Information Technology and the Economy: Where Are We and Where Do We Go From Here?

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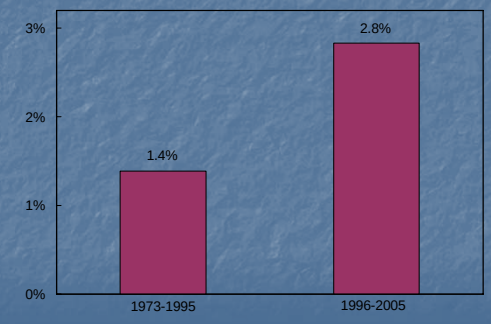
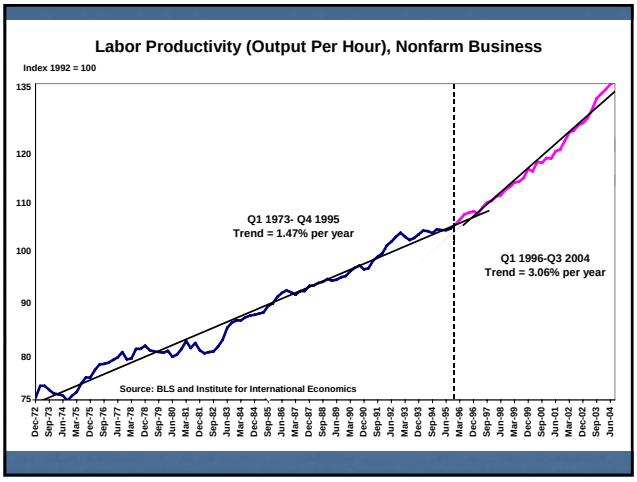
Overview

- (Mostly) Good News: IT & Productivity
  - Past and Present
  - Future
- Concerns
  - Inequality
  - Turbulence
  - Innovation Incentives
  - Mismeasurement: Beyond Productivity
- Policy Implications

U.S. Labor Productivity

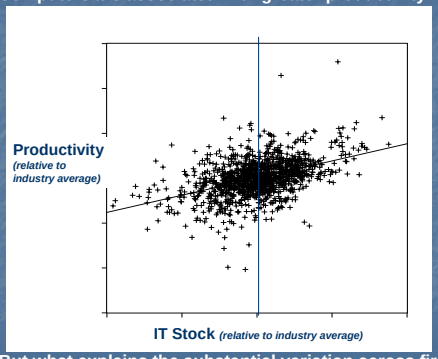


Source: Bureau of Labor Statistics



IT and Productivity: The Data Speak

Computers *are* associated with greater productivity...



...But what explains the substantial variation across firms?

Complementarities: More than computers alone

The "old' vs. "new" Johnson & Johnson

Old	New
• Mass production • Managers make decisions, workers are laborers • Piece rates • Hierarchy • Few Standard products, long runs	• Flexible Manufacturing • All employees make decisions • Team incentives/ownership • Flat design • Product diversity, short runs

Cost Structure of a Large IT Project

	$millions
Hardware Application, Web, and database servers including storage	$0.8
Software ERP application Suite License (HR, Financials, Distribution) 1,000 regular trained users, 2,000 casual users	$3.2
Implementation 9 months to complete pilot site including process engineering, apps configuration, and testing 30 external consultants as $1,200 a day 30 internal staffers at an average salary of $100,000	$9.3
Deployment 3 external consultants at 9 sites for 3 months 9 internal staffers at each site for 6 month 5 days of user training 3 full-time training staff at an average burdened	$7.5
Start-up Costs Total	$20.5

Source: Gormely et al.

Computerization > Computers

IT Capital (10%)

Technological Complements (15%)

Organizational Complements (75%)

Intangible Assets are more important in the Information Economy

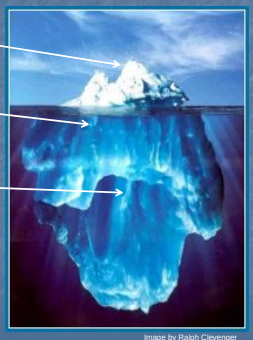
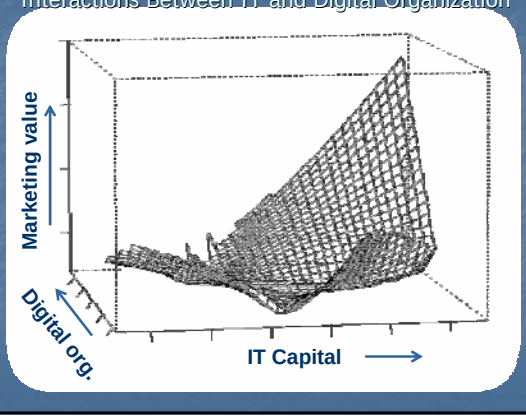


Image by Ralph Clevenger

Interactions Between IT and Digital Organization



Puzzle: Why Did Productivity Accelerate *Even More* After 2000?

- Post-2000 Surge caught most people by surprise
  - Simple growth accounting explanations of faster growth in the 90s do not work well
- The Story
  1. IT investment associated with very large intangible organizational capital investments: up to 10x size of computer investment (Brynjolfsson & Yang, 2002)
     - Business process redesign, training. Implementation, market and product strategy innovation
  2. Organizational investments are mostly "expensed" (Brynjolfsson & Fitoussi. 2005)
     - This shifts productivity from present to the future
  3. Businesses moved from "sowing" to "harvesting" after 2001
     - IT and BPR investment way down; big focus on cost-cutting and realizing potential gains vs gold rush of exploring opportunities in late 1990s

  => Consistent with data that show 5 year lags before peak productivity gains from IT (Brynjolfsson & Hitt, 2001)

Implications of Story

1. Standard growth accounting is wrong
   1. Major investments have been treated as expenses
2. Productivity surge in 2001-2004 was unsustainable because it reflects harvesting of past investments, and lack of future investments
3. Productivity is dipping back *below* trend now as a result

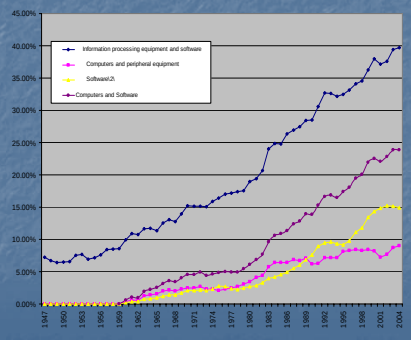
The Future of Productivity Growth

- Baumol's Disease and Carr's Complaint
- IT: The Elixir
  - From Asymptotic Stagnation to Increasingly Accelerating Growth
- If high productivity sectors have price elasticity > -1, then they will shrink as a share of the economy
- But, if high productivity sectors have price elasticity < -1, then they will grow as a share of economy
- Price elasticity of IT has been estimated to be

  …. ***-1.2*** (Brynjolfsson, 1996)
  - "I want to convert labor costs to IT costs to ride the technology curve" – Todd Thompson, Citi CFO
  - From *String Quartets* to *U2* replicated x 1million on iTunes

Information Technology Share

of private nonresidential fixed investments



Looking Forward

A) **Easy Prediction: Moore's Law and related trends for storage, communications, etc will continue**
- The power of exponentials

B) **IT share of GDP is likely to grow further**
- Common to assume constant share
- CFOs want to shift costs onto technology curve

C) **Points A) and B) imply *growing* impact of IT on productivity**

D) **Can IT Reverse the Curse of "Baumol's Disease"?**
- Depends on the substitutability of IT (and other rapidly improving inputs)
- IT economy-wide price elasticity has been ~1.2
- Long-term elasticity may be higher (a la Le Chatelier)

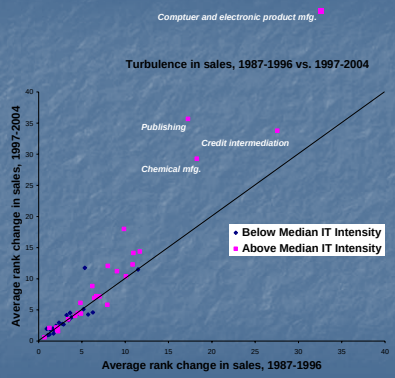
Concerns

- Inequality
- Turbulence
- Innovation Incentives
- Mismeasurement: Beyond Productivity

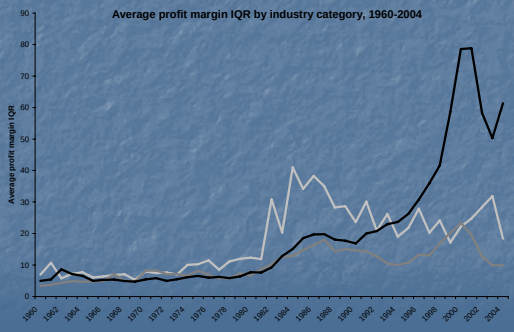
IT, Labor and Wealth

- The changing demand for labor
  - What types of work will be replaced by machines and which will be in greater demand?
- How will the distribution of wealth be affected by continuing advances in IT?
  - Computer-skill complementarity
    - Growing Inequality
  - The Superstar effect
    - The top 1%; the top 0.1%

Turbulence is Growing



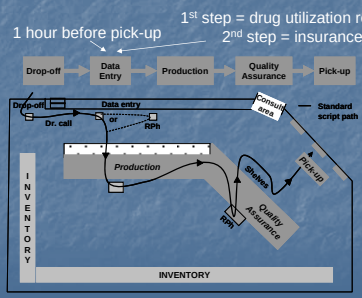
IT as a Strategic Differentiator



Business Process Replication: Achieving Scale Without Mass

Case Study: CVS

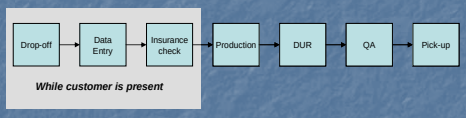
Basic 'script fulfillment process:



- 27% of scripts encountered a problem
- 16% of customers disappointed at pick-up

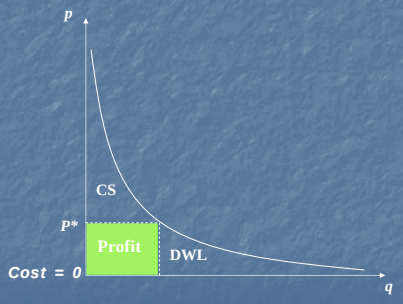
Case Study: CVS

New fulfillment process:



- Short-term results: customer satisfaction scores
  - Wait times: 76 → 86
  - Overall pharmacy satisfaction: 86 → 91
- New process embedded in EIT
  - 100% compliance
- < 1 year rollout to over 4000 retail pharmacies

Zero Marginal Costs and Efficiency



The Mismeasure of Value

- Value of New Goods, Product Variety and Quality
- Value of "free goods"
  - Wikipedia vs. Britannica
  - The growing gift economy

Product Variety Comparison

Product Category	*Amazon.com*	*Typical Large Brick-and-Mortar Store*
Books	2,100,000	40,000 – 100,000
CDs	250,000	5,000 – 15,000
DVDs	18,000	500 – 1,500
Digital Cameras	213	36
Portable MP3 players	128	16
Flatbed Scanners	171	13

Wal-Mart stocks six times as many SKUs online versus in superstore

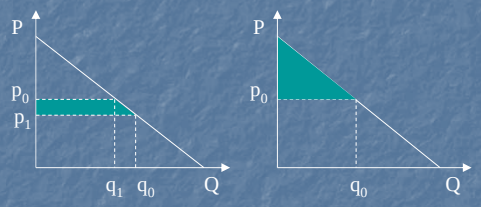
Policy Implications

- Beyond (Tangible) Technology
  - Two cheers for Management Consultants and B-Schools!
- Education: A win-win
- Managing Turbulence
  - Protect people, not firms or industries
- Incentives for Innovation
  - Pick prices, not winners
  - New institutions
- Opportunities for Better Measurement
  - Measuring Organizational Capital
  - Product Variety & Consumer Surplus
  - Micro-Micro Data

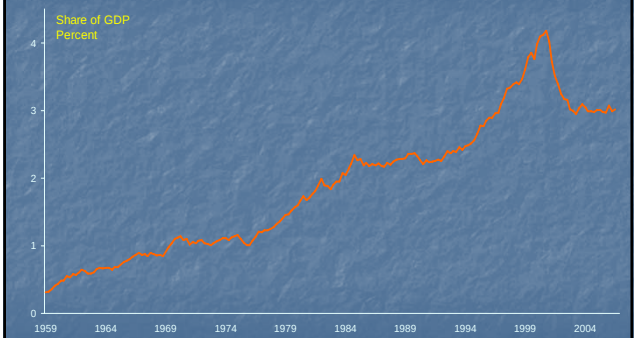
Beyond Productivity: Consumer Surplus

- Productivity is output/input
- Consumer surplus is difference between what consumer *would* pay vs. what consumer does pay

Consumer Surplus from Price Drop or from New Good

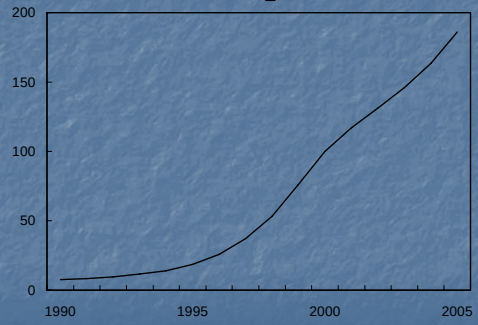


IT Investment Slowed after 2000



Note: Investment in computer hardware, software, and telecommunications equipment as a share of GDP. Data are from the National Income and Product Accounts.

Real U.S. Computer Stock



Source: Bureau of Economic Analysis. Nonresidential assets. Quantity index, Year 2000=100

Summary

Computerization → Creation of intangible assets.

- The value of these intangibles can be as much as 20 times as the value of computer assets alone
- Technology-enabled business process reengineering can lead to significantly higher market value than computers or reengineering alone.
- Finally, the **interaction** of business process reengineering, computer capital, ***and*** a cluster of new work practices and culture is even **more** valuable.

Organizational Capital and Intangibles

- Increasing share of all investment is in business processes, human capital, and other intangibles

Computerization > Computers

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Organizational Complements (75%)

Intangible Assets are more important in the Information Economy

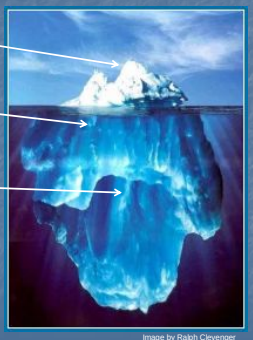


Image by Ralph Clevenger

Tobin's q in 2006

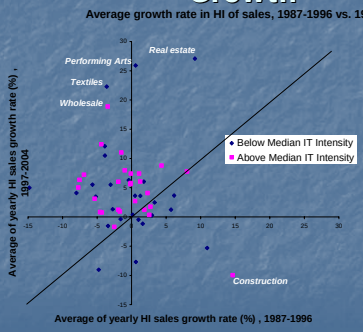
	Total Market Value	Book Value of Assets	Tobin's q
Walmart	**$278.7**	**$145.2**	**1.9**
Sears	$42.3	$28.4	1.5
Google	**$130.9**	**$5.3**	**24.7**
Yahoo	$35.0	$8.5	4.1
Dell	**$67.8**	**$15.0**	**4.5**
Hewlett-Packard	$140.1	$66.1	2.1
Amazon.com	**$18.3**	**$2.1**	**8.7**
Barnes and Noble	$4.7	$3.1	1.5

Source: Google Finance. Cash is subtracted from market value and assets.

Seven Practices of Digital Organizations

1. Move from analog to digital business processes
2. Distribute decision-rights
3. Foster open information access
4. Link incentives to performance
5. Maintain focus and communicate goals
6. Hire the best people
7. Invest in human capital

Scatterplot: Sales Concentration Growth

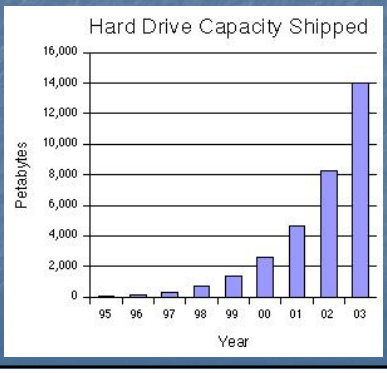


Competition in Product Markets

- How does IT affect product markets
  - Product variety and the Long Tail
  - Winner-take-all markets

Information Overload

Digital information is doubling every 1.1 years



Information Consumes Attention

"The scarce resource is not information, it is the processing capacity to attend to information"

- Herbert Simon

Responses to Information Overload

1. ***Automate***
   - *Off-load work from humans to machines*
2. ***Train and hire*** *skilled, educated workers*
   - *Increase the capacity of human processors*
3. ***Reorganize*** *to distribute decision making*
   - *Delegate to involve more brains*
4. ***Focus and Filter***
   - *Learn to ignore; Learn to prioritize; Learn to say no*
5. ***Combinations*** *of the above*
   - *Creativity needed to boost information metabolism*

Emerging topics

- Funding models for digital info
  - Bundling and aggregation, targeted ads, open source, information complements, etc.
- Innovation incentives for digital goods
- Online Communities
  - Cyberbalkanization or Global Village
- Platforms for products and innovation
- Reputation and Recommenders
- Stickiness

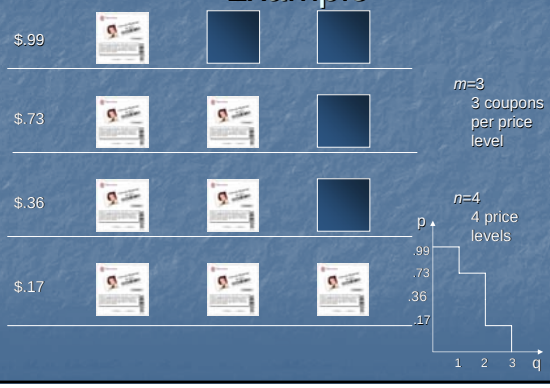
Innovation Incentives for Digital Goods

Couponing Mechanism

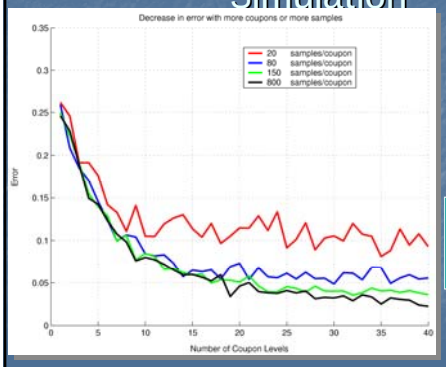
- Sell the bundle of *i* goods to each of *j* consumers
- Choose $m \times n$ random consumers and issue each of them a digital rebate coupon tied to DRM
  - *n* : **price levels**
  - *m* : **coupons offered for each price level**
  - $m \times n << i \times j$ so

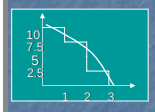
relatively few consumers face prices for a given good

Example

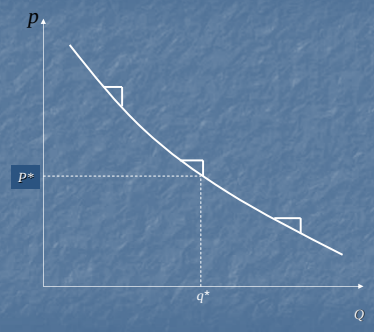


Simulation

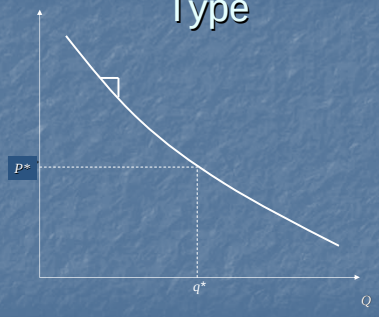




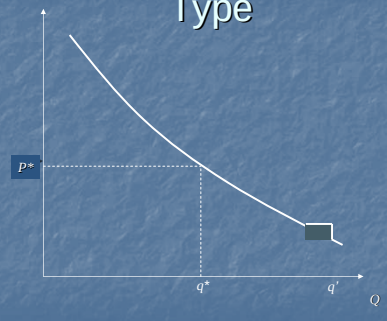
Which Innovation Will Be Pursued?



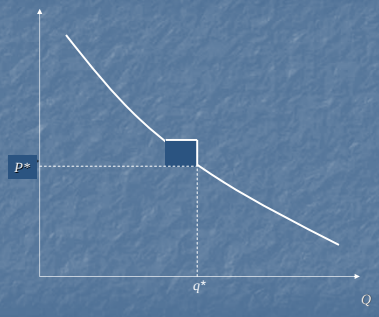
Targeted Innovation – High Type



Targeted Innovation – Low Type



Targeted Innovation – For Marginal Consumers



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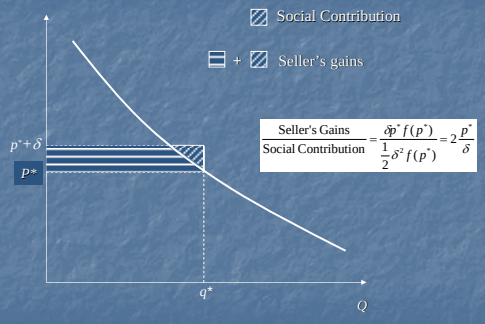


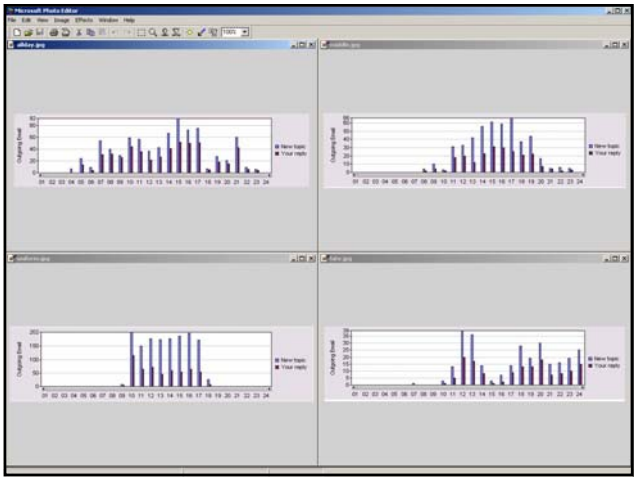
$$\frac{\text{Seller's Gains}}{\text{Social Contribution}} = \frac{\delta p^* f(p^*)}{\frac{1}{2}\delta^2 f(p^*)} = 2\frac{p^*}{\delta}$$

Frontier Research Opportunities

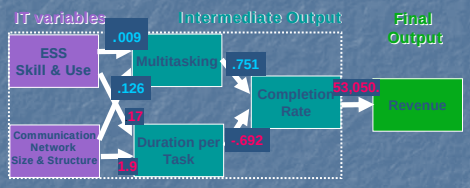
1. Using Task-level Data
   - Social Network Analysis
   - Controlled Experiments
2. Consumer Surplus
   - Beyond Productivity
3. Organizational Capital and Intangibles
4. IT, Labor and Wealth
   - Education, skills and income inequality
   - The economics of superstars
5. Competition in Product Markets
   - The long tail vs. winner take all markets?
6. Business Process Replication
   - Achieving scale without mass
7. Information Overload
   - How much information is produced each year?
   - Technological and organizational responses
8. Innovation Incentives in Information Goods
   - Mechanism design
   - Open source and the gift economy

Task-level data

- Finer grained data
  - Like using a microscope
- Look at communication flows to create social networks
- Designed experiments

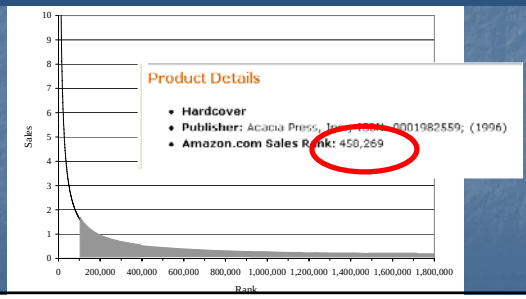


A Model of Information Work:

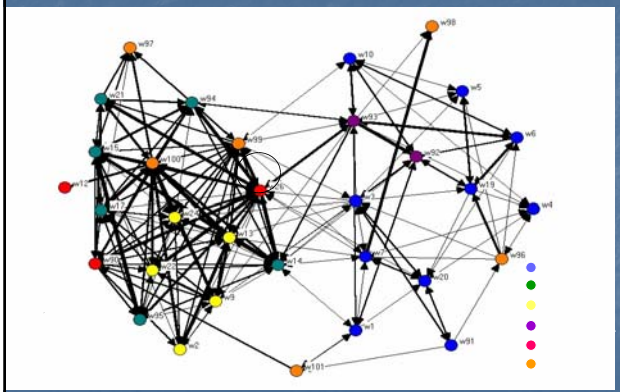


Revenue From Obscure Titles

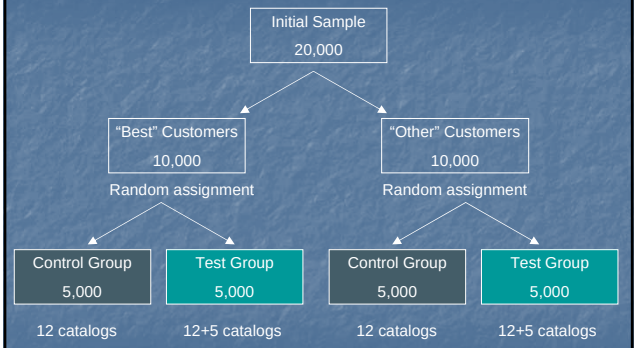
- What proportion of sales at Amazon.com are from obscure books?
- Use rank, assume Pareto relationship between rank and sales: $Q = a * Rank^{b}$

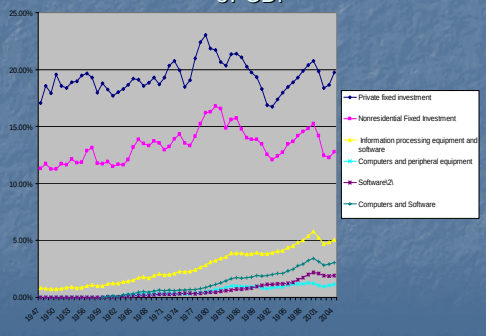


Mapping Communication Networks



Design of the Experiment



Fixed Investment and Information Technology Investment Share

of GDP