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Architectural Control and Value Migration in Platform Industries

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Outline

- Research agenda and tools
- Platform competition model
- Demo and simulation results

Research Agenda: Architectural Strategy

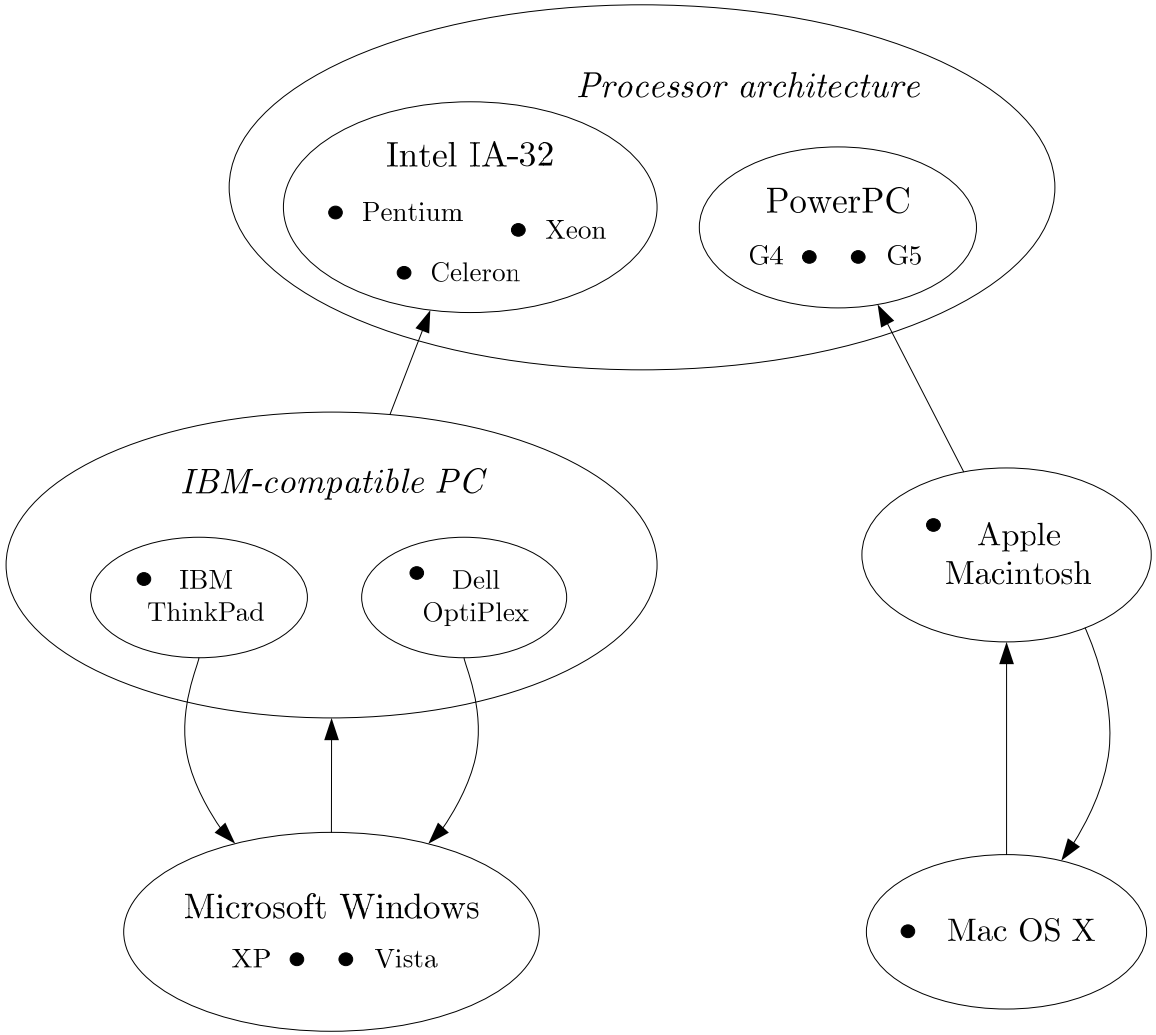
- How is value *created* and *captured* in complex engineered systems?

- How can (should) (do) value-seeking agents shape their structure and evolution?

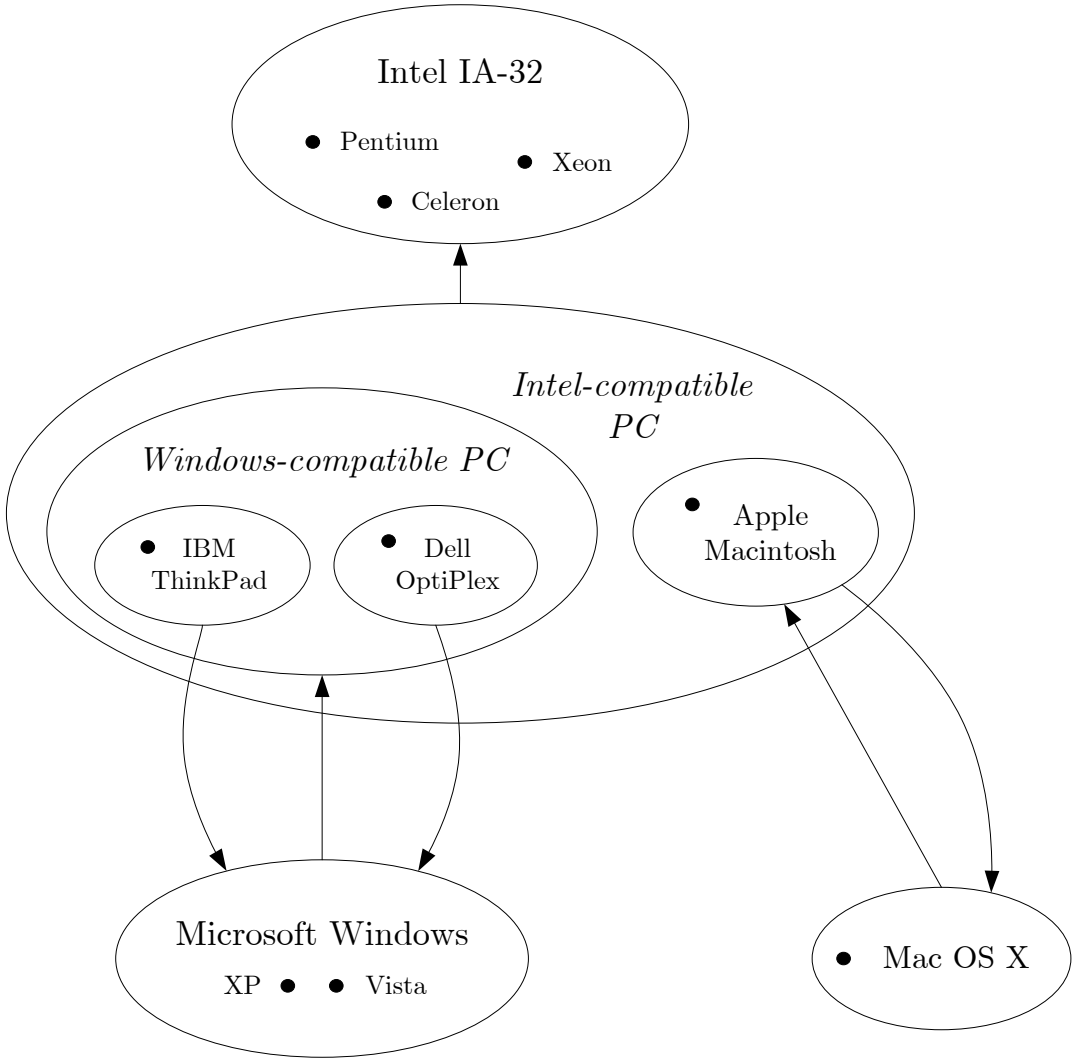
Motivation

- June 2005
  - Apple announces plans to transition Macintosh computers from PowerPC to Intel processors
- April 2006
  - Apple introduces Boot Camp software that enables Intel-based Macs to run Windows XP

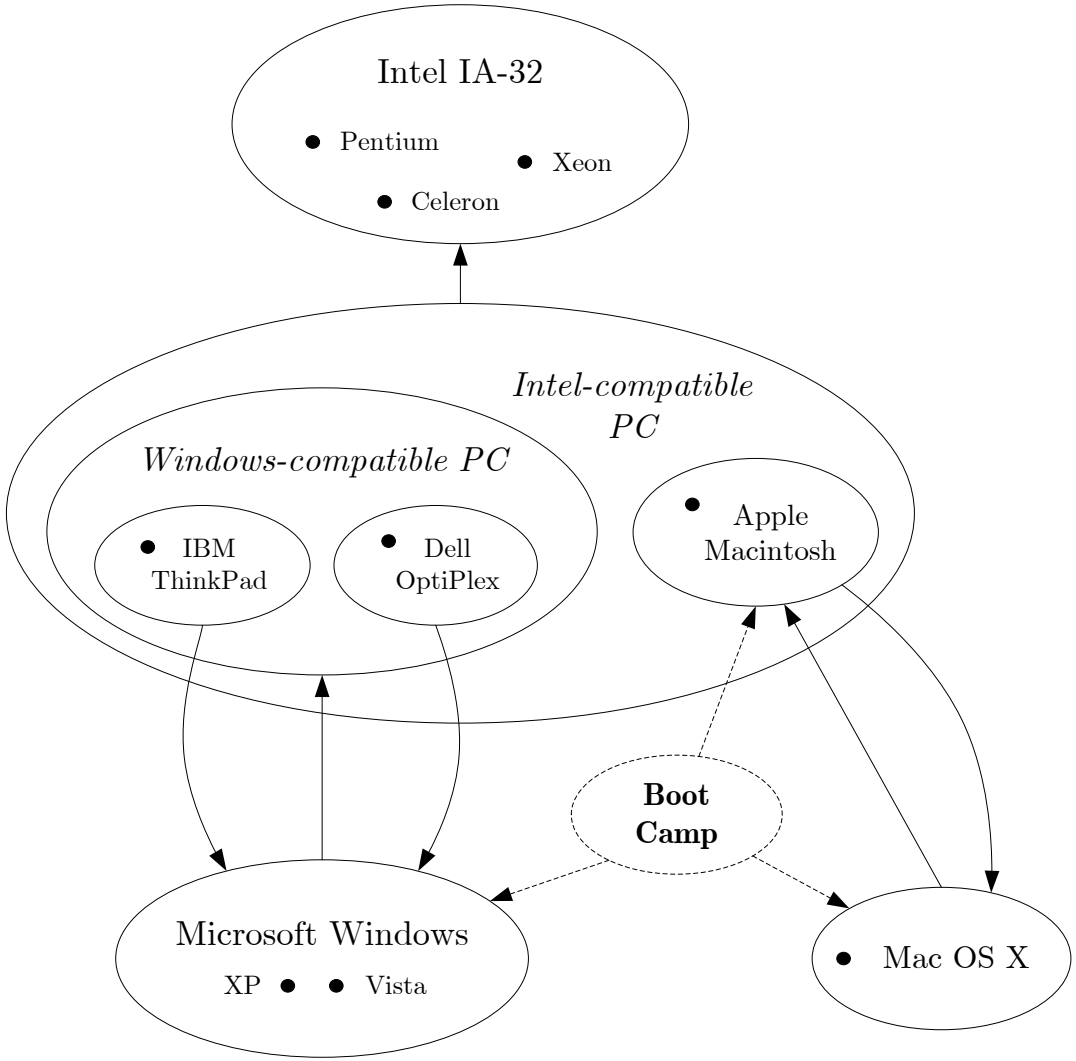
Old Game: Mac vs. PC



New Game: Mac *as* PC



Next: Mac as *Windows* PC?



Two Kinds of Research Challenges

- Explanation
  - Why did Apple make these design moves?

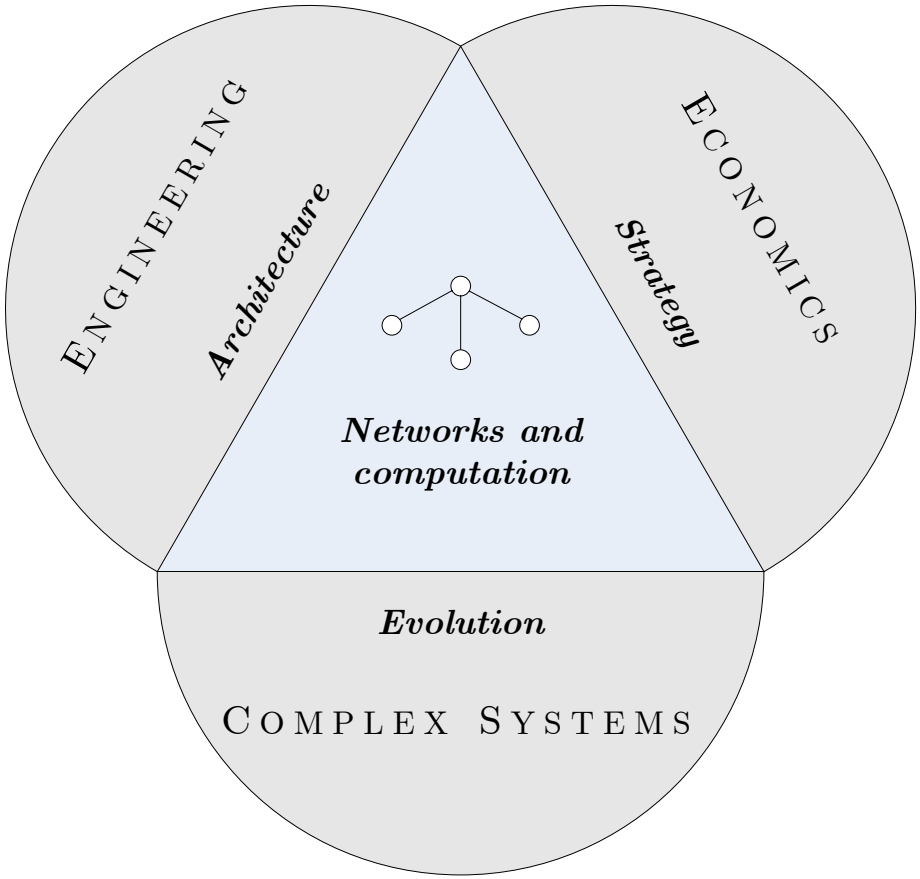
- Prediction
  - What will they do next?
  - How will their competitors respond?
  - What patterns will emerge at the industry level?

Why Is This Hard?

- Engineering tends to black-box “requirements”
- Economics tends to black-box “technologies”
  - Need to integrate across levels of abstraction

- But people do it in practice
  - Cases in point: Bill Gates, Scott McNealy

Related Fields and Concepts



Dissertation Work

- A formalism
  - Design structure networks (DSNs)
- A modeling approach
  - System design games (SDGs)
- Three models
  - Palm and Handspring in PDAs (analytical)
  - Value networks (computational / “closed”)
  - Platform competition (computational / “open”)

Dissertation Work

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  - **Platform competition (computational / “open”)**

Today’s focus!

A Model of Architectural Strategy in Platform Industries

- *Platform:* A system component (module) that is designed to be extended by *applications*
  - Software examples: Windows, Java, Google Earth
  - Examples from other engineering domains: NVIDIA nForce, Chrysler K-Car, Esplanade – Theatres on the Bay
  - What about chemical, biomedical, nanotech?

- Platforms may be built on top of other platforms ("*application-level platforms*")
    - Microsoft Outlook, Excel, Word
    - MSN Messenger? Skype?

Basic Setup

- Systems are tree-structured; new products and categories build on existing platforms

- Agents (firms) arrive in sequence, make a single product development decision
  - Where in the architecture to build?
  - How to attract applications and still make money?
    - What fraction of downstream profit to extract through *architectural control*?

Main Contributions

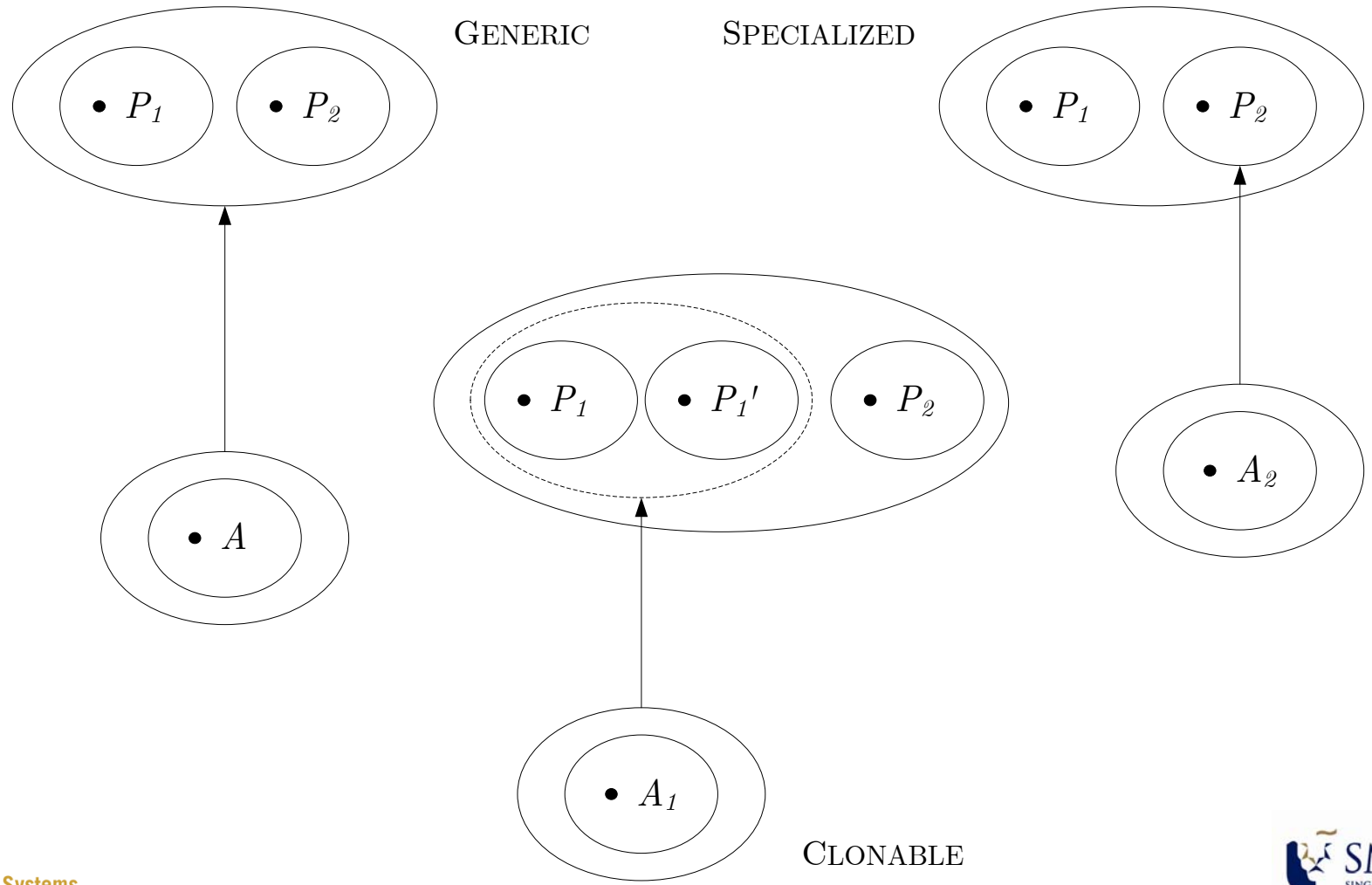
- Industrial economics: extends game-theoretic modeling in a “history-friendly” way
  - Network economics (Farrell & Saloner ’85, Katz & Shapiro ’94, …)
  - Industry evolution (Bresnahan & Greenstein ’99, Malerba et al. ’99, …)
- Technology management: connects industry dynamics to individual incentives
  - Platform competition (Baldwin & Clark ’00, Gawer & Cusumano ’02, …)
  - Industry evolution (Abernathy & Utterback ’78, Tushman & Murmann ’98, …)

Key Assumptions

- Firms are boundedly rational
  - Learn by observing payoffs of prior entrants
  - Choose action with highest expected payoff
    - Subject to cognitive limits; can only evaluate a fixed number of alternatives

- The future is uncertain
  - Innovation (product category arrival) is stochastic
  - Behavior of other firms also not fully predictable

Three Degrees of Dependence



From Use Value to Payoffs

- Each product category has a use value
  - Fixed at random upon arrival, then known to firms
  - Firms with products in category receive equal shares
    - Reduced form of a pricing game w/ differentiated goods

- Each platform owner chooses a “tax rate”
  - May be direct (e.g., licensing fees) or indirect (e.g., advantage in complementary product development)
    - Assumes platform owner can *exclude* application development through technical and/or legal means

From Use Value to Payoffs, Cont'd.

- Each firm's per-period payoff is its share of use value discounted by the tax rate of its parent platform
  - GENERIC case: no appropriability, so tax rate = 0
  - CLONABLE case: minimum of clones' tax rates

- Intuition check!
  - *A firm's payoff goes **down** over time as competitors enter its category, and **up** as complementors build on its product platform*

Learning Algorithm

- Firms run linear regressions of prior entrants' current NPV on characteristics of product location and tax choice
  - Category depth, width, and value
  - Parent tax, tax rate, tax^2, etc.

- Algorithm "seeded" by observations of prior runs (industry experience)

Questions for the Experiments

- Who makes the most money, and when?
- What is the optimal tax rate, and do firms learn to charge it?
- How does the level of taxation affect the "shape" of the system architecture?

Answers in a Nutshell

- Who makes the most money, and when?
  - *Generally top-level platforms (early in GENERIC case, later in others), but applications compensate through niche selection*
- What is the optimal tax rate, and do firms learn to charge it?
  - *Declines by level from ~0.7 → 0.2. Yes! (But high variance)*
- How does the level of taxation affect the "shape" of the system architecture?
  - *High taxes lead to shallow, "bushy" systems with few niches; low taxes to deep systems with "vine-like" dependencies*

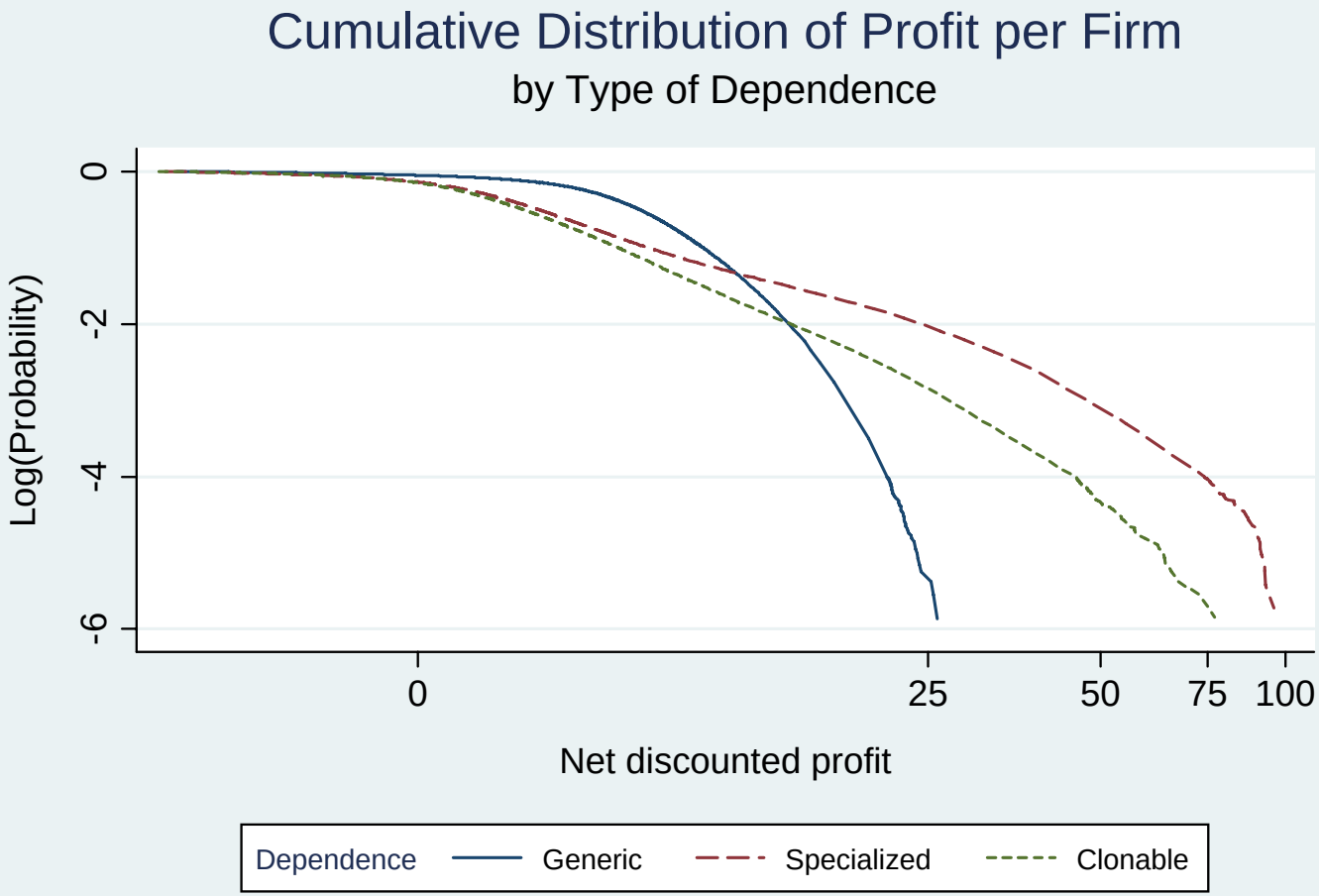
Key Takeaways

- Top-level architectural positions are scarce; it's generally "good to be the king"
- But platform owners voluntarily limit their exercise of architectural control to attract application developers
- Cause to be (cautiously) optimistic that market forces can sustain open multi-product systems even when appropriability is strong

Demo / Eye Candy

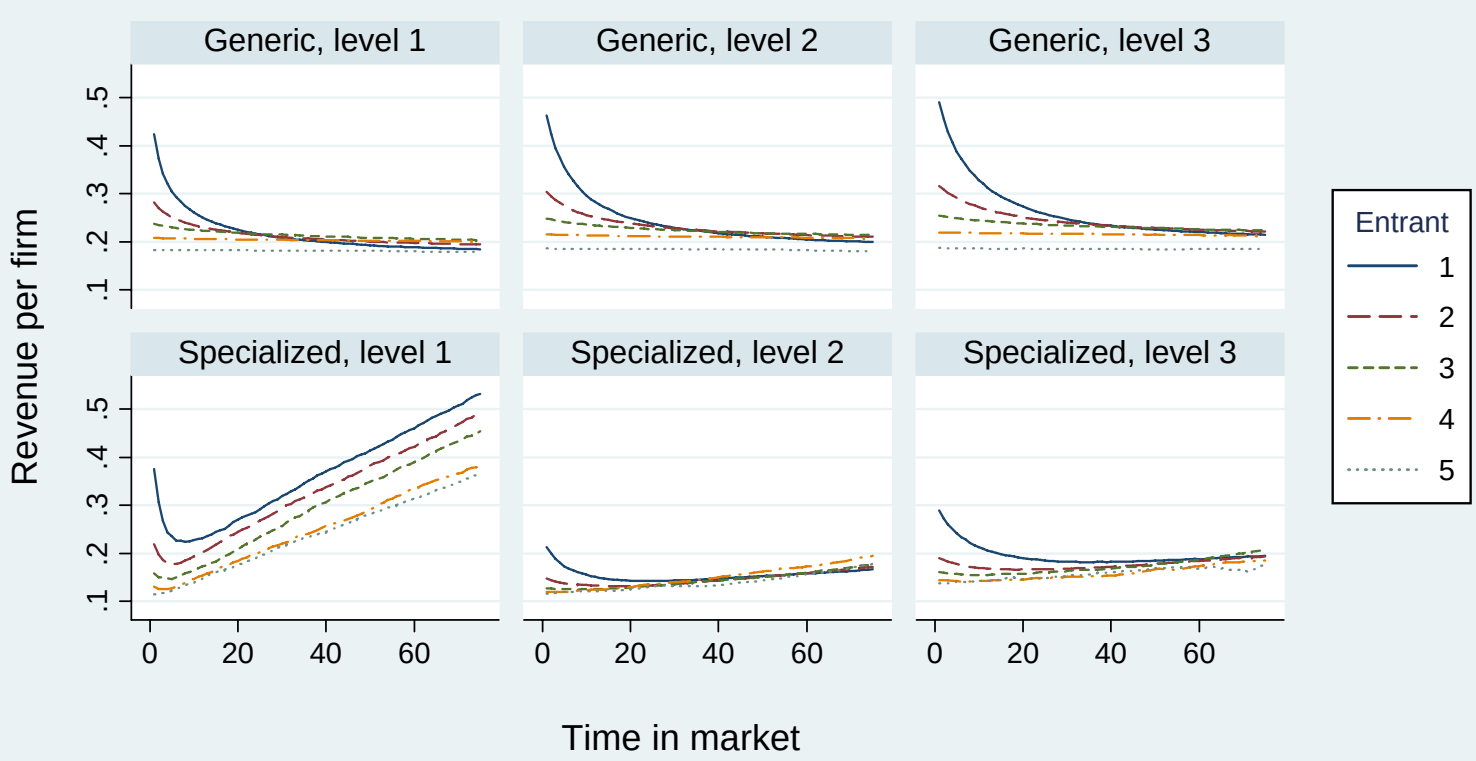
- How am I doing on time?

Cumulative Profits Are Power-Law Distributed



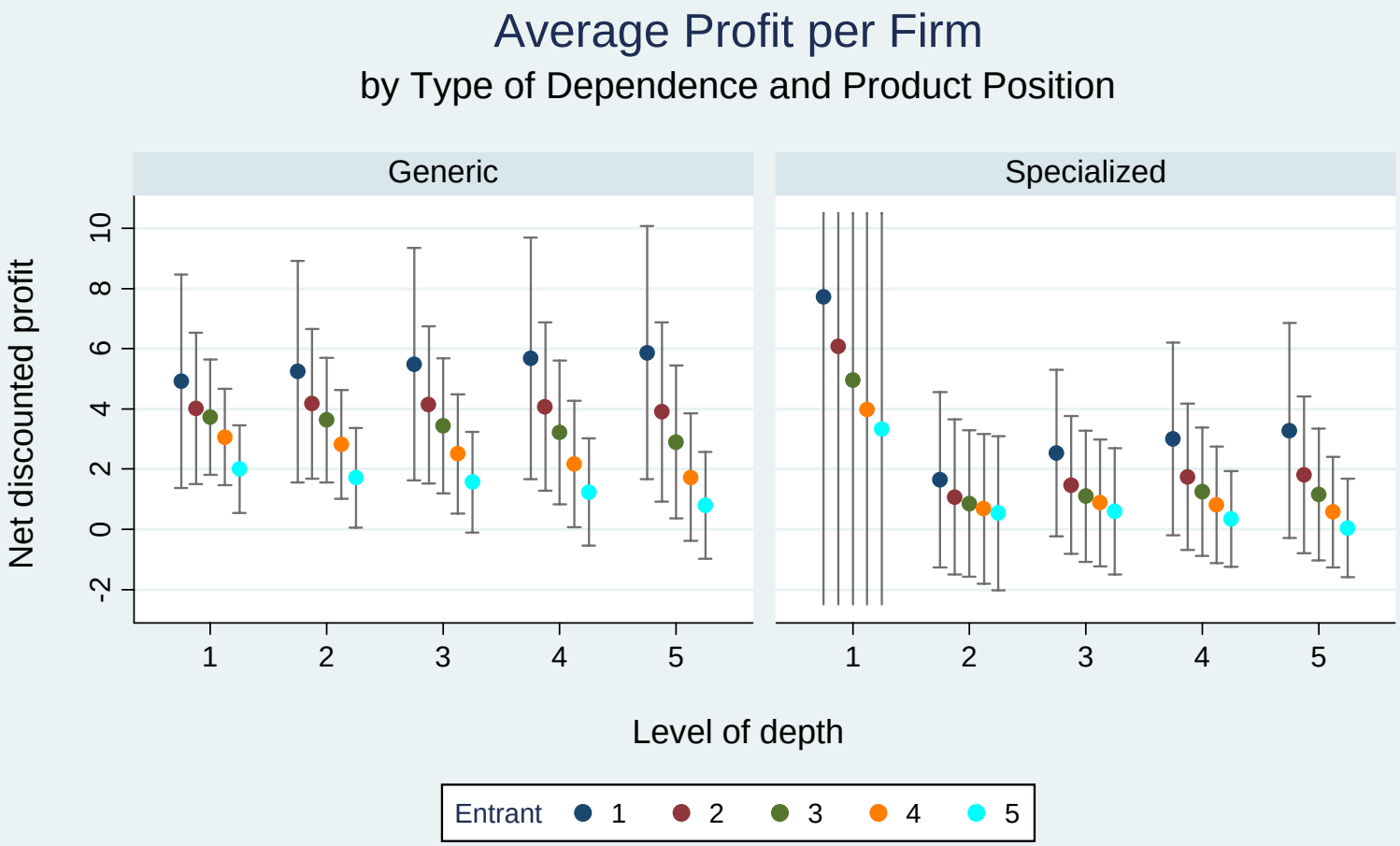
Experiments III-A, III-B, III-C

Top-Level Firms Enjoy Increasing Returns When Architectural Control is Strong



Experiments III-A, III-B

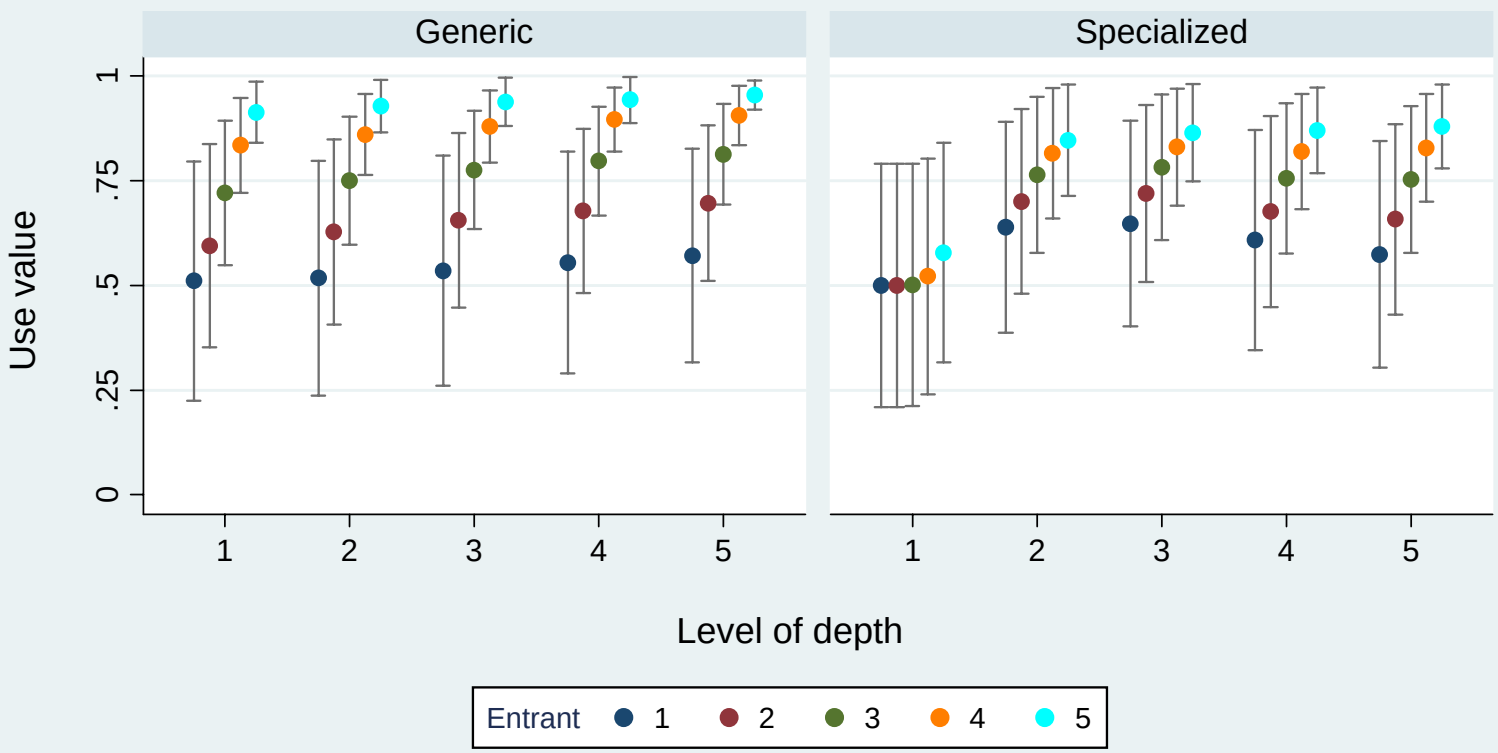
Leading to Higher Net Discounted Profit (But Note Upward Trend at Lower Levels)



Experiments III-A, III-B

Bars indicate +/- 1 s.d.

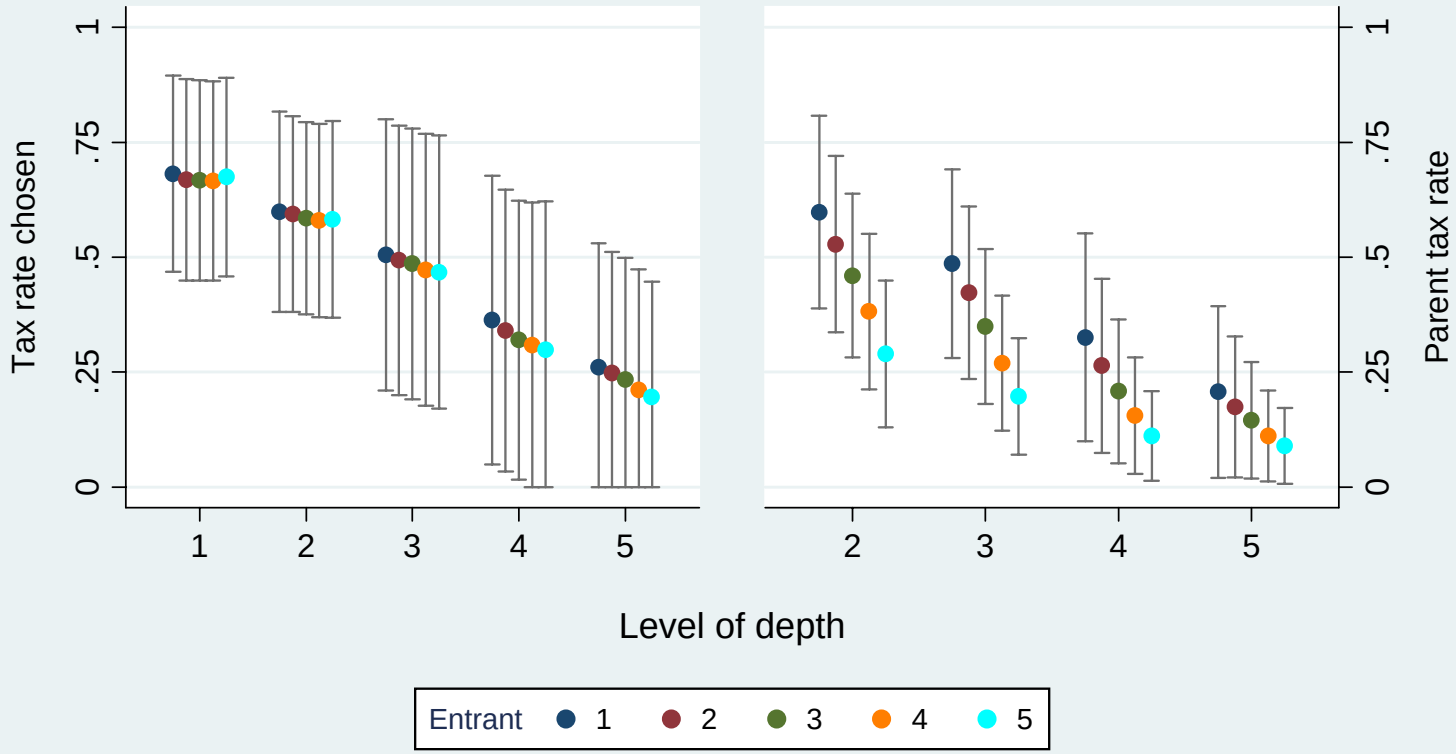
Revenge of the Applications (Part I)



Experiments III-A, III-B

Bars indicate +/- 1 s.d.

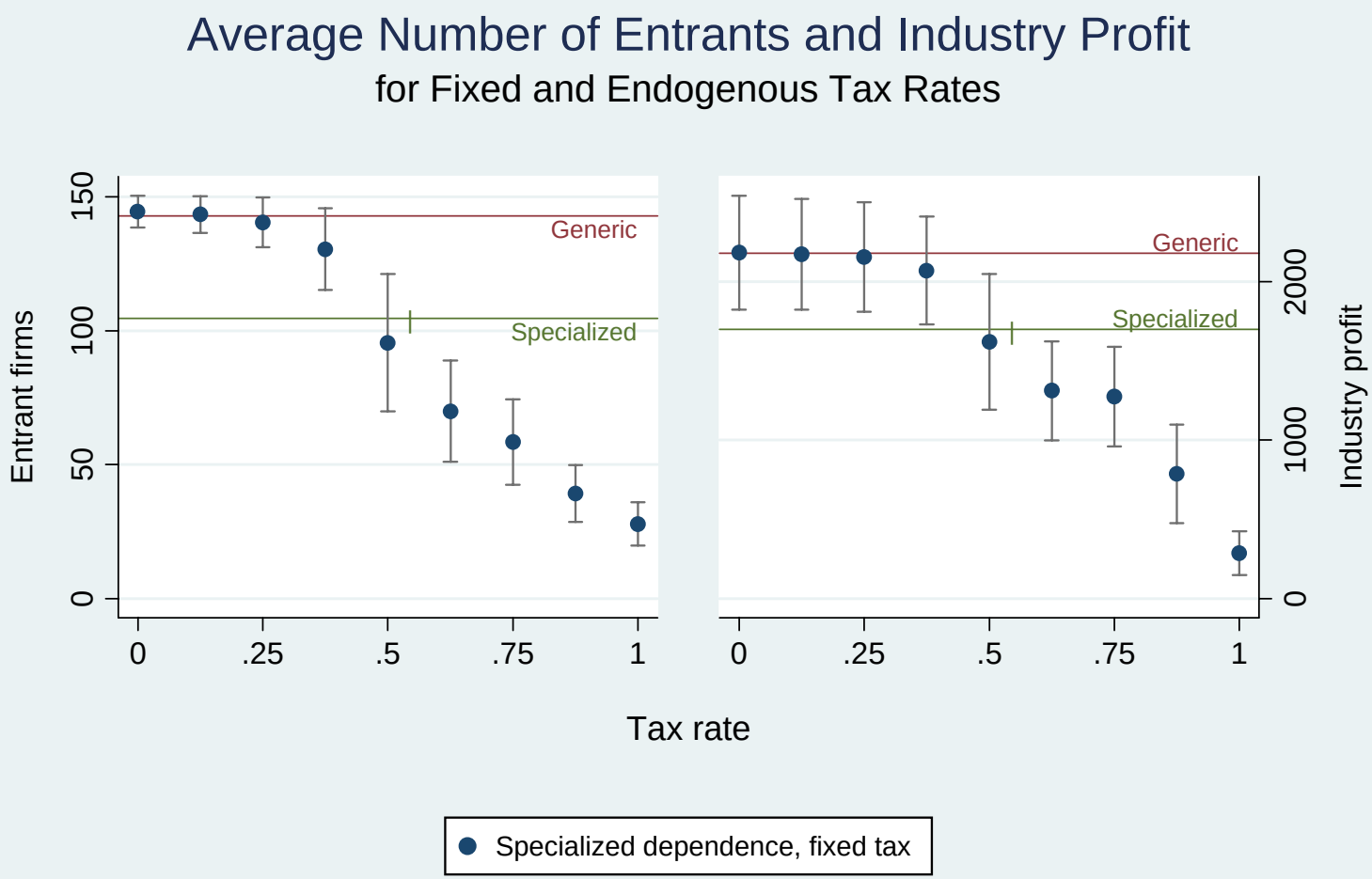
Revenge of the Applications (Part II)



Experiment III-B (specialized dependence)

Bars indicate +/- 1 s.d.

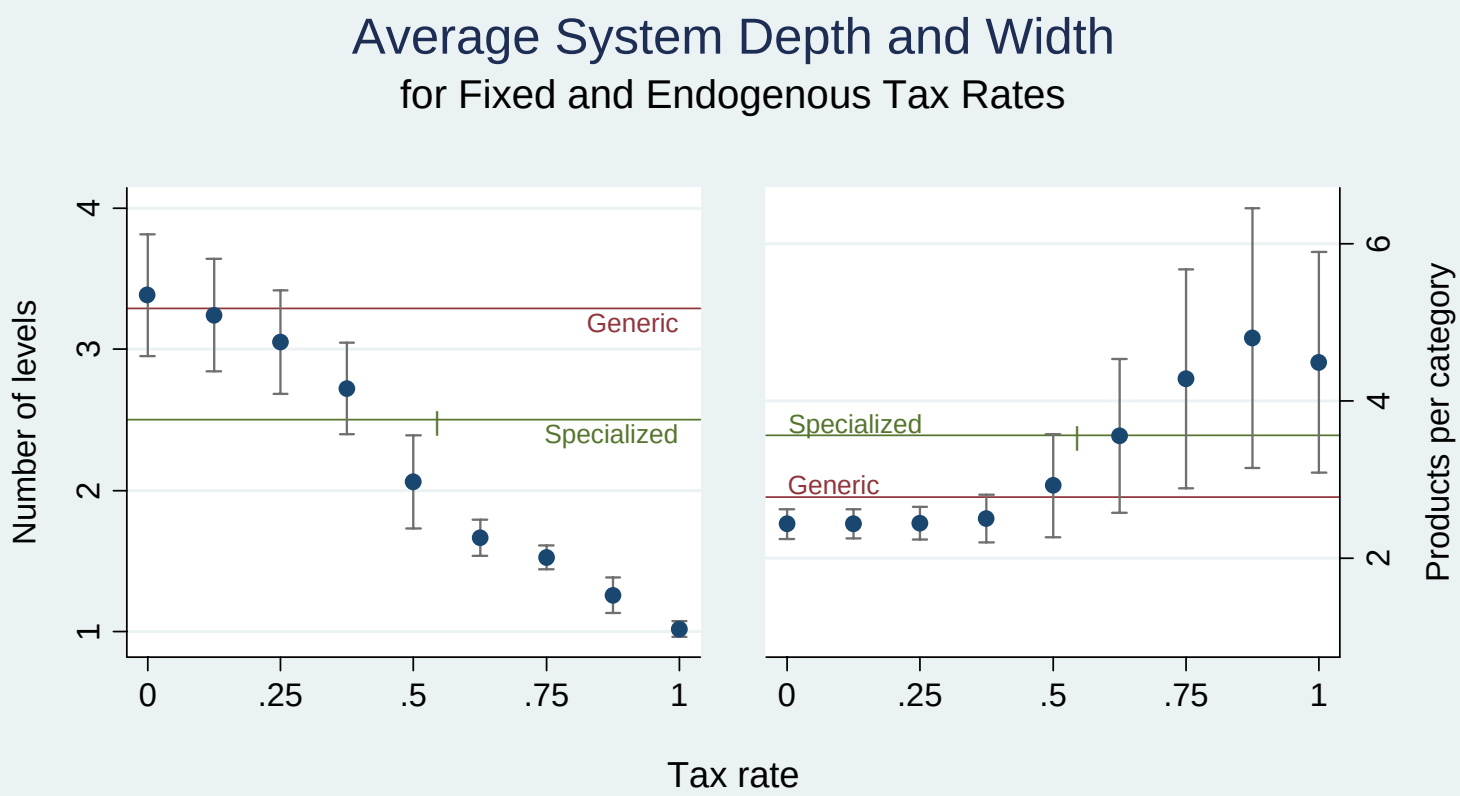
Fixed-Tax Result: Higher Taxes Lead to Less Entry, Lower Profit



Experiments II, III-A, III-B

Bars indicate +/- 1 s.d.

Under High Taxes, Firms Crowd Into Root Layers and Build Shallow Trees



Experiments II, III-A, III-B

Bars indicate +/- 1 s.d.

Summary

- Architectural strategy can and should be integrated with engineering design
- The resulting tools can help shed light on strategic moves like platform creation and the exercise of architectural control
- Computational models give dynamics for free – can study industry evolution *in silico*

Next Steps

- Platform model
  - More focus on value migration over time
  - Allow firms to develop multiple products
- Computational tools
  - An exercise in platform creation …
- Explanation and prediction
  - Engage directly with empirical evidence

Thank You!

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