The Optimal Assortativity of Teams Inside the Firm

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Motivation

- Teams are a fundamental unit of organization inside many firms.
  - Survey evidence: From 1987 to 1996, share of large firms with $\geq$ 20 percent of workers in problem-solving teams rose from 37 percent to 66 percent (Lawler, Mohrman, and Benson (2001), Lazear and Shaw (2007)).

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- Two questions for economic theory:
  1. How should a manager form teams?
     - Becker (1973): Complementarities $\Rightarrow$ **positive assortative matching (PAM)**.
  2. How should a manager provide incentives?
     - Holmström (1982): Overcoming free-riding problem under hidden effort.
     - McAfee and McMillan (1991): Extend to include private information.

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- Surprisingly little research on intersection.
  - Studying steel production lines Ichniowski, Shaw, and Prennushi (1997) find that clusters of human resources practices have large effects on productivity, while individual practices have little or no effect.

What We Do

- Unified analysis of optimal team composition and incentives in presence of both adverse selection and moral hazard.
- Beckerian matching setting in which PAM is full-information optimal.

Questions:

1. (This Talk) Is PAM profit-maximizing under informational frictions?
2. (In Paper) Is delegated matching a profitable alternative?

Results

- Complementarity is necessary, but not sufficient, for optimality of PAM.
- If complementarities weak, incentive costs *increase* in matching assortativity $\Rightarrow$ rent-efficiency tradeoff ("**disassortative incentives**").
- Identify necessary and sufficient conditions for optimality of PAM, **random matching (RM)**, and **negative assortative matching (NAM)**.
- (In Paper) If workers endowed with superior information about one another, might be better to delegate than distort.

Literature

- Sorting with Moral Hazard
  - Franco, Mitchell, and Vereschagina (2011)
  - Kaya and Vereschagina (2014)
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  - Damiano and Li (2007)
  - Johnson (2011)
- Sorting with Moral Hazard and Adverse Selection
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- Empirical
    - Adhvaryu, Bassi, Nyshadham, and Tamayo (2020) find NAM in Indian garment manufacturer despite estimated complementarities in production function.

Model

Environment (1/3)

- Single manager (residual claimant) employs $i = 1, \ldots, N$ workers, $N \geq 4$ and even.
- Each worker:
  - Exerts effort at cost $c > 0$ or shirks at zero cost.
  - IID type $t = H$ with probability p and $t = L$ otherwise.
- Workers protected by limited liability (cannot receive negative wages).
- All parties risk-neutral expected utility maximizers.

Environment (2/3)

- Binary output produced in pairs.
- No effort by some worker $\Rightarrow y = 0$ with probability one.
- Effort by both workers $\Rightarrow y = 1$ with probability determined by types

$$q(t, t') := \begin{cases} q_H & \text{if } t = t' = H \\ q_M & \text{if } t \neq t' \\ q_L & \text{if } t = t' = L \end{cases}$$

$$0 < q_L < q_M < q_H < 1.$$

- Notation: $\mathbf{q} := (q_H, q_M, q_L)$.

Environment (3/3)

- Strictly increasing differences

$$q_H - q_M > q_M - q_L.$$

- Effort in all teams full-information optimal

$$q_L - 2c > 0.$$

- PAM optimal with moral hazard alone (Franco, Mitchell, and Vereschagina, 2011).

Contracts, Timing, and Information

Manager commits to contract.

- Matching

$$\mu : T^N \to \Delta(\underbrace{\mathcal{P}}_{\text{Pairings}}).$$

- Wage scheme

$$w_i : \mathcal{P} \times T^N \times Y^{N/2} \to \mathbb{R}_+ \text{ for all } i.$$

1. Each worker learns her type and reports it to manager.
2. Manager assigns workers to teams.
3. Each worker learns teammate type.
4. Workers exert effort.
5. Manager observes output in all teams and compensates each worker.

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Simplifying Assumptions for Talk: (1) No participation decisions. (2) Manager considers only contracts that induce effort in all teams.

Housekeeping Lemma

- Wlog to consider *equal treatment* matchings μ characterized by parameter

$$p_H^\mu,$$

interim probability with which worker matches a high given high report.
  - If $p_H^\mu = p$, then μ is a **random matching (RM)**.
  - If $p_H^\mu > p$, then μ exhibits **positive assortativity** (max p_H^μ is **PAM**).
  - If $p_H^\mu < p$, then μ exhibits **negative assortativity** (min p_H^μ is **NAM**).
- Wlog to consider *independent and anonymous* wage schemes that depend only on types and output within ones own team.

Main Results

Ratios

Definition

$\mathbf{q}$ satisfies *decreasing ratios* if $\frac{q_H}{q_M} \leq \frac{q_M}{q_L}$; *constant ratios* if $\frac{q_H}{q_M} = \frac{q_M}{q_L}$; *increasing ratios* if $\frac{q_H}{q_M} \geq \frac{q_M}{q_L}$.

Example (Strictly Increasing Differences and Strictly Decreasing Ratios)

$$q_H = \frac{6}{8} \quad q_M = \frac{3}{8} \quad q_L = \frac{1}{8}$$

$$q_H - q_M = \frac{3}{8} > \frac{2}{8} = q_M - q_L$$

$$\frac{q_H}{q_M} = 2 < 3 = \frac{q_M}{q_L}.$$

Alternative Terminology: "Log Increasing Differences".

Optimal Wages and Information Rents

Theorem 1 (Optimal Wages)

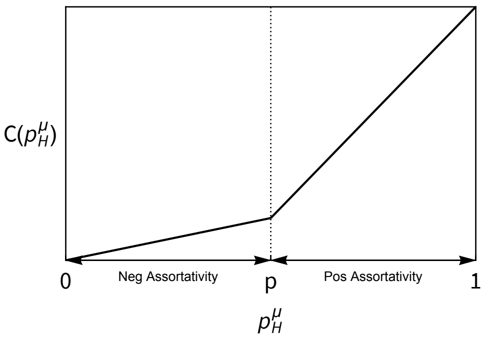
- Suppose μ exhibits positive assortativity. If $\mathbf{q}$ satisfies strictly decreasing ratios, then both types of workers receive a strictly positive information rent at the optimal wage scheme. If $\mathbf{q}$ satisfies increasing ratios, only highs receive a strictly positive information rent.
- Opposite relationship for μ exhibiting negative assortativity.

Intuition

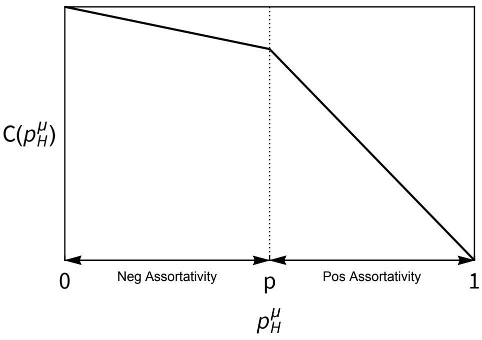
- Inducing effort by lows creates incentives for highs to misreport.
- Might think of satisfying truth-telling constraint for highs by distorting allocation to lows, i.e. implement PAM.
- Correct intuition under increasing ratios.
- But, under strictly decreasing ratios, highs prefer to match lows!
- So, to implement PAM, must increase wage payments to highs.
- But then, binding truth-telling constraint for lows forces manager to pay information rent to both types.

The Problem of Disassortative Incentives

$C(p_H^\mu) :=$ Expected Wage Payments at Optimal Wage Scheme.



(a) Strictly Decreasing Ratios



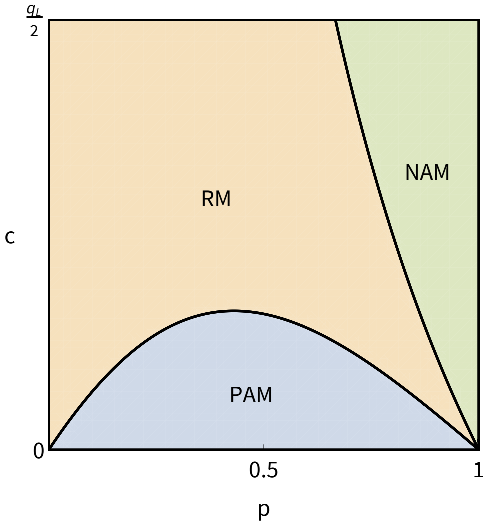
(b) Strictly Increasing Ratios

Optimal Matching

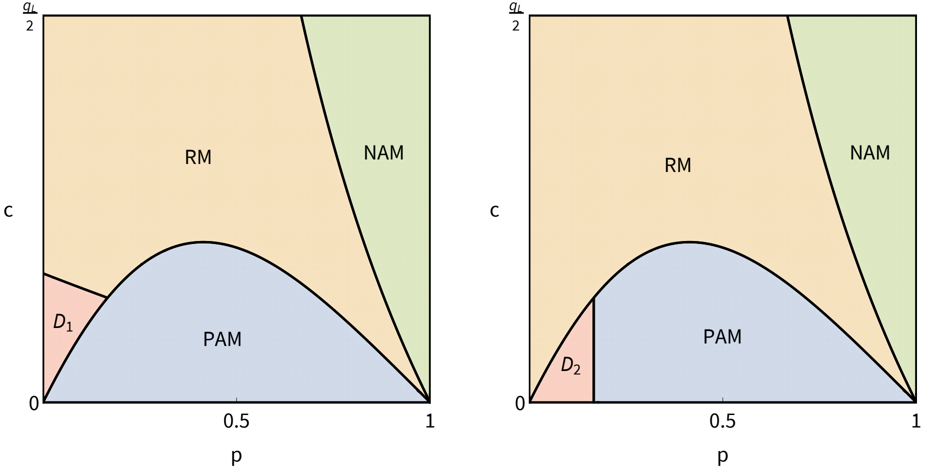
Theorem 2 (Optimal Matching)

- If $\mathbf{q}$ satisfies increasing ratios, then PAM is the unique optimal matching.
- If $\mathbf{q}$ satisfies strictly decreasing ratios, however, there exist two cutoff values on the cost of effort, $0 < \underline{c} < \bar{c}$, such that,
  1. PAM is the unique optimal matching if and only if $c < \underline{c}$;
  2. RM is the unique optimal matching if and only if $\underline{c} < c < \bar{c}$; and,
  3. NAM is the unique optimal matching if and only if $c > \bar{c}$.

Optimal Matching: Comparative Statics



Preview of Results on Delegation



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- Identify a new channel by which asymmetric information distorts PAM.
- Result has important empirical implication: Reasonable to expect RM/NAM inside of firms despite technological complementarities.
- In paper: Conditions under which delegation is a profitable alternative.
- Future work: Dynamic optimal matching with information arrival over time.

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Thank you!