e - \frac{ce^2}{2} \right) + \frac{(r\beta\sigma_s)^2}{2} = \log - U \]

\[\beta_0 + \beta_e = \frac{ce^2}{2} + \frac{r(\beta\sigma_s)^2}{2} + k\]

where \(k\) is a constant. Plugging both constraints into the principal’s maximization problem gives

\[
Max E \left[ \frac{\beta}{c} - \left( \frac{c (\beta/c)^2}{2} + \frac{r(\beta\sigma_s)^2}{2} + k \right) \right] = \frac{\beta}{c} - \frac{\beta^2}{2c} - \frac{r(\beta\sigma_s)^2}{2} - k
\]

The first order condition with respect to \(\beta\) gives

\[
\beta = \frac{1}{1 + rcs\sigma_s^2}
\]

**Interpretation**
\begin{itemize}
\item $0 \leq \beta \leq 1$
\item $\beta = 1$ if $r = 0$ or $\sigma_s^2 = 0$
\item $\beta < 1$ if $r > 0$ and $\sigma_s^2 > 0$
\item $\frac{d\beta}{dr} < 0$, more risk averse agents face less powerful incentives
\item $\frac{d\beta}{d\sigma} < 0$, less powerful incentive in more risky environments
\item $\frac{d\beta}{dc} < 0$, less powerful incentive when greater disutility of effort
\end{itemize}
Lecture 2: Moral Hazard-Evidence


Different kind of evidence: Testing incentive theory versus testing assumptions of the theory
1-Do incentives matter?

“An adequate test of the effect of pay on performance needs data on contracts offered to workers, measures of performance, and an understanding of why the contracts vary across workers.” Prendergast JEL 99

In both before-after studies and field experiments (unless mandatory adoption) one needs to separate the selection and incentive responses to change in incentives

Lazear (2000) finds that average output increases by 44% after the introduction of incentives in windshield installers and that selection explains about half of the change
Shearer (1999) finds that tree-planting workers respond by increasing productivity by 20% with the introduction of incentives in a random experiment.

Dysfunctional responses: Identify responses that are clearly related to the contract specifics (more in coming-up lectures)
2-Tests based on contract information: Incentive power

Applications: (a) CEO pay-for-performance, (b) Sharecropping, (c) Franchisees, (d) Sales force, (e) subcontracting

Kawasaki, and McMillan (1987) investigate how cost sharing contracts between firms and subcontractors depend on subcontractor size (ability to diversify risk) and cost uncertainty (riskiness)

Incentive Power Evidence from CEO Compensation

Cross-section studies on pay-performance sensitivity
CEO compensation: Does CEO compensation depend on company performance?

A $1,000 increase in the value of a typical large US company increases pay by approximately $3.25 and this comes mostly from stock ownership (Jensen and Murphy, 1990)

Is this too low? Under first-best effort (i.e. company ownership) pay should increase by $1,000

**Incentive Power Evidence from sharecropping**

Employment versus sharecropping should depend: (a) positively on crop riskiness, (b) negatively on risk aversion
Use wealth to proxy for risk aversion

No support (Prendergast, 2002) or mixed support for the theory (Chiappori and Salanie, 2002)

**Risk-sharing in partnerships**

Martin Gaynor and Paul Gertler (1995) study risk sharing in doctor partnership which is measured by the fraction of a doctor’s pay that depends on individual versus group earnings

They show that risk sharing and partnership size reduce effort (evidence of shirking when sharing rules are present) and also that risk sharing increases in response to risk preferences (contracts respond to risk attitudes)
Risk-Incentives Trade-off: Alternative models?

Overall, the evidence from executive compensation, sharecrop-ping, licensing, and sales people does not give striking support for the risk-incentives trade-off (Prendergast, JPE 2002)

Allocation of responsibility may depend on uncertainty: Risky environments may be those where the return to delegation are greater while monitoring and fixed salaries is more profitable in certain environments (variable marginal return of effort that may be correlated with performance noise)

Could also be due to endogenous matching on risk aversion and riskiness (see next topic)
Issues currently studied

Explain the heterogeneity in responses to incentives (e.g. gender issue, identify types who respond differently to incentives)

The social dimension of incentives and incentives with groups (peer pressure, punishment, norms)

Strength of response as incentive power increases (e.g. crowding out due for example to intrinsic motivation). Possibility of discontinuity in response with the initial introduction of incentives
Lecture 3: Selection

Adverse selection model (MGW 13-B)


The market collapse prediction is a rather dramatic conclusion but the concept of adverse selection is very general and had been applied in personnel economics (early retirement, compensation policies)
Labor market application: Identical firms hire workers who privately observe their productivity

Firms: Any number greater than one. Transform labor into output using CRS technologies. Firms are risk neutral. Assume that output price is one (partial equilibrium analysis)

Workers: Measure $N$ of heterogeneous workers. Worker of type $\theta$ produces $\theta$ in a firm and $r(\theta)$ in home production. $\theta \in [\theta, \bar{\theta}]$ with $0 \leq \theta < \bar{\theta} < \infty$. The distribution of types is $F(\theta)$ with density $f(\theta)$ such that $f(\theta) > 0$ for $\theta \in [\theta, \bar{\theta}]$
Market outcomes to be determined:

Equilibrium wage (wage function?)

Sorting of workers between firms and home production

**Equilibrium concept:** Competitive equilibrium

**Possible scenarios:**

Full information on workers’ type or productivity (standard approach)

Workers are privately informed about their productivity (asymmetric information)
Economic questions of interest:

1. Does the introduction of asymmetric information matter?

2. Does it change market outcomes?

3. Does it change the efficiency properties of the equilibrium?
Case 1: Symmetric Information and Competitive Equilibrium (Benchmark)

The wage can be function of the type $w^*(\theta)$

$$w^*(\theta) = \theta$$

$\{\theta \ s.t. \ r(\theta) \leq \theta\}$ are employed in a firm

Firms earn zero profits

Sorting according to principle of comparative advantage

Equilibrium is Pareto efficient

Standard conclusions from competitive equilibrium analysis
Case 2: Asymmetric Information and Competitive Equilibrium

Focus on case where (a) $r(\theta) \leq \theta$ and (b) $r'(\theta) \geq 0$

Firms and workers are price takers. We assume that those workers who are indifferent between working at a firm and home employment chose the former.

Asymmetric information implies that the wage rate must be independent of the workers' type. There is a single wage rate in equilibrium.

A competitive equilibrium is characterized by a wage $w^*$ and a sorting rule $\Theta \subset [\theta, \bar{\theta}]$ such that worker $\theta \in \Theta$ is employed in a firm and worker $\theta \notin \Theta$ is self-employed.
Supply of labor: Worker occupational choice (binary optimization problem) imply that $\Theta(w) = \{\theta \text{ s.t. } r(\theta) \leq w\}$

Demand for labor: Firms demand for labor depend on their expectations regarding the type of workers who apply to work in firms. Let $\mu$ represent the expected productivity of a worker who is not self employed (applies to a job and accept an equilibrium offer). Each firm demands zero unit of labor if $\mu < w$, any non-negative amount if $\mu = w$, and an infinite amount if $\mu > w$

Firm rational expectation: $\mu = E[\theta|\theta \in \Theta(w)]$ if positive employment ($\Theta \neq \emptyset$) and otherwise ($\Theta = \emptyset$) we will assume $\mu = E\theta$

Remark: Any equilibrium has to have positive employment, that is, $\Theta \neq \emptyset$. (Proof by contradiction)
Equilibrium in labor market: In any equilibrium with non-zero level of employment, demand for labor equals supply of labor implies that $w = E[\theta | \theta \in \Theta(w)]$

Equilibrium characterization: Any competitive equilibrium is a pair $(w^*, \Theta^*)$ such that (a) $\Theta^*(w^*) = \{\theta \text{ s.t. } r(\theta) \leq w^*\}$ and (b) $w^* = E[\theta | \theta \in \Theta^*(w^*)]$

Existence of equilibrium

Define the function $H(w) = E[\theta | \theta \in \Theta(w)] = E[\theta | r(\theta) \leq w]$. Any $w$ such that $w = H(w)$ is an equilibrium wage
Properties of the function $H(\cdot)$:

1. $H()$ is continuous and increasing

2. $H(r(\theta)) = \theta \geq r(\theta)$

3. $H(w) = E\theta < \bar{\theta}$ for any $w \geq r(\bar{\theta})$

An equilibrium always exists since the function $H()$ crosses the 45 degree line at least once.
Inefficiency in any equilibrium if and only if $r(\bar{\theta}) > E\theta$ (the highest type cannot be employed)

Possibility of multiple equilibria ($H$ may cross the 45 degree line multiple times)

No-trade (with positive measure) if $H(w) < w$ for $w > r(\theta)$ (only type $\theta$ are employed and earn $w = r(\theta) = \theta$)
Separating Adverse Selection and Moral Hazard (Karlan and Zinman, 2005)

Use an experimental design for pre-approved credit cards to identify adverse selection and moral hazard

**Asymmetric information in credit market**: A credit card issuer sends pre-approved credit cards with fixed credit limit but different interest rates for carry over balance. How should the default rate depend on the interest rate? Under pure AS, it is possible that poor risk individuals, who cannot find better credit otherwise, are more likely to accept the high interest offer and more likely to default. Under pure MH, identical individuals take the offers but those who face high interest rate have less incentive to invest in effort to reduce the likelihood of default.
The key insight of paper is to demonstrate that it is possible to identify the two dimensions of AI by distinguishing the offer rate $r^o$, which is the rate that is initially proposed in the mail offer, and the contract rate $r^c$, which is announced upon acceptance as the actual rate used to compute interest payments, and by randomly varying both rates.

**Model**

Assume the (final date) expected utility of a borrower is

$$U = p(q, e)[R(q) - (1 + r)B] - e,$$

where $q$ represents the borrower's riskiness type distributed with density $f$ and s.t. $p_q < 0$ and $R_q \gtrless 0$, $B$ is the principal of the loan, $r$ is the interest rate, and $e$ is the repayment effort such that
\( p_e > 0 \) and \( p_{ee} < 0 \) and associated cost \( c(e) = e \). The borrower’s outside option in the event they refuse a loan is 0

The lender’s (final date) expected profits is \( p(q, e)(1 + r)B - (1 + r^*)B \) where \( r^* \) is the refinancing cost

**Step 1**: Adverse selection alone (no effort \( e \))

All types \( q \) such that \( U = p(q)[R(q) - (1 + r)B] > 0 \) accept contract \( r \). Define \( q^* \) the type such that \( U = 0 \) (assume well-defined)

**Case 1**: Adverse selection, (Stiglitz-Weiss, AER 81). \( p(q)R(q) \) constant with \( q \), or \( p_q R + Rp_q = 0 \)
This implies that risky types accept the contract since \( \frac{dU}{dq} = -pq(1 + r)B > 0 \) and riskiness increases with the level of interest rate since

\[
\frac{dq^*}{dr} = -\frac{p}{(1 + r)pq} > 0
\]

**Remark:** Since riskiness increases with the interest rate, credit rationing may result (in an equilibrium model) even when there is competition because firms do not want to increase the interest rate (or the number of loans) when there is excess demand as this would decrease the average quality and result in negative profits (this was one of the original contributions of SW).

**Case 2:** Positive selection, (deMesa-Webb, QJE 87). \( R(q) \) constant with \( q \), or \( R_q = 0 \)
This implies that riskless types accept the contract since \( \frac{dU}{dq} = p_q(R - (1 + r)B) < 0 \) and riskiness decreases with the level of interest rate since

\[
\frac{dq^*}{dr} = -\frac{pB}{(R - (1 + r)B) p_q} < 0
\]

Under positive selection, applicant average quality increases with the interest rate. Assumptions on covariations across \((p, R)\) matter!

**Step 2:** Moral hazard alone (no selection \( q \))

The FOC of the borrower’s problem gives \( p_e(R - (1 + r)B) = 1 \). Taking full derivative w.r.t. \( r \) gives

\[
\frac{de}{dr} = \frac{p_eB}{p_{ee}(R - (1 + r)B)} < 0
\]
Effort and repayment probability \( \left( \frac{dp}{dr} = \frac{dp}{de} \frac{de}{dr} \right) \) decrease with the interest rate (debt-overhang effect)

**Step 3:** Responses to offer rate \( r^o \) and contract rate \( r^c \). The effort level \( e \) depends only on the contract rate \( r^c \) and not on the offer rate \( r^o \) because only the former determines the repayment burden. The marginal type \( q \) depends only on the contract rate \( r^c \) and not on the offer rate \( r^o \) because consumers know only the former when they decide to accept the offer.

**Conclusions:** Denote the expected default rate \( Ep = \int_A [1 - p(q, e)] \frac{f(q)}{\int_A f(x) dx} dq \) where \( A \) is the subset of consumers who accept the offer. (a) Evidence of MH if \( \frac{dEp}{dr^c} < 0 \). (b) Evidence of AS (SW) if \( \frac{dEp}{dr^o} > 0 \) and (MW) if \( \frac{dEp}{dr^o} < 0 \).
Experimental design: Time line of decisions with distinction between offer rate $r^o$ and contract rate $r^c$

Findings: (a) MH among male borrowers and AS among female borrowers. (b) AI problems decrease with length of relationship with lender. (c) AI explain about 20% of default in sample

Contribution: This paper contributes to three literatures:

(a) Test of information economics: It is possible to design a random experiment to separate adverse selection from moral hazard

(b) Policy issue: Can lenders perfectly predict default risks and price loans accordingly? Or are they asymmetrically informed?
Does this has an impact on market outcomes (e.g. credit rationing)? Understand potential breakdown in market for small loan (micro finance) that may be more sensitive to AI due to lack of collateral and reputation (poor credit rating)

(c) Try to tell apart different models of credit default: adverse selection (SW), positive selection (DW)
Asymmetric information in credit market (review)

Credit markets could be plagued by asymmetric information AI: adverse selection AS because borrowers are privately informed about their capacity to pay back loans (firms informed about profitability of projects); moral hazard MH because borrowers can take actions to improve chances to pay back debt (firm can select less risky projects and take actions to reduce risk). How prevalent are AI problems in credit markets? Is it possible to identify different sources of AI? Can AI explain phenomenon of credit rationing (some borrowers are willing to pay market rate but are denied a loan)?

Credit rationing: (Stiglitz and Weiss, 1987) Under MH or AS, the expected return of a loan may not increase monotonically
with the interest rate charged. Profit maximizing interest rates may be kept at levels that do no clear markets. Banks do not increase rates because this would attract worse borrowers. At equilibrium interest rate there is excess demand for credit (credit rationing). Among observationally identical groups of borrowers, some may obtain loans while others do not (or obtain only partial loans)

**Literature**: Survey asking whether consumers have been denied a loan (Japelli, QJE 1990). Estimate marginal propensity to consume out of exogenous change in liquidity. Take advantage of exogeneity in the timing rule used by credit card issuers to change credit limit changes (Gross and Souleles, QJE 2000)
Lazear uses an unusual dataset to estimate productivity responses to change in the method of compensation; from salary to piece rate. He distinguishes effort responses and change in the worker pool (turnover)

Theory: A simple model explains what should happen to the distribution of worker talent after the change to piece rate and to individual productivity

Results: (Test of model) (a) Productivity increases by 44% after the introduction of incentives. (b) Individual productivity
increases by 22% (consistent with Proposition 1). (c) PPP workers have higher productivity than salary ones; top performers are not less likely to quit under PPP than salary; median productivity for those who quit after PPP is lower than for those who stay. (Proposition 2) (c) Variance in output increases with PPP but not variance in ability (against Proposition 3)

(Additional results) (a) Individual productivity increases over time after the introduction of piece rate (‘time since PPP’ independently of the tenure effect). (b) Fixed effects under salary and PPP are highly correlated
Questions

1-Why is the dataset exceptional? [individual level data, measure of productivity, large sample, frequent sampling—monthly]

2-Does the case study offer a ‘natural experiment’? [change in management, 19 months roll-over that is exogenous]

3-What can be identified from the data (distribution of ability, of effort...)? [difficult to separate effort and ability without structural assumptions]

4-What is the main contribution of the model? [understand the interplay between effort, ability, and selection, in the determination of output]
5-What is missing from the model? [role of short and long term turnover and impact on distribution of tenure; could matter, since tenure is shown to have a large impact on productivity. it could be a problem if tenure and ability interact (more able workers learn faster)]

6-What is the interpretation of the 'tenure' coefficient in Table 3, row 3? [captures tenure effect and a sorting effect; workers with higher tenure are of higher ability. because this specification does not control for individual fixed effects, the tenure effect is overestimated]

7-Why is ‘time since PPP’ in Table 3 row 4 positive and large in magnitude (economic interpretation)? [surprising result! could be that workers learn new tricks over time under PPP; or could be
due to change in distribution of tenure interacted with ability—see point 5 above]

8-Why does the $R^2$ increases dramatically in Table 3 when one moves from 1 to 2 and 3 to 4? [most of the variations are explained by individual differences]

9-What is the model’s prediction for the joint distribution of output and does it match Figure 2? [if one plot output then all points should fall on a vertical line corresponding to $e_0$; if one plot ability, all points should fall on 45 degree line; since most of the variation in output is explained by individual effects, ability and output are highly correlated, and the prediction that workers can adjust effort to meet a given output target is rejected!]
10-Assume PPP is introduced first in some pilot high productivity locations. Does this introduce a bias in the estimation of the overall impact of incentives? What about the incentive effect measured w/ individual fixed effect? [bias in overall effect in specification w/o individual fixed effect because locations that are initially treated have higher average; correct the bias by introducing location dummies; no bias in the incentive effect because the individual fixed effect control for location]
Contributions

Similar evidence to Paarsch and Shearer

Real world case-study showing the role of selection (turnover) and incentive (individual productivity) responses to a change in compensation policy

Not clear how the paper deals with the change in distribution of tenure after the introduction of PPP (distribution of tenure also influences indirectly productivity)

The paper does not address possible transitory and permanent responses to the change in incentives (for example, short and long term turnover)
Application is very specific but evidence applies to occupations where piece rate could be implemented. Still need to understand why firms rarely use piece rate...
Referee report exercise

It is very difficult to assess other people’s work (and even more difficult to assess your own work) but we have to do this all the time. This is even more true for new pieces of research that have not been legitimized and distilled by the profession. Although there is no unique formula to do so, the following points should be useful.

State the main punchline of the paper and briefly summarize the argument. Keep your summary short (no more than 2 paragraphs or 15 lines) if you do not add anything to what the paper has already said. The goal of this summary is to convey the essence of the paper in very simple and understandable terms and in very few words.
Your summary can add to the paper. Example of constructive comments include: (a) Restate some of the point of the paper in a language different from the one used by the authors clarifying the contribution, or suggesting new connections that were not evident in the paper. (b) Identify simplifications in the presentation of the argument that could further clarify the authors’ contribution. (c) Discuss the robustness of the results. Point out that some conclusions may be more/less general than stated in the paper. (d) Add points that support or challenge the paper (facts, research piece not cited but (in)consistent with the argument, ...). (e) Point out assumptions that have not received enough emphasis (motivations missing) and explain why this is a problem. (f) Make connections with other economic fields or point out new applications where the paper has something relevant to say.
Following your summary, provide an assessment of the importance of the article’s contribution to the literature. How do you do that? (a) Do you think the paper achieves its stated goal and makes the contribution it proposes to make. There is often a disconnect between what the paper states in the introduction and what it does in the core of the analysis. You may also have to discuss the issue of robustness and generality of the results presented. (b) How does the paper fit within the broader economic literature? Carefully put the paper within broader economic context and if necessary make connections with economic fields that the paper does not mention. (c) Note that it is sometimes difficult to identify and state the main contribution of the paper. Often, papers make many poorly connected points, putting in the same package parts that do not necessarily belong together. If so, you need to demonstrate that this is the
case, and then chose the most important points that are worth focusing on.

You should also point out potential flaws in the analysis. You should distinguish those major flaws that question the basic punchline of the paper (this was discussed in the previous point above), and those flaws that can be fixed. For example, you could argue that the model needs to be extended in a more realistic and relevant set up (e.g. different assumptions on behavior, timing, ...). These are minor comments, however, at least as long as you think the analysis will still carry through. Similarly, you could ask for robustness check in the empirical analysis. If there are too many problems with the paper and too many issues to be addressed, then it is sometimes best to write a new paper from scratch.
For an applied/empirical paper, you should explain how the article proposes to bring the theory to the data. Explain (a) What hypothesis the article tests? (b) What is the empirical strategy? (c) What are the strength and weaknesses of the data used to test the theory? Most importantly, you should investigate whether there are alternative models/hypothesis that could explain the evidence.
3-Performance Measurement and Personnel Economics

Because the linear-normal-exponential model is flexible, it has been extended in several directions to capture different organizational problems. One can consider multiple performance measures, multiple effort dimensions or tasks, multiple agents, and multiple principals

Aggregation of multiple performance measures in incentive contracts (BD 4.6.1)

Relative performance evaluation (BD 8.1.3, Prendergast 2.1.2)

Multi-tasking (HM 91, Baker 92, BD 6.2.1)
Cooperation and collusion amongst agents (BD 8.2.2, HM 90)

Multi-principal (Dixit, AER 97)

The solution approach in these applications follows the three steps taken before. First solve the agent(s) choice of effort taking the incentive weights as given. In the single agent case, one has to solve an optimization problem while if there are multiple agents one has to solve for the non-cooperative Nash equilibrium. Given the agent(s) effort response(s), the next step is to compute the principal(s) profits. Finally, the analysis is completed by solving for the principal’s optimization problem in the single principal case. Otherwise, one has to solve the non-cooperative Nash equilibrium if there are multiple principals.
A-Relative weight of performance measure in incentive contracts

BD 4.6.1 and see also Prendergast 2.1.2

Agent takes privately observed effort $a$ and principal observes two performance measures

Profits $q = a + \varepsilon_q$, where $\varepsilon_q \sim N(0, \sigma_q^2)$

Stock price $P = a + \varepsilon_P$, where $\varepsilon_P \sim N(0, \sigma_P^2)$

Covariance between $q$ and $P$ is $\sigma_{qP}$

Payment $w = t + sq + fP$
Utility $U(w, a) = -\exp[-\eta(w - \frac{1}{2}ca^2)]$

Optimal agent action $a = \frac{s+f}{c}$

The optimal contract minimizes the risk premium for a given action and trades off risk and incentives. Let $\Omega = \frac{\sigma_q^2 \sigma_P^2 - \sigma q P}{\sigma_q^2 + 2\sigma q P + \sigma_P^2}$. The optimal contract is

$$s = \frac{\sigma_P^2 - \sigma q P}{\sigma_q^2 + 2\sigma q P + \sigma_P^2} \frac{1}{1 + \eta c \Omega}$$

$$f = \frac{\sigma_q^2 - \sigma q P}{\sigma_q^2 + 2\sigma q P + \sigma_P^2} \frac{1}{1 + \eta c \Omega}$$

To illustrate, consider the case $\sigma q P = 0$. Then $s = \frac{\sigma_P^2}{\sigma_q^2 + \sigma_P^2 + \eta c \sigma_q^2 \sigma_P^2}$
and \( f = \frac{\sigma^2_q}{\sigma^2_q + \sigma^2_P + \eta \sigma^2_q \sigma^2_P} \) and the relative importance of a performance measure depends on its relative variance \( \frac{s}{f} = \frac{\sigma^2_P}{\sigma^2_q} \). More generally \( \frac{s}{f} = \frac{\sigma^2_P - \sigma_q P}{\sigma^2_q - \sigma_q P} \).

Similarly, if stock price is a noisy measure of profits \( \varepsilon_P = \varepsilon_q + \varepsilon \) where \( \varepsilon \) is a normally distributed, independent, such that \( \sigma^2_P = \sigma^2_q + \sigma^2 \) and \( \sigma_q P = \sigma^2_q \), then, \( f = 0 \) and \( s = \frac{1}{1 + \eta \sigma^2_q} \).

Information principle: Any signal that lowers variance of “risk” should be included. For example, the shocks could be \( \varepsilon_P = \varepsilon + \varepsilon_{industry} \) and \( \varepsilon_q = \varepsilon' + \varepsilon_{industry} \) where \( \varepsilon_{industry} \) a common industry risk. Or \( \varepsilon_P = \varepsilon + \varepsilon_{exchangerate} \) where the firm’s profits depends on the exchange rate at which oversea profits will be valued.
B-Relative performance evaluation

BD 8.1.3 and see also Prendergast 2.3

Assume a single principal observes performance from two agents according to

\[ q_i = a_i + \epsilon_i + \alpha \epsilon_{-i} \]

Note that the two agents’ incentive problems can be solved independently.

The optimal contract, then is

\[
w_1 = t_1 + \frac{1 + \alpha^2}{1 + \alpha^2 + \eta c \sigma^2 (1 - \alpha^2)^2 q_1} - \frac{2\alpha}{1 + \alpha^2} \frac{1 + \alpha^2}{1 + \alpha^2 + \eta c \sigma^2 (1 - \alpha^2)^2 q_2}
\]

When \( \alpha = 0 \) we get the same formula as before. Relative performance evaluation should be used when agents face common
risk. When $\alpha$ is close to $+/-1$, the principal can filter out all risk by subtracting (or adding) both performance measures and the first best is approximated
Bertrand and Mullainathan (2000) look at a specific application where firms should control for shocks are outside the control of managers. They collect data on a pool of Indian software companies selling a large fraction of their services in the U.S. They argue that compensation should not depend the Indian-U.S. exchange rate (pay for luck).

The reject the hypothesis that “pay for luck” does not matter but find better governed firms (e.g. large shareholder) give less pay for luck.

Relative performance evaluation (RPE) should be used in environments where there are common factors affecting performance.
of different workers. For example, a manager's performance should be evaluated against its competitors if all firms in the industry face common shocks.

Firms do not seem to use RPE for CEO compensation (test if competitor or industry performance is negatively correlated with CEO compensation).

Gibbons and Murphy (1990) find that CEO are punished when the entire stock market does better. This establishes evidence of RPE but the peer group is broad.

They also show that firms whose stocks are more correlated with the stock market are more likely to use RPE as one would expect.
C-Multi-tasking

Holmstrom and Milgrom 91, Baker 92, BD 6.2.1 and see also Prendergast 2.2.1

Assume two tasks with cost function \( \psi(a_1, a_2) = \frac{1}{2}(c_1a_1^2 + c_2a_2^2) + \delta a_1a_2 \) where the two tasks are substitute \( \sqrt{c_1c_2} \geq \delta \geq 0 \)

Tasks are independent when \( \delta = 0 \) and perfect substitute (linear iso-cost curves) when \( \delta = \sqrt{c_1c_2} \)

Performance measures \( q_i = a_i + \epsilon_i \), where \( \epsilon_i \sim N(0, \sigma_i^2) \) and covariance \( \sigma_{12} = 0 \)

Payment \( w = t + s_1q_1 + s_2q_2 \) and the principal’s objective function is \( a_1 + a_2 - w \)
Optimal actions $a_i = \frac{s_i c_i - \delta s_j}{c_i c_j - \delta^2}$

The effort put in task $i$ decreases as the weight on task $j$ increases and this is because tasks are substitutes $\delta \geq 0$

Say task $j$ captures outside activity (e.g. independent sales person). As the return on outside activity increases ($s_j$ increases), the firm has to increase the incentives it gives the agent if it wants to hold the level of effort constant. It may be optimal at some point to prevent the agent from engaging in outside activities (theory to task allocation)

The optimal contract sets the weight on task 1

$$s_1 = \frac{1 + (c_2 - \delta)\eta \sigma_2^2}{1 + \eta c_2 \sigma_2^2 + \eta c_1 \sigma_1^2 + \eta^2 \sigma_1^2 \sigma_2^2 (c_1 c_2 - \delta^2)}$$
and the symmetric formula holds for $s_2$. When the tasks are independent, $\delta = 0$, we have as before $s_1 = \frac{1}{1 + \eta c_1 \sigma_1^2}$

As the quality of measure 2 worsens ($\sigma_2$ increases), both weights decrease (notice that $\text{sgn}\left[\frac{d}{d\sigma_2} s_1\right] = \text{sgn}\left[(\delta - c_1)\eta \sigma_1^2 - 1\right] \leq 0$). This is because effort substitution implies that performance weights are complement.

If one performance measure becomes very noisy ($\sigma_i \to \infty$, that is, the task outcome is ‘unobservable’) the incentive effect on the other task may be so small ($\lim_{\sigma_2 \to \infty} s_1 = \frac{c_2 - \delta}{c_2 + \eta \sigma_1^2(c_1 c_2 - \delta^2)}$) that it becomes optimal to use alternative methods to induce effort or to separate tasks.
Multi-Tasking and Complementarity: Evidence

Multi-Tasking occurs when multiples tasks are bundled within the same job. Performance measures may capture well some tasks but ignore others.

Examples: Quantity and quality, quantity and machine maintenance, quantity and training junior workers.

Application: Evidence from gas stations (Slade, 1996) consistent with the model (task are gas retail and convenience store and/or repair car).
Threshold Effects

Incentive systems typically have performance thresholds.

Performance thresholds do not provide uniform incentives if (a) Performance outcomes are aggregated over fixed periods and the agent is rewarded on the basis of cumulated performance. (b) Performance outcomes vary randomly, (c) Agent has some discretion over reporting at intermediate periods.
Evidence

Executives discretion over accounting reporting to manipulate year-end bonuses (Healy, 1985)

Navy recruiter time effort over year cycle (Asch, 1990)

Salespeople discretion over sales reporting (Oyer, 1996)

Fund managers strategically choose portfolio risk (Chevalier and Elison, 1997)

Training bureaucrats (Courty and Marschke, 1996)
Demonstrate flaws in performance of measurement and accounting systems but what are the policy implications? (a) Rent transfer due to performance inflation (b) Possible distortion in information reporting (c) Possible inefficient allocation of manager time

Clear evidence of unintended behavior... but difficult to distinguish between accounting manipulation and inefficient behavior (could still be first-best)
D-Gaming or dysfunctional responses

Gaming occurs when workers maximize a measured objective that does not represent the intended or stated objective.

Example: Cream-skimming (Heckman-Heinrich-Smith, 1997), high school teachers discretion over student test scores (Jacob and Levitt, 2002).

To demonstrate distortions in agent’s responses, one needs to show that the agents’ responses are consistent with the logic of the incentives but inconsistent with the true goal of the principal.
Application: Identifying Distortions in a Job Training Program

Evidence of Dysfunctional Response (Courty and Marschke, 1996 and 2004)

The principal (Department of Labor) measures the performance of local training centers based on the labor market outcomes of program participants.

Training centers strategically use their discretion over the graduation date. They report enrollees at training end if they are employed, otherwise they postpone reporting them.

Consequently, many enrollees are terminated when the year ends.
At the end of their contract year, they report poorly performing enrollees as long as they qualify for an award and postpone their reporting otherwise.

It may be optimal to graduate some poorly performing enrollees at the end of the program year. Do training agencies prematurely truncate some training spells at the end of the program year?

Do gaming activities take resources away from more productive activities? Are earning impact lower in those training agencies who are more likely to delay graduation? Are earning impact lower for those enrollees who are trained toward the program year end?
A General Test for Distortions in Performance Measures  
(Courty and Marschke, 2008)

Is it possible to identify distortions (behavior that does not maximize the true objective of the organization) from simple statistics on performance outcomes?

Does a performance measure ‘degrades’ after it is activated? Does the measure become a worse indicator of value added?

Courty and Marschke (2008) show that if there exists distortions, the regression coefficient of the measure on the true goal of the organization should decrease after the measure receives relatively more emphasis. In particular, the regression coefficient should decrease after the measure is activated.
Levitt uses a proprietary dataset to investigate the effectiveness of a honor payment system. Bagels and donuts are available on self-serve, prices are posted, and people are expected to leave money in a lockbox.

Theory: Under pure self-interest one would expect low payment rates (but this assumes anonymous consumption; people do not observe others’ contribution). People may also internalize the possibility that too much free-riding may end supply and may self-restrain. Levitt also mentions other behavioral motives such as honesty and fairness but do not refer to economic or psychology theories.
Main results: (a) Payment rates are high (90 percent) which is inconsistent with self-interest. (b) Payment rates do not depend on group size which is inconsistent with free-riding. (c) Some additional stylized facts that are more difficult to relate with theories
Free Riding

Assume employees get a benefit from eating a bagel $u$. The disutility of paying is $x$ and the disutility in the event of termination $C$. There are $N$ employees.

Termination is a decreasing and concave function of average payment $C((1/N) \sum_{i=1}^{N} x_i)$

The representative employee chooses payment to maximize

$$u - x + C((1/N) \sum_{i=1}^{N} x_i)$$

The FOC gives

$$1 = (1/N)C'(x)$$
Writing payment as a function of group size and taking full derivative with respect to group size, we get

\[ x' = \frac{1}{C'''} < 0 \]

Individual payment decreases with group size
Questions

(1) Should we worry about endogeneity problem for some of the RHS variables (groups size, price, and uneaten bagels)?

(2) Why is the effect of a price increase permanent (a 40 percent increase in price decreases payments by 1 to 3 percent)? What are the implications for free-rider and fairness theories?

(3) Problems with specification (time series, endogeneity, bounded LHS)

(4) Why choose delivery size on first day as a proxy for group size?
(5) How to interpret the effect of September 11?

(6) Disconnect (?) between evidence and broader topic on white collar crime?

(7) Is the cost of cheating really zero? Stigma if caught walking away without paying

(8) How to interpret the finding that the payment rate is lower for donuts? (fairness or unobserved heterogeneity)

(9) Firm fixed effects explain much of the variations (unobserved heterogeneity or multiple equilibrium story)

(10) Do not elaborate on how company has framed what would be a proper behavior, and whether the company tries to enforce
compliance with the honor system (threat of termination? posting past payment rates to help coordination?)
Discussion

The paper is highly descriptive, factual, and based on simple statistical evidence. The main result is on mean payment rate (uncontroversial) and the second main results on free riding is based on a correlation (more controversial). Other findings are open to interpretation.

Lay down the case study and the most relevant economic issues right away. Present very little theory background and do not systematically attempt to propose explanations. Instead use vague and general labels such as 'nonpecuniary costs' or 'doing the wrong thing'.

Introduction: present the case study and the main economic puzzles (90 payment rate and no group effect) up front. Then,
report several issues that could be of interest in the future but do not elaborate

Do not bother with (important) econometric issues. This is a descriptive paper and the objective is to keep the analysis simple (hopefully not at the cost of robustness). Similarly, Levitt deliberately avoids to explain some of the evidence (do not want to open a Pandora box)

Use eyeball visual evidence early in the paper
4-Worker Motivation: Intrinsic Motivation and Pro-Social Behavior


To reduce conflicts of interest, a principal may control the agent’s action through, for example, a minimum performance requirement, that reduces the agent’s choice set in favor of the principal.

Doing so, however, may send a negative signal of distrust to the agent, or a signal of low expectation. The agent could respond negatively and this is known as the ‘self-fulfilling prophecy of distrust’
Whether control increases or decreases the principal’s payoff is an empirical issue

**The control experiment**

The principal chooses the agent’s choice set $C \in \{X, X\}$ where $X = \{1, 2, \ldots, 120\}$ and $X = \{x, \ldots, 120\}$ and the agent chooses a payment $x(C) \in C$ to the principal

The agent’s payoff is $120 - x$ and the principal’s payoff is $2x$ (the experimenter doubles the payment made by the agent to the principal)

Prediction: Under rational behavior $C = X$ and $x = x$; under social preferences $C = X$ and the agent choose the maximum
of her preferred payoff and \( x \); under intrinsic motivation, the agent’s response may be non-linear U-shaped in \( x \).

Under the strategy method, the agent reports her strategy profile. She is not told the decision of the principal but is told that her strategy will be played using her strategy profile applied to the principal’s strategy choice.

Main results: (1) Conditionally on giving more than the minimum, agents give less when controlled, (2) Principals earn more by not using control except for high level of control \( Ex(X) > Ex(X) \), (3) Most agents react negatively to control \( x(X) > x(X) \) but some are indifferent or react positively, (4) Most principal do not control \( C = X \), (5) Principals who control have a lower expectation about \( x \).
Questions

(1) The strategy method permits to compute the population distribution of response to control ($\{x_i(X) - x_i(\bar{X})\}_i$ where $i$ belongs to the set of agents). This would not be possible under the specific response method (can only compute mean difference $E[x_i(X) - x_i(\bar{X})]$). Why?

(2) Can reciprocity explain the responses observed?

(3) Other ways to implement control. Assume the principal thinks the agent gives too much $C \in \{X, \bar{X}\}$ where $\bar{X} = \{0, 1, \ldots, \bar{x}\}$ and $\bar{x} < 120$
(4) How one should model intrinsic motivation? The principal changes the agent's belief about what is right? The principal signals expectation?

(5) Extrinsic and intrinsic motivation are substitute. Implications for design of incentives with heterogeneous agents. How to control opportunistic agents and trust those who are intrinsically motivated?

(6) Is the use of control also perceived negatively when it is applied to reduce free-riding in public good setting or to help individuals with self-control problems (time inconsistent preferences)?

(7) What explains the heterogeneity in principal behavior? Heterogeneity in risk aversion?
Intrinsic and Extrinsic Motivation

Benabou and Tirole (RES, 2003)

For psychologists and sociologists, rewards and punishments are often counterproductive because they undermine “intrinsic motivation”. What exactly is behind intrinsic motivation, however, is subject to debates

Benabou and Tirole propose one mechanism to rationalize intrinsic motivation. In their model, the principal knows the agent’s ability (or the task difficulty) while the agent has imperfect self-knowledge (knowledge of the job)
The principal’s choice of incentive schemes signals the principal’s information. In equilibrium, this choice changes the agent’s posterior about her ability.

Incentives are only weak reinforcers (because of the updating effect) in the short run and negative reinforcers in the long run (because updating is permanent).

This demonstrates the existence of a hidden cost of rewards and punishments. The agent attributes a meaning to the use of incentive and makes inference on herself; the “looking-glass” self effect.
**Model: Timing**

(1) The principal privately observes the agent’s cost of effort $c \in C = [\underline{c}, \bar{c}]$ and selects an incentive contract $b$

(2) The agent observes the principal’s contract $b$ and a signal $\sigma$ on her cost of effort. She then chooses effort $e \in \{0, 1\}$

(3) Nature draws the outcome: success with probability $\theta$ only if $e = 1$ and otherwise failure

(4) The agent’s payoff under success is $U_A = e[\theta(V + b) - c]$ and the principal’s is $U_P = \theta e(W - b)$ and both receive 0 under failure

Note that effort and ability are complement, the higher the ability the greater the return to effort, $d/dc[U_A(e = 1) - U_A(e = 0)] = -1 < 0$
Information structure

The principal observes $c$ but not $\sigma$ while the agent observes $\sigma$ but not $c$. Only $c$ enters the payoffs but $\sigma$ is an informative signal of $c$ according to MLRP.

The agent starts with the prior that $c$ is distributed according to distribution $F(c)$ and associated density $f(c)$. The agent updates her belief about $c$ after observing $b$ and $\sigma$.

We denote $\mu(c|\sigma, b)$ the agent’s updated belief and $\hat{c}(\sigma, b) = E_{\mu}(c|\sigma, b)$ the agent’s expected cost of effort.

If the agent would not receive private signal $\sigma$ (or if both the agent and the principal would observe $\sigma$) then there would be
pooling: all principals would pay $Ec/\theta - V$ (or $E(c|\sigma)/\theta - V$) in the event of success (and would do so only if this amount is greater than $W$)

What makes signalling possible is that the agent receives a private signal before having to exert effort
MLRP and Milgrom’s representation theorem

Milgrom, Bell’s Journal, 1981: 380-91

MLRP=Monotone likelihood ratio property

The conditional density \( g(\sigma|c) \) satisfies the MLRP if for every \( \sigma_1 > \sigma_2 \) and \( c_1 > c_2 \),
\[
\frac{g(\sigma_1|c_2)}{g(\sigma_2|c_2)} > \frac{g(\sigma_1|c_1)}{g(\sigma_2|c_1)}
\]

The likelihood ratio \( \frac{g(\sigma|c_1)}{g(\sigma|c_2)} \) is monotone in \( \sigma \), decreasing if \( c_1 > c_2 \) and increasing if \( c_1 < c_2 \)

In the case with two costs level \( c_l < c_h \) and two signals \( \sigma_h > \sigma_l \), we have \( Pr(\sigma_h|c_h) < Pr(\sigma_h|c_l) \)
Let $\mu'(c|\sigma)$ denote the agent’s posterior based on signal $\sigma$,

$$
\mu'(c|\sigma) = \frac{f(c)g(\sigma|c)}{\int_C f(c')g(\sigma|c')dc'}
$$

We say that signal $\sigma_1$ is more favorable than signal $\sigma_2$ if $\mu'(c|\sigma_2)$ first order stochastically dominates $\mu'(c|\sigma_1)$ (the distribution of cost under $\sigma_1$ puts more mass on low cost realizations)

**Lemma:** The conditional density $g(\sigma|c)$ satisfies the MLRP iff $\sigma_1 > \sigma_2$ implies that $\sigma_1$ is more favorable than signal $\sigma_2$

In particular, this says that the agent believes that the expected cost is lower when she observes $\sigma_1$ than when she observes $\sigma_2$
Signalling

This is a game of imperfect information because the agent does not observe the principal’s type $c$.

The agent observes only the contract offered and she must decide whether to exert effort based on this observation and her signal.

Can get separation because principals with lower cost can get the agent to supply effort even with low incentives since these agents are more likely to get a better signal.

This is the same setup as Spence’s signalling model. In Spence’s model, the worker is privately informed about her type (productivity) and can take some education to signal her type to the firm.
The firm’s belief on the worker’s type will depend in equilibrium on the education signal. But the worker’s choice of investment in education depends on wage offers.

This is a chicken and egg problem in the sense that the rationale for investment in education has to be self-fulfilling. Read about the initial treatment of the issue in the original work by Spence. Since then, these concepts have been formalized under different equilibrium concepts.

Each equilibrium concept specifies how the firms form beliefs. The restrictions imposed on how firms form beliefs can greatly constrain the set of strategies that can be sustained as part of an equilibrium.
Perfect Bayesian Equilibrium

(a) The agent’s updated belief is computed according to Baye’s rule whenever applicable

\[ \mu(c|\sigma, b) = \frac{f(c)g(\sigma|c)I[b(c) = b]}{\int_{C} f(c)g(\sigma|c)I[b(c) = b]} dc \]

(b) The agent’s effort is optimal given her belief: \( e = 1 \) iff \( \hat{c}(\sigma, b) \leq \theta(V + b) \)

(c) The principal’s choice of contract is optimal

\[ \theta A(b(c), c)(W - b(c)) \geq \theta A(b', c)(W - b') \]

for any \( b' \). Where \( A(b, c) = Pr[\hat{c}(\sigma, b) \leq \theta(V + b)] \) denotes the probability that the agent exerts effort
**Analysis** There cannot be a separating equilibrium in pure strategy. If this were the case, the agent would know her cost with certainty and her decision to exert effort would be deterministic. All principals would send the cost signal that gets the agent to supply effort for sure. In a separating equilibrium, it has to be the case that the agent’s decision to exert effort depends on her signal $\sigma$

MLRP implies that $\hat{c}(\sigma, b)$ is weakly decreasing in $\sigma$

Let $\sigma^*(b)$ such that $\hat{c}(\sigma^*(b), b) = \theta(V + b)$. All agents with signal $\sigma > \sigma^*(b)$ exert effort

$$A(b, c) = Pr[\sigma \geq \sigma^*(b)|c] = 1 - G(\sigma^*(b)|c)$$
The principal's chooses $b$ such that

$$[1 - G(\sigma^*(b)|c])(W - b) \geq [1 - G(\sigma^*(b')|c)](W - b')$$

for any $b'$
Proposition

(a) $b_1 < b_2$ implies $\sigma^*(b_1) > (\sigma^*(b_2)$

(b) $b(c)$ is weakly increasing in $c$

(c) $b_1 < b_2$ implies $\hat{c}(\sigma, b_1) < \hat{c}(\sigma', b_2)$ for any $\sigma$ and $\sigma'$

The proposition says that (a) rewards are positive short-term reinforcers (higher rewards convince agents with worse signals to exert effort), (b) higher rewards are bad news (the principal has observed a higher cost), (c) rewards undermine the agent’s assessment of $c$ independently of the agent’s private signal
Pay Enough or Don’t Pay at All

Uri Gneezy and Aldo Rustichini (QJE, 2000)

They propose two experiments to address the disagreement between economists and psychologists on the impact of contingent rewards on performance.

Economists say that rewards increase performance because agents respond to incentives. Motivation enters the economist’s analysis through a price effect (increasing monetary rewards increases effort).

Psychologists argue that an activity has a reward of its own called intrinsic motivation. External rewards have a negative
impact on intrinsic motivation and this holds only for rewards that are contingent on performance (the hidden cost or rewards). Applications include rewards for blood donation, volunteer work, recycling, taking prescribed drugs, civic duties, contribution to public good...

In both experiments, subjects are asked to complete a task without performance rewards, with small performance rewards, and with large ones. The compare the performance outcomes under the different incentive schemes
IQ experiment

Subjects are promised 60 for participation to answer quiz questions similar to GMAT ones. The performance outcomes (average number of correct answers) are the following:

- 28.4 for treatment with no additional payment
- 24.07 for the treatment with 0.1 per additional question correct
- 34.7 (and 34.1) for the treatment with 1 (and 3) per additional question correct
The differences between the three groups are significant at conventional levels.

In the other experiment, high school students were asked to collect donations and were promised to earn a fraction—0, 1, or 10 percent—of what they collected. The reward would be paid from an independent source. The results were similar (collection is non-monotonic with rewards); the only difference being that collection for the highest reward was still smaller than collection with no reward.

They conclude that the relation between rewards and performance displays a discontinuity at zero and is non-monotonic.
The introduction of small incentives (awards conditional on performance) lowers performance but performance increases as incentives get stronger. Rewards below a certain threshold will have a negative impact on performance (crowding out effect).

While economics would predict that the rewards should have a monotonic impact on performance, the results suggest that the initial introduction of incentives has a negative impact on performance as psychologists would have anticipated.

The use of conditional rewards could change the agent’s preferences (reveal information to agent on her type) or change perception of task (information on task difficulty). Alternatively, accepting rewards could be a way for the agent to signal to the outside world some information on own type (signal pro-social behavior by giving blood).
A Fine is a Price (Journal of Legal Studies, 2000)

In a different study, they study the impact of penalties for parents who come late to pick-up children at day-care centers

They introduce penalties in a random group of centers and observe the impact on the fraction of late arrivals

The introduction of incentives increase the number of late arrivals and the number does not return to the level of the control group even after the incentives are removed

There is a permanent change in behavior!
Psychology and Economics: Evidence from the Field Stefano DellaVigna (JEL, 2009)

The behavioral economics literature questions the standard utility paradigm
\[ U_i = \sum_{t=0}^{\infty} \delta^t_s p_s u_i(x_i^t|s) \]
that is used to model decision making.

The established themes in the literature are: (1) Hyperbolic discounting and self-control (changes discount factor \( \delta \)), (2) Reference dependence and loss aversion (changes the function \( u(.) \)), (3) Social preferences (changes the argument \( x_i \) that enters \( u \)).

More recently, people have started to study many other issues that were previously assumed beyond the reach of economics.
Reservations with Behavioral Economics

Behavioral economics questions standard theory based on lab experiments. The relevance of these results has been challenged on two grounds: (1) Actual market players are selected through market survival and they may be different from lab subjects (i.e. cannot extrapolate findings from undergraduate behavior to fund managers). (2) More generally, biases may not persist in actual markets because biased behavior will be exploited and driven out of the market.

An important concern about decision making (and economics in general) is to keep the models general and parsimonious. Some argue that none of the models proposed to accommodate behavioral biases meet these criteria.
Time Preferences: Discounting and Self-Control

Is time discounting constant over different periods in the future? Or is there a preference for immediate gratification?

Lab evidence indicates preferences for immediate satisfaction that is inconsistent with exponential discounting.

For example, Thaler (1981) shows that the median subject is indifferent between 15 today and 20 in a month which suggests a 345 percent interest rate while they are indifferent between 15 today and 100 in a year which gives a 19 percent interest rate.

If discounting gets steeper as time approaches, people’s plans for what they would like to do in the future may differ from what they actually do when the future gets near (time inconsistency).
Quasi-Hyperbolic Discounting

People tend to have a preference for the present although they may discount properly two dates in the future. The \((\beta, \delta)\) model captures this present bias

\[
U_t = u_t + \beta[\delta u_{t+1} + \delta^2 u_{t+2} + ...]
\]

\(\delta\) is the discount factor and \(\beta \in [0, 1]\) is the self-control parameter

\(\beta = 1\) delivers the standard model while \(\beta < 1\) implies a preference for the present

Another wrinkle about the model is that the decision maker may, or may not, be aware of her present bias. To model expectations about 'future self', we introduce the parameter \(\hat{\beta} \in [\beta, 1]\).
The individual’s view at time $t$ regarding how she will evaluate consumption from $t + s$ onwards is

$$U_{t+s} = u_{t+s} + \hat{\beta}[\delta u_{t+s+1} + \delta^2 u_{t+s+2} + ...]$$

If $\hat{\beta} = \beta$, the decision maker is sophisticated (understands how her future self will behave)

If $\hat{\beta} = 1$ the decision maker is naive (she has the wrong expectation about how her future self will behave)
Example: Investment versus leisure good

An investment good has present cost and future gratifications (search for job, read The Economist, stop smoking). A leisure good gives present gratifications and future costs (read a gossip magazine, start smoking).

An hyperbolic discounter consumes too much leisure good and too little investment good.

A sophisticated decision maker who can commit ends up to consumes the same as an individual with no self-control.

A non-sophisticated decision maker has the wrong expectations about her future consumption (overestimates future consumption of investment goods and underestimates leisure ones).
Applications

People oversubscribe to gym membership (would be better off paying the fee-per-visit)

Students self-impose deadlines before the official deadline when they are offered the option

Job search: workers postpone job search (investment good)
Reference Dependence

Decision making is not made using a global utility function.

Lab evidence: Endowment effect (willingness-to-pay is different from willingness-to-accept)

Excessive risk aversion (refuses a lottery that gives −5 and 8 with equal probabilities)
Reference dependence utility

Denote \( \{x_i, p_i\} \) a lottery that gives \( x_i \) with probability \( p_i \) such that \( \sum_i p_i = 1 \). We have

\[
U(\{x_i, p_i\}) = \sum_i p_i v(x_i|r)
\]

where \( v(x|r) \) is equal to \( x - r \) if \( x \geq r \) and \( \lambda(x - r) \) otherwise with \( \lambda > 1 \)

The decision maker puts greater weight on losses below the reference point \( r \) than on gains above \( r \)

Narrow framing: \( r \) is not lifetime income. People do not tend to put proposed gambles in perspective relative to the risk associated with their lifetime wealth. Otherwise, they should accept lotteries with high expected return and small risks
The reference point is a 'free parameter' and it is not clear what it should be.

In practice, researchers often use $r = 0$. 
**Application: Target earning**

The standard theory of labor supply emphasizes income and substitution effect.

For day labourers (e.g. taxi drivers, messengers), the daily wage rate can vary quite substantially from day to day but the income effect should be negligible.

The daily wage is $w$ and the worker has to decide the number of hours worked $h$ to maximize $U(Y) - \frac{\theta}{2}h^2$ subject to $Y = wh$.

Under standard utility, we get $h^* = \frac{w}{\theta}$.

Under reference utility, the labor supply is non-monotonic.
\[ h^* = \frac{\lambda w}{\theta}, \text{ for } w < \sqrt{\frac{r\theta}{\lambda}} \]

\[ h^* = \frac{r}{w}, \text{ for } w \in [\sqrt{\frac{r\theta}{\lambda}}, \sqrt{r\theta}] \]

\[ h^* = \frac{w}{\theta}, \text{ for } w > \sqrt{r\theta} \]

The labor supply is downward sloping for \( w \in [\sqrt{\frac{r\theta}{\lambda}}, \sqrt{r\theta}] \). The intuition is that the worker does not respond to small changes in wages once she has met her income target.
Finding for taxicabs (Camerer et al. 1997)

The hours worked per day respond negatively to the daily earnings. The story is that the demand for taxi services may change from day to day due to random variations in demand (weather, convention in town) and the researcher uses these random variations in the daily earnings to study the labor supply responses by taxi drivers.

But the daily variations in day earnings could also be due to variations in labor supply. It could be that all taxi drivers prefer to take vacation on the same days, do not like to work during rainy days, or to drive people who attend conventions.

Farber (2009) considers the probability of stopping work as a function of cumulated earnings and finds no effect, as predicted.
under standard theory (reference dependence predicts a positive relation)
Social preferences

Lab evidence: Subject appear to care about the payoff of others in the dictator game and in gift exchange games

In a two-players case, the utility function depends on one’s own payoff and on the other player’s payoff

\[ U_1(x_1, x_2) = \alpha(x_1, x_2)x_2 + (1 - \alpha(x_1, x_2))x_1 \]

where \( \alpha(x_1, x_2) \) is equal to \( \rho > 0 \) if \( x_1 \geq x_2 \) and to \( 0 < \sigma < \rho \) if \( x_2 > x_1 \) to reflect the feature that people care more about others when they are ahead.
Evidence

Krueger and Mas (2004) show that the defect rate increases tenfold during a three year period of labor unrest at a unionized tire plant.

Bandiera, Barankay, and Rasul (2005) study the responses of farm fruit pickers to two incentive schemes. Workers are initially paid a piece rate that is declining in farm average productivity (type or relative performance evaluation where they use other workers as a benchmark). Subsequently, the farm moves to piece rate.

Productivity increases by 51.5 percent although the flat rate is lower than the relative rate. In addition, the response is larger for workers with larger networks of friends.
There are two interpretations: altruism or collusion

Gneezy and List (2006) post an initial wage and increase the actual wage for workers who accept the job. In a controlled experiment, they show that productivity increases although the effect is temporary. Others have shown a stronger response to a decrease in wage relative to the posted wage.
Lecture 3: Matching and Contracts


Two Sided Markets

There are two sides to the market whom members belong to disjoint sets (e.g. men and women, firms and workers). This rules out, for example, partnerships where pools of physicians can form independent practices.

The matching is one-on-one and this capture the bilateral nature of marriage and many employment contracts that do not involve collective bargaining.
One Dimensional Characteristic

Use standard application to matching (marriage) of men and women. Assume men and women can be ordered and ranked by a single characteristic or trait (e.g. education or wealth) $m \in M = \{m_1, .., m_M\}$ such that $m_1 < .. < m_M$ and $w \in W = \{w_1, .., w_W\}$ such that $w_1 < .. < w_W$. Individual characteristic is public information.

Types $m$ and $w$ produce joint output $h(m, w)$. We assume throughout that $h(m, w)$ is increasing in both traits. This imposes a great deal of commonality in agents’ interest over types since all men produce more with $w_W$ than with $w_{W-1}$ and so on... and similarly all women produce more with $m_M$ than with $m_{M-1}$ and so on...
We distinguish the transferable and non-transferable utility cases. Under transferable utility, both parties can bargain over the joint output and agree on a sharing rule. Alternatively, we could assume that the surplus that each party obtains from a match is given and non-negotiable (non-transferable utility). This would be reasonable, for example, if the surplus corresponds to a public good, or if the sharing rule is exogenously given.
Stable Matching

A matching $\mu$ is a one-on-one function of $M \cup W$ into itself such that $\mu^2(m) = m$, $\mu(w) \in M \cup \{w\}$ and $\mu(m) \in W \cup \{m\}$.

A matching $\mu$ is blocked by $k \in M \cup W$ if $k$ prefers being single to being matched with $\mu(k)$.

A matching $\mu$ is blocked by pair $(m, w) \in M \times W$ if they both prefer each other to their match under $\mu$ (or at most one weakly does so).

A matching is stable if it isn’t blocked by any agent or any pair of agents. Under non-transferable utilities, a stable matching
is Pareto-efficient (Why? Consider a stable matching where everyone is matched—to simplify—that is not PE. There exists an alternative matching such that at least someone is better off and no one is worse off. The pair with the person who is better off is a blocking pair)

Restricting attention to stable matching is reasonable if preferences are public information or if there exists a matchmaker who knows all agents’ preferences

We say that the matching is positive assortative, or PAM, if (among all married couples) the highest man marries the highest woman, the second highest types marry each other, and so on... Negative Assortative Matching (NAM) is defined as top marrying bottom and so on...
Issues

Which agents marry and which prefer to remain single? When should we expect PAM? NAM?

Under transferrable utility, how is the surplus shared between men and women?

How do changes in market characteristics (e.g. share of men relative to women, or shift in distribution of types) influence matching and surplus sharing?

Implications for how the distribution of utility across types depends on the distribution of types (explain changes in distribution of earning in a labor application)
Non-Transferable Utilities (NTU)

We assume that both partners receive surplus $h$ (public good interpretation)

The assumptions of NTU and $h$ increasing in type imply that both men and women prefer to match with higher types

**Proposition:** There exists a unique stable matching and it is PAM

Under NTU, PAM occurs because both men and women have commonality in preferences (this condition not sufficient to warrant PAM under transferable utilities)
Transferable Utilities (TU)

If there is no interaction in traits, $h(m, w) = h^m(m) + h^f(w)$, then it does not matter who marries whom because utility is fully transferable. Any matching is stable. The interesting case occurs when there are interactions in traits

We say that $h$ is super modular if for all $m' > m$ and $w' > w$

$$h(m', w') + h(m, w) \geq h(m, w') + h(m', w)$$

Supermodularity is equivalent to say that the contribution of $w'$ relative to $w$ increases with male characteristics since the above condition is equivalent to

$$h(m', w') - h(m', w) \geq h(m, w') - h(m, w)$$
In the continuous and twice differentiable case, $h$ is supermodular iff $h_{wm} > 0$ (divide $[h(m', w') - h(m', w)] - [h(m, w') - h(m, w)]$ by $(w' - w)(m' - m)$ and take the limit)

Assume that all men and women prefer to marry (with anyone) than to remain single

**Proposition:** If $h$ is supermodular, the only stable matching is PAM

The intuition is that under supermodularity $m'$ is willing to pay more than $m$ to get $w'$ instead of $w$. Respectively $w'$ is willing to pay more than $w$ to get $m'$ instead $m$. Therefore, either $m'$ (resp. $w'$) will outbid $m$ (resp. $w$) for $w'$ (resp. $m'$)
Supermodularity is a sufficient condition but not necessary. It is possible to have assortative matching for non-supermodular production functions.

Under transferable utility, one needs a stronger assumption (supermodularity in addition to increasing surplus in type) to warrant PAM.
Application: Principal Agent matching (Serfes, 2005)

Consider the standard principal-agent framework and assume that there is a continuum of principals indexed by the variance of their asset of production $\sigma \in [\sigma_0, \sigma_1]$ and a continuum of agent indexed by their risk attitude $r \in [r_0, r_1]$. (To simplify, we assume continuous type support but the argument also holds for discrete types.) Principals and agents match in pairs and agree on a contract. We restrict to allocations that are stable in the sense that no agent or principal want to change match under any contract.

Following Holmstrom and Milgrom (1987), the agent chooses effort $e \geq 0$ at cost $c(e) = \frac{ce^2}{2}$. The agent has utility over effort $e$ and wage $w$, $U(e, w) = -\exp[-r(w - c(e))]$. Principal $\sigma$ observes
performance outcome \( y = e + \epsilon_\sigma \), where \( \epsilon_\sigma \sim N(0, \sigma^2) \). The principal uses linear compensation contracts, i.e. \( w = \beta + \alpha y \). The Principal is risk neutral and maximizes expected profits, assumed to be equal to the effort expensed by the agent, minus compensation, \( E(e - w) \)

In any stable equilibrium, the optimal incentive contract between principal \( \sigma \) and agent \( r \) has

\[
\alpha = \frac{1}{1 + r_c \sigma^2}
\]

If this were not the case, the agent and the principal could renegotiate and set the piece rate to \( \frac{1}{1 + r_c \sigma^2} \). This would increase joint surplus, and they could split the increase in a way that would make both of them better off, contradicting the assumption that the allocation is stable.
**Proposition:** If \( \sigma_1^2 r_1 \leq 1/c \) then NAM takes place in any equilibrium. If \( \sigma_0^2 r_0 \geq 1/c \) then PAM takes place in any equilibrium.

**Proof:** The certainty equivalent expected surplus (measured in monetary units) of pair \( \sigma \) and \( r \) is

\[
\pi = \frac{1}{2c \left(1 + r c \sigma^2\right)}
\]

The cross derivative is given by

\[
\pi_{r\sigma} = \frac{r c \sigma^2 - 1}{2 \left(1 + r c \sigma^2\right)^3}
\]

When \( \sigma_1^2 r_1 \leq 1/c \) the cross derivative is negative over the entire support of types and NAM follows. When \( \sigma_0^2 r_0 \geq 1/c \) the opposite holds and PAM follows. QED
Remark: The equilibrium is undertermined when \( \sigma_1^2 r_1 \geq 1/c \geq \sigma_0^2 r_0 \). When this is the case, the cross derivative can be positive or negative depending on the location of the types.

In markets where the degree of risk aversions are low and/or the variance of the asset are low, efficiency dictates that agents with low degree of risk aversion should match with principals with high variance asset. The opposite happens when risk aversion and/or variance are high.

In equilibrium, the piece rate depends on both types in the match \( \alpha(r, \sigma) = \frac{1}{1 + rc\sigma^2} \).

Assume that NAM holds. Equilibrium matching determines which agent works with asset \( \sigma \), and denote this relation \( r(\sigma^2) \).
NAM implies $\frac{dr}{d\sigma^2} \leq 0$. The relationship between the sharing rule and asset variance can be negative

$$\frac{d\alpha}{d\sigma^2} = \frac{\partial \alpha}{\partial \sigma^2} + \frac{\partial \alpha}{\partial r} \frac{dr}{d\sigma^2}$$

and this will be the case when the second effect (sorting) dominates the first effect (contracting)

Clearly, the piece rate decreases with the variance of the asset under PAM because the sorting and contracting effects both go in the same direction
Continuous Type Case (TU)

Under discrete type, sharing rules cannot be uniquely pinned down. Discrete gaps between types imposes only bounds on sharing rules

To simplify, assume that types are continuous, $m \in [0,1]$ and $w \in [0,1]$. We normalize the measure of men to 1 and we denote the female-male ratio as $r$ such that $r > 1$

We write the surplus function of couple $m$ and $w$ as $h(m,w) + g$ where $g$ is a common gain from marriage unrelated to characteristics. We assume that $h$ is increasing in types, supermodular, and normalize $h(0,0) = 0$
Man $m$ gets $h(m, 0)$ if he remains single and similarly woman $w$ gets $h(0, w)$

The net surplus of $m$ and $w$ from getting married is

$$h(m, w) + g - h(0, w) - h(m, 0)$$
Matching Function

In equilibrium, we have PAM. The top male marries the top female, and matching continues one-on-one till there is no man left,

\[ 1 - F(m) = r(1 - G(\psi(m))) \]

where \( \psi(m) \) is the female mate of man \( m \). After simplification

\[ \psi(m) = G^{-1} \left[ 1 - \frac{1-F(m)}{r} \right] \] for all \( m \in [0, 1] \)

Among married couples, man’s trait increases as woman trait increases according to

\[ \frac{dw}{dm} = \psi'(m) = \frac{1}{r} \frac{f(m)}{g(\psi(m))} \]

For example, if both \( F \) and \( G \) are uniform, \( \frac{dw}{dm} < 1 \) and man’s trait increases faster than woman’s trait across married couples
Sharing Rules

We denote $v(m)$ the equilibrium utility of man $m$ and $u(w)$ the equilibrium utility of woman $f$

In any stable matching we must have that no man $m$ and woman $w$ want to deviate. This implies that

$$v(m) + u(w) \geq h(m, w) + g$$

with equality only if $w = \psi(m)$

Another way to state the problem is to look at the individual’s choice problem. Any man $m$ takes the women’s demand $u()$ as given and maximizes his residual benefit from marriage. This implies

$$v(m) = g + \max_w \{h(m, w) - u(w)\}$$
The same applies for women. The first order conditions imply

\[ h_w(m, w) = u'(w) \]
\[ h_m(m, w) = v'(m) \]

**Remark:** Under supermodularity, the second order conditions to the men and women’s optimization problems hold

The equilibrium surplus function must satisfy the differential equation

\[ v'(m) = h_m(m, \psi(m)) \]

The increase in men’s utility depends only on men’s contribution to marriage. The fact that better men marry better women cancels out and has no impact on the rate of increase of men’s surplus. The rate of change, however, is higher if a man marries a higher women
The last married women must be indifferent between marriage and singlehood

\[ u(w_0) = h(0, w_0) \]

The lowest married women is of a higher type than the lowest married man, \( w_0 > 0 \)

Interestingly, \( w_0 \) gets all the variable surplus from marriage. As a result, the worst man gets all the fixed rent from getting married

\[ v(0) = g \geq h(0, 0) = 0 \]

After integration, we can compute the equilibrium utilities as

\[ u(w) = h(0, w_0) + \int_{w_0}^{w} h_w(\psi^{-1}(w'), w') \, dw' \]

\[ v(m) = g + \int_{0}^{m} h_m(m', \psi(m')) \, dm' \]
Remark: If \( r = 1 \), then \( u(0) \) and \( v(0) \) is left undetermined up to \( u(0) + v(0) = g \) and \( u(0) \geq 0, v(0) \geq 0 \). Although the fixed gain from marrying is left undetermined (up to an upper bound), the marginal gain from marriage is the same as when \( r \neq 1 \).
How does utility vary with types?

The partner who is worse off in the least productive marriage depends on \( g \lesssim h(0, w_0) \), that is, the relative difference between the rent from marriage scarcity and the outside option from marrying

Otherwise women’s utility \( \tilde{u}(m) = u(\psi(m)) \) varies according to

\[
\frac{d\tilde{u}}{dm} = \frac{\partial u}{\partial \psi'} \frac{\partial \psi'}{\partial w}
\]

Under uniform distribution and \( h(m, w) = h(m + w) \), man’s utility increases faster than women’s utility across marriages, \( \frac{d\tilde{u}}{dm} = \frac{1}{r} \frac{\partial v}{\partial m} < \frac{\partial v}{\partial m} \)
Comparative Statics

Consider an increase in the female-male ratio $r$

Denote $\varphi(m|r)$ the type of the women married with man $m$ when the sex ration is $r$, $\frac{1-F(m)}{r} = 1 - G(\varphi(m|r))$. When the sex ratio increases, a given type of man $m$ marries a woman of higher type

$$\frac{d}{dr} \varphi(m|r) = \frac{1 - G(\varphi(m|r))}{r g(\varphi(m,r))} \geq 0$$

and receives a higher utility $\frac{d}{dr} v(m|r) \geq 0$. Women are less likely to marry and those who marry are worse off $\frac{d}{dr} u(w|r) \leq 0$

Consider a shift in the distribution of type. For example, assume that the distribution of women shifts according to first order stochastic dominance
Men become better-off (they marry higher type women). A woman of given characteristic is worse-off (marry lower men) while a woman in a given percentile is better off
Application to distribution of earnings (Sattinger III-b)

Assume the two traits are capital (e.g. machine, technology) and skill and both are positive.

The production function is \( f(g, k) = g^\alpha k^\beta \) with \( \alpha, \beta > 0 \). Skill and capital are complement \( f_{gk}(g, k) = \alpha \beta g^{\alpha - 1} k^{\beta - 1} > 0 \).

Assume \( g \) and \( k \) are lognormal with variance \( \sigma_g^2 \) and \( \sigma_k^2 \).

Under lognormality, the cumulative distribution of \( g \) is

\[
G(g) = \int_0^g \frac{1}{\sqrt{2\pi}\sigma_g} e^{-\frac{1}{2}\left(\frac{\ln x - \mu_g}{\sigma_g}\right)^2} \, dx
\]
The cumulative distribution of \( k \) is similarly defined as \( K(k) \). The matching function \( k(g) \) is given by

\[
1 - G(g) = 1 - K(k(g))
\]

\[
\int_0^g \frac{1}{\sqrt{2\pi} \sigma_g x} e^{-\frac{1}{2} \left( \frac{\ln x - \mu_g}{\sigma_g} \right)^2} \, dx = \int_0^{k(g)} \frac{1}{\sqrt{2\pi} \sigma_k x} e^{-\frac{1}{2} \left( \frac{\ln x - \mu_k}{\sigma_k} \right)^2} \, dx
\]

After a change of variable \( y = \frac{\ln x - \mu}{\sigma} \) we get

\[
\frac{\ln k(g) - \mu_k}{\sigma_k} = \frac{\ln g - \mu_g}{\sigma_g}
\]

and rearranging terms gives

\[
k(g) = A_1 g^{\frac{\sigma_k}{\sigma_g}}
\]

where \( A_1 \) is a constant
The wage function is given by

\[ w'(g) = f(g, k(g)) = \alpha g^{\alpha - 1}k(g)^{\beta} = A_2g^{\alpha + \beta \frac{\sigma_k}{\sigma_g} - 1} \]

If all workers work with the same capital (machines are identical and \( \sigma_k = 0 \)), we have \( w'(g) = \alpha g^{\alpha - 1} \). Marginally better workers get paid their marginal product. Under matching, workers get paid more than their marginal product (\( \beta \frac{\sigma_k}{\sigma_g} > 0 \)) and the distribution of wage will be skewed relative to a world without matching.

Integrating, and assuming \( w(0) = 0 \), we have

\[ w(g) = A_3g^{\frac{\alpha \sigma_g + \beta \sigma_k}{\sigma_g}} \]

Matching distorts the relation between skill and wage. Wage, \( w(g) \), is convex in skill if \( \frac{\alpha \sigma_g + \beta \sigma_k}{\sigma_g} > 1 \).
For example, under constant return to scale, $\alpha + \beta = 1$, $w(g)$ is convex in skill if the variance of capital is greater than the variance of skill $\sigma_k > \sigma_g$. Better talents get matched with even greater capital and this increases their marginal productivity.
Endogenous Matching and the Empirical Determinants of Contract Form


A-B tackle the problem of identifying the determinants of contract choice ($\beta = 1/(1 + r c \sigma^2)$) under endogenous matching (between $r$ and $\sigma$) and proxy variables ($r$ is imperfectly measured)

$y$ type of contract (1=fixed rent or high incentive and 0=sharing rule or partial insurance)

$p$ principal characteristics or riskiness (0=cereal and 1=wine which is high risk and subject to multitasking because need to invest to maintain the asset)
a agent characteristics or risk lovingness (not observed)

w wealth which is a proxy for agent risk lovingness
Contract equation

Using the principal agent theory of moral hazard ($\beta = 1/(1 + r\sigma^2)$)

$$y = \beta_0 + \beta_1 p + \beta_2 a + \epsilon$$

and we assume that $\epsilon \perp (p, a)$

The theory predicts that $\beta_1 < 0$ and $\beta_2 > 0$

Proxy equation

Wealth is an imperfect measure of risk aversion: $a = \theta w + \eta$

with $\theta > 0$ and $\eta \perp w$
Matching equation

Matching between agent (risk aversion) and principal (riskiness) as in (Serfes). Alternatively, under multitasking we would have that multitasking occupations (wine) would not use incentives (to avoid damaging the asset) and therefore should match with risk averse agents. Overall, the outcome of matching is under-termined

\[ p = \nu_0 + \nu_1 a + \nu \]

where \( \nu \) is some random source of matching that allows for identification of the separate effect from \( p \) and \( a \)

The sign of \( \nu_1 \) will turn out to be negative (\( \nu_1 < 0 \) in Table 4 Column 1 and 2) in the case study
Estimation

The model to be estimated is

\[ y = \beta_0 + \beta_1 p + \beta_2 \theta w + (\beta_2 \eta + \varepsilon) \]

and the error term \( \beta_2 \eta + \varepsilon \) is correlated with \( p \) through the matching equation. As a consequence, the estimated coefficients are biased.

Remark: Matching alone or proxy variable alone do not generate a bias: Under matching and perfect measurement \( p \) is correlated with \( a \) but not with the error term. Proxy variable is not a problem.
Sign the bias

Assuming that all variables have been demeaned, we get

\[ \hat{\beta}_1 = \frac{\text{Epy} \text{Ew}^2 - \text{Ewy} \text{Epw}}{\text{Ep}^2 \text{Ew}^2 - \text{Epw}} \]

To simplify, we assume that \( \text{Epw} = \nu_1 \theta \text{Ew}^2 \) is second order (which is realistic if \( \theta \) small) we get

\[ \hat{\beta}_1 \approx \frac{\text{Epy}}{\text{Ep}^2} \]

and we have

\[ \frac{\text{Epy}}{\text{Ep}^2} = \beta_1 + \beta_2 \nu_1 \theta^2 \frac{\text{Ew}^2}{\text{Ep}^2} + \beta_2 \nu_1 \frac{\text{E}\eta^2}{\text{Ep}^2} \]

Since \( \beta_2 \nu_1 < 0 \) the impact of riskiness on contract choice will be overestimated (\( -\hat{\beta}_1 > -\beta_1 \) under the assumption that \( \theta \) is small). One can generalise the argument and show that this is always the case and also show that \( \hat{\beta}_2 \) underestimates the impact of risk attitudes.
**Instrumental Variable Approach**

An instrument for $p$ should be correlated with $\nu$ (from the matching equation) but uncorrelated with $\varepsilon$ (do not belong to contract equation) or $(\eta, w)$ in the proxy equation.

A-B propose to use market dummies as an instrument for $p$. They observe 902 contracts from 128 landlords across 3 different markets. In practice this comes down to averaging $p$ within a town:

$$y = \beta_0 + \beta_1 \bar{p} + \beta_2 \theta w + (\beta_2 \eta + \varepsilon)$$

The rationale for $\bar{p} \perp \beta_2 \eta + \varepsilon$ is as follows: (a) land type distribution may vary across geographical areas for exogenous reasons and this influences the riskiness variables, (b) wealth is uncorrelated with market dummies (rules out migration and general...
Among other things, this rules out the possibility that the crop type is set to accommodate the agent’s risk preferences. Similarly wealth and contract cannot be endogenous (there are good reasons to believe that the would be in a repeated framework where contracts determine wealth which in term influence contracts).
Results

The raw data suggests that rich tenants are more likely to farm cereals under fixed rent while poor tenants are more likely to farm wine under sharing rule.

This suggests that matching takes place and it is confirmed by the estimation of the matching equation.

The use of IV shows that matching on risk aversion influences the estimation coefficients of the determinants of contracts. The impact of crop riskiness matters less with IV (the OLS estimator overestimated the impact of riskiness) while the impact of risk aversion turns out to be more important!

One can control for landlord fixed effect (e.g. landlord specific monitoring technology) with landlord fixed effects.
Policy implications

Important methodological contribution on the interaction between the use of proxy variables and matching in understanding choice of contracts. General point when one studies determinants of contracts

Understand sources of market failure: incomplete insurance (matching on wealth), moral hazard (contract depend on riskiness), capital constraint (wealth allow access to more productive occupations)

Compromise between demand for insurance and moral hazard can be mediated through matching
Tips for your project

A Few thoughts on methodology... with some suggestions to carry on research in applied micro-economics


See also resources on the web e.g. http://personal.lse.ac.uk/kudamats/
Issues of methodology are rarely taught formally but are still essential. These issues are particularly relevant for our course since we are not following a well-defined research agenda (with a clear set of research questions and methodological tools) but rather we have been trying to go back and forth from theory to empirical evidence, covering various topics in labor economics. One can easily get lost in such a journey. I try to discuss some issues that are important to move on from this course.

Discussion of methodology can quickly get boring with little value added. My objective is modest and I want to keep this short. First, I want to raise some important questions regarding how one can assess and improve the impact of one's own ideas and research. Second, I want to share a few practical tips that I have personally found useful.
Influence of Theory on Empirical Research in Microeconomics

Chiappori and Levitt ask the following questions: Does microeconomics theory influence empirical research? What fields influence empirical research the most? Where is the cross-fertilization the most productive? How long it takes for theory ideas to influence empirical work?

They break down the field of micro theory in different areas: price theory, application of price theory, information economics, game theory, behavioral economics, and general equilibrium. Then they sort theory and empirical contribution in these categories. They also associate for each empirical paper a referenced theory paper. Their main findings are:
Point 1: The ratio of theory and empirical work published is not constant across fields. More recent theories may not produce testable implication or may be more difficult to test due to data constraints? The only recent field that has influenced empirical work is information economics.

Point 2: Empirical work, however, disproportionately cite recent theory work over older work. Empiricists do refer to recent theory contributions.

Point 3: A handful of economists have had a disproportionately important influence (winner take all)... although their influence has been through multiple ideas (the distribution of influence is less concentrated among papers than authors).
How to build and economic model?

According to Varian, a model is an idealization of reality that has enough connection with reality to make it useful. We often forget this reality and waste much space trying to make our models too real, not making enough simplifications to focus on the essential message we want to convey.

Where to start? One needs to start with an idea, insight, puzzle... and there are many ways to get and select ideas: literature, media, business insider story.

Identify the central catch and build around it (example of ticket pricing). If the catch is good you should be able to express it with a simple story and illustrative example. Start with a simple
model where the idea is transparent (the 2 principle—2 periods, 2 agents, 2 types, 2 states, 2 goods...) 

“Simplify to get the result, complexify to see how general it is”

Search the literature and establish connections with your idea

Use techniques you know to make your idea more general and to embed it within the literature

Working on a paper is rarely an incremental and predictable process. We often end up spending much time on questions that are of little interest. To avoid that, some people follow a method of work: (a) Let your ideas compete with one another in a kind of
elimination tournament (Stage A, B, and C), (b) Work in batch and leave time between iterations (ideas are like cheese)

Put simply, the idea is to try to spend time-consuming writing time only on thoughts that can be read and published
How to write an introduction?

The goal is to raise interest and establish credibility: Get to the point quickly, use examples, keep the point as simple as possible and avoid details. Include in the introduction only statements that your reader can understand. Use an illustrative example but make sure it fits perfectly your story

Hook: Attract the reader’s interest. Be careful in delineating the boundary of your problem. Show that your problem is economically relevant. (a) Plug into a policy debate (give figures showing economic importance). (b) Plug into an academic debate (argue that there is need for more knowledge on the issue)

Question: Define your problem and your contribution
Present your answer to the problem: explain the main idea and give also a sense of depth by discussing reasonable but non trivial implications, as well as logical consequence.

Antecedent and value added: Acknowledge what was already known and make the case for your contribution. This section is central to convince your reader (editor/referee) that your paper presents something new that is worth circulating/citing/publishing...
The Value of Interaction

As you work more on your model you tend to lose perspective. You tend to think that something is obvious when it really isn’t. You tend to think something is complicated when it really isn’t. To compensate for this, you should use all opportunities to interact, but beware of your audience’s background and characteristics.

For example, use classmates for in depth analysis of specific points, a working group as a captive audience from which it is more difficult to get targeted feedback, and seminar speakers and visitors to get feedback on the big picture (elevator talk).
Literature Search

Research what others have said about your problem (Econlit, Repec, google, NBER, other working paper series)

Research the impact on the profession of past contributions on your topic (web of science, google scholar)

Use citation tools: Use both backward citations to go back to the roots and also forward citation to find out what has been done recently in your field. Is there any current research that cite the articles you cite?

More generally, citation research helps you to get an idea of what are the main ideas in your research area (citation impact)
and how ideas have developed (forward citation). This will give you a better idea of how your ideas fit within the literature and whether they are likely to contribute to the profession.
Match Theory and Empirical Evidence

A large fraction of empirical work attempts to measure relations that rest on accepted theories (e.g. return on human capital)

To investigate the relevance of new theories, several approaches are available: (a) discuss descriptive statistics (typical at the early development stages), (b) consider formal tests either non-parametric or reduced form based on theoretical predictions typically derived from comparative statics, (c) Fully structural model assumes the model is correct, add some error structure, and attempt to derive the ‘deep parameters’

The standard for testing a theory is much higher because one needs to rule out alternative explanations (Popperian approach).
To be convincing, one needs to discuss in details how the data were generated (sources of heterogeneity, what is un/observed by the actors and the econometrician...). In addition, one may consider as many ‘comparative static’ dimensions as possible (e.g. how do the predictions change as a function of market parameters)

It is often difficult to report findings that are inconsistent with a theory, especially if the model rests on many assumptions that may not hold in practice. One may easily argue that the model is too specialized for the data at hand and one does not reject the model but picked the wrong model in the first place. More generally, it is not clear if one should conclude that the theory does not hold or if it was tested in the wrong environment where some of the assumptions were violated
In practice, it is less risky to contrast two theories that make opposite predictions
Data Sources

Data can come from a wide variety of sources. For example, the different papers covered in class use data from:

Gaynor-Gertler: Survey and public data sources

Levitt, Lazear: Proprietary data on company sales

Karlan-Zinman: Proprietary data + experiment (field experiment South African credit card)

Falk and Kolfelt: Lab experiment
Courty-Marschke: Publicly available and collected (Experimental study and DoL JTPA administrative data)

Ackerman-Botticini: library archives—publicly available

The data used come from a wide variety of sources. The main considerations are whether the data are proprietary, the time it would take the owner to extract non-sensitive information, and the time it would take the researcher to put together the final dataset.
Do Scientists Pay to Be Scientists? Stern (MS, 2004)

Science is the production and free circulation of abstract knowledge. It is distinct from RD because of its public good nature (no privately appropriable benefits)

Why do private firms invest in science?

There are two answers (that could both play a role): (a) compensating differential (workers like to engage in science and firms get to pay workers less by giving them the freedom to pursue scientific aspirations) (b) firms get private benefits from nurturing workers who engage in science

These two rationales have different implications for the relationship between researcher wage and freedom to engage in science
The empirical objective of the paper is to uncover the empirical relation to make inference on which rationale dominates.

Ideally, one would like to randomly mandate how much firms can engage in science and measure the firm’s response in term of the wage offered. Do those firms who are not allowed to engage in science pay less/more?

In practice, wage and science participation are both correlated with unobserved worker ability. More scientifically able workers command higher wages and are more likely to work in firms that engage more in science.

To circumvent this identification problem, the paper proposes to hold worker characteristics constant by focusing on job searchers who receive multiple offers.
Scientist preference: Taste for science

Stylized facts about science as an institution (Merton, 1973): peer refereeing, public disclosure through journal publication, and priority in the allocation of rewards

The first person to make a discovery gets certified through peer evaluation, the entire scientific community benefits through publication, and the winner receives all the 'prestige benefits' due to the priority reward system

Winner-take-all: a close second or all those who independently worked on the discovery but were not first obtain no rewards

This view of science mixes ethics (scientists have intrinsic preferences for producing science), moral hazard or shirking (that is
resolved through the use of a tournament system), and in addition, scientists receive utility for recognition or that there are long-term career motivations

Under the preference view, scientists who engage more in science should be compensated less (firms sell them the right to engage in science) and the relationship between wage and science should be negative.
Firm productivity: Ticket for admission

Technological innovation benefits from knowledge spillovers due to the engagement in science.

Those firms that invest in science can better capture the commercial benefits of fundamental research. Investment in science can increase profits.

Under the productivity hypothesis, firms will share the rents from science and the relationship between wage and science should be positive.
Hedonic relation between wage and science

$SCI_j \in \{0, 1\}$ measures scientific orientation of job $j$

$\gamma_i$ measures scientist’s $i$ unobserved productivity

$w_j$ is the wage paid in job $j$

Scientist $i$ gets utility from working in firm $j$

$$U_i = \lambda_0 + \alpha_s \gamma_i SCI_j + w_j$$

Complementarity between ability and science orientation (more able workers get more private benefits from doing science)
Firm $j$’s profits from hiring scientist $i$ is

$$\pi_{i,j} = \gamma_i (\beta_0 + \beta_s SCI_j) - w_{i,j} - \delta SCI_j$$

Complementarity between the ability and science orientation (more able workers produce more knowledge spillover)

$\delta$ measures the non-labor costs of doing science

Firms are identical (no heterogeneity in production technology)

Note: the worker’s private benefit is not a ’distraction’ cost due to science because it would then have to enter the profit function
Wage equation

The hedonic wage equation with compensating differential

\[ w_{i,j} = \gamma_i \beta_0 + \gamma_i (\phi \beta_s - \alpha_s) SCI_j \]

Scientist \( i \) receives her private productivity benefits \( \gamma_i \beta_0 \) (competition between firms), has to pay for the private benefit \( \gamma_i \alpha_s \) (compensating differential argument that keeps workers indifferent between occupations), and bargains with firm \( j \) over the return from scientific orientation.

Given the equilibrium wage equation, a firm engages in science if

\[ \gamma \geq \frac{\delta}{(1-\phi) \beta_s + \alpha_s} \]

Firms that engage in science hire better workers both because they benefit more \( (\beta_s) \) and because they extract more rent from
the worker (\(\alpha_s\)). There is no market clearing because firms that engage in science earn profit (\(SCI_j(\beta_s(1 - \phi) + \alpha - \delta)\)). They all want better workers!

Question: How could you solve the problem that there is no market clearing and that firms earn profits?

In a more realistic model, firms would be heterogenous in \(\beta_{s,j}\) and better firms (high \(\beta_{s,j}\)) would bid for better workers. In addition, the worst firm would have to dissipate the rents from \(SCI\alpha\) and would earn zero profit.
Unobserved heterogeneity

The econometrician observes $w_{i,j}$ and $SCI_j$. Consider regressing wage on science orientation

$$w_{i,j} = \theta_0 + \theta_s SCI_j + \epsilon_{i,j}$$

**Case 1:** Unobserved ability is random

The estimated coefficient for $\theta_s$ measures the impact effect of science for the average scientist $\bar{\gamma}(\phi \beta_s - \alpha_s)$

**Case 2:** Unobserved ability is not random

The measured impact if one does not control for unobserved heterogeneity is

$$(\phi \beta_s - \alpha_s)E(\gamma|SCI = 1) + \beta_0(E(\gamma|SCI = 1) - E(\gamma|SCI = 0))$$
The true impact is underestimated if better scientists join firms that are more likely to engage in science $E(\gamma|SCI = 1) > E(\gamma|SCI = 0)$, that is, if $\gamma$ is correlated with $SCI$

Question: Difference between assuming $\gamma \perp SCI$ and $E(\gamma|SCI = 1) = E(\gamma|SCI = 0)$
Multiple job offers

Can hold \( \gamma_i \) constant if observe multiple offers for the same individual (use fixed effect model)

Assumptions: (a) Job offers are all equally serious (not the case that scientific firms are more likely to make long-shot low-offers). (b) Candidates who receive multiple offers are representative of the entire population. (c) No omitted variable (scientific orientation is uncorrelated with productivity(firm heterogeneity in \((\beta_0, \beta_s, \delta)\)). (d) Firms equally observe candidate ability (scientifically orientated firms do not have better information about \( \gamma \))
Results

There is a 20 percent discount in the wage rate of science-oriented firms

The preference effect outweighs the productivity effect. There is a compensating differential to engage in science

There is much heterogeneity in ability that is correlated with science orientation. Without fixed-effect, the wage is independent of science orientation

Robustness: multiple offers are similar to single offer, no change in results if add job accepted dummy (control for job seriousness)
Discussion

Measure worker’s willingness to pay to engage in ethical occupations (profession specific values and professional ethics, Friedman and Kuznets(1954))

Multiple offer methodology to hold constant individual fixed effects

Policy implications for the design of incentives for scientists (leverage the preference effect)
Is Mobility of Technical Personnel a Source of R&D Spillover?
Moen (JoLE, 2005)

Workers who quit a job take with them knowledge from the past employer. Labor mobility is a source of knowledge spillover.

Can firms who invest in R&D appropriate the returns from knowledge? Arrow wrote ‘no amount of legal protection can make a thoroughly appropriable commodity of something so intangible as information’

If property right do not work for intangible knowledge, what other mechanisms are available to firms?

Reduce compensation of workers who get to acquire firm’s knowledge that has market value. This holds in a model of perfect
competition (Rosen, 1972) or in a model of imperfect competition (Pakes and Nizan, 1983)

Workers exposed to R&D knowledge are paid less than marginal productivity early and more later in their career.
Rosen's on-the-job training

The ‘optimal human captial investments program is implemented by a sequence of job assignements in which workers systematically move and are promoted across jobs that offer successively smaller learning opportunities’

Wage equation $y = wH - P(k)$ ($P()$ is increasing and concave)

Learning equation $\frac{dH}{dt} = \alpha k$

Optimization problem $\text{Max}_{k_t} \int_0^T [wH_t - P(k_t)] e^{-rt} dt$

$\text{FOC} \quad \frac{P'(k_t)}{\alpha} = \frac{w}{r} [1 - e^{-r(T-t)}]$
Investment $k$ decrease over career

Workers with higher ability $\alpha$ invest more in learning (and may also apply to job with greater learning potential)

Implication: Wage profile is steeper in more R&D industries
Pakes-Nitzan's strategic threat of quitting

Workers acquire valuable information by working on a project. They can threat to leave with this information. Firms internalize this threat by lowering wages early in the career and increasing them later on.

Similar to a bonding model: the payment scheme deters workers from moving and taking information with them.

Mobility should be observed only when it increases the joint-benefit of the firm and the scientist.
Predictions

Steeper wage profile associated with experience in firms that have high learning potential (R&D firms)

Measure experience in R&D intensive jobs (exposure to knowledge)

Log-linear hedonic wage equation with experience, experience interacted with current R&D, and experience interacted with past intensity
Results

Firms doing R&D tend to pay workers 6.1 percent less early and 6.8 percent more later both for scientists and for workers with only secondary education.

Work experience at a R&D firm increases wages while for workers with less than 20 years of experience, working at a R&D firm reduces wage.

Younger workers invest most in on-the-job training.
Discussion

1-Alternative explanations for impact of experience in R&D industries

2-General human capital versus firm-specific human capital

3-Decomposition of the effects of experience and current and past R&D intensity. In principle, experience is 2-dimensions (R&D and non-R&D) and one is interested in the impact in R&D and non-R&D industries. The econometric approach assumes constant R&D intensity over career and linearity in experience and R&D intensity