Young, Restless and Creative: Openness to Disruption and Creative Innovations

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Creative Innovations

- More than half a million patents per year are granted in the U.S.
- Only a handful are truly transformative:
  - Amazon^{TM}s patent for "method and system for placing a purchase order via a communications network"
    - 263 citations within 5 years (median: 5)
- **Argument:** a key determinant of creative innovations is a society's or an organization's openness to disruption.
- Captured by Facebook's inscription on its headquarter walls: *"move fast and break things."*
- A function of the "corporate culture" of a company and potentially related to social norms, "national culture" or institutions.

Roadmap

- **Theory:** We first provide a simple model of the interplay between "corporate culture "(firm type) and innovation strategies.
  - Firms can do radical and/or incremental innovations.
  - Skills of young managers who have more recently acquired general skills can be fruitfully utilized in the process of radical innovation.
  - Prediction: reduced-form cross-sectional and within-firm relationship between manager and creativity of innovations.
    - Not necessarily causal: Manager age is also a proxy for openness for disruption.
- **Empirics:** We investigate whether companies with younger CEOs or managers engage in more radical and creative innovations.
  - In addition, using indirect inference we quantify:
    - causal effect of manager age on creative innovations
    - sorting effect

Model

- Economy consists of continuum of product lines along the circle $\mathcal{C}$.
- Each product line has a quality q_j.
- Profits for a monopolist with a leading-edge product quality q_j:

$$\pi\left(q_j\right) = \beta q_j.$$

- Two types of firms (θ_H, θ_L), distinguished by their "corporate culture" determining their openness to disruption and radical innovation.
  - $\theta_H = 1 > \theta_L = 0$
  - follows a Markov chain

Managers

- When a manager is born, she acquires knowledge of the average technology in the period that she is born:

$$\bar{q}_b \equiv \int_{\mathcal{C}} q_{jb} dj.$$

- Manager of age $a \equiv t - b$ has two contributions:
  1. cost reduction by the amount of $f(a)\bar{q}_t$.
  2. producing more radical innovations

Innovations

- Firms choose between two types of innovations:
  1. *incremental innovations:* improvements within a given *technology cluster*.
  2. *radical innovations*: starts a new technology cluster.
- Incremental innovation:
  - Arrives at the rate ξ
  - Improves the latest quality q_j:

$$q_{j,t+\Delta t} = q_{j,t} + \eta_n(q_j, \bar{q}_t)$$

where

$$\eta_n(q_j, \bar{q}_t) = \left[\kappa \bar{q}_t + (1-\kappa)\, q_j\right] \eta \alpha^n$$

and $\alpha < 1$ and n is the number of prior incremental innovations in this technology cluster.

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Innovation: Radical Innovations

- Radical innovation arrives at the rate

$$\theta \left[\psi + \Lambda \frac{\bar{q}_b}{\bar{q}_t} \right], \tag{1}$$

  - θ : Firm type, corporate culture, openness to disruption
  - ψ : arrival independent of manager
  - $\frac{\bar{q}_b}{\bar{q}_t} \equiv \bar{q}^a$: impact of manager as a function of its age
  - $\Lambda < 1$: institutional restrictions on manager's radical innovation

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Stationary Equilibrium Characterization

Proposition

- *Low-type firms ($\theta = \theta_L$) hire "old" managers ($a > a^*$), pursue incremental innovations.*
- *High-type firms ($\theta = \theta_H$) generate radical innovations at the rate $\theta\psi$.*
- *High-type firms pursue radical innovations on product lines with more than $n^*(q)$ prior incremental innovations (where q is current productivity), and hire "young" managers ($a \leq a^*$), generating radical innovations at the additional rate $\Lambda\bar{q}^a$.*
- *$n^*(q)$ is decreasing in q—radical innovations less likely for currently more productive firms.*

- Within-firm prediction: after switching from low-type to high-type, a firm on average increases radical innovation rate to ψ and then after additional incremental innovations, it switches to a younger manager and increases the rate of radical innovation further.

Firm-Level Results

- Baseline **balanced** sample comprises 279 with complete information between 1995 and 2000.
- **Unbalanced** sample extended to 1992-2004 for all firms with CEO age or patent information.
- Use average manager/CEO age as proxy for a corporate culture that is more open to disruption.
- All regressions are weighted by patent counts and include: firm age, log employment, log sales and log patent counts.
- Robust standard errors are in parentheses.

Firm-Level Results

Table 2: Baseline Firm-Level Regressions

	Innovation Quality	Superstar Fraction	Tail Innovation	Generality
CEO age	-0.278	-0.300	-0.151	-0.183
	(0.088)	(0.141)	(0.054)	(0.055)
firm age	-0.219	-0.238	-0.063	0.029
	(0.078)	(0.106)	(0.029)	(0.046)
log employment	-1.599	-4.813	-0.908	-4.574
	(1.937)	(3.376)	(0.793)	(1.500)
log sales	1.833	5.215	0.743	4.421
	(1.425)	(2.645)	(0.650)	(1.331)
log patent	1.073	0.093	0.662	-0.696
	(0.769)	(1.336)	(0.356)	(0.633)
R^2	0.88	0.81	0.79	0.83
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Table 5: Firm-Level Panel Regressions

	Innovation Quality	Superstar Fraction	Tail Innovation	Generality
Panel C: CEO Age (Fixed Effects), Unbalanced Firm Sample, 1992-2004				
CEO age	-0.188	-0.149	-0.076	0.036
	(0.044)	(0.051)	(0.023)	(0.029)
R^2	0.78	0.80	0.44	0.85
N	7,111	7,111	5,803	6,232
Panel F: CEO Age and Lead CEO Age (Fixed Effects), Unbalanced Firm Sample, 1992-2003				
CEO age	-0.113	-0.084	-0.042	0.042
	(0.042)	(0.048)	(0.019)	(0.029)
lead CEO age	-0.125	-0.109	-0.043	-0.007
	(0.049)	(0.044)	(0.022)	(0.028)
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Table 8: Patent-Level Panel Regressions

	Innovation Quality	Tail Innovation (Above 99)	Tail Innovation (Above 90)	Generality
Panel E: CEO Age and Inventor Age, Unbalanced Firm Sample, 1992-2004				
CEO age	-0.119	-0.317	-1.218	0.028
	(0.036)	(0.126)	(0.388)	(0.022)
inventor age	-0.233	-0.438	-2.876	-0.019
	(0.026)	(0.121)	(0.321)	(0.022)
R^2	0.14	0.03	0.09	0.15
N	316,516	316,516	316,516	263,641

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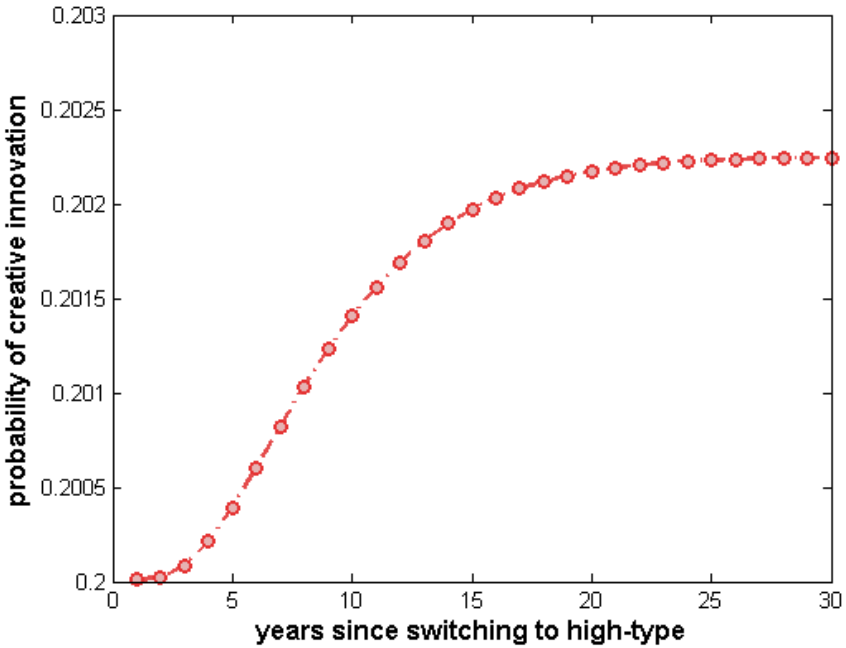
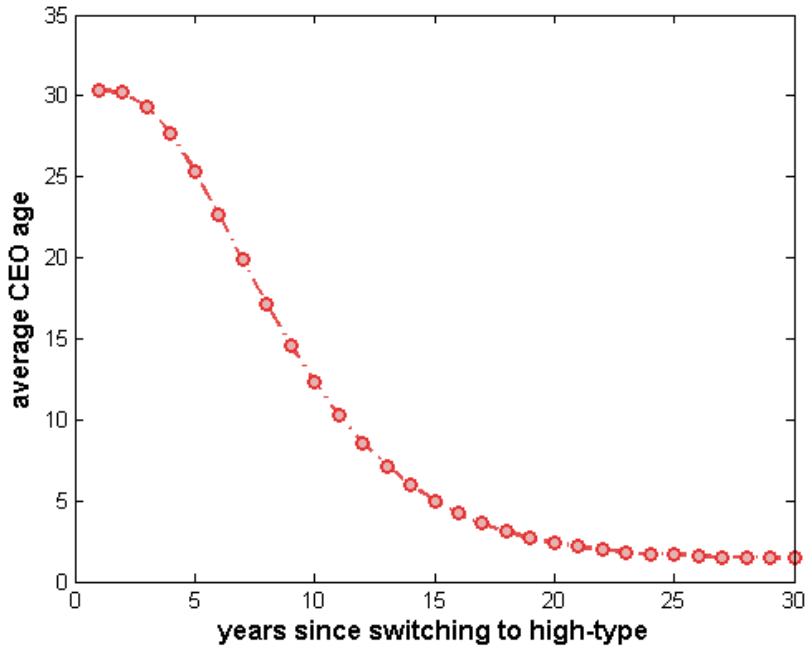
Indirect Inference: Causal vs Sorting Effects

- Sorting or the causal effect of manager age?
- We use indirect inference procedure utilizing the structure of our model to obtain an estimate of the size of this causal effect of manager age on creative innovations.
- **Exogenous Calibration**
  - discount rate to $\rho = 0.02$
  - normalize $\pi = 1$
  - entry rate $x = 0.05$
  - exit rate δ : fit and exponential distribution to the age distribution of managers in our sample.

- **Indirect Inference:** With the remaining parameters, we target:
  - sales per worker growth
  - share of young managers (age < 45)
  - probability of switching to younger manager
  - ratio of the coefficients of lead to current CEO age of Table 5F.

Indirect Inference: Identification





- **Thought experiment:** A firm wishing to hire a young manager is prevented from doing so.

- **Finding:** Causal effects explain less than 1% of the relationship between CEO age and creative innovations—, the rest being due to corporate culture and sorting effects .

- Consistent with the importance of corporate culture, it is a combination of inventor age and CEO age that matters for creative innovations.

Stock of Knowledge and Opportunity Cost Effect

- Is it—as predicted by theory—currently less productive firms that are more likely like you to switch to radical innovation?

Table 10: Stock of Knowledge, Opportunity Cost, and Creative Innovations, Unbalanced Firm Sample, 1992-2004

	Innovation Quality	Superstar Fraction	Tail Innovation	Generality
CEO age	-0.180	-0.216	-0.087	-0.044
	(0.027)	(0.027)	(0.017)	(0.016)
log sales	1.465	2.081	0.285	1.201
	(0.449)	(0.611)	(0.272)	(0.328)
log patent	-0.394	-0.072	0.391	-0.020
	(0.193)	(0.257)	(0.136)	(0.151)
CEO age	-0.005	-0.071	-0.016	-0.037
$\times$ log patent	(0.014)	(0.021)	(0.011)	(0.011)
CEO age	0.024	0.079	0.009	0.044
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Cross-country Results

- Similar patterns at the cross-country level.

Table 11: Baseline Cross-Country Regressions

	Innovation Quality	Superstar Fraction	Tail Innovation	Generality
	Panel A: Average Manager Age			
manager age	-0.484	-0.960	-0.225	-0.278
	(0.225)	(0.221)	(0.058)	(0.056)
log income per capita	-0.491	-0.702	-0.136	0.211
	(1.153)	(1.066)	(0.291)	(0.468)
secondary years of schooling	-1.000	-1.359	-0.291	-0.231
	(1.481)	(1.462)	(0.396)	(0.341)
log patent	2.232	2.331	0.591	1.072
	(0.706)	(0.695)	(0.193)	(0.222)
R^2	0.74	0.82	0.80	0.80
N	37	37	37	37

Cross-country Results

- Similar patterns at the cross-country level.

Table 11: Baseline Cross-Country Regressions

	Innovation Quality	Superstar Fraction	Tail Innovation	Generality
	Panel A: Average Manager Age			
manager age	-0.484	-0.960	-0.225	-0.278
	(0.225)	(0.221)	(0.058)	(0.056)
log income per capita	-0.491	-0.702	-0.136	0.211
	(1.153)	(1.066)	(0.291)	(0.468)
secondary years of schooling	-1.000	-1.359	-0.291	-0.231
	(1.481)	(1.462)	(0.396)	(0.341)
log patent	2.232	2.331	0.591	1.072
	(0.706)	(0.695)	(0.193)	(0.222)
R^2	0.74	0.82	0.80	0.80
N	37	37	37	37

Conclusion

- Extending the Schumpeterian approach to innovation by bringing in social incentives and openness to disruption in modeling the creativity of innovations.
- First step in thinking about a broader set of incentives for innovation (and perhaps opening the black box of innovative organizations).
- Much to be done...