Kim, Olmstead-Rumsey, and Wang (2026): "Ideas and Firm Dynamics When It Takes Two to Tango"

Discussion by Lukas Freund

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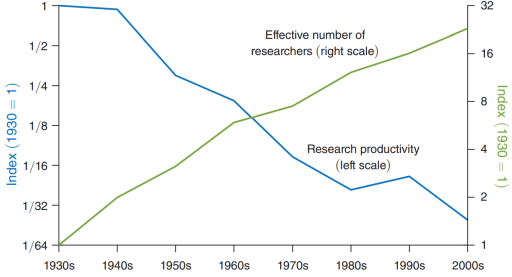
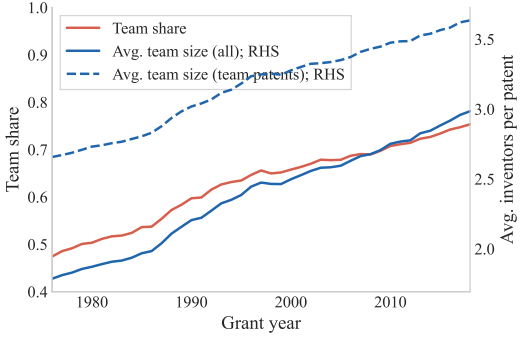
SF Fed Economic Growth Meeting

the Big Picture

(a) Declining research productivity



(b) Rise of team production



Notes. Left panel is Fig. 2 from Bloom-Jones-VanReenen-Webb (2020). Right panel is constructed from Patentsview data, where team size = no. of listed inventors.

The iPhone multitouch patent: a team effort inside Apple

US007479949B2

(12) **United States Patent**
Jobs et al.

(10) **Patent No.: US 7,479,949 B2**
(45) **Date of Patent: *Jan. 20, 2009**

(54) **TOUCH SCREEN DEVICE, METHOD, AND GRAPHICAL USER INTERFACE FOR DETERMINING COMMANDS BY APPLYING HEURISTICS**

(75) Inventors: **Steven P. Jobs**, Palo Alto, CA (US); **Scott Forstall**, Mountain View, CA (US); **Greg Christie**, San Jose, CA (US); **Stephen O. Lemay**, San Francisco, CA (US); **Scott Herz**, San Jose, CA (US); **Marcel van Os**, San Francisco, CA (US); **Bas Ording**, San Francisco, CA (US); **Gregory Novick**, Santa Clara, CA (US); **Wayne C. Westerman**, San Francisco, CA (US); **Imran Chaudhri**, San Francisco, CA (US); **Patrick Lee Coffman**, Menlo Park, CA (US); **Kenneth Kocienda**, Sunnyvale, CA (US); **Nitin K. Ganatra**, San Jose, CA (US); **Freddy Allen Anzures**, San Francisco, CA (US); **Jeremy A. Wyld**, San Jose, CA (US); **Jeffrey Bush**, San Jose, CA (US); **Michael Matas**, San Francisco, CA (US); **Paul D. Marcos**, Los Altos, CA (US); **Charles J. Pisula**, San Jose, CA (US); **Virgil Scott King**, Mountain View, CA (US); **Chris Blumenberg**, San Francisco, CA (US); **Francisco Ryan Tolmasky**, Cupertino, CA (US); **Richard Williamson**, Los Gatos, CA (US); **Andre M. J. Boule**, Sunnyvale, CA (US); **Henri C. Lamiraux**, San Carlos, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(65) **Prior Publication Data**

US 2008/0174570 A1 Jul. 24, 2008

Related U.S. Application Data

(63) Continuation of application No. 11/850,635, filed on Sep. 5, 2007.

(60) Provisional application No. 60/937,993, filed on Jun. 29, 2007, provisional application No. 60/937,991, filed on Jun. 29, 2007, provisional application No. 60/879,469, filed on Jan. 8, 2007, provisional application No. 60/879,253, filed on Jan. 7, 2007, provisional application No. 60/824,769, filed on Sep. 6, 2006.

(51) **Int. Cl.**
G09G 5/00 (2006.01)
G06F 3/048 (2006.01)

(52) **U.S. Cl.** **345/173**; 345/169; 715/786; 715/784

(58) **Field of Classification Search** 345/156, 345/157, 173–181
See application file for complete search history.

(56) **References Cited**

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This paper

- **Connecting piece: the firm size distribution**
  1. Nearly all team patents are produced by inventors within the same firm
  2. Inventors are increasingly concentrated in large firms

- **Model**
  - Hopenhayn-type setup where teams are formed inside the firm
  - Team production raises returns to scale in inventor labor
  - Economy-wide knowledge spillovers that are concave in firm size

- **Key results**
  - Team productivity advantage in innovation has grown from pre- to post-2000
  - This shift can account for the observed rise in inventor concentration
  - Rising concentration lowers knowledge spillovers and thus agg. innovative output

Discussion

- **Great paper** that takes *both* team-based innovation *and* firm boundaries seriously
  - Big questions: rise of teams, rising emp. concentration, declining R&D productivity
  - Link via parsimonious mechanism
  - Thought-provoking policy implications: subsidize small (innovative) firms?

- Three main comments:
  1. What's the relevant boundary to team formation? Likely narrower than entire firm?
  2. What drives the rise of teams? Skill heterogeneity seems key, alternative mechanism.
  3. How to discipline knowledge spillovers? Thorny problem.

Comment #1: What is the relevant boundary of inventor collaboration?

- **Fact 2**: ∼90% of team patents are by inventors at the same firm
  → **"firm boundaries impose meaningful constraints on inventor collaboration"**

- **Novel**: existing team-innovation models assume matching w/o firms

- Paper then assumes that firm boundary determines # of potential pair draws, n
  - Each inventor draws bilateral productivity w every other inventor in firm: $z_{ij} \sim \text{Pareto}(x_{\min}, \gamma)$.
  - Firm assigns each inventor to their best match. By Fisher–Tippett–Gnedenko:

$$\mathbb{E}\left[\max_{j \leq n} z_{ij}\right] = x_{\min}\, \Gamma\left(1 - \tfrac{1}{\gamma}\right) n^{1/\gamma} \propto n^{1/\gamma} \quad \Longrightarrow \quad \text{RTS: } \alpha + \tfrac{1}{\gamma}$$

Comment #1: What is the relevant boundary of inventor collaboration?

- Is the paper not taking its central premise far enough?
- Most patents come from **firms with labs in multiple regions** *[Chikis-Kleinman-Prato, 2025]*
- **Majority of same-firm team patents are by inventors in same area aka "same-lab"**

	All team patents		2-inventor only	
	Same CBSA	Diff CBSA	Same CBSA	Diff CBSA
Same firm	52.3%	36.7%	65.5%	27.7%

Notes. "Location" based on inventor's self-reported address on the patent, geocoded to CBSA. "Same CBSA" only if *all* listed inventors have address in same CBSA = v conservative.

- $\rightarrow$ Mean inventor pool is 2-3 times larger at firm- than at lab-level

This matters for the production-function estimates

▸ More reg. specs. ▸ And for ↑ concentration

→ At the "lab" level, team production doesn't raise returns to scale in the early period
→ Consistent ↑ upside potential of using teams

	Kim et al.	Full sample		CBSA-only	
$\log(n)$	0.757***	0.754***	0.769***	0.764***	0.785***
$\log(n) \times$ Team	0.039***	0.042***	−0.075***	−0.047***	−0.128***
Post	−0.019***	−0.034***	0.005*	−0.021***	0.013***
$\log(n) \times$ Team $\times$ Post	0.031***	0.035***	0.049***	0.078***	0.096***
Unit	Firm	Firm	Estab	Firm	Estab
Threshold	0.88	0.88	0.88	0.88	0.88
N	1,105,437	758,502	1,290,322	440,553	867,736

Notes. "CBSA-only": drop inventor-patent obs. that fall outside a CBSA (foreign, US non-metro).

$$\log(pats_{ft}) = \mu_f + \alpha \log(n_{ft}) + \frac{1}{\gamma^{pre}}(\log n_{ft} \times \mathbb{I}(team_{ft})) + \frac{1}{\gamma^{post}}(\log n_{ft} \times \mathbb{I}(team_{ft}) \times Post_t) + \nu_{ft}$$

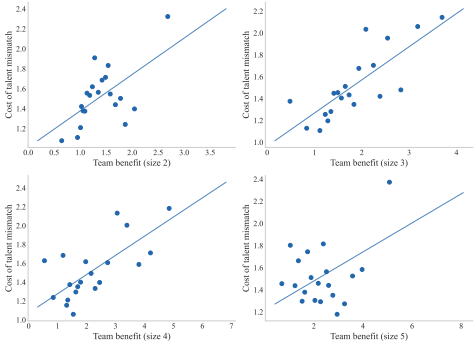
Comment #2: *why* are teams becoming more advantageous, and does it matter?

- Key **macro result:** upside potential of teams ↑ → firm exit, more concentration → lower knowledge spillovers → agg. innovation output ↓
- Paper is agnostic about *why* team benefit rises. Does it matter for the mechanism?
  - Assumes inventors are ex-ante homogeneous both vertically and horizontally, gains from collaboration arise mechanically
- **Burden-of-knowledge mechanism** *[Jones, 2009]*: ↑ specialization → ↑ team benefit
  - Pearce (2023) estimates that team advantage rises as "patents exhibit a stronger response to team depth and breadth"
- But success requires the *right* teams being formed: bringing together the expertise of heterogeneous individuals *[Freund, 2024]*

  → teams not automatically more productive ("weak links")

Evidence from Ahmadpoor and Jones (2019)

→ **Penalty for talent mismatch is high precisely when *potential* team benefit large**



Notes. Figure is constructed from replication files for Ahmadpoor and B. Jones (2019). Binscatter based on estimates for 384 different primary technology classes. Estimated prod. fn. $y = \beta_n \left[\frac{1}{n} \sum_{i=1}^{n} a_i^{\rho} \right]^{\frac{1}{\rho}}$, where a_i is inventor productivity FE, β_n is "Team benefit", $1 - \rho$ is "Cost of talent mismatch".

Implications

- **Alternative mechanism for ↓ innovation productivity**:
  1. success increasingly require teams of inventors with complementary expertise
  2. but process of forming these teams is frictional
  3. innovation productivity can decline w/o requiring size-dependent spillovers

- More generally, **skill heterogeneity** seems essential to team innovation
  - rising specialization (horizontal differentiation)
  - high dispersion in inventor productivity (vertical differentiation)

- Intuitively plausible that both mechanisms are operative
  - policy of subsidizing small firms may backfire if large firms have advantage in organizing teams with diverse technological expertise that produce breakthroughs

- Suggestion: at min., control for ex-ante heterogeneity in innovators productivity

Comment #3: large firms and spillovers

- Model introduces knowledge spillovers; β **governs concavity of spillover in firm size**

$$\bar{z}^{\text{spillover}} = \left(\int_{f \in \mathcal{F}} z_f^{1-\beta} n_f^{\beta} \right)^{\theta}$$

$$Y^{\text{solo}} = \bar{z}^{\text{spillover}} \cdot \bar{z} \epsilon_f (n_f^{\text{solo}})^{\alpha} \qquad Y^{\text{team}} = \bar{z}^{\text{spillover}} \cdot \epsilon_f \left(x_{\min}^{\text{team}} \Gamma(1 - \frac{1}{\gamma^{\text{team}}}) \right) (n_f^{\text{team}})^{\frac{1}{\gamma^{\text{team}}} + \alpha}.$$

- Propositions 1 + 2: any $\beta < 1$ guarantees that the marginal social return to additional inventor is higher at small firms than large firms; no countervailing force
- Paper raises **important, open question: do spillovers vary by firm size? Trends?**
  - Strategic use of patents by large firms, esp. since 2000? *[Akcigit and Ates, 2023]*
  - 'The share of novel patents [...] by mega firms [...] has rebounded sharply since [2000] and [...] knowledge diffusion from novel patents by mega firms have grown relative to those by non-mega firms after 2001." *[Braguinsky-Choi-Ding-Jo-**Kim**, 2025]*

How should we calibrate β?

- **Quantitative results** given $\theta = 0.08$ and $\beta = 0.25$ *[Chikis-Kleinman-Prato, 2025]*
  - efficiency loss from employment concentration grow from 4% to 13%
  - welfare gains from subsidizing small firms increase
- **But β captures different concepts in the two papers**
  - This paper: how does a firm's contribution to economy-wide knowledge scale with its total inventor count?
  - CKP: how does a firm's contribution to local innovation productivity (CZ zone) scale with its local employment? firms in eqm may operate in too few or too many markets
  - Aggregate & local elasticities need not coincide
- Policy recommendations reflect conceptual difference
  - This paper: β small, so should subsidize small firms to counteract excess concentration
  - CKP: β small, so should subsidize geographic expansion of firms
- **Directly estimating aggregate spillover elasticity is hard, but payoff would be large**
  - Use share of novel *[Kalyani, 2023]* and breakthrough *[Kelly et al., 2021]* patents as proxies?

Summary

Additional comments

Great paper that shifts our perspective in explaining R&D productivity (trends) toward teams & firm size heterogeneity.

- Suggestions for paper:
  1. Boundaries for team collaboration: accounting for *both* firm and space important
  2. Mechanism: either explicitly model or try control for skill heterogeneity
  3. Spillovers: progress in measurement would be a tremendous contribution

- Suggestion for everyone: read the paper, it's great.

Thank You!

Extra Slides

Additional comments

- Teams and the focus on pairs
  - avg. team size conditional on team is ~ 3 ¿ 2
  - avg. team size rises *conditional* on team patents: upward shift across $\sim$ all firm sizes
  - current model can't accommodate or explain these patterns
  - but all data analyses are (?) performed on the full sample $\rightarrow$ disconnect
  - $\rightarrow$ either use a richer model or use sub-sample of teams of 2 throughout?
- Paper uses number of patents as baseline outcome variable. But we know quality/impact/value of patents is v skewed, so weighted version seems more appropriate?
- Most of increasing emp. share of large firms (Fig. 2) just reflect more firms crossing the 145 emp cutoff
  - suggestion: Cao et al. (2022) decomposition of change in avg. "firm size" instead; quick look suggests its encouraging for the paper's narrative
- Decomposing the Role of Idea Production Function Changes (e.g. Table 5): nonlinear $\rightarrow$ use Shapley-Owen-Shorrocks method

More regression specifications

Dep. var.: log(*patents*)									
	Kim et al.	**Full sample**				**CBSA-only**			
log(n)	0.757***	0.757***	0.754***	0.767***	0.769***	0.763***	0.764***	0.779***	0.785***
log(n) × Team	0.039***	0.097***	0.042***	−0.016***	−0.075***	0.050***	−0.047***	−0.048***	−0.128***
Post	−0.019***	−0.028***	−0.034***	0.003	0.005*	−0.015***	−0.021***	0.006*	0.013***
log(n) × Team × Post	0.031***	0.036***	0.035***	0.034***	0.049***	0.054***	0.078***	0.061***	0.096***
Unit	Firm	Firm	Firm	Estab	Estab	Firm	Firm	Estab	Estab
Threshold	0.88	0.774	0.88	0.774	0.88	0.774	0.88	0.774	0.88
N	1,105,437	758,502	758,502	1,290,322	1,290,322	440,553	440,553	867,736	867,736

Notes. "Restricted sample": drop inventor-patent observations that fall outside a CBSA (foreign inventors or US non-metro areas). "Threshold" for indicator variable (own sample vs. paper).

More regression specifications

Dep. var.: $\log(1 + \textit{citations})$

	Full sample				Restricted			
$\log(n)$	0.739***	0.744***	0.751***	0.764***	0.767***	0.777***	0.776***	0.798***
$\log(n) \times$ Team	0.105***	0.046***	−0.016***	−0.086***	0.087***	−0.010	−0.035***	−0.130***
Post	−0.223***	−0.229***	−0.215***	−0.213***	−0.210***	−0.214***	−0.226***	−0.215***
$\log(n) \times$ Team $\times$ Post	−0.004	−0.007	0.020***	0.041***	−0.007	0.021**	0.019***	0.068***
Unit	Firm	Firm	Estab	Estab	Firm	Firm	Estab	Estab
Threshold	0.774	0.88	0.774	0.88	0.774	0.88	0.774	0.88
N	758,502	758,502	1,290,322	1,290,322	440,553	440,553	867,736	867,736

Notes. "Restricted sample": drop inventor-patent observations that fall outside a CBSA (foreign inventors or US non-metro areas). "Threshold" for indicator variable (own sample vs. paper).