Discussion: Innovation Networks and R&D Allocation
Ernest Liu and Song Ma

Elvira Sojli

UNSW Sydney

Transistor and IC chips

Bell Laboratories

TEXAS INSTRUMENTS

FAIRCHILD SEMICONDUCTOR

intel

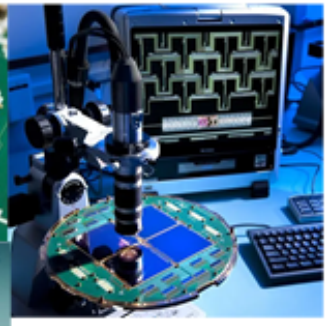
ASML

nVIDIA

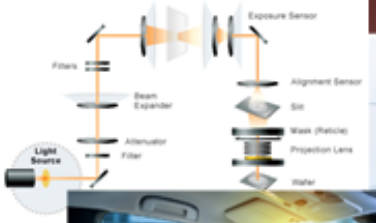
Microsoft

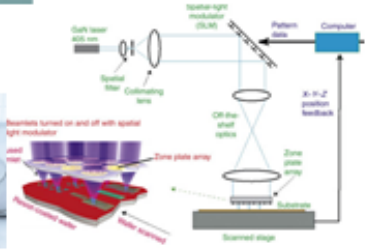
AMD

John Bardeen, William Shockley and Walter Brattain at Bell Labs, 1948


Photolithography

ASML EUV lithography






Television


Advanced Medical Care


Personal Computer


Mobile Phones / Smart Phones


Automobile

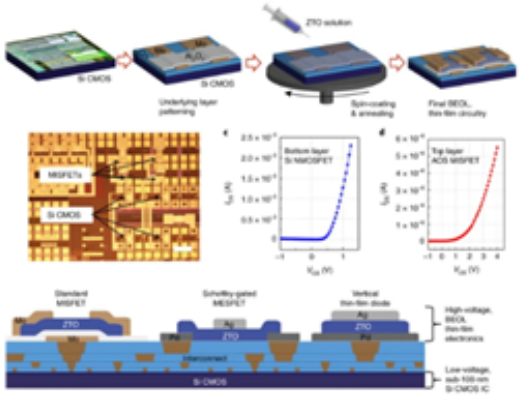
Thin Film Oxidization Process - Foundational

Foundational Process - Thin Film Processes that propel Breakthrough Products

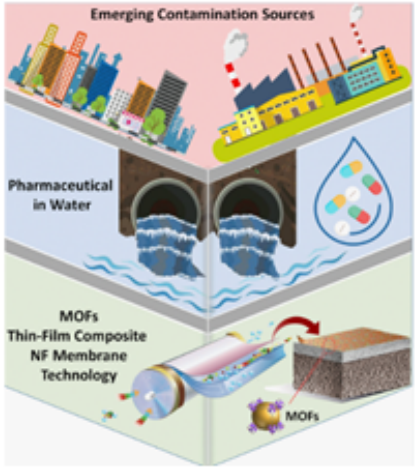
Thin film IC chips, photovoltaic Cells, Liquid Crystal Display, Modern Mobile Devices (touch screen technology), Environmental applications (water and air purification), Sensors and Instrumentation, Advanced Coatings, Laptops, Wearable Devices

First Solar.
Pragmatic
SONY
BOE
SAMSUNG
LG
GLOBAL SOLAR A Hanergy Company
IBM

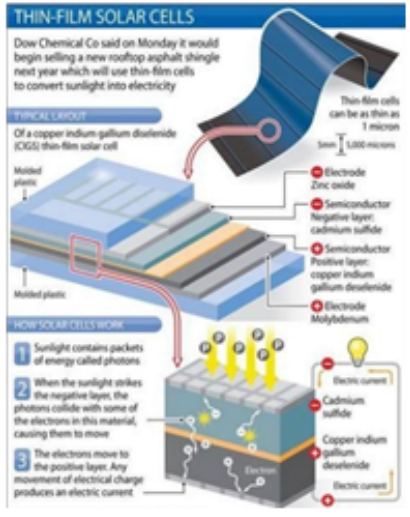
Thin film transistor and IC chips



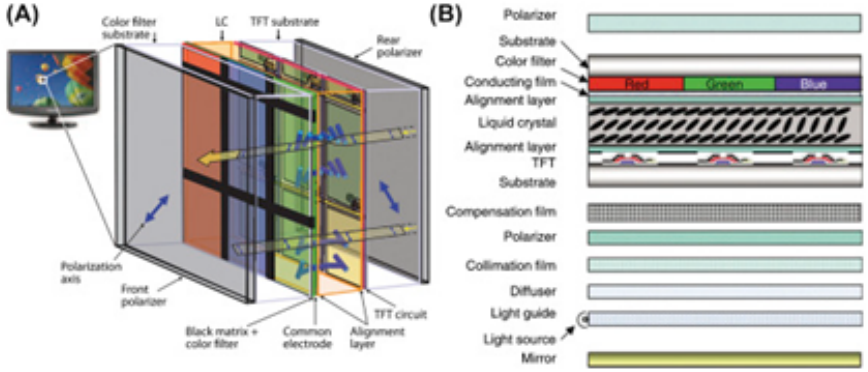
Thin-Film Environmental Application – Water purification

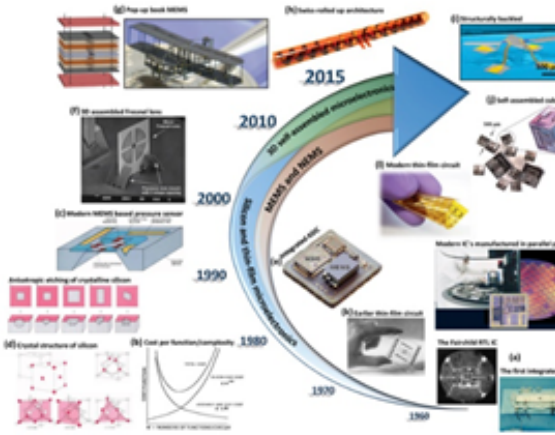


Thin-Film Solar Cell



Electronics products - Liquid Crystal Display





Why We Care?

- Industrial policy has two effects
  - Direct - on the entities that receive subsidies
  - Indirect - innovation spillovers central to growth: amplify returns to R&D, drive technological progress, and promote productivity gains

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  - Direct - on the entities that receive subsidies
  - Indirect - innovation spillovers central to growth: amplify returns to R&D, drive technological progress, and promote productivity gains
- We use industrial policy not for direct effects to recipient firm, but to harness indirect effects
- We confer patent (excludability) rights to incentivise inventors to disclose their technology to generate spillovers

Key Contributions

- This paper is natural step in the innovation literature
  - No industry exists in isolation, many firms straddle multiple industries
  - Central sectors are critical nodes amplifying spillovers and innovation impact
- Understanding network centrality essential for targeted policy and effective resource allocation

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- This paper is natural step in the innovation literature
  - No industry exists in isolation, many firms straddle multiple industries
  - Central sectors are critical nodes amplifying spillovers and innovation impact
- Understanding network centrality essential for targeted policy and effective resource allocation
- Excellent paper with rigorous theoretical and empirical integration
- Innovative network perspective: differentiates explicit sectoral spillovers vs. traditional aggregate spillovers
- Meticulous patent citation network construction over 40 million patents to measure sector centrality

Great data work, clearly a labor of love!

The Model

The Model

- Traditional endogenous growth models (e.g., Romer '90, Aghion & Howitt '92) knowledge spillovers are uniform (benefit all sectors symmetrically) here *spillovers explicitly depend on which sector produces knowledge and which sectors directly benefit (not homogeneous)*

  $\longrightarrow$ where R&D is allocated is crucial

- This differentiation is even more important in international context where industrial policy should depend on technological reliance

Interpretation and Implications

- Clearly shows that sector centrality is crucial—targeted R&D investments outperform generic subsidies
- Optimal policy based on explicit network metrics (innovation centrality) is persuasive
- Results align with insights from Tham et al. (2024): Foundational processes drive sustained innovation by creating "process-driven products"

Questions on first paper

- What defines sector centrality?
  - Are sectors central due to intrinsic innovation dynamics or because investments and firm capabilities?
  - Is it more about knowledge intensity or market structure?
  - Role of firms in leveraging central sectors (large est. firms vs. small, agile innovators)?
- Role of foundational processes as more general purpose technology
  - Could the innovation centrality measure explicitly capture foundational vs. incremental processes?
- Propagation
  - How does the knowledge propagate?
  - Human capital?
  - How long does it take?

Knowledge spillover measure

- Citations - notoriously flimsy, esp. internationally
  - More than 50% of patents don't have citations
  - Kept to bare minimum due to licensing considerations
  - Strategic to draw the 'right' examiner
- What to do?
  - Patent similarity providers richer links
  - Non-primary IPC class pairs

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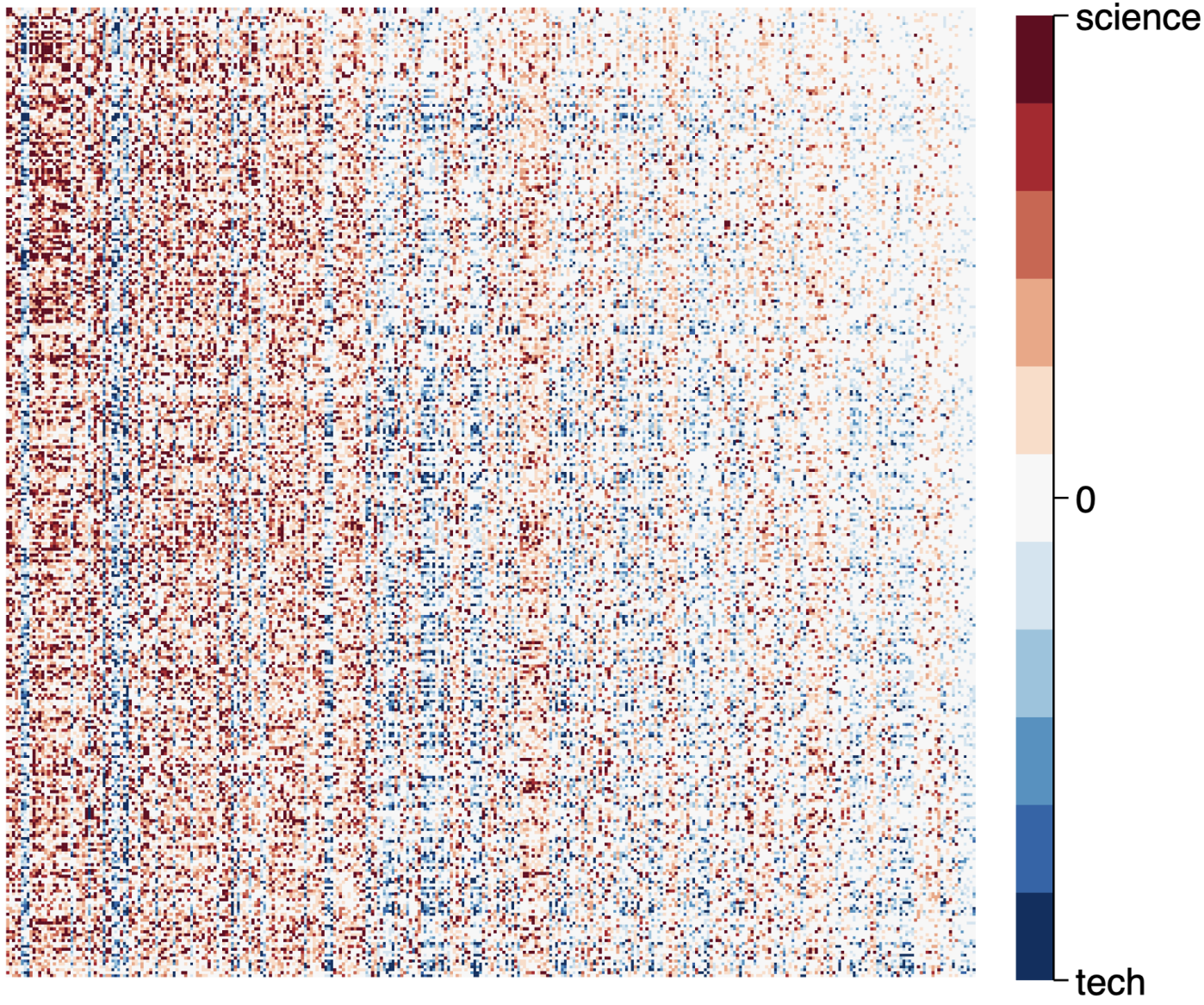
- Incorporate economic value of citations:
  - Use market-based valuation of patents (e.g., Kogan et al., 2017)
  - Weight spillovers by economic rather than purely citation-based significance
- Temporal dynamics of spillovers:
  - Incorporate timing explicitly — yearly non static citations
  - Decaying spillover intensity over time?

Et voila ... second paper



Et voila ... second paper

- Takes a step back at understanding the role of basic science in invention (patenting and technology network)
- A equally important question looking at role of knowledge intensity in defining sector centrality
- Prior work has linked patents to publications (Marx and Fuegi, 2021; Marx and Scharfmann, 2024) the network mapping here is thorougher and dynamic

Knowledge diffusion measure

- How to do it?
  - ✓ Scientific publications - patent similarity TFIDF (Hoberg-Phillips '16, Kelly et al. '21)

    Removing previous (t-1) overlap between fields
  - ✓ Benchmark with NPL citations and IPC class pairs

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  - ✓ Benchmark with NPL citations and IPC class pairs
- ✓ Temporal dynamics of spillovers:
  - Incorporate lead-lag effects in diffusion of scientific ideas
  - Q Is there a role for reverse effects?
    Existence of applicability of an abstract scientific idea opens way to more scientific publications in the area
  - Q Very slowly propagating ideas? Yizhou's examples on Monday

Open (hard) questions

- What is the optimal allocation of R&D resources? Basic science vs. innovation split
- What is the right timing of investment in each?
- Who should fund basic science? Google vs. OpenAI gave us GPT

Conclusion

- Valuable contribution with significant implications for policy and firm strategy
- Network approach important insights for R&D allocations across science and invention
- Raises critical questions about invention dynamics, especially in the context of rapidly evolving technological frontiers

Very insightful and important work—look forward to reading the paper!