Growth Options, Incentives, and Pay-for-Performance: Theory and Evidence

Sebastian Gryglewicz (Erasmus)
Barney Hartman-Glaser (UCLA Anderson)
Geoffery Zheng (UCLA Anderson)

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How do growth opportunities affect managerial incentives?

- Manager effort increases productivity of assets in place and future assets.
  - Leads to interaction between growth opportunities and incentives.
- We find evidence that larger growth opportunities are associated with lower incentives as measured by exposure to firm value.

- Growth options generate convexity of firm value in productivity.
- We show that optimal incentives should account for the convexity of firm value.
- In particular, low sensitivity of pay to firm value does not mean low-powered incentives.

Real options investment

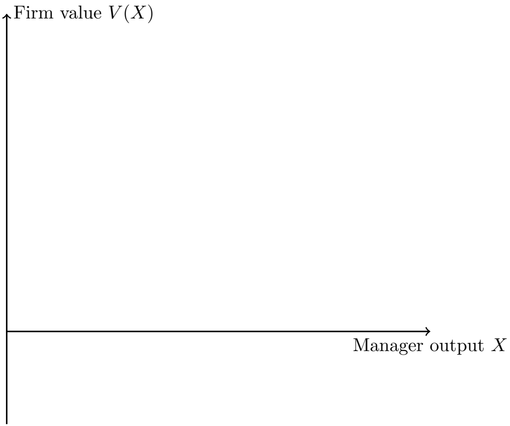
Real options approach is a useful investment model to capture the idea of growth opportunities.

- When cash flows per capital (or productivity) are sufficiently high, firms invest.
- Optimal investment policy given by a *threshold* at which investment option is exercised.
- Firm value comprises of the value of assets in place plus the value of growth options.

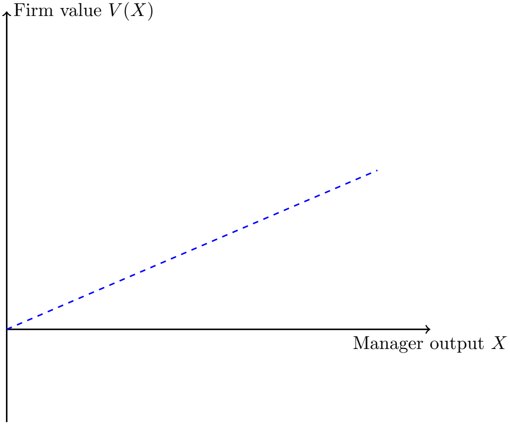
Agency conflicts affect real options

- In the standard model, firm cash flows/productivity are exogenous.
- In reality, a manager is required to increase and maintain productivity.
- If effort is unobservable, a moral hazard problem arises.

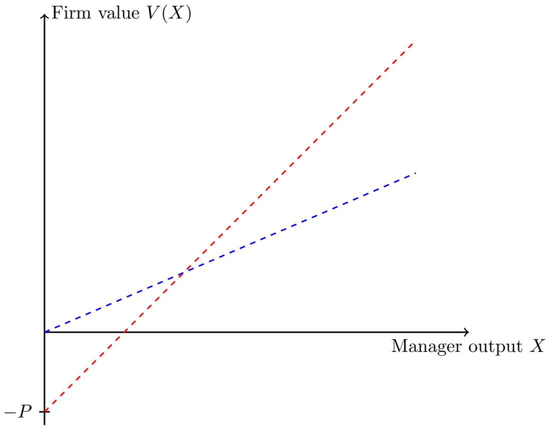
Basic intuition



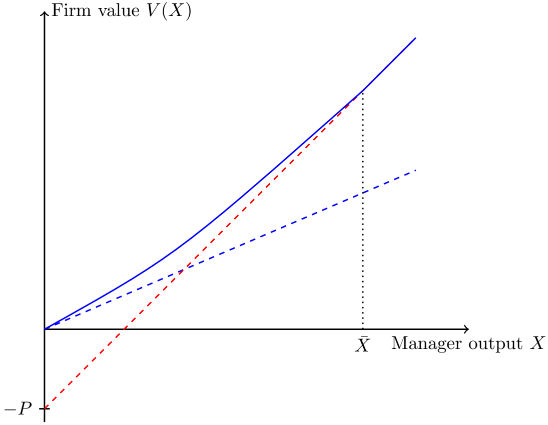
Basic intuition



Basic intuition



Basic intuition



To provide *the same* incentives to generate manager output, less exposure is needed to firm value with growth options.

Literature review

- Dynamic contracting in continuous time
  - DeMarzo and Sannikov (2006), Biais, Mariotti, Plantin, and Rochet (2007), Sannikov (2008), DeMarzo, Fishman, He, and Wang (2012)
  - He (2011), Gryglewicz and Hartman-Glaser (2015)
- Agency problems and investment
  - Grenadier and Wang (2005), DeMarzo and Fishman (2007), DeMarzo, Fishman, He, and Wang (2012)
  - Gryglewicz and Hartman-Glaser (2015)

Model overview

- Continuous time dynamic moral-hazard model a la Sannikov (2008) and He (2011).
  - A risk-neutral investor owns a firm and contracts with a manager to run the firm.
  - The manager controls growth rate of cash flows through costly hidden effort.
- Classic real-options problem a la Brennan and Schwartz (1985).
  - The firm starts with some capital.
  - The investor has a one-time option to irreversibly increase capital by a fixed amount.

Dynamic moral hazard

- Time is infinite and continuous and the risk free rate is r.
- A risk-neutral investor (the principal) hires a risk-averse manager (the agent) to operate a firm.
- The firm produces cash flow $X_t K_t dt$, where X_t is productivity and K_t is capital.
- Prior to investment, X_t is given by

$$dX_t = a_t \mu X_t dt + \sigma X_t dZ_t,$$

  where $a_t \in [0, 1]$ is the manager's effort, Z_t is standard Brownian motion.
- After investment at time τ, productivity stays at X_τ forever.
- Effort is unobservable to the investor and costly to the manager.
- The manager may maintain hidden savings (or debt) at the risk-free rate.

Real option to invest

- The firm begins with capital $K_0 = k_s$.
- At any time, the firm can irreversibly increase capital to $k_b > k_s$ at cost P.
- Investment is observable and contractable.
- The investor always has sufficient funds to pay the cost of investment.

The manager's preferences

- The manager has CARA preferences over consumption and effort:

$$u(c_t, a_t) = -\frac{1}{\gamma} e^{-\gamma(c_t - g(a_t) X_t)},$$

  where $g(a_t)$ is the managers normalized cost of effort in units of consumption.

- $g(a)$ a smooth increasing convex function such that an optimal contract will specify interior effort in $(0, 1)$.

- Why is the cost of effort proportional to productivity?
  - It is more difficult and costly for the manager to improve productivity of an already productive firm.

Contracts

- A contract is denoted by $\Pi(\{c_t, a_t\}, \tau)$.
- c_t is the manager's time t recommended consumption (with no savings, it is equal to compensation).
- a_t is the recommended effort level.
- τ is a stopping time specifying the timing of investment, contractable and observable.

Deriving the optimal contracts

1. Restrict attention to incentive-compatible no-savings contracts.
2. Find simple condition relating manager's flow utility to her continuation utility imposed by no-savings restriction.
3. Given a contract, characterize the dynamics of the manager's continuation value W_t.
4. Find an incentive-compatibility condition.
5. Using dynamic programing technique to derive HJB equations for the investor's value.
6. The HJB equation simplifies to an ODE for total firm value (investor's value + CE of manager's value) in X only.

The HJB equation

- $V(X)$ satisfies the following HJB equation:

$$rV = \max_{a\in[0,1]} \left\{ Xk_s - g(a)X - \rho(a,X) + a\mu XV' + \frac{1}{2}\sigma^2 X^2 V'' \right\}.$$

- ρ is the incentive cost of effort:

$$\rho(a,X) = \frac{1}{2}\gamma r\sigma^2 \left(\frac{g'(a)}{\mu}\right)^2 X^2.$$

- Value function after investment equals $(X_\tau k_b)/r$.

The optimal investment time

- Optimal investment time given by standard threshold rule

$$\tau = \inf\{t, X_t \geq \overline{X}\}.$$

- $\overline{X}$ is determined by value-matching and smooth-pasting conditions:

$$V(\overline{X}) = \frac{\overline{X} k_b}{r} - P,$$
$$V'(\overline{X}) = \frac{k_b}{r}.$$

Pay-performance sensitivity (PPS)

- The certainty equivalent of the manager's value, Y_t, can be interpreted as the manager's dollar value.
- The sensitivity of Y_t to the changes of a performance metric is a measure of the manager's incentives in our model.

Two measures of PPS

- Output based: sensitivity of manager's continuation value to productivity shocks
$$\beta_t = \frac{g'(a_t)}{\mu}.$$
  - Directly measures managers incentives to exert effort.
  - Can be difficult to measure empirically.
- Value based: sensitivity of manager's continuation value to dollar changes in firm value:
$$\phi_t = \frac{\beta_t}{V'(X_t)}.$$
  - Corresponds to Jensen and Murphy (1990)'s measure of PPS.
  - Scales incentives by sensitivity of firm value to productivity.
  - Easy to measure empirically and easy to implement.

Incentives and growth options

Keeping everything else constant, an increase in post-investment capital k_b makes the growth option larger and more valuable.

Proposition

Output-based incentives for the manager always increase in k_b. Value-based incentives decrease in k_b if the cost of effort is increasingly convex, $g'''(a) > 0$.

- Optimal effort increases in the size of the growth option, incentives β_t must also increase.
- Increasing the growth option also increases $V'(X)$, the sensitivity of firm value to productivity — makes the firm more "risky".
- The manager does not need exposure to this additional risk for incentives and value-based PPS ϕ_t can decrease if managerial effort is not too cheap.

Empirical strategy

- Measuring output-based PPS is a daunting task as manager output is not observable.
- We aim at analyzing the association of value-based PPS and growth options.

- PPS: Standard Jensen and Murphy (1990)'s PPS.
- Growth options: a number of proxies.

Data

- U.S. public firms in 1992-2010.
- Exectutive-firm observations from Execucomp.
- Other data from CRSP/Compustat.

- Dependent variable: log of dollar-to-dollar Jensen and Murphy (1990)'s PPS.
- Independent variables: Firm Size, Firm Age, Tangibility, Profitability, Advertisement, Leverage, Dividend Paying, CEO Chair, Fraction of Inside Directors, CEO, Female (all lagged one year).

Market-to-Book proxy

	(1)	(2)	(3)
Market-to-Book	-0.055^{**}	-0.060^{**}	-0.037^{**}
	(-7.23)	(-5.88)	(-6.28)
Firm Size	-0.406^{**}	-0.361^{**}	-0.327^{**}
	(-46.36)	(-32.57)	(-16.79)
Controls	No	Yes	Yes
Industry FE	Yes	Yes	No
Firm-Manager FE	No	No	Yes
Year FE	Yes	Yes	Yes
Observations	128974	70260	70269
R^2	0.276	0.496	0.126

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

Value-to-Book proxy

- Market-to-Book can proxy for (mis)valuation of stock.
- Following Rhodes-Kropf, Robinson, and Viswanathan (2005) and Lyandres and Zhdanov (2013) we replace Market by estimated "true" Value.
- Estimate of Value-to-Book is a size adjusted industry-year mean Market-to-Book ratio.

Value-to-book proxy

	(1)	(2)	(3)
Value-to-Book	-0.052^{*}	-0.070^{**}	-0.029^{*}
	(−2.24)	(−2.59)	(−1.99)
Firm Size	-0.403^{**}	-0.365^{**}	-0.312^{**}
	(−45.46)	(−32.72)	(−16.04)
Controls	*No*	*Yes*	*Yes*
Industry FE	*Yes*	*Yes*	*No*
Firm-Manager FE	*No*	*No*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*
Observations	128995	70275	70284
R^2	0.274	0.495	0.124

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

R&D proxy

	(1)	(2)	(3)
R&D	-0.557^{*}	-0.824^{**}	-0.562^{*}
	(-2.49)	(-2.67)	(-2.03)
Firm Size	-0.429^{**}	-0.401^{**}	-0.308^{**}
	(-41.04)	(-30.48)	(-11.85)
Controls	*No*	*Yes*	*Yes*
Industry FE	*Yes*	*Yes*	*No*
Firm-Manager FE	*No*	*No*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*
Observations	67180	38125	38129
R^2	0.277	0.527	0.121

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

Exercise of Growth Options proxies

- Following Purnanandam and Rajan (2016), we use variables related to (unexpected) capital expenditures to proxy conversion of growth options into assets in place.
- First, use CapEx, in particular with firm fixed effect.
- Second, use residual from a first-order regression on CapEx.

Capital Expenditure proxy

	(1)	(2)	(3)
CapEx	0.470*	1.622**	0.391**
	(1.99)	(5.04)	(2.68)
Firm Size	−0.396**	−0.359**	−0.310**
	(−44.23)	(−31.73)	(−15.32)
Controls	*No*	*Yes*	*Yes*
Industry FE	*Yes*	*Yes*	*No*
Firm-Manager FE	*No*	*No*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*
Observations	122522	67241	67250
R^2	0.277	0.499	0.124

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

Capital Expenditure Residual proxy

	(1)	(2)	(3)
CapEx Residual	0.550	1.201**	0.258*
	(1.92)	(4.03)	(2.13)
Firm Size	−0.384**	−0.354**	−0.308**
	(−35.91)	(−27.25)	(−13.52)
Controls	*No*	*Yes*	*Yes*
Industry FE	*Yes*	*Yes*	*No*
Firm-Manager FE	*No*	*No*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*
Observations	69326	46206	46211
R^2	0.273	0.511	0.124

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

Conclusion

- With our model, we interpret the negative correlation of PPS and growth options not as low incentives but as a reflection of efficient incentives with a sensitive exposure to firm value.

- It is easier to incentivize a manager by exposing her to firm value in a firm with growth options.
- Even accounting for higher required manager effort, the optimal exposure to firm value can decrease in the size of growth options.
- Pay-performance sensitivity measures should account for growth opportunities.