Contracts, Risk-Sharing, and Incentives

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The labour relationship: Generally a long-term one

The labour contract: Often
- a relationship of subordination specifying rights and duties;
- does not list the consequences of every possible eventuality.

Remuneration:
- In some cases linked to performance, in others not.
Aims

- Why firms and workers engage in long term relationships?
- How the trade-off between insurance and incentives acts upon the remuneration rule for labor?
- Why firms make use of hierarchical promotions and internal markets?
- The links between seniority, experience and wages.
- Introducing the so-called “efficiency wage theory”.
- Do we need a broader view about preferences? What do we learn then?
Standard approach in economics

Standard stylized (narrow) view about human motivation: Employees seek to earn as much money as possible with minimal effort on the job (or minimal hours worked).

- The work done has no value *per se*.
- No possibility of identification with the firm (hence, no effort of the firm to affect employee’s identification).
- No norms of behavior (Which effort is “normal”? What is a “fair” wage?)
- Worker’s preferences are the same whether or not there is an incentive scheme or a supervisor.

First, these slides follow this approach. Later, so-called “social preferences” are considered.

References: Chap. 6 of Cahuc, Carcillo and Zylberberg (2014), Garibaldi (2006) and some articles.
1. The Labour Contract

2. Standard narrow view about motivation
   - 2.1. Risk-sharing
   - 2.2. Incentives with verifiable results
   - 2.3. Incentives in the Absence of Verifiable Results

3. Social Preferences
   - 3.1. Why enlarged preferences?
   - 3.2. Fairness
   - 3.3. Intrinsic Motivation
   - 3.4. Envy
1. The Labour Contract

Contract theory explains how such contracts can be understood as a rational response to:

1. *uncertainty of the environment*
2. *private information of the employer or the employee*

Uncertainty ⇒ To what extent do labour contracts ensure workers (employers?) against risks?

Private information ⇒ How do labour contracts provide incentives to reveal private information?

The economics of human resource management is often called “Personnel Economics” (Lazear, 1995, Garibaldi, 2006).
Typology of contracts

Key questions:
Can the employee’s (and the employer’s) activity be observed and if so is it verifiable by a third party (a court)?

Two types of contract can be distinguished:

1. **Complete or explicit contracts** ⇔
   - All clauses of the contract can be verified by a third party, a court;
   - At the moment of signing, all circumstances can be foreseen.

2. **Incomplete or implicit contracts** ⇔
   - All the clauses of the contract cannot be verified by a court or circumstances are too numerous;
   - The contract must then be *self-enforcing*: both parties have a mutual interest in continuing the relationship;
   - Only feasible in long-term relationship.
Agency model or principal-agent model

We study contracts within a principal-agent framework:
- The principal (=employer) proposes a contract;
- The agent (=employee) can either accept or refuse.

In this chapter, by assumption,
- no search-matching frictions,
- workers have no bargaining power,
- it make sense to talk about the “output of the agent”.

Two textbook cases:
1. employee’s effort is observed and verifiable but employee’s output is random
2. employee’s effort is not verifiable: employer faces a moral hazard problem
2. Standard narrow view about motivation

2.1. Risk-sharing

Assume a one-worker one-firm setting.

A1 The agent’s preferences are represented by a quasi-concave utility function $U(C, L) = U(C, 1 - h)$, where $C$ denotes the agent’s consumption, $h$ the number of hours worked (or “effort”) and, therefore, $L = 1 - h$, the agent’s leisure time. Hours observed and verifiable.

A2 The production of the agent $y = f(h, \varepsilon)$, where $f_h > 0$, $f_\varepsilon > 0$, $f_{hh} \leq 0$ and $f_{h\varepsilon} > 0$. A very simple situation with two possible states: $\varepsilon = \{\varepsilon_1, \varepsilon_2\}$, $\varepsilon_1 < \varepsilon_2$.

A3 The profit of the principal is defined by the equality $\Pi = f(h, \varepsilon) - W$, $W$ being real compensation (or earnings) for $h$ hours of work (wage rate is then $W/h$).

A4 The random variable $\varepsilon$ is verifiable.
Benchmark case
Pure competition and “spot markets”

Definition: “spot markets” = markets open when the realization of \( \varepsilon \) is known (i.e. “ex-post”).

Interpretation: \( \varepsilon \) captures the business cycle.

Under perfect competition, free entry implies \( \Pi = 0 = f(h, \varepsilon) - W \). In equilibrium, \( \forall \varepsilon \), the pair \((h, W)\) verifies:

\[
\begin{align*}
f(h, \varepsilon) &= W \quad \text{and} \quad f_h(h, \varepsilon) = \left[ \frac{dW}{dh} \right]_U = \frac{U_L(W, 1 - h)}{U_C(W, 1 - h)}
\end{align*}
\]

(see next figure)

Note: unchanged if the principal was risk-averse and maximizing \( v(\Pi) \), with \( v' > 0 \) and \( v'' \leq 0 \).
Benchmark case

Pure competition and “spot markets”

Figure: 6.1 Earnings and hours worked in a perfectly competitive spot market
Benchmark case
Pure competition and “spot markets”

Two major implications:

1. The allocation of labour is efficient ex-post but, from an “ex-ante” perspective, risks are not shared efficiently (a notion made precise below): In particular, the wage fluctuates (a lot) with the realisation of $\varepsilon$.

2. Variations in real earnings are greater than variations in hours worked if, as empirical analyses suggest, the elasticity of the labor supply is weak w.r.to wages. Although some care is needed (earnings $\neq$ wage rates and hours $\neq$ employment), empirical observations suggest that real wage rigidity and large fluctuations in employment are standard.

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1 I.e. before the realisation of the “state” $\varepsilon$ is observed
Motivation of this literature
(started in the 1970s)

1. Can real-wage rigidity be explained by the desire of workers to be insured against the risk of layoff (when they are not (fully) insured by a public unemployment insurance scheme)?

2. Can this real-wage rigidity explain
   - an inefficient allocation of labour
   - and/or employment fluctuations?
2. Standard narrow view about motivation

2.1. Risk-sharing

2.1.1. Symmetric or verifiable information

An individual insurance contract model

Assumptions (slightly different from above)

A1 Preferences: Unchanged. Note: “effort” (understood as hours worked) $h$ is observable and verifiable.

A2 Same technology but $\varepsilon$ is a continuous random variable defined over the interval $\varepsilon = [\varepsilon^-, \varepsilon^+]$ the density of which is denoted by $g(\varepsilon)$.

A3 The profit of the principal: Unchanged.

A4 Verifiability: Unchanged.

A5 The principal may be risk-averse: $\nu(\Pi)$, with $\nu' > 0$ and $\nu'' \leq 0$. 
An individual insurance contract model

A *contingent* insurance contract

A *contingent* insurance contract specifies *ex-ante*...  
... a level of earnings $W$ and a number of hours worked...  
... for each possible realisation of $\varepsilon$ (hence, the expression “contingent contract”)

Formally, contract $A = \{ W(\varepsilon), h(\varepsilon) \}$ solves:

$$\max \ Ev[\Pi(\varepsilon)] \quad \text{s. to} \quad EU (W(\varepsilon), 1 - h(\varepsilon)) \geq \overline{U}$$

or

$$\max \ EU (W(\varepsilon), 1 - h(\varepsilon)) \quad \text{s. to} \quad Ev[\Pi(\varepsilon)] \geq \overline{\Pi}$$

where $\overline{U}$ (resp. $\overline{\Pi}$) measures expected external opportunities
An individual insurance contract model

Optimality conditions

The optimality conditions lead to two strong properties.

1. Whatever the state $\varepsilon$, labour is allocated efficiently (!):

$$\frac{U_L[W(\varepsilon), 1 - h(\varepsilon)]}{U_C[W(\varepsilon), 1 - h(\varepsilon)]} = f_h[h(\varepsilon), \varepsilon], \ \forall \varepsilon \in \mathcal{E}$$

(3)

2. The so-called “Arrow-Borch” condition for optimal risk-sharing:

$$\frac{U_C[W(\varepsilon), 1 - h(\varepsilon)]}{U_C[W(\theta), 1 - h(\theta)]} = \frac{v'[\Pi(\varepsilon)]}{v'[\Pi(\theta)]}, \ \forall (\varepsilon, \theta) \in \mathcal{E}^2$$

Risk-sharing efficiency requires that the marginal rate of substitution between any pair of state contingent payoffs be equal for all economic agents
An individual insurance contract model
Real wage rigidity?

- Employers typically own assets while for most workers their human capital is their only (or major) asset.
- Hence, employers can diversify risks in financial markets.
- So, if $\varepsilon$ only captures diversifiable risks (hence, not macroeconomic nor “systemic” risks), taking employers as risk neutral is a sensible assumption.

Then,

1. the Arrow-Borch condition implies that the marginal utility of consumption has to be equal in all states $\varepsilon$;
2. this does not *in general* imply full real wage rigidity.
An individual insurance contract model
Properties of the contract if employers are risk neutral

Differentiating the FOCs wrt to $\varepsilon$, we obtain

$$\left( \frac{U_{CL}^2 - U_{CC} U_{LL}}{U_C U_{CC}} - f_{hh} \right) \frac{dh}{d\varepsilon} = f_{h\varepsilon} \text{ and } \frac{dW}{d\varepsilon} = \frac{U_{CL}}{U_{CC}} \frac{dh}{d\varepsilon}$$

(4)

1. If we assume that $U_{CC} < 0$ and $(U_{CL})^2 - U_{CC} U_{LL} < 0$ (sufficient conditions for quasi-concavity\(^2\)), hours worked are an increasing function of $\varepsilon$, since $f_h$ increases in $\varepsilon$. No ambiguity “substitution vs income effects”.

2. Earnings $W$ is insensitive to the cycle if $U_{CL} = 0$. Reflects risk-sharing.

\(^2\)i.e. $U_{CC} (U_L/U_C)^2 - 2U_{CL} (U_L/U_C) + U_{LL} < 0 \ \forall(C, L)$
An individual insurance contract model

Properties of the contract if employers are risk neutral

About \( \frac{dW}{d\varepsilon} = \frac{U_{CL}}{U_{CC}} \frac{dh}{d\varepsilon} \):

3 *Earnings* \( W \) are *pro-cyclical* only if \( U_{CL} < 0 \).

Usually, \( U_{CL} > 0 \) is assumed. For leisure to be a normal good, it can be shown that the following condition should be fulfilled:

\[
U_{CC} U_L - U_{CL} U_C < 0
\]

A sufficient condition is therefore \( U_{CL} \geq 0 \).

1+3 \( \Rightarrow \) when leisure is a normal good, in a “bad state”, there is more leisure and hence the marginal utility of consumption increases. Then, to equate this marginal utility across states, higher earnings are needed in states with more leisure \( (dW/d\varepsilon \leq 0) \).
2. Standard narrow view about motivation

2.1. Risk-sharing

An individual insurance contract model
Properties of the contract if employers are risk neutral

4. If leisure is a normal good, the real wage rate $w$ evolves counter-cyclicly:
Deriving $W(\varepsilon) \equiv w(\varepsilon) \cdot h(\varepsilon)$ wrt $\varepsilon$ and using (4), we find that:

$$\frac{dw}{d\varepsilon} = \left( \frac{U_{CL} - wU_{CC}}{hU_{CC}} \right) \frac{dh}{d\varepsilon} < 0$$

5. Other implications if leisure is a normal good:

1. The agent’s utility is counter-cyclical:
   $$dU/d\varepsilon = U_C dW/d\varepsilon - U_L dh/d\varepsilon = [U_C(U_{CL}/U_{CC}) - U_L] dh/d\varepsilon < 0.$$  

2. The firm has an interest to announce to the worker that the “state” $\varepsilon$ is good, since then the worker accepts a contract in which he works more and receives a lower compensation $W$: profits then increase (see below)
Exercise

Consider the utility function $U[W + \phi(1 - h)]$ with

$U' \equiv \frac{dU}{d(W + \phi(1-h))} > 0$, $U'' \equiv \frac{d^2U}{d(W + \phi(1-h))^2} < 0$, $\phi' > 0$ and $\phi'' < 0$.

- What are the signs of $U_{CL}$ and $U_{CC}U_L - U_{CL}U_C$?
- Knowing this revisit Properties 1 to 5 above.

- Properties 3, 4, 5-1 are odd. Extension: “Insurance and ex-post labor mobility”.

- Prop. 5-2 $\Rightarrow$ what if $\varepsilon$ non verifiable? Extension: “Asymmetric or unverifiable information”.

2. Standard narrow view about motivation

2.1. Risk-sharing

An individual insurance contract model
What if ex-post, there is a spot market where the worker can get the competitive spot wage $W(\varepsilon)$? Assume a stationary framework:

- **A1’** The number of hours worked is fixed: utility of an employee is a function of wage only $U(W)$; infinite life and discount factor $\delta \in ]0, 1[$.
- **A2’** $f(h, \varepsilon) = \varepsilon$
- **A3’** Expected lifetime profits $= E[\varepsilon - W(\varepsilon)]/(1 - \delta)$,
- **A4** Verifiability: Unchanged.
- **A5’** The principal is risk neutral
- **A6** The worker can quit at each moment and earn the outside wage $\overline{W}(\varepsilon)$, where $\overline{W}'(\varepsilon) > 0$

Without mobility, insurance contract $\Rightarrow$ constant $W$ (and $w$).
Insurance and ex-post labor mobility

Expected present value outside the contract:

\[ \bar{V}(\varepsilon) = U[\bar{W}(\varepsilon)] + \delta E_\theta \bar{V}(\theta) \]

Expected present value in a firm offering a contract \( \mathcal{A} = \{ W(\varepsilon) \} \):

\[ V(\varepsilon) = U[W(\varepsilon)] + \delta E_\theta \text{Max} [V(\theta), \bar{V}(\theta)] \]

State-specific participation constraints:

\[ V(\varepsilon) \geq \bar{V}(\varepsilon), \forall \varepsilon \]

If \( \bar{U} \) denotes \( EU_\varepsilon[\bar{W}(\varepsilon)] \), the participation constraints can be written as:

\[ U[W(\varepsilon)] + \frac{\delta}{1 - \delta} EU[W(\theta)] \geq U[\bar{W}(\varepsilon)] + \frac{\delta}{1 - \delta} \bar{U}, \forall \varepsilon \]
Maximizing expected profits s. to the participation constraints (6):

\[
\max_{A=\{W(\epsilon)\}} \int \frac{\epsilon - W(\epsilon)}{1 - \delta} \left[ U[W(\epsilon)] + \frac{\delta}{1 - \delta} EU[W(\theta)] - U[\bar{W}(\epsilon)] - \frac{\delta}{1 - \delta} U \right] g(\epsilon) d\epsilon
\]

where \( \lambda(\epsilon) \geq 0 \) is the Lagrangian multiplier associated to (6).

For any \( \epsilon \), the F.O.C. w.r. to \( W(\epsilon) \) can be written as:

\[
[(1 - \delta)\lambda(\epsilon) + \delta E\lambda(\theta)] U'[W(\epsilon)] = 1
\]
Insurance and ex-post labor mobility

Exploiting (7), i.e. \([ (1 - \delta) \lambda(\varepsilon) + \delta E\lambda(\theta) ] U' [W(\varepsilon)] = 1:\)

Let \(\Lambda^+ = \{\varepsilon \mid \lambda(\varepsilon) > 0\}\) (participation constraints are binding).

From (7), \(W(\varepsilon)\) is no more fully rigid for \(\varepsilon \in \Lambda^+\).

Let \(\varepsilon_1 > \varepsilon_2\), both in \(\Lambda^+\). Subtracting equalities (6), i.e.

\[
U [W(\varepsilon)] + \frac{\delta}{1 - \delta} E U [W(\theta)] = U [\overline{W}(\varepsilon)] + \frac{\delta}{1 - \delta} \overline{U}
\]

leads to

\[
U [W(\varepsilon_1)] - U [W(\varepsilon_2)] = U [\overline{W}(\varepsilon_1)] - U [\overline{W}(\varepsilon_2)] > 0 \text{ since } \overline{W}'(\varepsilon) > 0
\]

\(\Rightarrow \overline{W}'(\varepsilon) > 0\) over the set \(\Lambda^+\).

Then, from (7), in \(\Lambda^+\), as \(U'' < 0\), one has \(\lambda'(\varepsilon) > 0\).

\(\Rightarrow \Lambda^+ = \{\varepsilon \mid \varepsilon \geq \varepsilon_\lambda\}\), i.e. the set \(\Lambda^+\) is made of all \(\varepsilon\) above a certain threshold value \((\varepsilon_\lambda)\).
Insurance and ex-post labor mobility

Figure: 6.2 The wage contract with labor mobility

If principal could break the contract if profits become too low, then wages should not be completely rigid downwards.
2.1.2. Asymmetric or Unverifiable Information

Static model

Only the (risk-neutral) principal observes the true values of the productivity shock $\varepsilon$. The principal may have an incentive to hide this information to the agent. How can one design a contract such that the principle has an incentive to reveal the correct information?

The Revelation Principle
Consider any contingent contract $A = \{W(\varepsilon), h(\varepsilon)\}$. For any true state $\varepsilon$, the principal announces the state $m(\varepsilon)$ that maximizes its profits:

$$m(\varepsilon) = \text{ArgMax}_\theta \{f[h(\theta), \varepsilon] - W(\theta)\}$$  \hspace{1cm} (8)
The Revelation Principle

Consider now a contingent contract

\[ \hat{A} = \{ \hat{W}(\varepsilon), \hat{h}(\varepsilon) \} = \{ W(m(\varepsilon)), h(m(\varepsilon)) \} \]

\[ \hat{A} \] is incentive-compatible, i.e. the principal can never make more profit by “lying” then by revealing the truth. Assume that \( \hat{A} \) is in force, the principal announces that the state is \( \theta \) while it is actually \( \varepsilon \). Then the principal makes a loss:

\[
\begin{align*}
    f \left[ \hat{h}(\theta), \varepsilon \right] - \hat{W}(\theta) & \equiv f \{ h[m(\theta)], \varepsilon \} - W[m(\theta)] \\
    & \leq \operatorname{Max} \{ f[h(s), \varepsilon] - W(s) \} \\
    & \equiv f[h(m(\varepsilon)), \varepsilon] - W(m(\varepsilon)) = f[\hat{h}(\varepsilon), \varepsilon] - \hat{W}(\varepsilon)
\end{align*}
\]

\( \hat{A} \) and \( \hat{A} \) lead to the same allocations and compensations.
Asymmetric or Unverifiable Information

The Incentive-Compatible contract

Since it is possible to associate any contract with an incentive-compatible contract that leads to the same allocation of resources, the search for the optimal contract can be confined to the set of incentive-compatible contracts.

This “second-best” contract solves: \( \max_{A} E \Pi(\varepsilon) \) s. to

\[
EU (W(\varepsilon), 1 - h(\varepsilon)) \geq U \\
f [h(\varepsilon), \varepsilon] - W(\varepsilon) \geq f [h(\theta), \varepsilon] - W(\theta), \ \forall (\varepsilon, \theta) \quad (I-C)
\]

In general, complex problem!
Asymmetric or Unverifiable Information

◊ The first-best contract (i.e. the one when (I-C) constraints are ignored) is also optimal under asymmetric information if leisure is not affected by the income level. For then, from the optimality conditions, announcing that the state is better than the true one increases real output and the wage bill to the same extent.

◊ If \( U_{CL} \geq 0 \) (hence, leisure normal good), we saw (see Prop 5.2 above) that the first-best contract is characterized by \( dh/d\varepsilon > 0 > dW/d\varepsilon \). So, the firm has an interest to announce to the worker that the state is good (actually, \( \varepsilon^+ \)) since then the worker accepts a contract in which he works more and receives a lower compensation \( W \).

◊ If leisure is an inferior good, the firm announces \( \varepsilon^- \).
Asymmetric or Unverifiable Information

An example with two equiprobable states of nature $\varepsilon^+ > \varepsilon^-$

A3” $f(h, \varepsilon) = \varepsilon h \ (\Rightarrow f_h(h, \varepsilon) = \varepsilon)$. 

The Principal’s Problem

$$\max_{(h^i, W^i)_{i=+,-}} \left[ \frac{1}{2} (\varepsilon^+ h^+ - W^+) + \frac{1}{2} (\varepsilon^- h^- - W^-) \right]$$

Subject to constraints:

$$\frac{1}{2} U(W^+, 1 - h^+) + \frac{1}{2} U(W^-, 1 - h^-) \geq \bar{U} \quad (14)$$

$$\varepsilon^+ h^+ - W^+ \geq \varepsilon^+ h^- - W^- \quad (15)$$

$$\varepsilon^- h^- - W^- \geq \varepsilon^- h^+ - W^+ \quad (16)$$
Asymmetric or Unverifiable Information
An example with two equiprobable states of nature $\varepsilon^+ > \varepsilon^-$

The optimal contract when leisure is a normal good

- The principal only has an incentive to lie if the bad state realises;
- The incentive compatible contract avoids this, since it requires the principal to pay a high wages if it announces a good state. $\Rightarrow$ wages (and hours) and economic conditions *unambiguously* move in the same direction: $h^+ > h^-, W^+ > W^-$.  
- The FOC also results in over-employment in good states, but not in underemployment in bad states:

  $$MRS_{CL}(\varepsilon^+) = \frac{U_L(W^+, 1 - h^+)}{U_C(W^+, 1 - h^+)} > \varepsilon^+ = MPL(\varepsilon^+) \quad (22)$$

  $$MRS_{CL}(\varepsilon^-) = \frac{U_L(W^-, 1 - h^-)}{U_C(W^-, 1 - h^-)} = \varepsilon^- = MPL(\varepsilon^-) \quad (23)$$
It is standard to conclude that taking risk-sharing between employers and employees into account

- can help understanding the low variability of real wages,
- can help understanding the procyclicality of hours and compensation,
- does not yield insight into the reasons for underemployment in bad states.

The last conclusion is however questioned by e.g. Drèze (1997) who stresses that coordination failures sustained by wage rigidities cause pervasive underutilisation of resources. For him, risk-sharing is a natural reason for these wage rigidities.
2.2. Incentives if results are verifiable (Nobel Prize 2016: Holmström)

2.2.1. The principal-agent model with hidden action

The problem

1. Actions followed by the realization of some random process lead to results of an agent’s activity.
2. Actions of the agent (effort) are not verifiable by a third party, but results of actions are.
3. Consequence: a trade-off between providing incentives (to induce effort) and insurance.

The solution: An explicit performance contract:

1. Define the action of the agent as a reaction to a wage contract, before a random shock, affecting the result of this action, realises.
2. Determine the choice of the principal, anticipating the action of the agent.

3. In the words of some authors: “effort is not contractible”.

(ESL-UCL)
Assumptions and Notations: Timing of decisions

Decisions unfold in the following sequence:

1. The principal offers a contract;
2. The agent accepts the contract, or turns it down;
3. If the agent turns it down, the protagonists go their separate ways, but if the agent accepts it, he or she then supplies an effort; let $e^*$ denote the optimally chosen effort level.
4. A random event $\varepsilon$ which affects the result of the agent’s effort $e$ occurs;
5. The principal and the agent observe the result;
6. The principal remunerates the agent according to the terms of the contract.

Note: This requires that the notion of “the result of an agent” makes sense. OK e.g. for a salesman. One often only measures the output of a team of workers! These slides do not deal with “incentives in teams”.

(ESL-UCL)
Assumptions and Notations

A1 Preferences of the agent of the CARA type:

\[ U [W − C(e)] = − \exp \{−a [W − C(e)]\} \]  (24)

\( W \) is wage income, \( e \) the agent’s unverifiable effort, \( C(e) \) is the cost of effort, with \( C' > 0 \) \( C(0) = 0 \) and \( C'' > 0 \), and \( a = −U''/U' > 0 \) (absolute risk aversion).

A2 Effort results in a certain level of verifiable but random production: \( y = e + \varepsilon \), where \( \varepsilon \) is a normal random variable with zero mean and standard error \( \sigma \).

A3 The explicit performance wage contract is linear in \( y \): \( W = w + by \), where \( w \) is a fixed wage and \( b \) is a piece-rate on production (also called the variable wage component; \( by \) also called the bonus).

\(^4\) With a more general specification \( U(W, e) \) one could let \( \partial U/\partial e > 0 \) over some range. Yet, the optimum cannot be in this range since the worker would unilaterally increase \( e \) (and hence profits) and his own utility.
The agent’s effort level

If the agent accepts the contract, he takes the wage contract as given and chooses his effort as to maximize expected utility:

\[ EU = -\exp \{-a[w + be - C(e)]\} E[\exp(-ab\varepsilon)] \]
\[ = -\exp \left\{ -a \left[ w + be - C(e) - \frac{ab^2\sigma^2}{2} \right] \right\} \]

since the exponential of a Normal random variable \( X \sim \mathcal{N}(\mu, \sigma^2) \) is log-normally distributed with mean \( \exp \left[ \mu + \frac{\sigma^2}{2} \right] \).

The chosen effort \( e^* \) trades-off the benefits and costs of marginally increasing effort:

\[ C'(e^*) = b \text{ defines } e^* = e^*(b) \text{ with } \frac{de^*}{db} = \frac{1}{C''(e^*)} \]
The Principal’s Behaviour

The expected profit of the principal is
\[ E(y - W) = E(1 - b)(e^* + \varepsilon) - w = (1 - b)e^* - w. \]

\[
\begin{align*}
\operatorname{Max} & \quad [(1 - b)e^* - w] \quad \text{s. to} \quad C'(e^*) = b, \quad EU \geq U \equiv -\exp\{-a \cdot \bar{x}\} \\
\{w, b, e^* \} & \quad \text{(25)}
\end{align*}
\]

The \textit{binding} participation constraint can be rewritten as:

\[
\begin{align*}
w & = \bar{x} - be^* + C(e^*) + \frac{ab^2\sigma^2}{2} \\
\text{(26)}
\end{align*}
\]

The optimisation problem can therefore be rewritten as:

\[
\begin{align*}
\operatorname{Max} & \quad \left[ e^*(b) - C[e^*(b)] - \frac{a\left\{ C'[e^*(b)] \right\}^2 \sigma^2}{2} - \bar{x} \right] \\
\{b\} & \quad \text{(ESL-UCL)}
\end{align*}
\]
The Optimal Remuneration Rule

The piece rate (or variable part of total remuneration) is

\[ b^* = \frac{1}{1 + aC''(e^*)\sigma^2} < 1 \Rightarrow \frac{\partial b^*}{\partial a} < 0, \frac{\partial b^*}{\partial \sigma^2} < 0, \] (27)

and \( w \) is given by (26) evaluated at \( b^* \). (27) captures the trade-off between providing incentives and insurance:

The magnitude of the piece rate decreases with

- absolute risk-aversion
- the variance of the “noise” \( \varepsilon \)
- the concavity of the cost of effort (i.e. how the marginal cost of effort varies)
Note 1: risk-aversion is taken into account by the principal because of the participation constraint $EU \geq \overline{U}$ is binding.

Note 2: Is it worth hiring the agent?
The expected profit of the principal

$$E(y - W) = E(1 - b^*)(e^* + \varepsilon) - w = (1 - b)e^* - w$$

$$= (1 - b)e^* - \left( \bar{x} - b^*e^* + C(e^*) + \frac{ab^*2\sigma^2}{2} \right)$$

$$= e^* - \left( \bar{x} + C(e^*) + \frac{ab^*2\sigma^2}{2} \right)$$

has to be non-negative (or bigger than an outside opportunity of the principal, if any).
Put another way, $\bar{x}$ cannot be too high compared to the expected output ($e^*$).
The Optimal Remuneration Rule: An example

Let \( C(e) = c \cdot e^2/2, \ c > 0 \).

Then as \( C''(e) = c \) i.e. is constant:
\[
0 \leq b^* = 1/(1 + a \sigma^2 c) < 1,
\]
where \( a \sigma^2 \) is called the “risk factor”, and \( e^* = b^*/c \).

Then, it can be checked that:
\[
w^* = \bar{x} - \frac{1 - a \sigma^2 c}{2c (1 + a \sigma^2 c)^2} = \bar{x} - (b^*)^2 \frac{1 - a \sigma^2 c}{2c}
\]

A rise in \( \sigma \) or in \( a \) induces an increase in the fixed wage component \( w^* \) if \( a \sigma^2 c < 3 \).
The principal-agent model with hidden action

Two limit cases for comparison

1) The first-best outcome: $e$ verifiable $\Rightarrow$ is part of the contract chosen by the firm. The latter solves:

$$\max_{\{w, b, e\}} [e - (w + be)] \text{ subject to } w + be - C(e) - \frac{ab^2\sigma^2}{2} \geq \bar{x}$$

Indexing the first-best with superscript $o$:

$$b^o = 0, \quad C'(e^o) = 1, \quad w^o = \bar{x} + C(e^o)$$

i.e. full insurance; $e^o > e^*$ since $C'(e^*) = b < 1$.

Here also $\bar{x}$ cannot be too high so that $E(y - W) \geq 0$. 
2) Risk-neutral workers \( (U = W - C(e)) \), as \( a = 0 \), the optimal formulas lead to

\[
b^* = 1 \Rightarrow e^* = e^0.
\]

The expected profit of the principal

\[
E(y - W) = E(1 - b^*)(e^* + \varepsilon) - w = -w
\]

\[
= -(\bar{x} - e^* + C(e^*))
\]

has to be non-negative. So, the fixed part of the explicit performance contract has to be non-positive \( (w \leq 0) \). As \( e^* - C(e^*) > 0 \), it is not worth hiring the agent if \( \bar{x} > e^* - C(e^*) \).

With risk-neutral agents, the optimal explicit performance contract is a \textit{Franchising Scheme} since

- the worker becomes the residual claimant;
- the worker rents his job by paying \( |w| \) to the principal if it is worth hiring the agent.
In practice, how does the employer know the employee’s best response?

The employer can arrive at an estimate of the best effort response

\[ C'(e^*) = b \]

by varying \( b \) and observing the effects on output since on average

\[ Ey = e \]

Above, it has been assumed that the estimate \( e^*(b) \) is accurate.
Exercise

Assume a one-worker-one-firm setting where the worker has the following utility function:

\[ U(W, e) = EW - \lambda \text{Var}W - c \frac{e^2}{2}. \]

\[ W = \alpha + \beta \cdot x \] and the output \( x = e + \eta \), where \( e \) designates the unobservable effort of the worker and \( \eta \) is a random shock with mean zero and variance \( v \).

Adopt the principal-agent framework and the timing of decisions introduced above (slide 35). What are the optimal parameters \( \alpha \) and \( \beta \) of the explicit performance contract if the outside option of the worker is denoted \( u \) and the expected profit of the firm is \( E(p \cdot x - W) \), \( p > 0 \) being some exogenous deterministic output price?
Empirical findings I

   a. raises productivity;
   b. increases variance of individual performance;
   c. reduces (increases) quit rate of most (least) productive workers.
   d. attracts more productive applicants.

Because of the latter sorting, a comparison of output under an incentive contract versus a fixed pay is not an easy econometric exercise (due to sample selection).

Example (CCZ2014 p. 348-9): A large autoglass installer in the US moved from a fixed hourly pay to a piece rate scheme. An evaluation by Lazear leads to the conclusion of strong [a] and [d] effects.
Empirical findings II

2. A clear comparative statics prediction ("greater risk should be associated with weaker pay-for-performance incentives") turns out to be very hard to confirm empirically (Oyer and Schaefer, 2011, p.1779-81). The econometrician faces several problems:

- Measurement of "risk";
- Incentives are stronger ($b^*$ is higher) when the agent is less risk averse, more responsive to strong incentives (lower $c$) and when the marginal return of effort ($\partial y / \partial e$) is higher. These parameters are largely unobservable and any correlation between these unobservables and $\sigma^2$ "can confound tests of the risk/incentive tradeoff" (p.1781)

Example: $y = \gamma e + \varepsilon$, with $\partial \gamma / \partial \sigma > 0$. 
Empirical findings III

However, financial incentives can have counterproductive effects:

“Experimental and field evidence indicates that *extrinsic* motivation (contingent rewards) can sometimes conflict with *intrinsic* motivation (the individual’s desire to perform the task for its own sake)” (Bénabou and Tirole, 2003, p. 490).

⇒ In what cases should financial incentives be used with caution? A growing literature that requires a less narrow view about human motivation...

→ see Part 2...
2.2.2. Should Remuneration Always Be Individualized?

Initial idea: Why a contract influenced exclusively by individual production?
If there are other verifiable variables, their utilization could lead to more efficient contracts (the so-called Informativeness Principle).

The Agency Model with Two Signals

A5 The principal observes a verifiable signal $\tilde{\epsilon} \sim N(0, \sigma^2)$ that is possibly correlated with the component of individual production $y$ that is unrelated to effort, i.e. with $\epsilon \sim N(0, \sigma^2): \text{cov}(\epsilon, \tilde{\epsilon}) = \rho \sigma^2$.

Main application: If the results of the agent’s effort are correlated to the results of colleagues (because, say, of common random shocks).

A3’ The linear wage contract takes the following form:

$$W = w + by - \tilde{b}\tilde{\epsilon}$$
The Agency Model with Two Signals

Now, the expected utility is:

\[
EU = - \exp \left\{ -a \left[ w + be - C(e) \right] \right\} \mathbb{E} \left[ \exp \left( -a \left[ b\tilde{\epsilon} - \tilde{b}\tilde{\epsilon} \right] \right) \right]
\]

\[
= - \exp \left\{ -a \left[ w + be - C(e) - \frac{a\sigma^2}{2} \left( b^2 + \tilde{b}^2 - 2\rho b\tilde{b} \right) \right] \right\}
\]

The chosen effort still verifies:

\[
C'(e^*) = b \quad \text{which defines} \quad e^* = e^*(b)
\]

As \( E\tilde{\epsilon} = 0 \), the problem of the principal is:

\[
\max \quad \{ (1 - b)e^* - w \} \quad \text{s.to} \quad C'(e^*) = b, \quad EU \geq - \exp \{ -a \cdot \bar{x} \}
\]
The *binding* participation constraint can be rewritten as:

\[
    w = \bar{x} - be^* + C(e^*) + \frac{a\sigma^2}{2} \left( b^2 + \tilde{b}^2 - 2\rho b\tilde{b} \right)
\]  

(30)

The optimisation problem can therefore be rewritten as:

\[
    \text{Max} \left\{ b, \tilde{b} \right\} \left[ e^*(b) - C[e^*(b)] - \frac{a\sigma^2}{2} \left( b^2 + \tilde{b}^2 - 2\rho b\tilde{b} \right) - \bar{x} \right]
\]
The Optimal Compensation Rule

From the f.o.c.’s:

\[ b^* = \frac{1}{1 + a[1 - \rho^2]C''(e^*)\sigma^2} < 1 \Rightarrow \frac{\partial b^*}{\partial |\rho|} > 0; \frac{\partial b^*}{\partial a}, \frac{\partial b^*}{\partial \sigma^2} < 0, \]

\[ \tilde{b}^* = \rho b^* \Rightarrow \frac{d\tilde{b}^*}{d\rho} = b^* + \rho \cdot \frac{\partial b^*}{\partial \rho} > 0 \text{ if } \rho > 0, \]

\[ W^* = w^* + b^* y - \tilde{b}^* \tilde{\varepsilon}, w^* \text{ from (30)} \]

1. \( \rho = 0 \Rightarrow \tilde{b} = 0 \):
   The second signal just adds in “noise” \( \Rightarrow \) ignore it

2. \( 1 \geq \rho > 0 \Rightarrow b^* \geq \tilde{b}^* > 0. \)
   An increase in the signal \( \tilde{\varepsilon} \) reduces the compensation \( W^* \) since the positive correlation induces that (statistically) \( y \) is higher “because” \( \varepsilon \) is bigger, too.

3. \( -1 \leq \rho < 0 \Leftrightarrow \tilde{b}^* < 0 < b^*. \)
2.2.3. Some reasons why performance pay may be inefficient

A. Multitasking

- The productive activities of most workers have not one but many dimensions.
- Some of these activities are verifiable but some other not because they are much harder to measure.
  - Take the case of teacher in compulsory education.
  - Test scores of their pupils are verifiable but
  - Several other achievements (being able to work together in groups, to explain orally a result and the like) are much less easy to measure.
- If the agent’s remuneration is based on those verifiable outputs only, then the agent has an incentive
  - to orient all his/her effort in order to rise those verifiable outputs
  - and to neglect non verifiable outputs.
So, whenever it’s difficult to measure the performance of one task, performance pay becomes inefficient if the various effort levels $e_i, i \in \{1, 2, \ldots\}$ are substitutable. Alternatives?

- Where feasible, use an aggregate (verifiable) index of performance that is well aligned with the principal objective. E.g. Stock option compensation in the case of CEOs:
  - Aim: to link their remuneration directly to share prices to give an incentive to increase shareholder value.
  - However, due to asymmetric information, there are examples of accounting scandals (MCI, Enron,...).
  - Alternatives? See e.g. http://balancedscorecard.org/Resources/About-the-Balanced-Scorecard

- Replace “objective” performance measure by “subjective” assessments of performance (by a supervisor or through peer reviews). However, these assessments lack verifiability and thus cannot be enforced by courts.
B. Supervision and rent-seeking

Often the principal does not observe agent’s output

But well supervisors who are themselves agents:

1. To avoid friction with collaborators, supervisors tend to write favorable performance reports ⇒ problem of measurement of performance.

2. Or, agents try to influence performance reports by undertaking actions that attempt to “impress” supervisors: rent-seeking or lobbying

The book focuses on case 2.
A Model with Rent-Seeking

A1” Preferences and cost of effort as in A1. In addition, there is a cost for rent-seeking activity $\alpha$: $K(\alpha)$, where $K' > 0$ and $K'' > 0$.

A3”” Output is $y$ but the supervisor reports to the principal that it is $y + \alpha \Rightarrow W = w + b(y + \alpha)$

Observe that $\alpha$ has no productive value: Assumption A2 is maintained: $y = e + \varepsilon$

The behaviour of the agent

$$C'(e^*) = K'(\alpha^*) = b$$
The less costly rent-seeking, the smaller $K''(\alpha^*)$, the smaller is the performance pay. With risk-neutral agents ($a = 0$) the first-best solution, $b^* = 1$, can no longer be attained.
Conclusion of Subsection 2.2

“... Contracting parties write performance-based contracts ex ante and enforce appropriate rewards ex post. However, we noted that measuring performance may be difficult. Even if performance can be evaluated ex post, it may be difficult to write a sufficiently detailed contract ex ante, specifying exactly what aspect of performance will be rewarded. Finally, even if such a contract could be written, it may be difficult to enforce it, because a third party (e.g., a judge) may not be able to verify the performance ex post. In view of the difficulties involved in writing and enforcing detailed contracts, it is not surprising that many of the contracts we actually observe are highly incomplete.” (p. 17 of the file available at https://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2016/advanced-economicsciences2016.pdf)
Conclusion of Subsection 2.2

If performance is not *verifiable* due to multi-tasking, components of which are not measurable, or due to rent seeking activities, then other contractual arrangements should be designed to provide incentives:

- Promotions on the basis of relative performance;
- Seniority rules in long-term contracts.

Developed below.

Another branch of the literature (not covered):
The *incomplete-contracts approach* associated to Oliver Hart (Nobel prize 2016):

> “When performance-based contracts are hard to write or hard to enforce, carefully allocated decision rights may produce good incentives and thus substitute for contractually specified rewards.” (p. 3 of the file mentioned on the previous slide)
2.3. Incentives when results are not verifiable

Based on Garibaldi (2006)

What if both, effort and individual performance are unverifiable? Double moral hazard problem.

Answers:

2.3.1 An internal market + a system of promotions
If relative performance (= ordinal) is easier to measure than absolute performance (= cardinal), The principal can publicly announce in advance the wage increase to which the promotion entitles and the number of promoted workers = verifiable clauses;

2.3.2 Efficiency wages or compensation rules based on seniority
2.3.1. Promotions and Tournaments

A (single period) Tournament Model

A1P A firm has only two workers (j and k) and there are two jobs. Workers compete against one another and the winner will become the “boss” and will earn $W_1$ while the loser becomes the “operator” and will earn $W_2$. No wages are paid before the end of the contest.

A2P (Homogeneous) workers are risk-neutral: $U = W - c \frac{e^2}{2}$, where $c > 0$.

A3P Effort ($e \geq 0$) results in a level of unverifiable and random production: $q_j = e_j - \frac{1}{2} \varepsilon$, and $q_k = e_k + \frac{1}{2} \varepsilon$, where $\varepsilon$ is uniformly distributed over $[-b, b]$.

Properties of the uniform distribution:

$$E(\varepsilon) = 0, \ Var(\varepsilon) = \frac{b^2}{3}, \ P(\varepsilon \leq x) = \frac{x + b}{2b}$$
A Tournament Model
The Behaviour of the Agents

The probability that agent $j$ wins the contest is

$$P(q_j > q_k) = P\left( e_j - \frac{1}{2}\varepsilon > e_k + \frac{1}{2}\varepsilon \right) = P(\varepsilon < e_j - e_k) = \frac{e_j - e_k + b}{2b}$$

Worker $j$ chooses effort to maximize his/her expected utility:

$$e^*_j = \arg\max_{e_j} \frac{e_j - e_k + b}{2b} W_1 + \left(1 - \frac{e_j - e_k + b}{2b}\right) W_2 - c \frac{e_j^2}{2}$$

F.O.C. for worker $j$: $\frac{W_1 - W_2}{2b} = c e^*_j$ and similarly for worker $k$, so that both choose the same effort level $e^* = \frac{W_1 - W_2}{2bc}$.

The participation constraint is $EU = \frac{W_1 + W_2}{2} - c \frac{(e^*)^2}{2} \geq U$. 


A Tournament Model
The Behaviour of the Principal

The principal maximises expected profits *per worker* taking the incentive and participation constraints into account.

\[ W_1^*, W_2^* = \arg\max_{W_1, W_2} e^* - \frac{W_1 + W_2}{2} \]

s.to

\[ e^* = \frac{W_1 - W_2}{2bc} \]

\[ \frac{W_1 + W_2}{2} - c(e^*)^2 \geq U \]

Combining the F.O.C. and the binding participation constraint leads to:

\[ W_1^* = U + b + \frac{1}{2c} \quad \text{and} \quad W_2^* = U - b + \frac{1}{2c} \]

from which, one can deduct that *the tournament elicits the efficient level of effort* \( e^* = 1/c \) when workers are risk-neutral.
Some problems with tournaments (I)

- In addition to devoting effort, the worker can engage in a rent-seeking activity to impress his supervisor if the latter observes relative output with some noise; *Rent-seeking* behavior could be limited:
  (i) If the firm systematically favors candidates without merit, this will harm the firm’s *reputation* and one will no longer be willing to work in this firm.
  (ii) One may design procedures such that *rent-seeking* behavior is hampered: e.g. assign outside members to the promotion committee.

- Sabotage by or lack of cooperation between competing colleagues to win the contest (Lazear, 1989).
Some problems with tournaments (II)

- If workers are averse to inequality and can respond by retaliating (e.g. lower effort), there is some empirical evidence that the productivity of non-promoted workers is affected by tournaments (see the summary by Rebitzer and Taylor, 2011, p. 728-734).

- “Rat race” in an adverse selection setting: If
  - Workers have unobserved heterogeneous characteristics (e.g. preferences over “long work hours”),
  - Promotion takes place if the output of the worker $y$ exceeds a threshold $\bar{y}$,

Then the principal can choose a threshold $\bar{y}$ above the first-best one (e.g. “overwork”) to induce workers to signal their type (Landers, Rebitzer and Taylor, 1996).

Exercise

1. What is an “explicit performance” contract? To answer that question, you do not need to model such a contract. Explain in words the economic assumptions needed for such a contract and the main features of it.

2. Why do employers offer such a contract rather than a fixed wage contract?

3. Linear performance contracts, maximizing profits, usually index wages only partially and not completely to performance (single task, no rent-seeking). What are the key factors that determine the degree in which wages should be linked to performance? How do they affect the optimal performance contract and thereby profits? What’s the intuition behind?

4. Why may it be sensible – rather than directly relating wages to measured performance - to link wages to a system of promotions?
2.3.2. Efficiency wages

A. The “shirking” model (Shapiro and Stiglitz, 1984)

**Static** one-job-one-firm version of the model where the agent’s production is not verifiable.

**A1S** The worker is risk neutral and exerts two levels of effort: 0 or 1 to which are associated costs of respectively 0 and $c/2$: $U = w - \frac{c}{2} \cdot e$.

**A2S** *Unverifiable* production $y > 0$ is only realized if $e = 1$ (otherwise nothing is produced), but due to costs of supervision the firm inspects the production level (and therefore effort) only with an *exogenous* probability $p \in (0, 1)$.

**A3S** Since effort and the output are *unverifiable*, the employer offers a very simply contract, namely a wage $w > 0$ is paid until the worker is caught shirking; if caught the worker gets nothing and is fired. Then $U = z$. 
The behaviour of the Agent
The worker devotes effort if

\[ w - \frac{c}{2} \geq (1 - p)w + pz \iff w \geq z + \frac{c}{2p} \]

where \( z \) denotes the outside option of the worker.

The behaviour of the Principal
The firm’s problem is to induce positive effort at the lowest cost. So, the firm chooses the lowest possible wage such that the above condition is met:

\[ w = z + \frac{c}{2p} \]

Therefore, the workers gets a surplus:

\[ U - z = z + \frac{c}{2p} - \frac{c}{2} - z = \frac{c(1 - p)}{2p} \]

which is positive if \( p < 1 \).
In sum, the worker is ready to work at a wage equal to his/her outside option. However, because of the asymmetric information problem about effort, the firm chooses to offer more than $z$ to induce effort.

Closing the model in a simple way
Let us relate $z$ to what happens in the labor market. Assume that there is a continuum of homogeneous workers and firms. It is reasonable to assume that:

$$z = (1 - u)\overline{U} + u \cdot b$$

where $u$ is the unemployment rate, $\overline{U}$ is the average utility of holding a job in the economy and $b$ denotes the value in unemployment.

In a symmetric equilibrium $U = \overline{U}$. Hence,

$$z = (1 - u)\left(z + \frac{c(1 - p)}{2p}\right) + u \cdot b \Rightarrow z = b + \frac{c(1 - p)}{2p} \frac{1 - u}{u}.$$
So,

\[ w = z + \frac{c}{2p} = b + \frac{c}{2p} \frac{1 - p(1 - u)}{u}. \]

This is the wage-setting curve in a symmetric equilibrium \((\partial w / \partial u < 0)\).

Assume finally that firms can enter freely the market at a fixed cost \(k > 0\). Under free-entry with \(e = 1\), the wage has to verify:

\[ y - w = k. \]

So, the unemployment rate solves

\[ y - k = b + \frac{c}{2p} \frac{1 - p(1 - u)}{u}. \]

Hence,

\[ u = \frac{c}{2(y - k - b) - c} \frac{1 - p}{p}. \]

The parameters such that \(u \in (0, 1)\) should verify:

- \(y > k + b + (c/2)\);
- \(p > \frac{c}{2(y - k - b)}\) i.e. “\(p\) not too low”.
B. Deferred compensation
A simple example of a compensation based on seniority

Developing the previous model in a two-period setting will deeply change a major conclusion.
More generally, this illustrates the role of implicit assumptions in many efficiency wage models.

Assumptions

A1D The worker lives 2 periods: during the fist one, he/she is young (subscript $y$) and during the second one old (subscript $o$).

A2D For simplicity there is no discounting. So, intertemporal utility is $U_y + U_o = w_y - \frac{c}{2} \cdot e_y + w_o - \frac{c}{2} \cdot e_o$, $e \in \{0, 1\}$. An output is produced only if $e = 1$, effort being unobservable.

A3D We won’t close the model here.

\[5\] For a similar argument with infinitely lived agents, see CCZ2014 (p. 362-377)
The second period’s problem is the static one. Hence, $w_0 = z + \frac{c}{2p}$.

The incentive-compatibility constraint for the (forward-looking) young worker is an inter-temporal condition expressing that the young worker prefer not to shirk:

$$w_y - \frac{c}{2} + w_o - \frac{c}{2} \geq (1-p) \left[ w_y + w_o - \frac{c}{2} \right] + p \left( \frac{2 \cdot z}{2} \right)$$

Substituting $w_0$ from above and considering that the principal proposes a wage just enough to guarantee the latter condition:

$$w_y = z + \frac{c}{2p} - \frac{(1-p)c}{2p} < w_o \text{ if } p < 1,$$

which is an example of \textit{deferred payment}. Notice that $w_y < w_o$ despite worker’s productivity is the same whether young or old.
It can easily be checked that $w_y = z + \frac{c}{2}$, so that the workers is now indifferent between working (and not shirking) and benefiting from the outside option $z$:

$$U_y - z = w_y - \frac{c}{2} - z = 0.$$  

Put another way, the young worker gets no surplus any more.

With infinitely lived agents, CCZ2014 show p. 367 that the expected lifetime utility of the (non-shirker) worker equals the outside expected life time utility at the time of recruitment.
Note
There are numerous reasons why wages rise with seniority and experience.

1. The accumulation of general human capital leads to an increasing relationship between experience (i.e. \( \sum \) employment durations) and wages;

2. The accumulation of specific human capital leads to an increasing relationship between seniority (i.e. duration of employment in the same firm) and wages if workers have some bargaining power;

3. On-the-job search leads to an increasing relationship between experience and wages;

4. Revelation of information on the worker’s abilities allows to assign to worker to tasks that match their abilities and may therefore lead to an increasing relationship between seniority and wages;

5. A “deferred payment” scheme provides incentives to work hard and explain why wages rise with seniority.
2. Standard narrow view about motivation

2.3. Incentives in the Absence of Verifiable Results

Exercice about efficiency wage theory
Inspired by Solow (1979) and Layard, Nickell and Jackman (1991)

Exercise

Assume that the effort of a worker employed in firm i, $E_i$, is not verifiable. Assume moreover a black-box relationship $E_i = (w_i - B)^\lambda$, $B > 0$, $0 < \lambda < 1$.

1. Assuming that each employer $i$ sets the wage and labour demand. What are the first-order conditions of the following problem: $\max_{L_i, w_i} s_i F_i (E_i \cdot L_i) - w_i L_i$, where

- $L_i =$ labour demand in firm i; $w_i =$ the real wage rate;
- $s_i =$ a firm-specific technological parameter ($s_i > 0$);
- $F_i[...] =$ the revenue function ($F' > 0$, $F'' < 0$).

2. Show that the optimal value of $w_i$ is independent of $s_i$ and is a mark-up over $B$. So, real wages are fully rigid (i.e. do not respond to changes in the multiplicative parameter $s_i$).

3. Let $B = (1 - u)w^e + u b$, $u$ being the unemployment rate, $w^e$ the average wage in the economy and $b$ the level of unemployment benefit. In general equilibrium, if all firms are identical, one has $w_i = w^e, \forall i$. Assume an exogenous constant replacement ratio $\beta$: $b = \beta w^e (0 < \beta < 1)$. Compute the unemployment rate in equilibrium. Interpret the role of $\beta$ and of $\lambda$. 
“Incentives work, often affecting the targeted behavior almost exactly as conventional economic theory predicts [...] But explicit economic incentives sometimes have surprisingly limited effects, and may even be counterproductive.” (Bowles and Polanía-Reyes, 2012, p. 369)

“Psychologists have provided compelling evidence that rewards can crowd-out intrinsic motivation (...). Economists became recently interested in this issue (...) and empirical (mostly experimental) evidence has been collected on this ambiguous effect of rewards. (Dickinson and Villeval, 2008, p. 58)

The introduction of a penalty in case of a misconduct can increase this behavior. (see e.g. Gneezy and Rustichini, 2000)
Social preferences

“Social” or “other regarding preferences” are now introduced in principal-agent problems (see the overview by Rebitzer and Taylor, 2011): They deal with pay status, effort and professional norms, identity (related e.g. to gender or ethnic origin),...

Different definitions of “social preferences” coexist. E.g.:

- People “are not solely motivated by material self-interest but also care positively or negatively for the material payoffs of relevant reference agents”. (Fehr and Fischbacher, 2002, p. C1) *(Definition retained below)*

- Bowles and Polanía-Reyes (2012) “refer to motives such as altruism, reciprocity, intrinsic pleasure in helping others, inequity aversion, ethical commitments, and other motives that induce people to help others more than would an own-material-payoff maximizing individual. Our use of the term is thus not restricted to cases in which the actor assigns some value to the payoffs received by another person, (...)” (p.370)
Arguably, the introduction of “social preferences” can be seen as part of “behavioral economics” which questions standard economics in a broader way:

“Behavioral economics uses insights from psychology to investigate human decision making that is at odds with mainstream economic models, which postulate a rational, selfish, forward-looking utility maximizing agent, also known as homo economicus. (Dohmen, 2014, p. 72)

The introduction of “social preferences” can lead to very “flexible” models able to account for a wide range of behaviors.

⇒ A difficulty: The generation of falsifiable hypotheses for testing those models.
3.2. Fairness

CCZ2014 present on p. 378 - 9 a basic framework due to Akerlof (1982), where a social norm of fairness affects wage formation and the level of effort of the employees. This setting can be seen as a specific version of the efficiency wage model where the determinant of the effort level chosen by a worker is the comparison between her wage and the wage of a reference group (in the firm).

Then CCZ2014 look at empirical evidence. Here, I sum up a more recent and innovative experiment “in the field” (i.e. in the real word) due to Cohn, Fehr and Goette (2015).
Motivation

Akerlof and Yellen (1990), henceforth AY, developed the gift-exchange hypothesis that “fair-minded workers” reciprocate higher wages with greater effort with a number of consequences on the functioning of the labor market.

- There is evidence in the lab in favor of this hypothesis.
- However, the evidence “in the field” (in the real word) is mixed.
- So, Cohn, Fehr and Goette (2015) develop a large-scale controlled field experiment to test the AY hypothesis.
AY Gift exchange: The fair-wage effort hypothesis

Hypothesis:
- If the actual wage is perceived to be below the fair wage an increase in wages raises effort.
- If the actual wage is perceived to be at or above the fair wage an increase in wages leaves effort unchanged.
Potentially far-reaching consequences

- The fair reference wage may be affected by all kinds of factors that have nothing to do with the market clearing wage
  - Past wages
  - Current or past profits of the company or industry
  - There is no reason at all that the fair wage coincides with the market clearing wage

- If the fair wage is above the market clearing wage firms may have an incentive to pay non-competitive wages.
  - After a positive labor shock or a negative labor demand supply the market clearing wage falls but not necessarily the fair wage
  - Involuntary unemployment
  - Employed workers earn non-competitive rents
Concepts

Two main approaches can be distinguished (Fehr-Schmidt, “Theories of fairness and reciprocity”).

1. (At least some) agents have “social preferences”, i.e., the utility function of these rational agents does not only depend on their own material payoff but also on how much the other players receive. Examples: altruism, envy, inequity aversion...

2. “Intention-based reciprocity”: Agents care about the intentions of her opponent.
   - She feels treated kindly ⇒ Be nice to her opponent
   - She feels treated badly ⇒ Hurt her opponent

Thus, in this approach it is crucial how a player interprets the behavior of the other players. This cannot be captured by traditional game theory but requires the framework of “psychological game theory”.

Note: In AY, only underpaid workers respond to higher wages!
Evidence of the Gift exchange hypothesis?

1. Laboratory Gift Exchange Experiments:
   - Each firm offers wages to the group of workers (Exogenous excess supply of workers; explicit performance pay or other incentive schemes excluded)

   - Workers can accept these wages. If they accept, they have to choose a costly level of effort:
     - Marginal revenue of effort $> \text{marginal cost of effort}$
     - Maximal effort is the efficient effort

   - Payoff functions are common knowledge

   - Standard theory predicts minimal effort and lowest possible wage

   - Evidence from the lab experiment:
     - Average effort is increasing in the wage level
     - Wages do not converge to the competitive level
Evidence?

2. Field experiments:

1. Aim at looking whether changes in compensation affect workers’ effort in real working conditions.

2. Field experimental evidence is mixed

- Some authors find a positive (temporary) effect of wage increase on effort

- Some authors do not or find very weak effects (see e.g. Della Vigna, List, Malmendier and Rao, 2016[^6]).

[^6]: Their results are instead consistent with the so-called “warm glow model”, i.e. “workers value contributing something to the employer, but are insensitive to the actual employer payoff” (of workers’ additional effort), p. 1.
Difficulties of field experiments

- Changes in compensation generally reflect firms’ choices and are therefore potentially endogenous due to unobservable confounds.
- Employment contracts are frequently embedded in ongoing relationships between workers and employers: reputation, punishment strategies, ... 
- Self-selection of workers

⇒ **Experimental approach** to control for above issues (random assignment of workers: baseline wage versus higher [or lower] wage).
Some weaknesses of previous field experiments:

- Rather small number of observations.

- No control of fairness perceptions with regard to the baseline wage and the wage increase:
  Is the baseline $\leq$ the “fair wage”? The higher the baseline wage, the higher the risk of a $>$ relationship. In some other experiments, experimenters paid a rather high base wage compared to the market wage for comparable jobs.

Here: a rather large sample with a baseline wage which is “well-chosen”.
The experiment (Cohn, Fehr and Goette, 2015)

- A publishing company commissioned a promotion agency to organize over a 3 month period a sales promotion (free distribution of a new newspaper) in Zurich. Effort? To approach passers-by actively or not. Output? Number of copies of newspapers distributed.
- Workers recruited by the publishing company on a one-shot basis: No prospect of being recruited later by the publishing company!
Before the promotion began:

- All workers had agreed to work for a **performance-unrelated** hourly wage of CHF 22 = “baseline treatment”.

- Workers could freely choose when to work, but they had to indicate their availability three to four weeks in advance, and once they had signed up for particular shifts they were not allowed to switch or cancel their chosen shifts. Workers had to sign up for blocks of three hours (4pm to 7pm) from Monday to Friday.

- The city is divided in two equally-sized sectors and workers are randomly assigned to a given sector.

- Team leaders (supervisors) were assigned different controlling tasks.

- Neither workers nor team leaders knew they were part of an experiment.
Treatment:

- Shortly before the beginning of a shift, a postcard and a text message announcing a wage supplement of CHF 5.

- Clear announcement: The publishing company, not the promotion agency, is paying the higher wage. Why?

- Randomization the two treatments across the two sectors on a weekly basis. Weekly rotation of the treatment during the last 4 weeks of the 3 month promotion period. See figure:
### 3. Social Preferences

#### 3.2. Fairness

**The Treatments**

- **Randomization**
- City of Zurich was divided into two regions
- Treatments were balanced across regions
- Assignment of workers to locations (regions) is randomly fixed ex-ante

<table>
<thead>
<tr>
<th>Region</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Baseline</td>
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<td>Baseline</td>
<td>Extra Pay</td>
</tr>
<tr>
<td>B</td>
<td>Extra Pay</td>
<td>Baseline</td>
<td>Extra Pay</td>
<td>Baseline</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
</tbody>
</table>

**Week 14 - 16**

- Survey & Lab exp.

---

**Question:** Could workers anticipate the wages? Answer of the authors

- No communication between workers in different sectors (???);
- The weekly rotation of the wages during a small part of the 3-month promotion;
- Workers with highly irregular workdays.
Three stages after the experiment

1. Anonymous survey conducted asking workers’ opinion: “I consider the regular (higher) hourly wage of CHF 22 (27) for doing this job to be [1 = very unfair, 2 = moderately unfair, 3 = neither ... nor, 4 = moderately fair, 5 = very fair]”.

Follow-up survey concerning 3 earlier employers:
2. “The questions of key interest to us asked the participants to state the wage they were effectively paid and the wage they considered to be fair for their work: “What hourly wage did you earn at employer X?” and “What hourly wage would you find appropriate for doing this job at employer X?”.

By subtracting the answers of the first question from the second, we are able to construct an individual measure of perceived underpayment.”
Three stages after the experiment

3. At the end of the follow-up survey, workers were asked to take part to a **one-shot** game played for real money. **Aim**: to measure workers’ inclination towards **reciprocal fairness**.

◊ “The first-movers could divide CHF 24 in three different ways: they could choose between (i) an unfair allocation (CHF 18 for the first-mover and CHF 6 for the second-mover), (ii) an equitable allocation (CHF 12 for both players), or (iii) a generous allocation (CHF 6 for the first-mover and CHF 18 for the second-mover).

◊ The second-movers (= workers of the experiment) could then reward or punish the first-movers by assigning up to two positive or negative points, respectively; they could also decide not to assign any points at all. The reward and punishment technology was designed in a way such that one positive (negative) point cost the second-mover CHF 2 and increased (decreased) the first-mover’s payoff by CHF 6.”
### Descriptive statistics

<table>
<thead>
<tr>
<th>Description</th>
<th>Number of workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed during 4 experimental weeks</td>
<td>196</td>
</tr>
<tr>
<td>Returned opinion survey (1)</td>
<td>113</td>
</tr>
<tr>
<td>Completed follow-up survey (2)</td>
<td>119</td>
</tr>
<tr>
<td>Took part to the one-shot game (3)</td>
<td>118</td>
</tr>
</tbody>
</table>
3. Social Preferences

3.2. Fairness

Descriptive statistics

- The experimental conditions were well balanced within individuals. Workers’ median exposure to the higher wage was 50 percent of the shifts (Table 1 in the paper);

- Fairness perception of wages (Table 1 and Fig 3): In the follow-up survey what wage workers would consider appropriate for this type of job.
  - The average reply was CHF 1 more than the CHF 22 paid in the baseline treatment.
  - Slightly less than half of the workers considered the base wage as the appropriate wage.
  - The majority of the workers (53 percent) perceived themselves to be underpaid at the base wage of CHF 22, with a sizable group of workers (20 percent) perceived CHF 25 to be the appropriate wage.
3. Social Preferences

3.2. Fairness

Game in the lab:

a) Who is reciprocal? “We classify the workers as **reciprocal** if they returned more positive points in the generous allocation than in the equitable allocation, or more positive points in the equitable allocation than in the unfair allocation” (p.1781). Result: reciprocal (N = 77) and the non-reciprocal (N = 41) participants.

b) Large quantitative differences between the two groups (Table 1).

Importantly, “Worker characteristics in the two treatments are statistically identical for every dimension we measured (e.g., underpayment judgments, age, gender, etc.).” (Table 2)

Further checks: Workers had to sign up for shifts well in advance. Table 3 confirms the absence of selectivity (Table 3). See also table 4 (Table 5).
Main results

**Empirical strategy**

- $y_{ikt} =$ Number of copies distributed per hour by individual $i$, at location $k$ and on day $t$.
- **basic specification:**
  \[
  \log(y_{ikt}) = \beta_0 + \beta_1 1[\text{CHF27}]_{kt} + (\nu_i) + \lambda_k + \delta_t + \varepsilon_{ikt}
  \]
- To investigate heterogeneity in treatment:
  \[
  \log(y_{ikt}) = \beta_0 + \beta_1 1[\text{CHF27}]_{kt} + \beta_2 1[\text{CHF27}]_{kt} \times \Delta_i \\
  + \beta_3 \Delta_i + \lambda_k + (\nu_i) + \delta_t + \varepsilon_{ikt}
  \]

where $\Delta_i$ measures worker $i$’s perceived underpayment, i.e. the max between 0 and the difference between what worker $i$ considered to be a fair wage for this job and the wage she was paid in the baseline treatment.
Main results

1. “The wage increase is associated with an increase in the perceived fairness of pay on average. However, there is strong heterogeneity in workers’ fairness perceptions. The wage increase raises the perceived fairness of pay particularly among workers who evaluate the base wage as unfairly low.”

2. “The wage increase has a positive and significant impact on workers’ performance on average.”

Basic specification:
Someone paid CHF 27 instead of CHF 22 will on average distribute 3.7% copies more. Not a huge effect...
3. Social Preferences

3.2. Fairness

“There is significant heterogeneity in workers’ response to a wage increase. Workers who perceive themselves to be underpaid at the base wage raise their performance significantly when they are paid a higher wage, while workers who feel adequately paid or overpaid at the base wage do not respond to a wage increase.” ⇒ consistent with the fair-wage effort hypothesis of AY.  

Table 8

Order of magnitude: For a worker who considers CHF 27 as the fair wage (frequent), i.e. if \( \Delta_i = \text{CHF 5} \), the treatment effect becomes: \( 0.005 + 5 \times 0.018 = 0.095 \). More substantial...

Robustness checks: Role of ability of the worker,...

4

“There is considerable heterogeneity in workers’ preferences for reciprocal fairness. Underpaid reciprocal workers strongly increase their performance when they are paid a higher wage, while the pattern is significantly different for non-reciprocal workers: even when feeling underpaid, non-reciprocal workers do not respond to a wage increase.”

Table 10
External validity of this study?
◊ The type of effort produced by the workers in this field experiment is quite specific and narrow.

◊ So, to what extent can we extrapolate what we have learned here to, say,
  • An ordinary production worker in an automobile factory,
  • ...
  • A salesman, ...

or to workers whose occupation is characterized by multitasking?

What is the persistence of positive reciprocal reaction of workers? On this, see e.g. Sliwka and Werner (2017).
Exercise

In the presence of moral hazard and with standard assumptions concerning preferences about consumption and leisure, we have discussed a number of ways of generating a relationship between the remuneration of the worker and his/her effort on the job, namely:

1. Explicit performance pay schemes,
2. Tournaments and
3. Deferred payments.

The paper of Cohn, Fehr and Goette tests the hypothesis that individuals have an inclination towards reciprocal fairness. How does the design of their field experiment avoid the critique according to which “what they capture is actually one of the above-mentioned 3 ways of eliciting effort that works with standard preferences”? Answering this question requires no mathematical reasoning, nor a discussion of results. A few sentences about key features of the design of their experiment is sufficient. Discuss each of the above-mentioned 3 ways.
3.3. Intrinsic Motivation

Akerlof and Kranton (2008) enlarge preferences in the following way.

- **Social Psychology:** intrinsic motivation depends on “how workers see themselves in relation to the firm” (p. 212)

- **Ethnography:**
  - Workers resent supervision;
  - In the absence of supervision, workers develop their own output (effort) norm.

On this basis, they assume:

- Workers have an identity $c$ that determines their *intrinsic* motivation:
  - No {Supervision+Monitoring} $\Rightarrow$ a work group identity ($c = G$) to which is associated a specific ideal (“norm”) of effort ($e_\Gamma$).
  - Supervision+Monitoring $\Rightarrow$ an outsider identity ($c = O$) to which is associated another, low, ideal of effort ($e_B < e_\Gamma$).
Preferences: Utility $U(W, e | c)$ sums three terms
- an increasing and concave function of consumption (say, $\ln W$),
- a decreasing function of non verifiable effort (say, $-e$),
- a loss if effort deviates from the ideal $e^*(c), c \in \{G, O\}$ (say, $-t_c \cdot |e^*(c) - e|$), where $0 \leq t_c < 1$.

The effort level takes three possible values: $e_A > e_\Gamma > e_B$.

*Verifiable* firms revenues are either high ($\pi_H$) or low ($\pi_L$). Let $0 \leq \gamma \leq 1$,

<table>
<thead>
<tr>
<th></th>
<th>$\pi_H$</th>
<th>$\pi_L$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e_A$</td>
<td>$1/2$</td>
<td>$1/2$</td>
</tr>
<tr>
<td>$e_\Gamma$</td>
<td>$\gamma/2$</td>
<td>$1 - \gamma/2$</td>
</tr>
<tr>
<td>$e_B$</td>
<td>$0$</td>
<td>$1$</td>
</tr>
</tbody>
</table>

**Table:** Probability of revenue for the firm as a function of effort level.

When there is a supervisor, a low effort, $e_B$, is verified with an exogenous probability $p$ while the high effort level, $e_A$, is never verifiable.
Akerlof and Kranton (2008) compare two settings:

1. **With Supervision+Monitoring**: Eliciting $e_A$ instead of $e_B$:
   - Instruments of the principal: contingent wages $w_H^O, w_L^O$ and a fine $f$ if the agent exerts $e_B$;
   - These instruments have to maximize expected profits subject to
     (i) a participation constraint,
     (ii) an incentive constraint to elicit effort $e_A$, knowing that $e^*(c = O) = e_B$,
     (iii) an upper-bound on $f$.

2. **No \{Supervision+Monitoring\}**: Eliciting $e_A$ or $e_\Gamma$?
   - Instruments of the principal: contingent wages $w_H^G, w_L^G$
   - These instruments maximize expected profits subject to
     (i) a participation constraint and
     (ii) *either* incentive constraints to elicit effort $e_A$ instead of $e_\Gamma$ or $e_B$, knowing that $e^*(c = G) = e_\Gamma$
     (ii’) *or* an incentive constraint to elicit $e_\Gamma$ instead of $e_B$.

---

Akerlof and Kranton (2008) assume that getting $\pi_L$ for sure cannot be preferable.
No detailed study of the solution. (many configurations are possible)

Some intuition of properties only:

- Obviously, the interest of a supervisor heavily depends on the detection probability $p$ and the upper-bound on $f$. If these are low, introducing a supervisor can be detrimental to the principal since there is a need to compensate for $t_O \cdot |e_B - e_A|$.

- In the absence of a supervisor, for high enough $\gamma$ and $t_G$, the principal prefers to elicit $e_\Gamma$ than $e_A$.

- Comparing across the principal’s options, there is a threshold $p' > 0$ under which the principal does not want to institute a supervisor.

Note that CCZ2014 develop on p. 383-387 another theoretical framework that combines intrinsic motivation and reputation.
3.4. Envy

Starting point: Section 2.2.2 “Should remuneration always be individualized?”.

If the principal observes a signal $\tilde{\varepsilon}$ positively correlated ($\rho > 0$) with the agent’s productivity, the optimal payment of this agent is negatively influenced by $\tilde{\varepsilon}$.

Application:
An industry with, say, 2 firms $i$ and $j$.
It is likely that there are common random shocks (like demand shocks). So, $\tilde{\varepsilon}$ above could reveal information on the performance of the other firm $j$. The incentive payment to the Chief Executive Officers (CEO) in $i$ should be negatively related to the performance of firm $j$.

Fershtman, Hvide and Weiss (2003) (henceforth, FHW) notice the lack of evidence of such a negative relationship in the empirical literature.
FHW develops a setting where managers’ wages can be positively related in an industry. This effect goes against the standard one and hence could explain this lack of empirical evidence.

Key ingredient: **interdependent preferences** of the following type:

◊ The agent is the CEO of firm \(i\) with a utility function given by:

\[
U(W_i, W_j, e_i; \beta) = -\exp\{-\alpha[W_i + \beta(W_i - W_j) - e_i^2/2]\}, \quad \alpha > 0, \quad (31)
\]

\(W_i\) is the wage of the manager in firm \(i\),

\(W_j\), the wage of the other manager, affects negatively the utility of manager \(i\) (if \(\beta > 0\); the higher \(\beta\), the higher the intensity of “envy”),

\(e_i\) is non verifiable effort of manager \(i\).

And symmetrically for the CEO in firm \(j\).

◊ The principal (firm owner) is risk-neutral (maximizes his expected profits \(\Rightarrow\) no interdependent preferences).
FHW assume in addition:

**A2** Effort $e_i$ results in a verifiable but random output: $y_i = e_i + \varepsilon_i$ with $\varepsilon_i \sim \mathcal{N}(0, \sigma^2)$, and similarly in firm $j$.
They assume that the random shocks $\varepsilon_i$ and $\varepsilon_j$ are independent. Seems odd. Why? To get that with standard preferences like (24) the incentive contract $i$ should not be affected by characteristics in firm $j$, and conversely.

**A3** The **explicit performance** wage contract is *linear* in outputs:

$$W_i = w_i + a_i y_i + b_i y_j \quad \text{and} \quad W_j = w_j + a_j y_j + b_j y_i$$  \hspace{1cm} (32)

where $w_i$ is a fixed wage and $a_i$ and $b_j$ are **piece-rates**.
The optimal effort level maximizes expected utility. So,

$$e_i^* = \max(a_i + \beta(a_i - b_j), 0), \quad \text{with } \partial e_i / \partial b_j \leq 0. \quad (33)$$

Expected profit of the principal in firm $i$ is:

$$e_i \cdot (1 - a_i) - e_j \cdot b_i - w_i \quad (34)$$

The two principals compete for (mobile) managers by offering contracts.

Without proof, the reaction function of the two firms are of the form:

$$a_i^* = \frac{1}{1 + \alpha \sigma^2} + A \cdot b_j \quad (35)$$

$$b_j^* = B \cdot a_i \quad (36)$$

where $1 > A > 0$ and $B > 0$ are positive and functions of parameters $\{\beta, \alpha, \sigma\}$. Note that $\beta = 0 \Rightarrow A = B = 0.$
Strategic interaction: Firm $i$ raises $a_i$ as $b_j$ increases since a rise in $b_j$ increases $W_j$ and hence make it more costly for $i$ to exert effort ($e_i^*$ shrinks, which is detrimental to the principal). The rise in $a_i$ intends to offset this effect. This increase in $a_i$ induces in turn firm $j$ to rise $b_j$ and so on.

Assume that the two firms are symmetric.

It can be shown that a unique Nash equilibrium with positive effort $e^*$ exists if the “risk factor” $\alpha \sigma^2$ is “sufficiently large” relative to the intensity of the envy effect $\beta$. This equilibrium is such that:

$$a^* = \frac{1}{1 + \alpha \sigma^2} + A \cdot b^* \quad (37)$$
$$b^* = B \cdot a^* \quad (38)$$
$$e^* = (1 + \beta)a^* - \beta b^* \quad (39)$$
If $\beta = 0$: We are back to the solution of Sec 3.2 (Part 1) in the particular case of a quadratic Cost of effort function.

$$a^* = \frac{1}{1 + \alpha \sigma^2}, \quad b^* = 0$$

If $\beta > 0$: The wage of agent $i$ is **increasing** in the wage of agent $j$.

In sum,

- In the presence of envy, strategic interaction can induce a positive correlation between the wages of CEOs who are sufficiently close for a comparison to take place.
- In reality, there is presumably a positive correlation between the random components $\varepsilon_i$ and $\varepsilon_j$. So, in the absence of envy, a negative correlation between their wages would be optimal.
- The combination of these two opposite effects can explain the lack of evidence about clear correlations between compensation of CEOs.
### Table 2: Randomization check for worker characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th></th>
<th>Treatment</th>
<th></th>
<th></th>
<th>p-value</th>
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<tbody>
<tr>
<td></td>
<td>CHF22</td>
<td>CHF27</td>
<td>CHF22</td>
<td>CHF27</td>
<td>CHF22</td>
<td>CHF27</td>
</tr>
<tr>
<td>Perceived underpayment (in CHF)</td>
<td>1.1</td>
<td>(2.1)</td>
<td>1.1</td>
<td>(2.1)</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
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<td>(5.3)</td>
<td>23.3</td>
<td>(5.4)</td>
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<td></td>
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<tr>
<td>Male (in %)</td>
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<td>(45.0)</td>
<td>26.7</td>
<td>(44.3)</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Foreigner (in %)</td>
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<td>17.2</td>
<td>(37.8)</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
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<td>(0.9)</td>
<td>1.4</td>
<td>(0.9)</td>
<td>0.91</td>
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</tr>
<tr>
<td>Secondary school (in %)</td>
<td>64.8</td>
<td>(47.8)</td>
<td>63.3</td>
<td>(48.3)</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>Apprenticeship/vocational school (in %)</td>
<td>33.1</td>
<td>(47.1)</td>
<td>30.8</td>
<td>(46.2)</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>Additional, further education (in %)</td>
<td>24.8</td>
<td>(43.2)</td>
<td>24.2</td>
<td>(42.9)</td>
<td>0.85</td>
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<tr>
<td>Baccalaureate (in %)</td>
<td>61.8</td>
<td>(48.7)</td>
<td>65.8</td>
<td>(47.5)</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Technical school (in %)</td>
<td>25.1</td>
<td>(43.4)</td>
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<td>(40.9)</td>
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<tr>
<td>University (in %)</td>
<td>24.5</td>
<td>(43.1)</td>
<td>21.1</td>
<td>(40.9)</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Points returned if 1st mover proposed (18, 6)</td>
<td>-0.65</td>
<td>(1.02)</td>
<td>-0.66</td>
<td>(1.00)</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>Points returned if 1st mover proposed (12, 12)</td>
<td>0.25</td>
<td>(0.73)</td>
<td>0.25</td>
<td>(0.68)</td>
<td>0.88</td>
<td></td>
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<tr>
<td>Points returned if 1st mover proposed (6, 18)</td>
<td>0.81</td>
<td>(0.90)</td>
<td>0.86</td>
<td>(0.89)</td>
<td>0.46</td>
<td></td>
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</tbody>
</table>

Because of the within-subject design most workers participated in both treatments. It was possible, however, that some workers worked x times (shifts) in treatment CHF22 and y times (shifts) in treatment CHF27. Therefore, our randomization check takes this into account, i.e., the characteristics of this worker count x times for treatment CHF22 and y times for treatment CHF27. This is a very conservative randomization check because showing insignificant differences in worker characteristics across treatments would be much easier if we were to count each worker only once. The first four columns in this table show the treatment averages and standard deviations of worker characteristics. The last column contains the p-values (t-tests for binary variables and Mann-Whitney tests for non-binary variables) for the null hypothesis of perfect randomization.
3. Social Preferences

3.4. Envy

Table 2: Randomization check for worker characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment CHF22</th>
<th>Treatment CHF27</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Perceived underpayment (in CHF)</td>
<td>1.1</td>
<td>(2.1)</td>
</tr>
<tr>
<td>Age (in years)</td>
<td>23.4</td>
<td>(5.3)</td>
</tr>
<tr>
<td>Male (in %)</td>
<td>28.1</td>
<td>(45.0)</td>
</tr>
<tr>
<td>Foreign (in %)</td>
<td>16.1</td>
<td>(36.8)</td>
</tr>
<tr>
<td>Number of siblings</td>
<td>1.4</td>
<td>(0.9)</td>
</tr>
<tr>
<td>Secondary school (in %)</td>
<td>64.8</td>
<td>(47.8)</td>
</tr>
<tr>
<td>Apprenticeship/vocational school (in %)</td>
<td>33.1</td>
<td>(47.1)</td>
</tr>
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</tr>
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Table 3: Participation at the individual level during the experiment

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable: Number of shifts per treatment</td>
<td>CHF27 0.189 (0.130)</td>
</tr>
<tr>
<td>Intercept</td>
<td>3.143*** (0.162)</td>
</tr>
<tr>
<td>Fixed effects Worker</td>
<td>No</td>
</tr>
<tr>
<td>N</td>
<td>392</td>
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</tbody>
</table>

OLS estimates. Standard errors in parentheses are clustered on the individual level. The unit of observation is a worker in each treatment. The dependent variable is the number of shifts per treatment and CHF27 is an indicator variable for treatment status. The levels of significance are * p < 0.10, ** p < 0.05, *** p < 0.01.
### Table 4: Participation at the sector-day level during the experiment

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable:</td>
<td>Fraction of unfilled shifts per day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHF27</td>
<td>0.008</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.028)</td>
<td>(0.028)</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.193***</td>
<td>0.193***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.019)</td>
<td></td>
</tr>
</tbody>
</table>

OLS estimates. Standard errors in parentheses are clustered on the day level. The unit of observation is a day in each treatment. The dependent variable is the fraction of unfilled shifts per day and CHF27 is an indicator variable for treatment status. The levels of significance are * p<0.10, ** p < 0.05, *** p < 0.01.

### Table 5: Randomization check for outcomes measured after the field experiment

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable:</td>
<td>Perceived underpayment</td>
<td>Points returned if 1st mover proposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(18, 6)</td>
<td>(12, 12)</td>
<td>(6, 18)</td>
</tr>
<tr>
<td>Fraction of shifts in CHF27</td>
<td>0.190</td>
<td>0.008</td>
<td>0.180</td>
<td>0.497</td>
</tr>
<tr>
<td></td>
<td>(0.684)</td>
<td>(0.431)</td>
<td>(0.299)</td>
<td>(0.360)</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.992**</td>
<td>-0.564**</td>
<td>0.155</td>
<td>0.617***</td>
</tr>
<tr>
<td></td>
<td>(0.431)</td>
<td>(0.256)</td>
<td>(0.178)</td>
<td>(0.214)</td>
</tr>
</tbody>
</table>

N | 119 | 118 | 118 | 118

Column (1) reports OLS estimates with robust standard errors in parentheses, while columns (2) to (4) report the estimates of seemingly unrelated regressions. Throughout all columns, the independent variable is workers’ exposure to treatment CHF27 indicated as the fraction of shifts they worked under the higher wage. In column (1) the dependent variable is the perceived underpayment at the base wage, and in columns (2) to (4) the dependent variable is workers’ back-transfers in the moonlighting game. The levels of significance are * p<0.10, ** p < 0.05, *** p < 0.01.
### Table 8: Heterogeneous treatment effect of the wage increase on workers’ performance

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>log(hourly copies distributed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHF27</td>
<td>0.039</td>
<td>0.018</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>(0.019)**</td>
<td>(0.023)</td>
<td>(0.020)</td>
</tr>
<tr>
<td>CHF27 × Δᵢ</td>
<td></td>
<td>0.019</td>
<td>0.019</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.008)**</td>
<td>(0.007)**</td>
</tr>
<tr>
<td>Δᵢ</td>
<td></td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.006)</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>5.619</td>
<td>5.633</td>
<td>5.317</td>
</tr>
<tr>
<td></td>
<td>(0.113)***</td>
<td>(0.108)***</td>
<td>(0.130)***</td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Location</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Day</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

N = 722

OLS estimates. Standard errors in parentheses take account of serial correlation within an individual’s residuals and spatial correlation among the residuals of spatially close observations on the same day (up to a distance of 3 km). The dependent variable is the logarithm of the number of hourly copies distributed and serves as our performance measure. The variable CHF27 is an indicator variable for the treatment in which the workers were paid the higher wage. The variable Δᵢ is the difference between the wage a worker considered to be fair and the base wage. The interaction term CHF27 × Δᵢ thus measures the treatment effect as a function of workers’ perceived underpayment. The levels of significance are * p < 0.10, ** p < 0.05, *** p < 0.01.
Table 10: The effect of the wage increase on the performance of reciprocal vs. non-reciprocal workers

<table>
<thead>
<tr>
<th>Sample:</th>
<th>Reciprocal workers</th>
<th>Non-reciprocal workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable:</td>
<td>log(hourly copies distributed)</td>
<td></td>
</tr>
<tr>
<td>CHF27</td>
<td>0.000</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.023)</td>
</tr>
<tr>
<td>CHF27 × Δ_i</td>
<td>0.028</td>
<td>-0.010</td>
</tr>
<tr>
<td></td>
<td>(0.012)**</td>
<td>(0.009)</td>
</tr>
<tr>
<td>Intercept</td>
<td>5.036</td>
<td>5.928</td>
</tr>
<tr>
<td></td>
<td>(0.148)***</td>
<td>(0.231)***</td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Location</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Day</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>466</td>
<td>243</td>
</tr>
</tbody>
</table>

OLS estimates. Standard errors in parentheses take account of serial correlation within an individual’s residuals and spatial correlation among the residuals of spatially close observations on the same day (up to a distance of 3 km). The dependent variable is the logarithm of the number of hourly copies distributed and serves as our performance measure. The variable CHF27 is an indicator variable for the treatment in which the workers were paid the higher wage. The variable Δ_i is the difference between the wage a worker considered to be fair and the base wage. The interaction term CHF27 × Δ_i thus measures the treatment effect as a function of workers’ perceived underpayment. Column (1) shows the estimates for reciprocal workers, while column (2) shows the same for non-reciprocal workers. The levels of significance are * p < 0.10, ** p < 0.05, *** p < 0.01.
References I


References II

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References V


References VI

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