

Generality, Recombination and Re-Use

Tim Bresnahan

NBER 50th Anniversary Conference on
The Rate and Direction of Inventive Activity

Recombination & GPT (Re-Use) Matter

- Most technical change is recombinant
- Some general purpose technologies involve re-use on an economywide scale

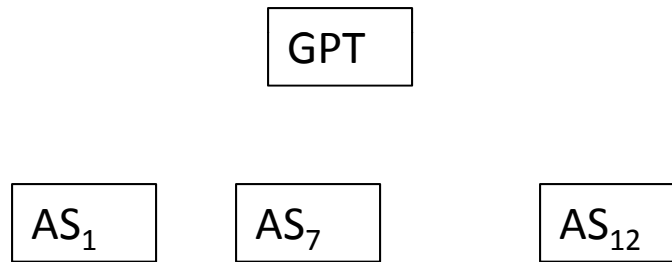
ORIGINS of GPT, Re-Usable Technologies?

- We (scholars of multiple disciplines) have only weak conjectures about the ORIGINS of re-usable technologies
- This paper:
- Equilibrium Interaction of Incentives and Knowledge
 - Getting serious about knowledge
- Examples from Information Technology (IT)
 - Future examples from Steam and Electricity?

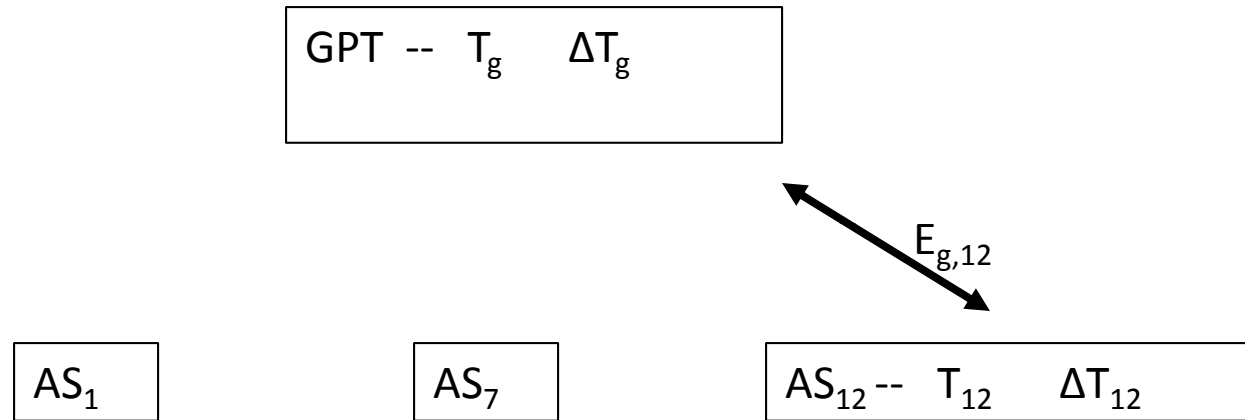
How are re-usable technologies innovated?

- Knowledge
 - Of use
 - Of future re-use?
 - of technical feasibility?
- Incentives?
- Leadership?
 - Systems entrepreneur? Tech Entrepreneur?
 - No coordination, invented for specific use?

A Familiar Structure AFTER Innovation



Knowledge of Two Fundamental Kinds



T ΔT Technical knowledge of sector's technology and possible inventions

E_{g,a} Entrepreneurial knowledge of market opportunities that would arise if innovation were to succeed in both GPT and AS

The Idea About Ideas

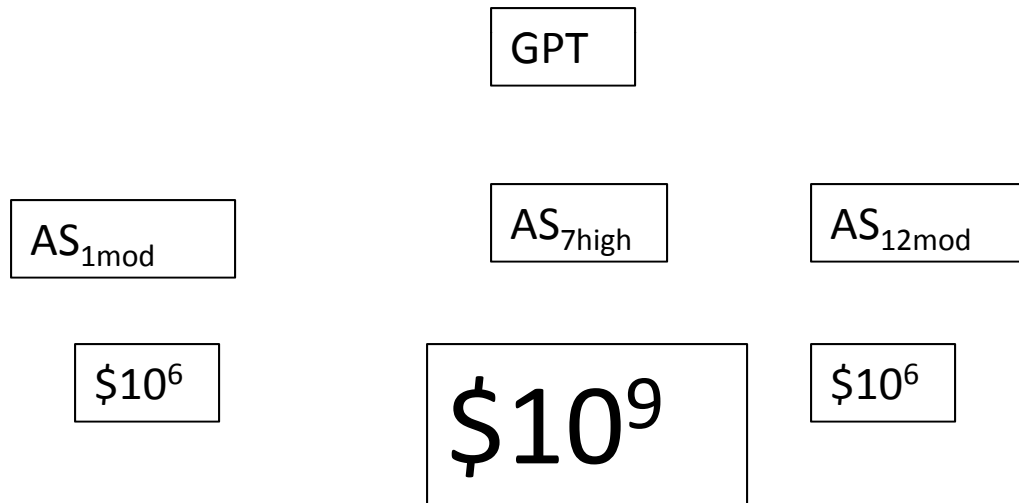
- Technical Knowledge
 - Specific, narrow, specialized
 - T and dT
- What is technically feasible at forecastable cost?
- Includes, e.g. organization techs
- “How”
- Entrepreneurial Knowledge
 - Overlaps, arbitrage, purposive
 - $E_{g,a}$ is seeing $V(T_g + \Delta T_g, T_a + \Delta T_a)$
- “Why”

A Common Fact Pattern (in ICT)

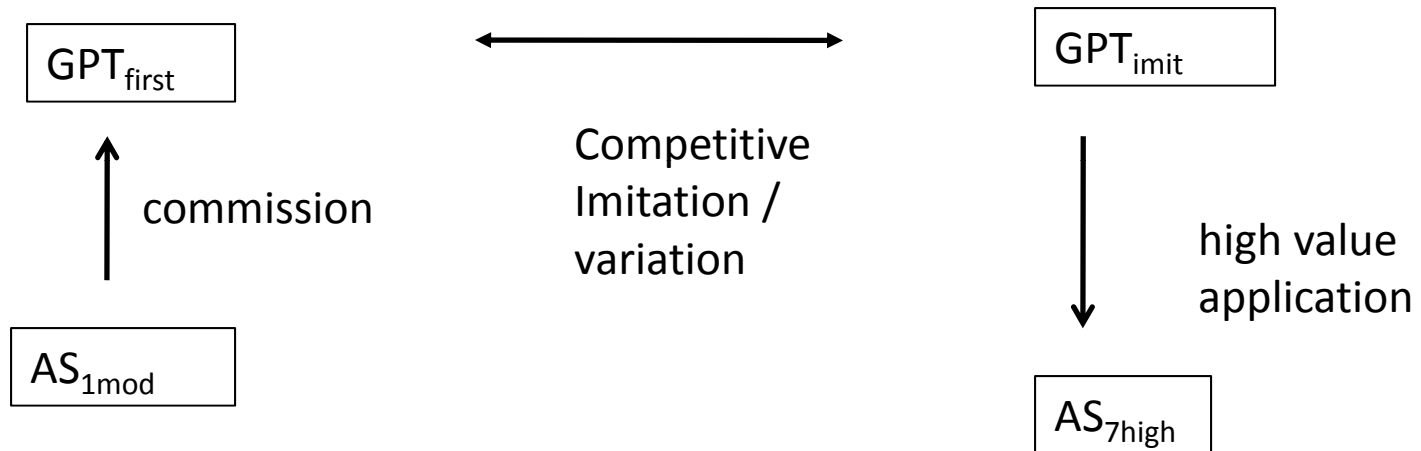
Circuitous Route to GPT

- Huge variation in value-in-use of the same GPT
- GPT
 - originally invented for a particular use
 - Later recombined to other uses
- Uses
 - Early use moderately valuable
 - Later use extremely valuable
- Examples include (justifying “extremely”)
 - Stored program computer
 - PC
 - Mass Market Internet

Sometimes wildly asymmetric
in social surplus generated...

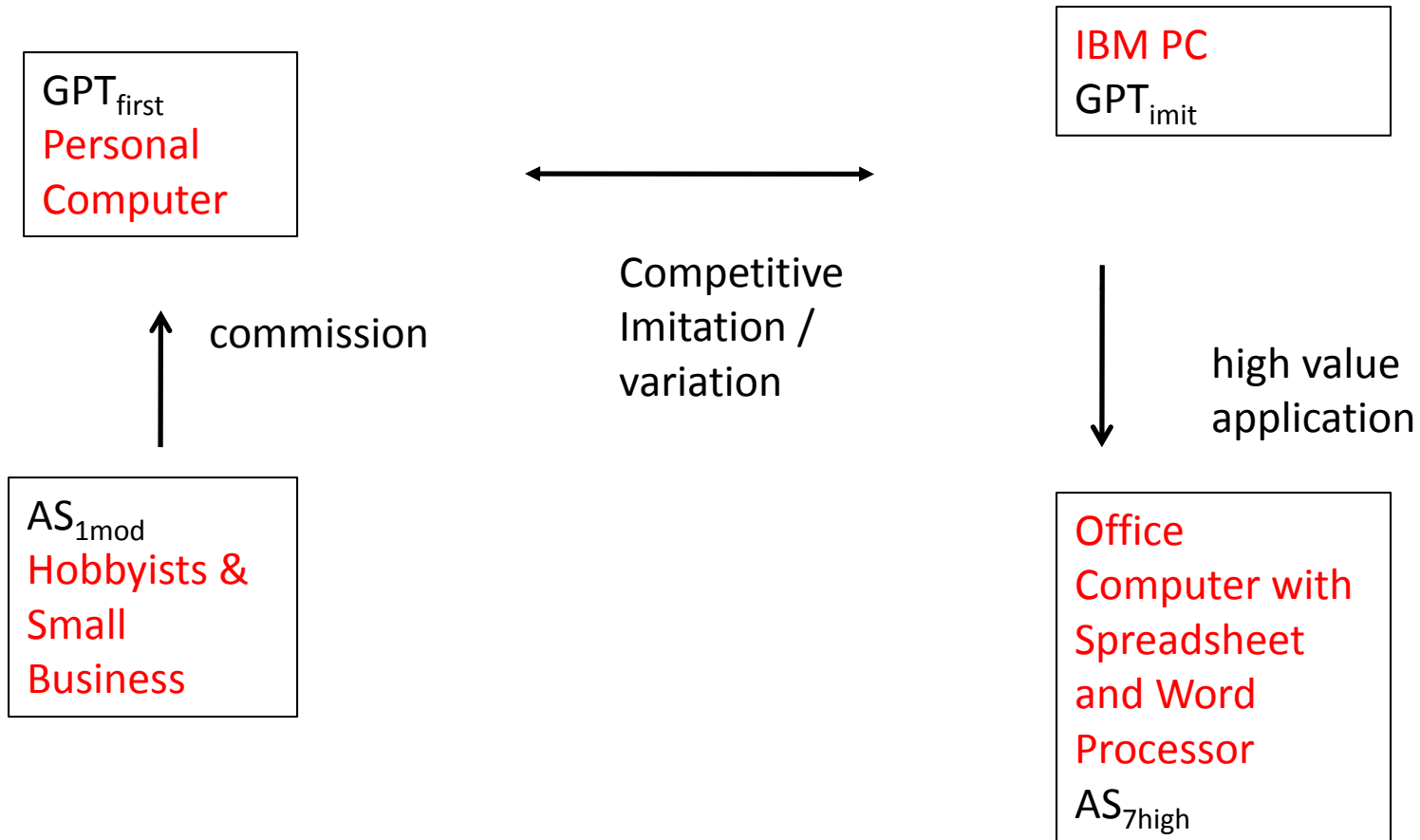


A Movie of a common path



A Movie of a common path

Example



My Information Story

Information View Explains Circuitous Route



A technologist in the AS can see the value of new technical advance WITHOUT anyone seeing its importance elsewhere – he is an “entrepreneur” in seeing an opportunity

Once a technology exists, alternative applications are easier to see.

This is the “jigsaw puzzle” model of invention.

Historical Investigation of Information Behind Circuitous Route

At founding of PC

- Founders see hobbyist, small business demand
 - Their statements
 - Their designs
- Founders, existing office automation firms have same viewpoint

After founding of PC

- Invention of spreadsheet, word processor recombines PC => white collar work
- Office Automation firms can now see value
 - IBM, AT&T, DEC ...
 - WordPerfect, etc.

Incentives

- Powerful After Innovation
 - Recombination to new domains
 - Low incremental cost
 - Benefits
 - SIRS
 - GPT diffuses
 - Ditto
- Bad moment for patents, closed systems
- Weak Before Innovation
 - Knowledge of future recombination?
 - Often strong historical evidence against this
 - Knowledge of scope of GPT usage?
 - Often strong historical evidence against this (ICT)
 - Sometimes entrepreneur and inventor are one (Edison)
- Patents, etc. push on a rope

A Movie of a common path

More Examples

GPT_{first}
Personal
Computer

GPT_{first}
Stored
Program
Computer

GPT_{first}
WWW,
Browser

AS_{1mod}
"Hobbyists"

AS_{1mod}
Atomic Bomb

AS_{1mod}
Physics Grad students
share data

White Collar tool
(spreadsheet,
word proc.)
AS_{7high}

Business Data
Processing
AS_{7high}

Online
Entertainment and
Commerce,
AS_{7high}

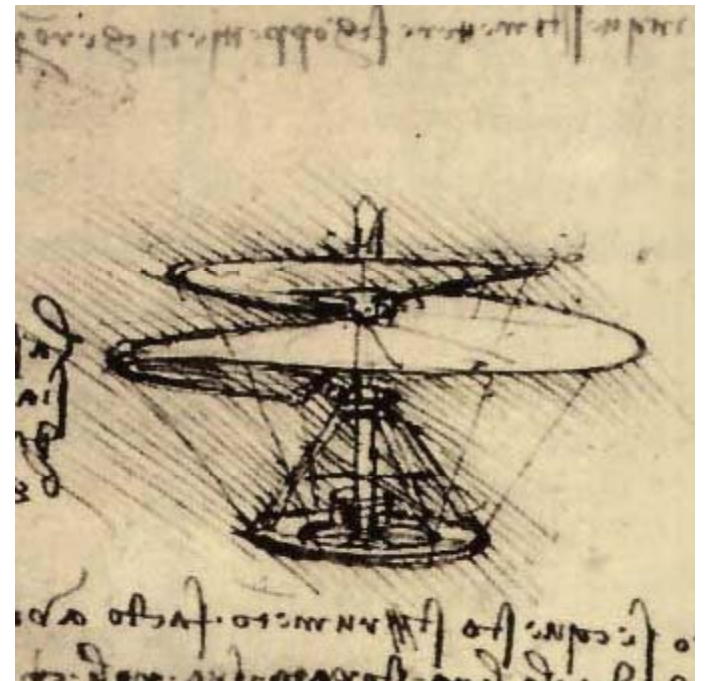
Preliminary Conclusions

(after looking only at ICT, which may be odd)

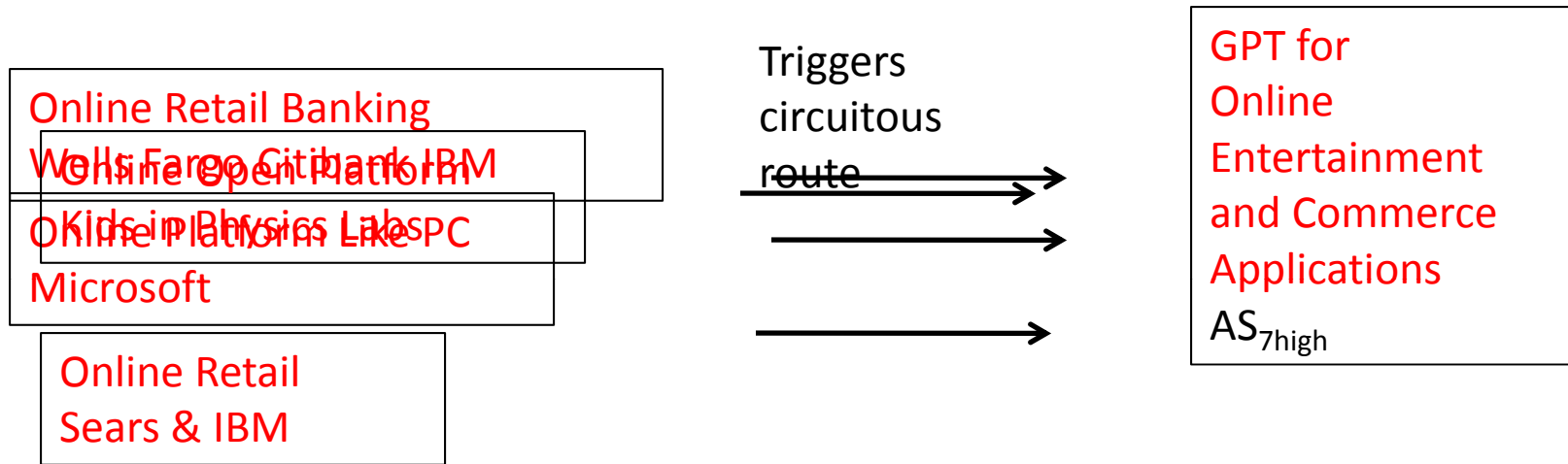
- Dispersed Knowledge
- Technical Knowledge of ICT, Technical Knowledge of Using Industries (and households) and entrepreneurial knowledge are distinct
 - Exceptions show the rule

The Leonardo Da Vinci Problem

- Many ideas have been anticipated
 - (c.f. history of science and technology literature.)
- This doesn't lessen importance of entrepreneurial (overlap) knowledge
- Example follows



Another Movie – Anticipated E_{ga} Still Matters!



Implications of a simple model (an example?)

- When the bottleneck is entrepreneurial information
 - Early incentives ineffective
 - Despite this, social rate of return on innovation is far above private as original application has to pay for G
 - Open access effective ex post innovation
 - Patents a poor tool
- Implications for information dissemination
- No systematic need for high value to come last
 - In ICT, high value is systematically also high jigsaw

Seeking Guidance

- A systems innovator to put in parallel
 - Edison?
 - IBM Mainframe?
 - Transport Network?
- Convincing historical evidence on “didn’t know”
 - What they wrote at the time?
 - Product, marketing, etc. decisions at the time?
 - Leonardo syndrome