Growth and Innovation in Platform Ecosystems

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Platform Questions

- Consider a platform ecosystem of consumers and developers. How do we motivate participation, extract rents, and stimulate innovation?
- Platforms often contain nonrival resources (e.g. code, interfaces, standards). Is it better to charge for access or open these to a developer community?
- When do we expire patents, i.e. absorb developer innovations into the platform?
- How much do we tax developer output?
- How much do we invest in the platform itself?

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Insight: We can treat the platform sponsor as the social planner for a mini economy and optimize over analogous growth parameters.

The Intellectual Property Debate

Long / Closed is Better

- Long but narrow patents (Gilbert & Shapiro '90)
- Infinitely renewable copyright (Landes & Posner '03)
- Sequential Innovation (Green & Scotchmer '95; Chang '95)

Free / Open is Better

- Fundamental right of access (Stallman '92)
- Collective production / Open science (Benkler '02; David '04)
- Tragedy of the "AntiCommons" (Heller & Eisenberg '98)

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We explicitly introduce downstream continuous production based on Solow (1956) and Romer (1986) to address platform questions.

The Innovation Debate

Monopoly is Better

- To promote progress in science and the useful arts (U.S. Constitution)
- Competition reduces incentive to enter (Salop '77, Dixit & Stiglitz '77)

Competition is Better

- Marginal cost pricing efficient (Econ 101)
- No double marginalization (Spengler '50, Motta '04)
- Innovation occurs to "escape" competition (Aghion, Bloom, Blundell, Griffith, Howitt '02)

We can model competition at the developer and platform layer with different implications.

Illustrations

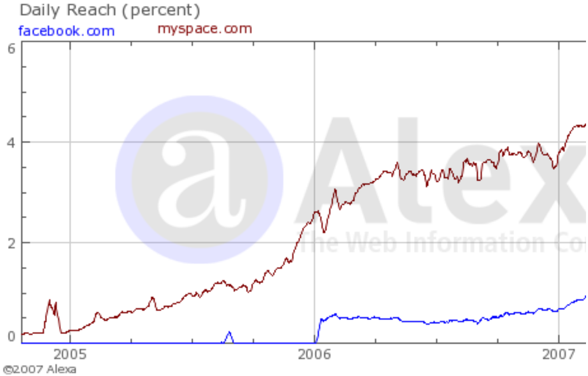
Downstream enhancements add value

Examples: Microsoft, Google, Facebook, Salesforce, Apple...

1981-1997 Microsoft beats Apple.

Apple launched the personal computer market but Microsoft licensed widely and built a huge developer ecosystem. By the time of the antitrust trial, Microsoft had more than 6 times the number of developers..

Does an Open Platform Work?



In 2004, MySpace was the leading social network site having overtaken Friendster and Orkut. Facebook followed over a year later in an industry with network effects.

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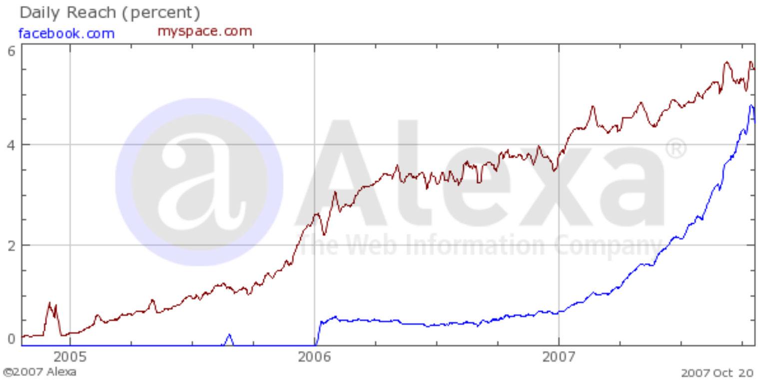
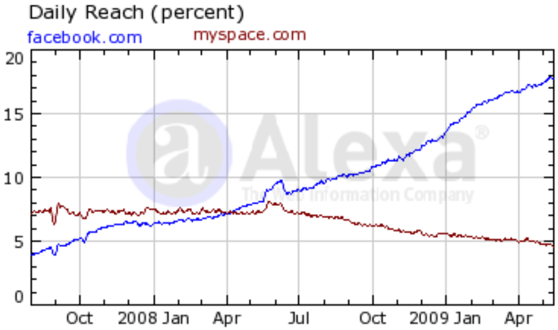


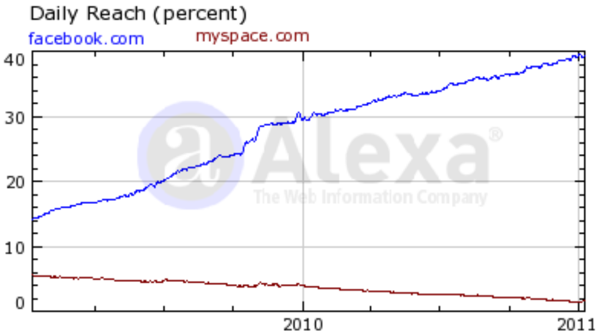
In Feb, 2007, Facebook opens the platform to developers.
MySpace does not follow until later.

Growth continues



Despite cash infusions from Rupert Murdoch, MySpace continues to lose the battle with Facebook over social networking consumers.

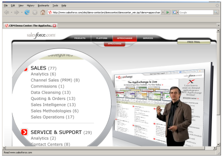
And continues



January, 2011: MySpace lays off 500 people

Platform Ecosystems with Taxes Ranging from 0 - 70%

Microsoft taxes 0%
for Windows



Salesforce taxes 30%
on AppExchange

Apple taxes 30%
for iPhone Apps

Amazon taxes 70%
for Kindle content

Apple passes Microsoft May 26, 2010

This shows percentage growth.

Focal Market: Platforms & Applications

- Platform: Components used in common across a product family whose functionality can be extended by applications (e.g., Boudreau '07).
- Examples: Operating systems, game consoles, multimedia, wi-fi, cellphones, social network platforms, application exchanges, etc

Model In Continuous Time

Model Ecosystem

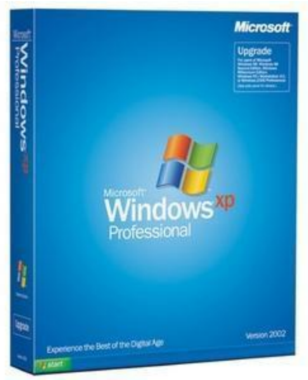
Platform Sponsor, Developers, Consumers

Public and Private Code

- Consider a dynamic model with a mass $K > 0$ of *private code* known only by the platform owner, and a mass $L > 0$ of *public code* that can be built on by others. The public and private code bases evolve with the passage of time.
- We posit geometric decreasing marginal consumption value of code $\psi(K + L)^{\alpha}$.
- The platform sponsor faces potential competition for the open value of the code ψL^{α}.
- Code erodes at a constant *depreciation rate* $\delta > 0$.

Key Tradeoffs in Managing the Ecosystem

- Openness & Time: Having opened its platform, does Microsoft (or Cisco or Google or Apple) kill its ecosystem by bundling developer value into Windows?
- Openness: Multithreading, Disk Compression, Internet Browsing, Streaming Media, Instant Messaging, . . .



Platform Sponsor Choices

- The platform sponsor, as landlord, must invest in platform maintenance and
  - balance current against future consumption (savings s)
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  - balance current against future consumption (savings s)
  - open code to developers at a cost of current profits (publication rate π)
- The platform sponsor also profits from the developer ecosystem via
  - choice of participation fee (ϕ) and tax rate (τ)
  - bundling innovations into the platform (expropriation rate ρ)

Platform Sponsor Choices

The platform owner chooses parameters ρ, π, s, τ to maximize the present value of the revenues from direct sales and developer taxes, discounted at interest rate $r > 0$. The revenue stream is:

$$(1 - s)\psi[(K + L)^{\alpha} - L^{\alpha}] + \tau D L^{\gamma}$$

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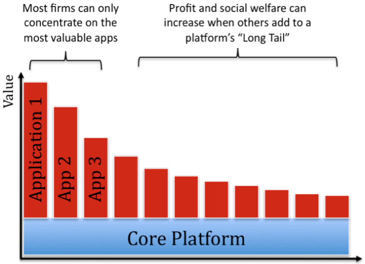
Similarly, the private code base evolves as:

$$\dot{K} = -(\delta + \pi)K + s\psi[(K+L)^{\alpha} - L^{\alpha}] + \rho D L^{\gamma}$$

Developer Ecosystem

- We assume free entry from a heterogeneous continuum of potential developers. The continuum assumption embodies a lack of market power by developers.
- Developers differ by their ideas $x > 0$. We assume that the mass of ideas x has density $g(x) = \beta x^{-\beta-1}$ on $[0, \infty)$, where $\beta > 2$.



Consumer prices

Developers cannot sell code of consumer value $v(x, m)$ for full-price, because consumers can wait until the code is rebundled into the platform. We assume developers set a price $p(x, m)$ that leaves consumers indifferent about waiting, and buying immediately. Given the expropriation rate ρ,

$$1 - R \equiv \int_0^\infty \rho e^{-\rho t} e^{-rt} dt = \frac{\rho}{r + \rho}$$

Then the market price $p(x, m)$ of developers solves the consumer indifference equation $v(x, m) - p(x, m) = (1 - R)v(x, m)$. So, the present value of developer code scales the revenue stream by the effective discount factor $\theta \equiv R/r = 1/(r + \rho)$.

Developer profit

The developer's expected present value of profits is then:

$$\theta(1-\tau)p(x,m) - wm - \phi \equiv \theta(1-\tau)Axm^{\sigma}L^{\xi} - wm - \phi$$

Taking first order conditions yields optimal input level $\hat{m}$ obeying $\sigma\theta Ax(1-\tau)\hat{m}^{\sigma-1}L^{\xi} = w$. So firms with better ideas are larger.

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$$(1-\sigma)\left[\theta A(1-\tau)xL^{\xi}\right]^{1/(1-\sigma)}(w/\sigma)^{-\sigma/(1-\sigma)} - \phi$$

Developer entry

Those firms with the best ideas $x \geq \underline{x}$ enter, and all but the marginal one earn positive profits. Here:

$$\underline{x} = \frac{(\phi/(1-\sigma))^{1-\sigma}(w/\sigma)^{\sigma}}{\theta A(1-\tau)L^{\xi}}$$

With a greater public code L, there is more entry.

Code production

Given optimal entry, total code produced has total value:

$$\int_{\underline{x}}^{\infty} A x \hat{m}^{\sigma} L^{\xi} \beta x^{-\beta-1} dx$$

where we have integrated the value coming from all active developers. Observe that this is finite if and only if $\beta(1-\sigma) > 1$.

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\begin{aligned}
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= \; & \int_{\underline{x}}^{\infty} A L^{\xi} \left(\sigma\theta A(1-\tau)L^{\xi}/w\right)^{\sigma/(1-\sigma)} \beta x^{\sigma/(1-\sigma)-\beta} dx \\
= \; & A L^{\xi} \left(\sigma\theta A(1-\tau)L^{\xi}/w\right)^{\sigma/(1-\sigma)} \beta \frac{\underline{x}^{1/(1-\sigma)-\beta}}{\beta - 1/(1-\sigma)}
\end{aligned}
$$

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Positive Spillovers

Lemma

The ecosystem supply of code has geometric returns factor $\gamma > \alpha$, i.e. greater than that of any one developer.

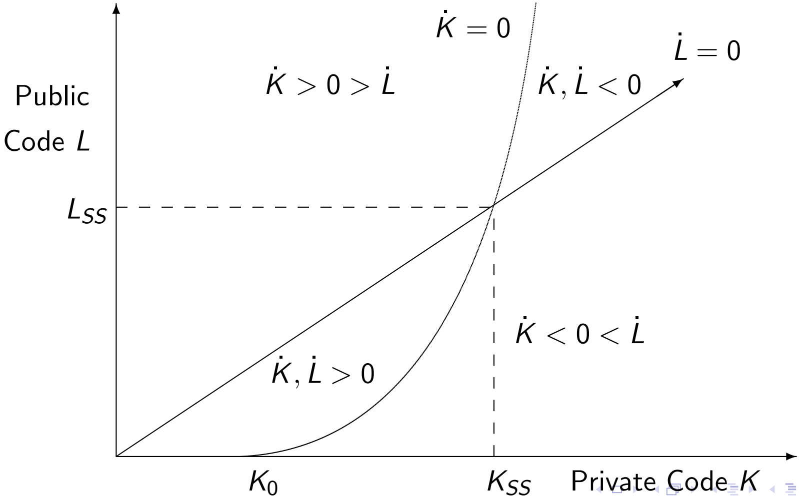
This follows at once from $\gamma = \xi\beta = (1-\sigma)\alpha\beta > \alpha$. More intuitively, this source of additional returns owes to the expansion of existing developer output and the entry of new ones.

Findings

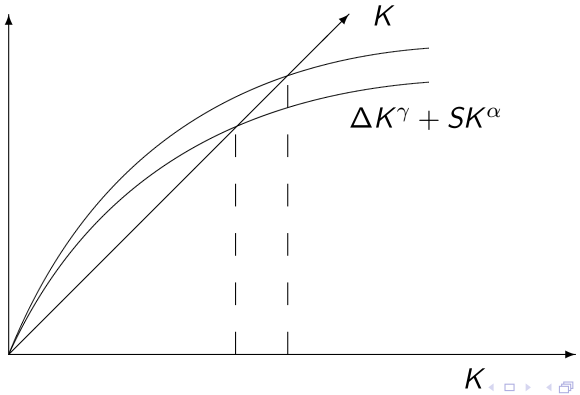
Theorem (Steady-State Private / Public Code)

The code fixed point (K_{SS}, L_{SS}) *is unique, and solves* $K_{SS} = \Delta K_{SS}^{\gamma} + S K_{SS}^{\alpha}$ *and* $L_{SS} = \frac{\pi}{\delta} K_{SS}$, *for coefficients* $\Delta, S > 0$. *The stationary private capital* K_{SS} *rises in* s, α *and* A, *and falls in* $\tau, \phi, r, \rho, \delta$ *and* w.

The fixed point for private and public code



Uniqueness of steady state private code



Platform Solution

Golden Rule is the 5-tuple that maximizes steady state payoffs subject to the laws of motion for private and public code. Substituting for K and L, the steady state value becomes:

$$V(s,\tau,\phi,\pi,\rho) = (1-s)\psi K_{SS}^{\alpha}[(1+\frac{\pi}{\delta})^{\alpha} - (\frac{\pi}{\delta})^{\alpha}] + \tau D(\frac{\pi}{\delta})^{\gamma} K_{SS}^{\gamma}$$

using our implicit definition for K_{SS}.

Findings

Theorem (Larger Platforms)

Assume that the platform grows, so that ψ rises. Then its golden-rule optimal savings rate s falls, the tax rate τ falls, the developer fees ϕ falls, and the code expropriation rate ρ rises.

Proof.

Apply the method of monotone comparative statics to $V_\psi(s, \tau, \phi, \pi, \rho)$ which simplifies easily due to the simple multiplicative way ψ enters the value equation. □

Propositions In Process

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- Absent other means of enforcement, developers themselves are better off with a platform sponsor that appropriates and publishes their code. L_{SS} is larger, aiding the marginal developer and increasing industry profits.
- A profit maximizing firm chooses to open its code when the reusability of code A is sufficiently great or the distribution of ideas $\beta x^{-\beta-1}$ is sufficiently fat headed. That is, we establish conditions for voluntary private provision of a public good.

Contributions & Conclusions

- We find that larger platforms impose higher developer fees & taxes, expropriate less, and save more.
- Positive spillovers emerge endogenously as a consequence of publication of developer innovations. Phenomenon is analogous to expiration of R&D patents.
- Introduces a macroeconomic growth model of IO questions
  - Includes both public and private capital.
  - Increasing returns despite decreasing returns technology.
  - Reduces to the Solow (1956) growth model.
- Explains private provision of a public good by a profit maximizing firm.
- Findings are consistent with behavior of existing platforms.

Coming Applications: Electronic Medical Records

Coming Applications: Smart Grid Platforms

Coming: Cloud Computing & Biz Model Experimentation

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