Training the Doubtful and Timid

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The Knightian view of the firm

"...the system under which the confident and venturesome "assume the risk" or "insure" the doubtful and timid by guaranteeing to the latter a specified income..."

- Following a seminal paper by Guiso et al. (2005), a growing empirical literature shows that workers are insured against shocks hitting their employers. Related empirical literatures:
  - Effects of technology-driven changes in labor productivity on wages. For example, Carlsson et al. (2011) show that it matters whether the productivity changes are shared with similar firms.
  - Effects of workers' sharing in rents generated by capital investments. For example, Card et al. (2011) find evidence of rent-sharing, but investments seem to earn the full cost of capital.

Our project

- We consider a firm that can invest into the human capital of its worker: “training”.
  - The investment generates rents for both the firm and the worker.
  - Other firms (“the industry”) can also benefit from the worker’s human capital, but some human capital is specific to the firm that trained the worker = the “incumbent”.
- The firm’s output market features demand uncertainty. As a result, the firm and the worker may earn risky cash flows.
  1. We analyze the worker’s exposure to risk if the wage is set after demand is known: “short-term contracting”.
  2. We analyze “insurance within the firm”, i.e. risk-sharing between the firm and the worker through “long-term” contracting.

Contribution

- We depart from a literature which assumes that firms can commit to remuneration and employment policies.
- Berk, Stanton and Zechner (2010) analyze how firms break their commitments by defaulting. We follow their lead.
  - In our model, firms can only commit to wages that they pay conditional on employing a worker, but they cannot commit to employing a worker in the future.
  - We are looking for empirical evidence backing our model.
- Of course, insurance within the firm is not necessarily constrained by a lack of commitment ability of firms. But, *if* the lack of commitment ability matters then human capital determines the extent to which workers bear wage risk.
  - We analyze human capital as a commitment device. Human capital has no such effect on insurance within the firm in the prior literature which assumed that firms need no separate commitment device.

Contribution (ctd.)

- We distinguish between three effects of human capital on the exposure of a worker to wage risk:
  1. Human capital increases the baseline exposure to wage risk that the worker would have under short-term (spot) contracting.
  2. Human capital also increases the exposure to wage risk that the worker has under long-term contracting.
  3. If "insurance within the firm" is constrained by the firms' ability to commit to employing the worker, then workers with more human capital receive less insurance.
- Our model highlights that workers may not need insurance within the firm.
  - In high-margin industries, the productivity of human capital must be measured relative to a worker without human capital.
  - Wages may not depend on measures of worker productivity based on firm-/industry-level sales, even though workers receive no insurance within the firm.

Training the doubtful and timid...

- We assume that the worker is risk averse (“doubtful and timid”), while the firm wants to maximize expected profits.
  - Long-term contracting can be used to transfer risk from the worker to the firm.
- In our model, training affects the worker’s exposure to risk:
  1. Effects on the worker’s outside options: employment within the industry.
  2. Effects on long-term contracting to transfer risk from the worker to the firm.
- In addition, training has externalities.
  3. training $\rightarrow$ higher rents at risk $\rightarrow$ output drops less with demand $\rightarrow$ higher risk exposure of other firms and workers

So far, we are busy analyzing the first two effects! For now, we assume that the price of the industry’s output varies exogenously.

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A single-worker model

- Output price follows a Markov process with two states: $\pi_1 > \pi_2$. In any of ∞ periods, output can be produced after the state is known.
- Worker can produce output at cost $c(h)$, where $c_0 := c(0)$, $c' < 0$.
- h is the worker's human capital, of which a fraction α is transferable to other firms ("the industry"):
  - $(1-\alpha)h$ is firm-specific human capital, the rest is "industry-specific" human capital.
- The human capital is perishable:
  - Industry-specific human capital disappears in the frist period in which it is not used to produce output for a firm in the industry.
  - Firm-specific human capital disappears once the worker switches to another firm. The worker's current employer is the "incumbent".

  For now, we assume that any loss of human capital is permanent.
- Outside the industry, the worker can earn a wage w.

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The worker's outside options

Employment in the industry dominates employment outside if:

$$\hat{E}_z := u(\hat{w}_z) + \rho\hat{E} \geq u(\underline{w}) + \rho\underline{E} = \underline{E},$$

where

- $u(\cdot)$ is the worker's (money-metric) utility function and ρ is the worker's discount factor,
- $\hat{w}_z$ is the (highest) wage the worker is offered by another firm in the industry,
- $\hat{E}$ is the value of the worker's future employment opportunities if she retains her industry-specific human capital in the current period,

$$\hat{E} := p_1 \max[\hat{E}_1, \underline{E}] + (1 - p_1) \max[\hat{E}_2, \underline{E}],$$

- $\underline{E}$ is the value of the worker's future employment opportunities if she leaves the industry (and her human capital perishes).

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where

$$\hat{w}_z = \min[\pi_z, \underline{w} + c_0] - c(\alpha h).$$

Lemma 1:
(i) If the wage $\hat{w}_z$ satisfies the PC only in the high-price state $z = 1$, then the constraint will bind for $\hat{w}_1 = \underline{w}$.
(ii) If the wage $\hat{w}_z$ satisfies the PC in both states, then the PC binds for $\hat{w}_2 = f(\hat{w}_1)$ in the low-price state $z = 2$, where

$$f(w) = u^{-1}\left(u(\underline{w}) - (u(w) - u(\underline{w}))\frac{\rho p_1}{1 - \rho p_1}\right).$$

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Proposition 1: *Employment inside the industry dominates outside employment in any state z in which the worker's PC holds:*

(i) *In the high-price state $z = 1$, the PC is satisfied iff $\pi_1 \geq \hat{\pi}_1^{crit} := \underline{w} + c(\alpha h)$.*

(ii) *In the low-price state $z = 2$, the PC is satisfied iff $\pi_1 \geq \hat{\pi}_1^{crit}$ and $\pi_2 \geq \hat{\pi}_2^{crit} := f(\hat{w}_1) + c(\alpha h)$.*

"Stacking" PCs...

In state z, the incumbent can employ the worker at a wage w_z if:

$$E_z := u(w_z) + \rho E \geq \max[u(\hat{w}_z) + \rho\hat{E}, u(\underline{w}) + \rho\underline{E}] = \max[\hat{E}_z, \underline{E}]$$

where

$$E := p_1 \max[E_1, \hat{E}_1, \underline{E}] + (1 - p_1) \max[E_2, \hat{E}_2, \underline{E}].$$

To analyze whether the incumbent can satisfy the worker's PC, we define the incumbent's reservation wage $\bar{w}_z$:

$$\pi_z - c(h) - \bar{w}_z = -R,$$

where R denotes the value of rents that the incumbent earns due to the worker's human capital.

"Stacking" PCs...

In state z, the incumbent can employ the worker at a wage w_z if:

$$E_z := u(w_z) + \rho E \geq \max[u(\hat{w}_z) + \rho \hat{E}, u(\underline{w}) + \rho \underline{E}] = \max[\hat{E}_z, \underline{E}]$$

Since $\bar{w}_z > \hat{w}_z$:

Lemma 3:
If the incumbent cannot profitably offer the worker a wage that satisfies the PC, then

$$\max[u(\hat{w}_z) + \rho \hat{E}, u(\underline{w}) + \rho \underline{E}] = u(\underline{w}) + \rho \underline{E}.$$

Short-term contracting

Proposition 2: *Suppose that $\pi_1 \geq \pi_1^{crit}$. Under-short term contracting, the incumbent satisfies the worker's PC by making the following wage offers:*

(i) *If $\hat{\pi}_1^{crit} > \pi_1 \geq \pi_1^{crit}$, the incumbent offers the worker a wage of $w_1 = \underline{w}$ in the high-price state $z = 1$. If, in addition, $\pi_2 \geq \pi_2^{crit}$, then the incumbent will also offer the worker a wage of $w_2 = \underline{w}$ in the low-price state $z = 2$.*

(ii) *If $\pi_1 \geq \hat{\pi}_1^{crit}$, the incumbent offers the worker a wage of $w_1 = \hat{w}_1$ in the high-price state $z = 1$. If, in addition, $\pi_2 \geq \pi_2^{crit}$, the incumbent also offers the worker a wage in the low-price state $z = 2$: $w_2 = f(\hat{w}_1)$ for $\pi_2 < \hat{\pi}_2^{crit}$ and $w_2 = \hat{w}_2$ for $\pi_2 \geq \hat{\pi}_2^{crit}$.*

If $\pi_2 < \pi_2^{crit}$, the worker will exit the industry in the low-price state.

Some observations...

- The worker earns rents if the incumbent has to compete with other firms in the industry in the high-price state.
  - The worker is exposed to the risk of loosing future rents if, in the low-demand state, she exits the industry. A rationale for severance pay...
- Within-industry competition for the worker also causes on-the-job wage risk. Let:

$$\pi_1 = \bar{\pi}\left(1 + \sqrt{\frac{1-p_1}{p_1}}\frac{\sigma}{\bar{\pi}}\right), \ \pi_2 = \bar{\pi}\left(1 - \sqrt{\frac{p_1}{1-p_1}}\frac{\sigma}{\bar{\pi}}\right),$$

  The worker will be exposed to on-the-job wage risk if $\sigma/\bar{\pi}$ is sufficiently high. But, any $\sigma > 0$ suffices if $\bar{\pi} \in [\underline{w} + c(\alpha h, \underline{w} + c_0]$.

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Training and on-the-job wage risk under short-term contracting

Proposition 3: *The worker's exposure to on-the-job wage risk will increase in her human capital h. Specifically,*

(i) *if $\pi_1, \pi_2 \geq \underline{w} + c_0$, then $w_1 = w_2$ (i.e., no on-the-job wage risk),*

(ii) *if $\pi_1 \geq \underline{w} + c_0 > \pi_2$, then $w_1 > w_2$ for any human capital $h > 0$,*

(iii) *if $\pi_1, \pi_2 < \underline{w} + c_0$, then $w_1 > w_2$ if the human capital h is sufficiently high so that $\pi_1 \geq \hat{\pi}_1^{crit} = \underline{w} + c(\alpha h)$.*

In cases (ii) and (iii), the difference $w_1 - w_2$ equals:

$$w_1 - w_2|_{\pi_2 < \underline{w} + c_0} = \min[\pi_1, \underline{w} + c_0] - \max[\pi_2, \hat{\pi}_2^{crit}].$$

As a consequence:

$$\frac{d}{dh} w_1 - w_2|_{\pi_2 < \underline{w} + c_0} = \begin{cases} 0 & \text{if } \pi_2 \geq \hat{\pi}_2^{crit}, \\ -c'(\alpha h)\left(\frac{u'(\hat{w}_1)}{u'(f(\hat{w}_1))} + 1\right) > 0 & \text{if } \pi_2 < \hat{\pi}_2^{crit}. \end{cases}$$

Insuring the doubtful and timid

We next explore long-term contracting. Our model allows for two rationales for such contracting:

- Severance pay
- Wage smoothing

For now, we focus on long-term contracting in order to transfer on-the-job wage risk from the worker to the firm:

- A long-term contract is a wage schedule (W_1, W_2).
- We assume that the parties to a long-term contract cannot renegotiate the contract after the state is known.
- But, they can always walk away from the contract. $\rightarrow$ both parties must earn rents that would be lost if they walked away.
  - It suffices to analyze long-term contracting between the worker and the incumbent.

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  - It suffices to analyze long-term contracting between the worker and the incumbent.

Long-term contracting: the problem

A long-term contract must specify wages for both states:

$$\min_{W_1, W_2} p_1 W_1 + p_2 W_2 \text{ subject to}$$

$$\begin{aligned}
\text{Worker's PC:} \quad & E^L \geq E, \\
\text{Incumbent's ICs, } ICI_z\text{:} \quad & W_z \leq \bar{W}_z := \pi_z - c(h) + R^L, \\
\text{Worker's ICs, } ICW_z\text{:} \quad & E_z^L := u(W_z) + \rho E^L \geq \max[\hat{E}_z, \underline{E}],
\end{aligned}$$

where R^L denotes the incumbent's rents under long-term contracting, and

$$E^L := p_1 \max[E_1^L, \hat{E}_1, \underline{E}] + (1 - p_1) \max[E_2^L, \hat{E}_2, \underline{E}].$$

Lemma 5: *$W_1 \leq w_1$ and $W_2 \geq w_2$. If $W_1 < w_1$, then $W_2 > w_2$.*

Long-term contracting: which constraints matter?

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\text{Worker's ICs, } ICW_z\text{:} \quad & E_z^L := u(W_z) + \rho E^L \geq \max[\hat{E}_z, \underline{E}],
\end{aligned}$$

Lemma 6:
*(i) If $W_1 = w_1$ and $W_2 = w_2$, then the PC (**??**) and the constraints ICW_1 and ICW_2 bind, but the constraints ICI_1 and ICI_2 do not bind.*
*(ii) If $W_1 < w_1$, then the PC (**??**) and the constraints ICI_1 and ICW_2 do not bind, but the constraint ICW_1 binds.*

Long-term contracting: worker incentive compatibility

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$$\begin{aligned} \text{Worker's PC:} \quad & E^L \geq E, \\ \text{Incumbent's ICs, } ICI_z\text{:} \quad & W_z \leq \bar{W}_z := \pi_z - c(h) + R^L, \\ \text{Worker's ICs, } ICW_z\text{:} \quad & E_z^L := u(W_z) + \rho E^L \geq \max[\hat{E}_z, \underline{E}], \end{aligned}$$

Consider changing the wages W_1 and W_2 relative to the wages w_1 and w_2. To keep constraint ICW_1 satisfied:

$$dW_1 = -\frac{u'(w_2)}{u'(w_1)} \frac{\rho p_2}{1 - \rho + \rho p_1} dW_2.$$

The expected wage bill will not decrease if $p_1 dW_1 + p_2 dW_2 \geq 0$.

Long-term contracting: the optimum

Proposition 4: *The optimal long-term contract W_z is given by:*

(i) *If* $\frac{U'(w_2)}{U'(w_1)} \leq 1 + \frac{1-\rho}{\rho p_1}$ *then* $W_z = w_z$ *for any* $z = 1, 2$.

(ii) *If* $\frac{U'(w_2)}{U'(w_1)} > 1 + \frac{1-\rho}{\rho p_1}$, *then* $W_1 = W_1^*(W_2)$ *defined by:*

$$U(W_1^*) = \frac{p_1}{1-\rho}(U(w_1) - \rho U(W_1^*)) + \frac{p_2}{1-\rho}(U(w_2) - \rho U(W_2)),$$

and $W_2 = \min[W_2^*, \bar{w}_2 + \Delta_R(W_1^*(W_2), W_2)]$, *for* W_2^* *defined by:*

$$\frac{U'(W_2^*)}{U'(W_1^*)} = 1 + \frac{1-\rho}{\rho p_1}$$

Some observations...

Corollary 4.1: *The worker is not exposed to on-the-job wage risk under long-term contracting iff she is not exposed to such risk under short-term contracting.*

Corollary 4.2: *If the optimal long-term contract is constrained by the incumbent's incentive compatibility constraint in the low-price state* $z = 2$*, then the contract will specify wages* W_1 *and* $W_2 = \bar{W}_2$ *for which*

$$\frac{u'(W_2)}{u'(W_1)} > 1 + \frac{1-\rho}{\rho p_1}.$$

Human capital & insurance within the firm

Backdrop: more human capital $\rightarrow$ higher (baseline) exposure to on-the-job wage risk under short-term contracting.

- If the long-term contract is not constrained by the incumbent's incentive compatibility constraint in the low-price state $z = 2$:
  - Human capital does not matter for the worker's exposure to on-the-job risk under long-term contracing.
  - More human capital $\rightarrow$ more insurance within the firm (since insurance within the firm is the difference between the worker's baseline exposure to wage risk and the exposure under long-term contracting).
- If the long-term contract is constrained by the incumbent's incentive compatibility constraint in the low-price state $z = 2$...

Human capital as a commitment device

Proposition 5: *An increase in the worker's human capital h will be associated with less on-the-job risk-sharing, i.e.*

$$\frac{\partial}{\partial h} dW_1 - dW_2 \geq 0,$$

in the following cases,

(i) *Under short-term contracting, the incumbent can employ the worker in the low-price state $z = 2$ by paying her a wage $w_2 = f(w_1)$ below the wage $\underline{w}$ that the worker can earn outside the industry.*

(ii) *Under short-term contracting, the incumbent can employ the worker in the low-price state $z = 2$ by paying her a wage $w_2 = \hat{w}_2$ which matches the wage $\hat{w}_2 \geq \underline{w}$ the worker gets offered by other firms in the industry, and*

$$\frac{\partial \hat{w}_2}{\partial h} \leq -c'(h).$$

Training and on-the-job wage risk under long-term contracting

Corollary 5.1: If the conditions in Proposition 5 hold, then an increase in the worker's human capital will increase her exposure to on-the-job wage risk under long-term contracting, i.e.

$$\frac{\partial}{\partial h} W_1 - W_2 \geq 0.$$