Will Fund Managers Survive to the Advent of Robots
An Optimal Contracting Approach

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Outline

Content:

Figure: ©:Vincent Fournier

Introduction

High-skill jobs are at threat of automation:

- Acemoglu and Restrepo (2018): "The automation of the complex tasks in which high-skill workers specialize [...] is on its way to becoming a potent force in the US labor market".

In particular, robots are able to drive funds:

- 2017 McKinsey report on automation in banking: "Technology-enabled process transformations are driving efficiency, consistency, speed, and better outcomes".

A striking illustration :
In 2017 : BlackRock has replaced some portfolio managers by algorithms to "change [its] ecosystem" according to its CEO.

And there is empirical evidence that such change in the contractual environment alter contracts:
Robots are eating into hedge fund managers pay (Bloomberg, 2018):

- The Annual Asset Management compensation study by Greenwich Associates (2018) shows that the advent of robots limits the managers' compensation pool.

Research Question

How does foreseeing the advent of robots alter the incentives to provide ?

Which are the fund managers the most at risk of automation ?

Why does the advent of robots decrease fund managers' bonuses ?

Main results

When a potential substitute is foreseen, **the optimal contract distorts the provision of incentives over time :**

- Boosts the fund manager's value to secure the delegation the advent of robots,
- Lets the representative investor reassess the value of the fund manager at the advent of robots and then it decreases the agency rent that the fund manager is able to extract.

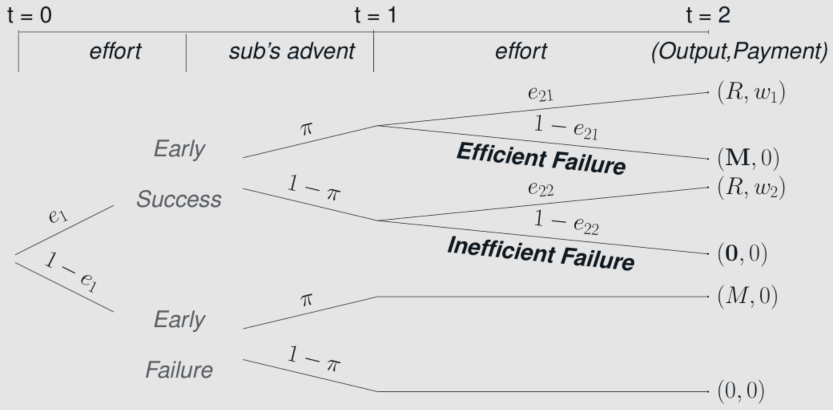
Main empirical prediction:

- The optimal contract has a skimming effect : the agents that have poorly performed up to the advent of robots are instantaneously laid off.

Discrete-time model

- one representative investor (the principal) and one fund manager (the agent)
- 2 period model: t= 0, 1, 2
- Incentive the agent to exert effort twice
- Robot may appear at t = 1 (interim stage) with proba π
- contract's termination and automation (if any) occurs at t = 2
- If automated, fund value is M
- If agent successful up to t = 2: fund value $R > M$ (active management is unique to the agent and can generate more value)
- Otherwise, project's value is 0.
- Principal observes payoff $(0, M, R)$ at date 2, and pays only to a successful agent

Discrete-time model



Discrete-time model

- The representative investor wants more effort to be exerted when the termination is more inefficient
- Thus, compensation is contingent on the availability of the substitute at the interim stage

Fix an arbitrary contract $\Pi = \{w_1, w_2\}$. At interim stage, the agent exerts $e_2 = \{(e_{21}, e_{22})\}$ s.t.

$$\max_{e_{2i}} \left[e_{2i} W_i - \frac{e_{2i}^2}{2} \right] \tag{1}$$

So he exerts at date 2 the effort strategy $e_2^* = \{w_1, w_2\}$.
e_1 solves

$$\max_{e_1} \left[e_1 \left(\pi \frac{w_1^2}{2} + (1-\pi) \frac{w_2^2}{2} \right) - \frac{e_1^2}{2} \right] \tag{2}$$

and it gives $e_1^* = (\pi w_1^2 + (1-\pi) w_2^2)/2$.

The representative investor's problem is:

$$\max_{w_1,w_2} \left[\frac{1}{2}(\pi w_1^2 + (1-\pi)w_2^2)\left(\pi(-w_1^2 + (R-M)w_1) + (1-\pi)(-w_2^2 + Rw_2)\right)\right. \quad (3)$$

subject to:

$$e_1 \in [0,1] \iff 0 \le \pi w_1^2 + (1-\pi)w_2^2 \le 2 \quad (4)$$
$$e_{21} \in [0,1] \iff 0 \le w_1 \le 1 \quad (5)$$
$$e_{22} \in [0,1] \iff 0 \le w_2 \le 1 \quad (6)$$

Which gives:

$$\mathbf{\Pi}^* = (\frac{\mathbf{3}}{\mathbf{4}}(\mathbf{R}-\mathbf{M}); \frac{\mathbf{3}}{\mathbf{4}}\mathbf{R})$$

▸ Go to my figure in continuous-time

Literature review I

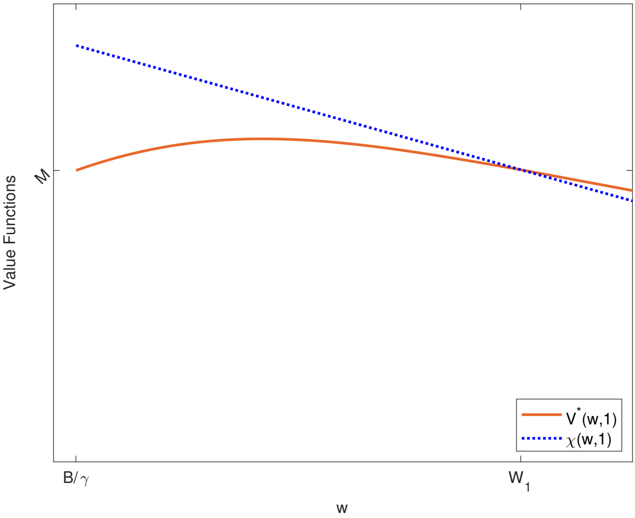
Continuous-time Principal-Agent framework of an everlasting fund that builds on:

P. DeMarzo and Y. Sannikov
Optimal Security Design and Dynamic Capital Structure in a Continuous-Time Agency Model.
The Journal of Finance, 2006

- Agency Friction
- Arithmetic Brownian Motion
- Lump-Sum Payments

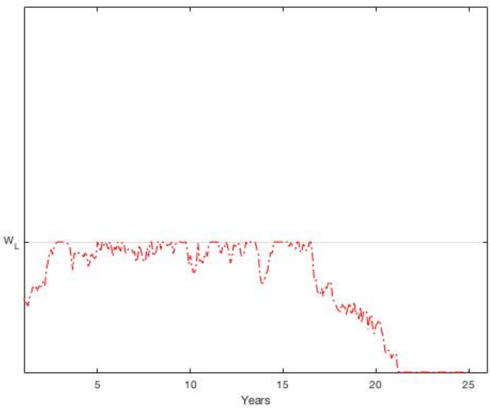
Illustration

Fund value V is concave in the manager's continuation value W.



Illustration

The manager's continuation value evolves stochastically between two boundaries. Payments are backloaded : only given when the process hits the upper boundary. At lower boundary : termination of the contract.



Substitute

We embed a forthcoming **real option** held by the principal: the technology of automation (the robot)

- Its advent is stochastic and out of scope of the firm and the agent
- Its implementation is irreversible

According to **Acemoglu and Restrepo (2018)**, automation substituting to agents offers "both descriptively realistic and leads to distinct and empirically plausible predictions".

Literature review I

Related to Reward for luck papers

F. Hoffmann and S. Pfeil
Reward for Luck in a Dynamic Agency Model.
Review of Financial Studies, 2010

Study how a lucky event (on the instantaneous profitability of the agent) impacts the contract.
Optimal compensation does not filter out this shock.

Continuous-time Model

Main Hypothesis

- **Full Commitment** to a long-term contract $\Pi = ((U_t)_t; \tau)$
- **Limited liability**
- Risk-neutrality
- Agent is more impatient than the principal
- Principal is deep-pocket

Fund Value: $dX_t = \underbrace{a_t \mu dt}_{\text{driven by effort}} + \sigma \underbrace{dZ_t^a}_{\text{with uncertainty of the fund}}$

Maximal value of the actively managed fund:

$$\mathbb{E}\left[\int_0^\infty e^{-rt}(\bar{a}\mu dt + \sigma dZ_t^{\bar{a}})\right] = \frac{\bar{a}\mu}{r}$$

$a \in \{0; \bar{a}\}$ unobservable : Moral-Hazard

At date T, the technology of automation arises $\sim Exp(\lambda)$

The value of the automation fund is noted M (It may be for instance the value of tracking the market return of the same basket of securities). $M >_0$, where $M_0 isthebestalternativeavaialblefromtheoutset$.

Agent is responding to a fixed and arbitrary contract by an effort strategy $a(\Pi) = \{(a_t(\Pi))_t \in \{0; \bar{a}\}, 0 \leq t < \tau\}$.

When no effort is exerted, he gets a private benefit Bdt.

$$V_t^{Agent}(\Pi) = \mathbb{E}^a \left[\int_t^\tau e^{-\gamma(s-t)} (dU_s + \frac{B}{\bar{a}}(\bar{a} - a_s)ds) + e^{-\gamma\tau} \frac{B}{\gamma} \right] \qquad (7)$$

$\frac{B}{\bar{a}}$: severity of moral hazard

$\frac{B}{\gamma}$: value of perpetual private benefit.

As an answer to a fixed and arbitrary contract Π, the *incentive-compatible* effort process $a^*(\Pi) = (a^*(\Pi))$ verifies :

$$\mathbb{E}^{a^*(\Pi)}\left[\int_0^\tau e^{-\gamma t}(dU_t + \tfrac{B}{\bar{a}}(\bar{a} - a_t^*(\Pi)dt) + e^{-\gamma\tau}\frac{B}{\gamma}\right] \geq$$
$$\mathbb{E}^{a}\left[\int_0^\tau e^{-\gamma t}(dU_t + \tfrac{B}{\bar{a}}(\bar{a} - a_t)dt) + e^{-\gamma\tau}\frac{B}{\gamma}\right]$$

The principal's problem is

$$max\left(M_0; V\right) \tag{8}$$

where V satisfies:

$$V = \sup_{\Pi} \mathbb{E}^{a^*(\Pi)} \left[\int_0^{\tau} e^{-rt} (a^*(\Pi)\mu dt - dU_t) + e^{-r\tau} \tilde{M} \right] \tag{9}$$

s.t.

- Π is incentive compatible
- Π satisfies the participation constraint.

Values as functions of the states variables

As it is standard in agency models in continuous time: we reformulate the problem as a function of the state variables: $(W_t)_t$ and $(H_t)_t$

- fund value before advent of substitute: $V(w_t, h_t = 0)$
- fund value after the advent: $V(w_t, h_t = 1)$

Applying the Martingale Representation Theorem, there is a unique pair of processes $\mathcal{G}_t$-predictable and square-integrable $((\beta_t)_{t\leq\tau}, (\delta_t)_{t\leq\tau})$ such that the continuation value of the agent evolves as

$$dW_t = (\gamma(W_t - \frac{B}{\gamma}) - \frac{B}{\bar{a}}(\bar{a} - a_t))dt \qquad (10)$$

$$+ \sigma\beta_t dZ_t^a + \delta_t(dH_t - \lambda dt) - dU_t \qquad \text{for } t \leq \tau$$

Controlled Sensitivities and Limited Liability

- Applying the Martingale Optimality Principle, $(\beta_t^{\Pi})_{t\leq\tau}$ guarantees I.C. effort iff

$$\beta_t \geq \underline{\beta} \qquad \text{for } t \leq \tau \tag{11}$$

where $\underline{\beta} = \frac{B}{\bar{a}\mu}$.

The contract must satisfy the L.L. condition until termination

- Termination for incentive reasons at $\tau^{w}_{\frac{B}{\gamma}} = inf\{t \geq 0 \mid W_t = \frac{B}{\gamma}\}$
- At any moment, $\delta_t \geq \underline{\delta} := \frac{B}{\gamma} - W_t$

Markovian formulation

$$V^p(w_0) = \max(\max_{w \geq w_0} V(w,0); M_0) \tag{12}$$

where

$$V(w,0) =$$

$$\sup_{\beta \geq \underline{\beta}; \delta \geq \underline{\delta}} \left(\sup_{U; \tau \leq \tau^w_{\frac{B}{\gamma}}} \mathbb{E}^{a^*} \left[\int_0^\tau e^{-rt}(a^* \mu dt - dU_t) + e^{-r\tau}(\nu \vee M) \right] \right) \tag{13}$$

together with

$$a^* = (\bar{a} 1_{\{\beta \geq \underline{\beta}\}})_{t \leq \tau},$$

$$dW_t = (\gamma(W_t - \frac{B}{\gamma}) + \sigma \beta_t dZ_t^{a^*} + \delta(dH_t - \lambda dt) - dU_t \tag{14}$$

$$\text{with } W_0 \geq w_0 \tag{15}$$

Solution

- The contracting problem is to find :
  - an ICC maximizing the fund value
  - delivering to the fund manager his reservation utility
  - satisfying the limited liability constraint
- The solution of this problem is found backward
  - Fund Value functions are forward looking processes!
- We assume that the fund manager may perform better than the robot, i.e. $\frac{\bar{a}\mu}{r} > M$ (otherwise, fund management disruption : every fund are instantaneously automated at the advent of robots).

The optimal contract after the advent of the technology

The dynamics of the manager's continuation value are:

$$dW_t = \gamma(W_t - \frac{B}{\gamma})dt + \sigma\underline{\beta} dZ_t - dU_t \tag{16}$$

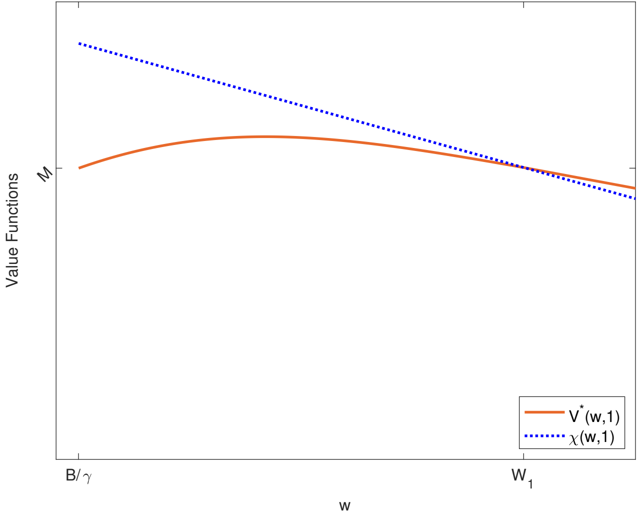
The fund value is characterized by the following HJB equation:

$$V(w,1) = \frac{\bar{a}\mu}{r} + \frac{\gamma}{r}(w - \frac{B}{\gamma})V'(w,1) + \frac{\underline{\beta}^2\sigma^2}{2r}V''(w,1) \quad \text{if } w \in [\frac{B}{\gamma}; \bar{W}_1]; \tag{17}$$

together with :

- $V(\frac{B}{\gamma}, 1) = M$ (value-matching condition);
- $V'(\overline{W}_1, 1) = -1$ (smooth-pasting condition) ;
- $V''(\overline{W}_1, 1) = 0$ (super-contact condition).

Illustration



The optimal contract before the advent of the substitute

The dynamics of the manager's continuation value are:

$$dW_t = \gamma(W_t - \frac{B}{\gamma})dt + \sigma\underline{\beta}dZ_t^{\bar{a}} + \delta_t(dH_t - \lambda dt) - dU_t \qquad (18)$$

The fund value is characterized by the following HJB equation:

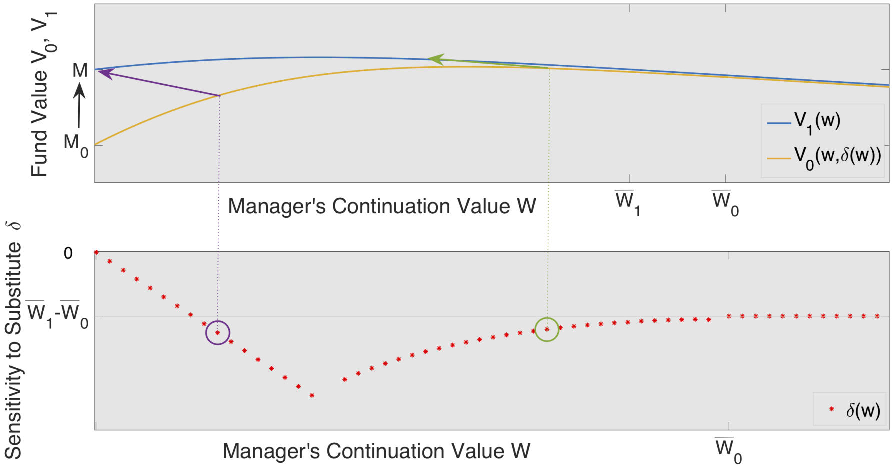
$$(\lambda + r)V(w,0) = \bar{a}\mu + \left(\gamma(w - \frac{B}{\gamma}) - \lambda\delta^*(w)\right) V'(w,0)$$
$$+ \frac{1}{2}\underline{\beta}^2\sigma^2 V''(w,0) + \lambda V\left(w + \delta^*(w), 1\right) \quad \text{if } w \in [\frac{B}{\gamma}; \bar{W}_0]; \qquad (19)$$

together with :

- $V(\frac{B}{\gamma}, 0) = M_0$ (value-matching condition);
- $V'(\overline{W}_0, 0) = -1$ (smooth-pasting condition) ;
- $V''(\overline{W}_0, 0) = 0$ (super-contact condition).

The optimal contract before the advent of the technology

- $\beta^* = \underline{\beta}$
- δ^*
  - satisfies by the FOC : $V'(w, 0) = V'(w + \delta^*(w), 1)$
  - but is constrained by the limited liability condition!


Fund Value V_0, V_1
M
M_0
$V_1(w)$
$V_0(w,\delta(w))$
Manager's Continuation Value W
$\overline{W}_1$
$\overline{W}_0$
Sensitivity to Substitute δ
0
$\overline{W}_1$-$\overline{W}_0$
$\delta(w)$
Manager's Continuation Value W
$\overline{W}_0$

The optimal response to the advent of a technology of automation

- At T, the representative investor reassesses the fund manager's value : he makes it drop by $\delta^*(W_T) < 0$.
- To compensate the fund manager for bearing such risk, his value was boosted up to T by $-\lambda\delta^*(W_T) > 0$.
- Thus, the presence of the martingale jump term only increases the efficiency of the contract!

The optimal response to the advent of a technology of automation

The optimal contract distorts the provision of incentives over time:

- Boosts the fund manager's value of continuation before the advent of robots to postpone the termination of the contract when it will become more efficient
- Let the representative investor reassess the fund manager's value at the advent of robots, and then increases the threat of termination

Empirical implications

- Provide theoretically-grounded prediction of Blackrock's substitution of 13% of their portfolio managers **Skimming Effect of the Optimal Contract**.

- Greenwich Associates' Annual Asset Management Compensation Study, claims that bonuses decrease because investment have eaten the compensation pool. Offers an alternative explanation to the decrease in bonuses of fund managers after the advent of robots : **Automation decreases the agency rent.**.

- Corroborate the depressing effect of automation on wages
  - the reduction of equilibrium wages due to the ability to automate observed by Acemoglu and Restrepo (2018)