

# The Medium is the Measure!

Library collections as indicators of economic changes

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# The Outline of the talk

1. Background
2. Present a new way to Measure Technological Change
3. Discuss the properties of the new indicators
4. Discuss applications of the measure

# Why are Measures of Technical Change So Important?

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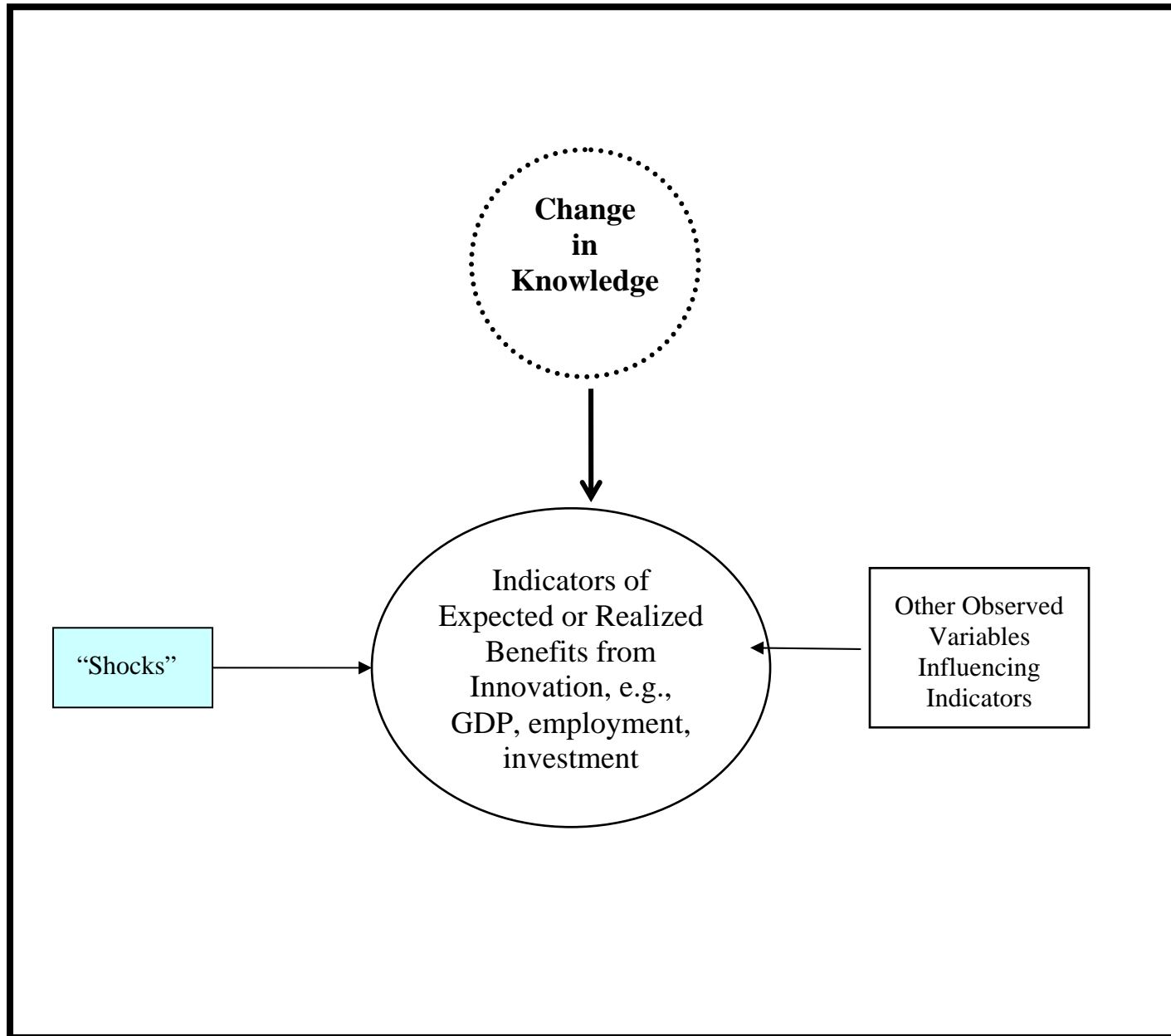
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- Without good measures, we can't test these theories

# Why are Measures of Technical Change So Important?

- Economists believe technical change is responsible for economic growth and a major cause of business cycles
- Without good measures, we can't test these theories
- Without good measures, we can't determine what areas of technology are growing rapidly and where we should invest R&D funds

# How Does Technological Change Affect the Economy?

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# Previous Direct Measures of Technological Change

## **In Economics:**

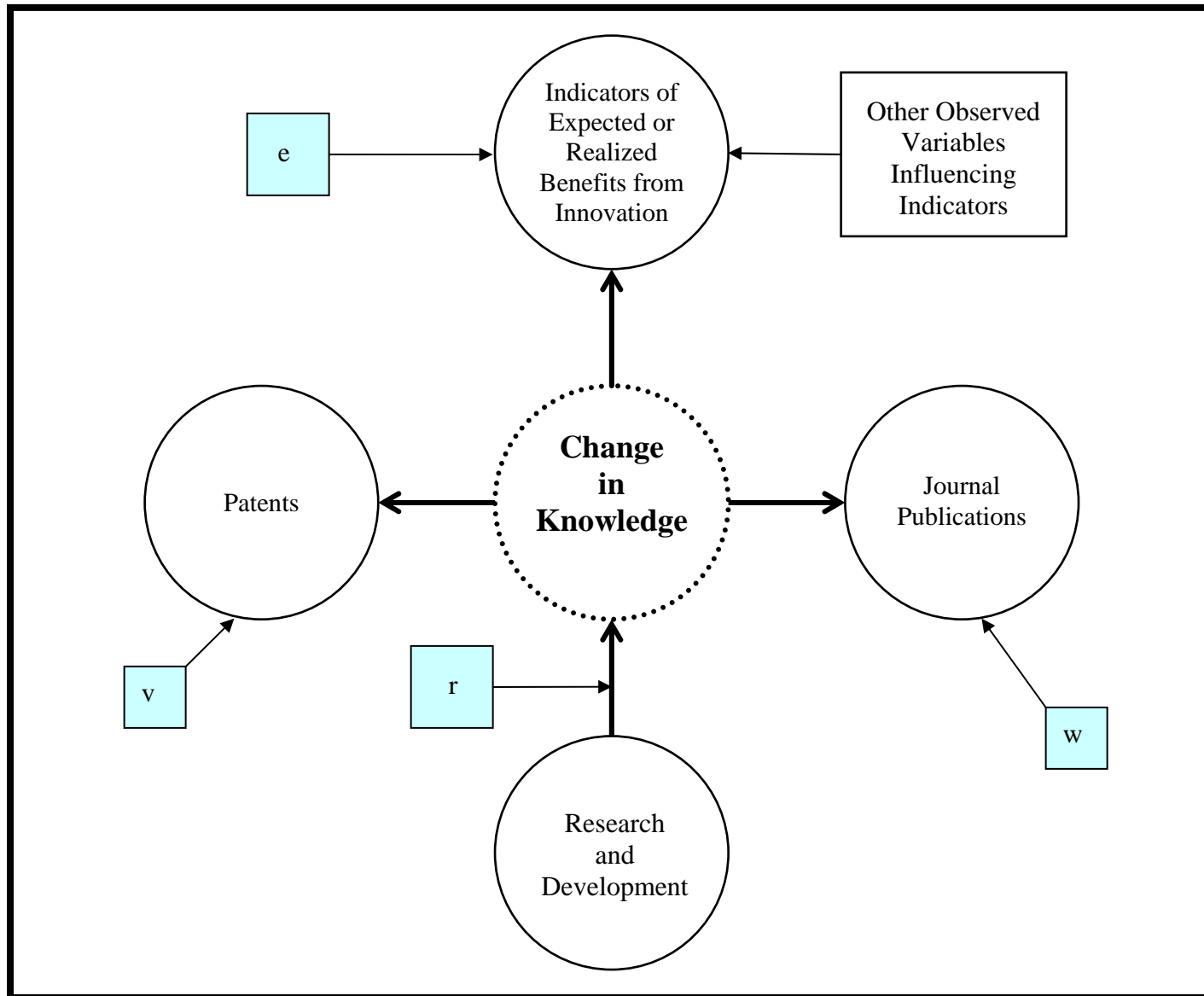
- a. Patents and Patent Citations
- b. R&D expenditures
- c. Major Innovation Counts

## **In Other Fields (Bibliometrics):**

Citations and Counts of Articles in Scientific Journals and conference Volumes

# The Knowledge Production Function

## A Simplified Path Analysis Diagram



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BUT...

- If we are interested in the effect of commercialized products and processes, there are a number of problems

# Measure: Patent indicators

- Annual time series available

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- Patenting should be linked to innovative activity



# Problems with using patent statistics:

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2. Patent filings do not guarantee there will be commercial innovation following
  - Schmookler (1961) claims over 1/2 of patents don't result in commercial products in early part of century (over 80% now)

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4. Not all goods/processes are patented

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- So should R&D expenditures in Industry

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# Measure: Major New Innovations Count

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\*\*How do you determine what a major innovation is and when it is dated?

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- Biases of editors potentially reflected in publication pattern
- Often need to search by keywords to find articles on same topic and keywords not uniform

Where do we go from here?

Create new and/or better  
indicators with available data

What are the minimum criteria  
that an indicator should meet for  
our purposes ?

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3. Be related to the introduction of the new good or process to market
4. Weight various technologies according to their importance
5. Cover all new technologies across industries

# The New Book-Based Indicators satisfy these criteria

## Key insights

- 1) Book publications are linked to changes in knowledge (How to books, etc)
- 2) Classification systems exist to allow objective groupings
- 3) Timing is right due to profit motivations for publishers

There are three main sources of information  
that can be used to create these types of  
indicators

# Sources

1. **Library Catalogues (e.g., Library of Congress or WorldCat)**  
(See e.g., Alexopoulos (forthcoming AER) and Alexopoulos & Cohen (2009 JME))
2. **Publishers lists (e.g., Books in Print or ABPR)**  
(See e.g., Alexopoulos (2008 EL))
3. **Book sellers (e.g., Amazon)**  
(See e.g., Alexopoulos and Cohen (2009 UofT WP))

# First Generation U.S. Book-Based Indicators

## (From Library Records)

Annual Series on Technology and sub-groups (chemicals, manufacturing/mechanical, electrical, automotive, telecommunications)

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- Focuses on non-historical books

# How are the MARC21 Records Used?

## Sample Marc Record:

00971cam2200277a4500001000800000005001700008008004100025035002100066906004500087010001700132020003900149040001800  
18805000270020608200170023310000240025024500550027426000460032930000270037544000460040250400250044850000200047365  
0003600493740003800529952006000567991006600627-2860358-20000328102341.0-850830s1986 mau b 001 0 eng -  
9(DLC) 85020087- a7bcbccorignewdleocipf19gy-gencatlg- a 85020087 - a020112078X (pbk.) :c\$21.95 (est.)- -  
aDLCcDLCdDLC-00aQA76.73.C153bS77 1986-00a005.13/3219-1 aStroustrup, Bjarne.-14aThe C++ programming language /-  
cBjarne Stroustrup.- aReading, Mass. :bAddison-Wesley,cc1986.- aviii, 327 p. ;c24 cm.- 0aAddison-Wesley series  
in computer science- aBibliography: p. 10.- aIncludes index.- 0aC++ (Computer program language)-0 aC plus plus  
programming language.- aAnother issue (not in LC) has: viii, 328 p. ta01 4-3-87- bc-GenCollhQA76.73.C153iS77  
1986p0003475293AtCopy 1wBOOKS-

## Online display of Record:

**LC Control Number:** 85020087

**Type of Material:** Text (Book, Microform, Electronic, etc.)

**Personal Name:** [Stroustrup, Bjarne.](#)

**Main Title:** The C++ programming language / Bjarne Stroustrup.

**Published/Created:** Reading, Mass. : Addison-Wesley, c1986.

**Related Titles:** C plus plus programming language.

**Description:** viii, 327 p. ; 24 cm.

**ISBN:** 020112078X (pbk.) :

**Notes:** Includes index. Bibliography: p. 10.

**Subjects:** [C++ \(Computer program language\)](#)

**Series:** [Addison-Wesley series in computer science](#)

**LC Classification:** QA76.73.C153 S77 1986

**Dewey Class No.:** 005.13/3 19

# MARC TAGS

**000** 00971cam a2200277 a 450

**001** 2860358

**005** 20000328102341.0

**008** 850830s1986 mau b 001 0 eng

**035** \_\_ |9 (DLC) 85020087

**906** \_\_ |a 7 |b cbc |c orignew |d 1 |e ocip |f 19 |g y-gencatlg

**010** \_\_ |a 85020087

**020** \_\_ |a 020112078X (pbk.) : |c \$21.95 (est.)

**040** \_\_ |a DLC |c DLC |d DLC

**050** 00 |a QA76.73.C153 |b S77 1986

**082** 00 |a 005.13/3 |2 19

**100** 1\_ |a Stroustrup, Bjarne.

**245** 14 |a The C++ programming language / |c Bjarne Stroustrup.

**260** \_\_ |a Reading, Mass. : |b Addison-Wesley, |c c1986.

**300** \_\_ |a viii, 327 p. ; |c 24 cm.

**440** \_0 |a Addison-Wesley series in computer science

**504** \_\_ |a Bibliography: p. 10.

**500** \_\_ |a Includes index.

**650** \_0 |a C++ (Computer program language)

+ field 250 (edition information)

# Intuition behind timing of book measure

New books are required with new technologies to teach people to use them, fix them etc.

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∴ Timing of first books related to commercialization date

# Timing of Books vs. Innovations

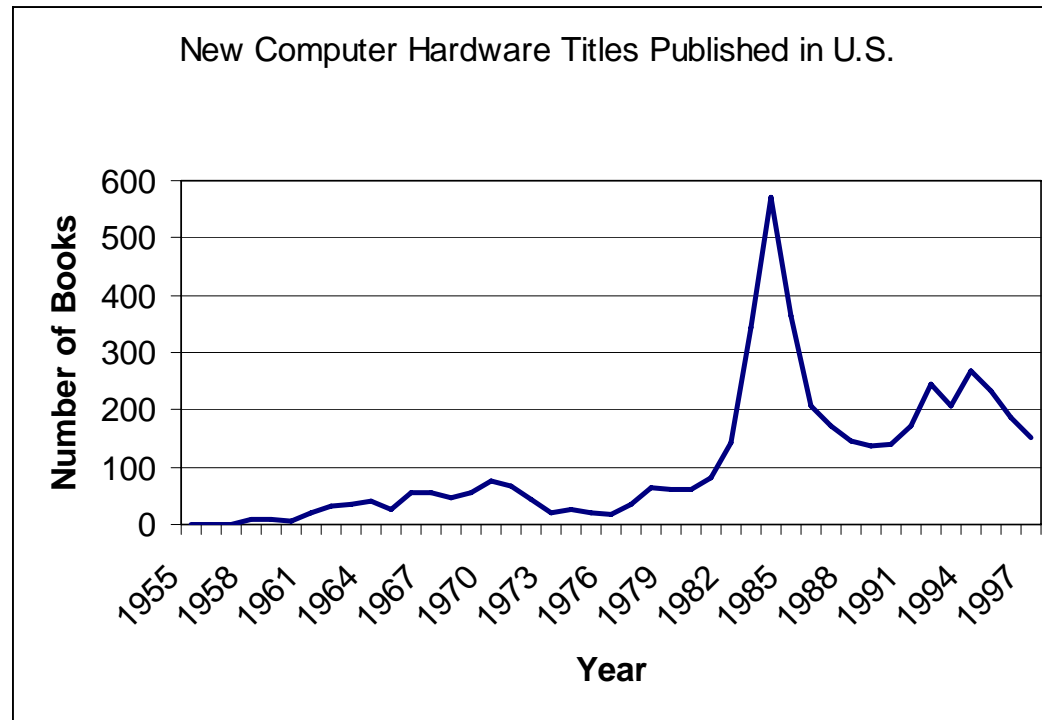
<i>Invention</i>	<i>Date of Invention</i>	<i>Date of Innovation</i>	<i>Date of Commercialization</i>	<i>Book Date</i>
Insulin	1889	1922	1922	1922
Neoprene/Duprene	1906	1932	1932	1937
Nylon	1927	1938	Dec. 1939	1939 (1940 in english)
Penicillin	1922	1941	1943	1943
Radio	1887	1922	1922	1910 (1922)
Streptomycin	1921	1944	1945	1945
Kodachrome	1910	1935	1935/1936	1937
Silicones	1904	1946	1946	1946
Terelyne/Polyester	1941	1955	1953	1953/1954
Automatic Transmission	1904	1939	1939	1939

Source: M. Alexopoulos and J. Cohen, "Volumes of Evidence: Examining technical change last century through a new lens"  
University of Toronto Working Paper, 2009.

Innovation	Date of innovation	Commercialization Date (in U.S.)	Book Date
Windows	Nov. 1983	Nov. 1985	1986
C++	1983	Oct. 1985	1986*
Lotus	Nov. 1982	Jan. 1983	1983
Apple II+	1978	June 1979	1981^
Macintosh	Jan. 1984	First Quarter 1984	1984
Lisa	1978	Jan. 1983	1983
IBM PC	July 1980	Aug. 1981	1982
IBM PC/AT	Aug. 1984	Fall 1984	1985*
Commodore 64	Jan. 1982	Nov. 1982	1982
Cellular Telephones	1973	1984	1984
Scientific Management (Taylor)	1911	1911	1911
Time in Motion Studies (Gilbreth)	1911	1911	1911
Industrial and General Administration (Fayol)	1918	Early 1930s	1930 (in English printed in UK)

Source: M. Alexopoulos and J. Cohen, "Volumes of Evidence: Examining technical change last century through a new lens" University of Toronto Working Paper, 2009.

# Do changes in the new indicators reflect changes in available technology?



Source: M. Alexopoulos, "Read all about it!! What Happens following a technology shock?" *Forthcoming American Economic Review*

1958: 1<sup>st</sup> commercial transistor computers

1959: beginning of second generation of computers

1960s: 1<sup>st</sup> mini-computer, harddrive, disk storage system, integrated circuit, 1Kb ram

1970-74: 1<sup>st</sup> floppy disk, mini-computer kits, Intel 8008 & 8080 microprocessors introduced

1975-79: Altair, Apple II, Commodore, and TRS-80 computers introduced

1980-84: Intel 80286 chip, and 1<sup>st</sup> portable computer, IBM, IBM clone, laptop, & Macintosh computers

1985-89: Intel 80386 and 80486 chips introduced

1990-97: WWW launched, Pentium chip introduced

New Technologies are weighted differently

Major innovation/General purpose technology

Major innovation/General purpose technology



Large market



Major innovation/General purpose technology



Large market



Large number of new titles

Small innovation/Sector specific technology

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Smaller market

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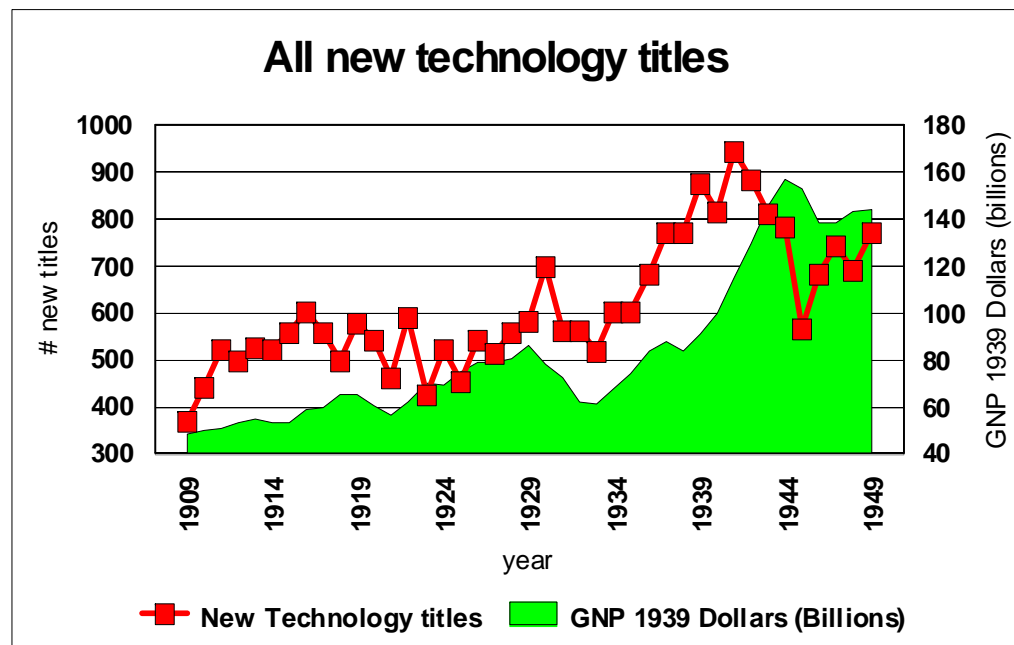
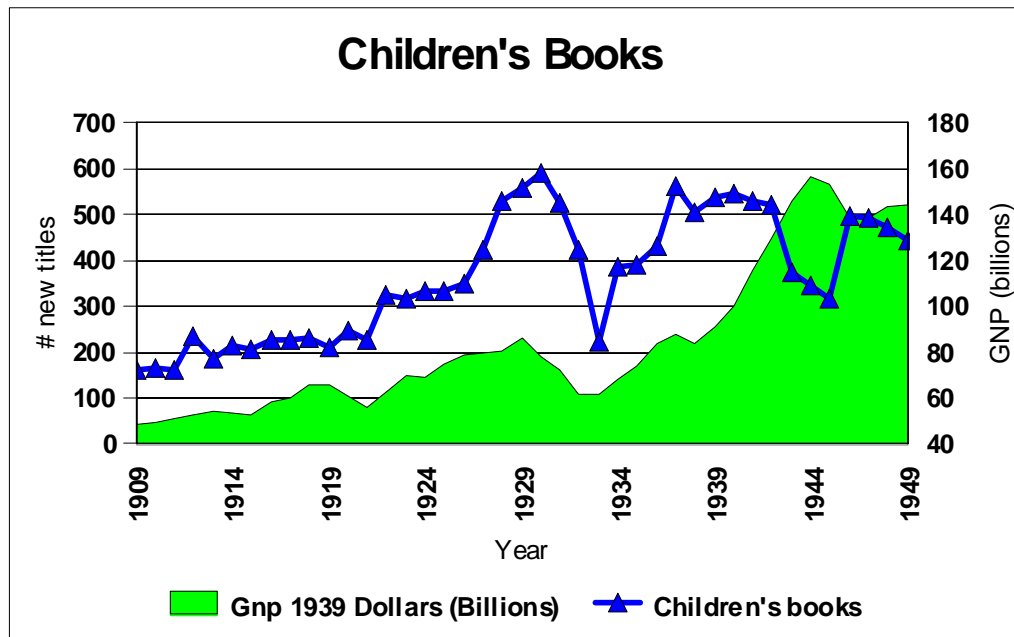


Less books

Do our technology indicators simply track trends in the publishing industry?

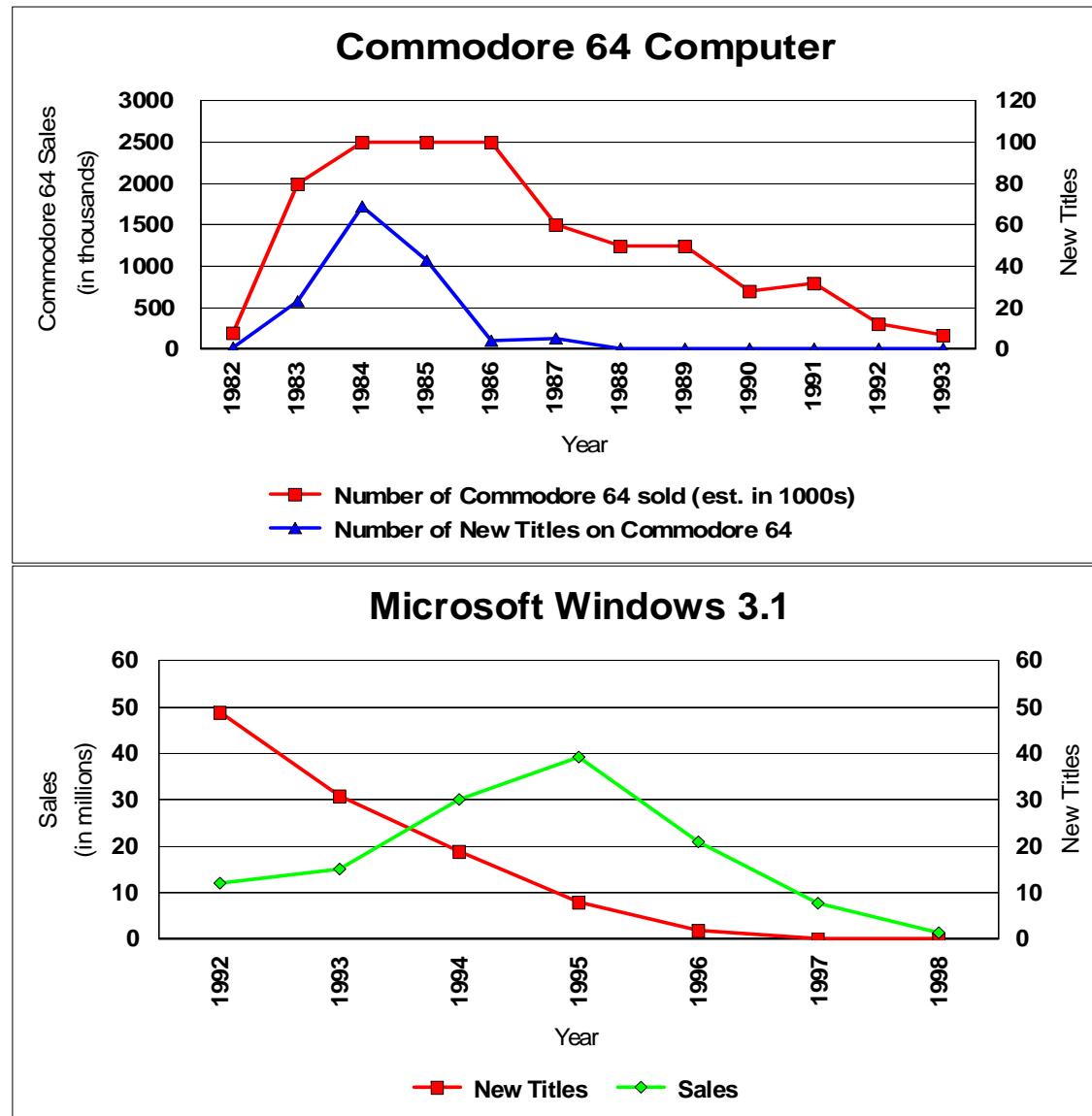
Do our technology indicators simply track trends in the publishing industry?

NO



Source: M. Alexopoulos and J. Cohen, 2009. "Volumes of Evidence: Examining technical change last century through a new lens"  
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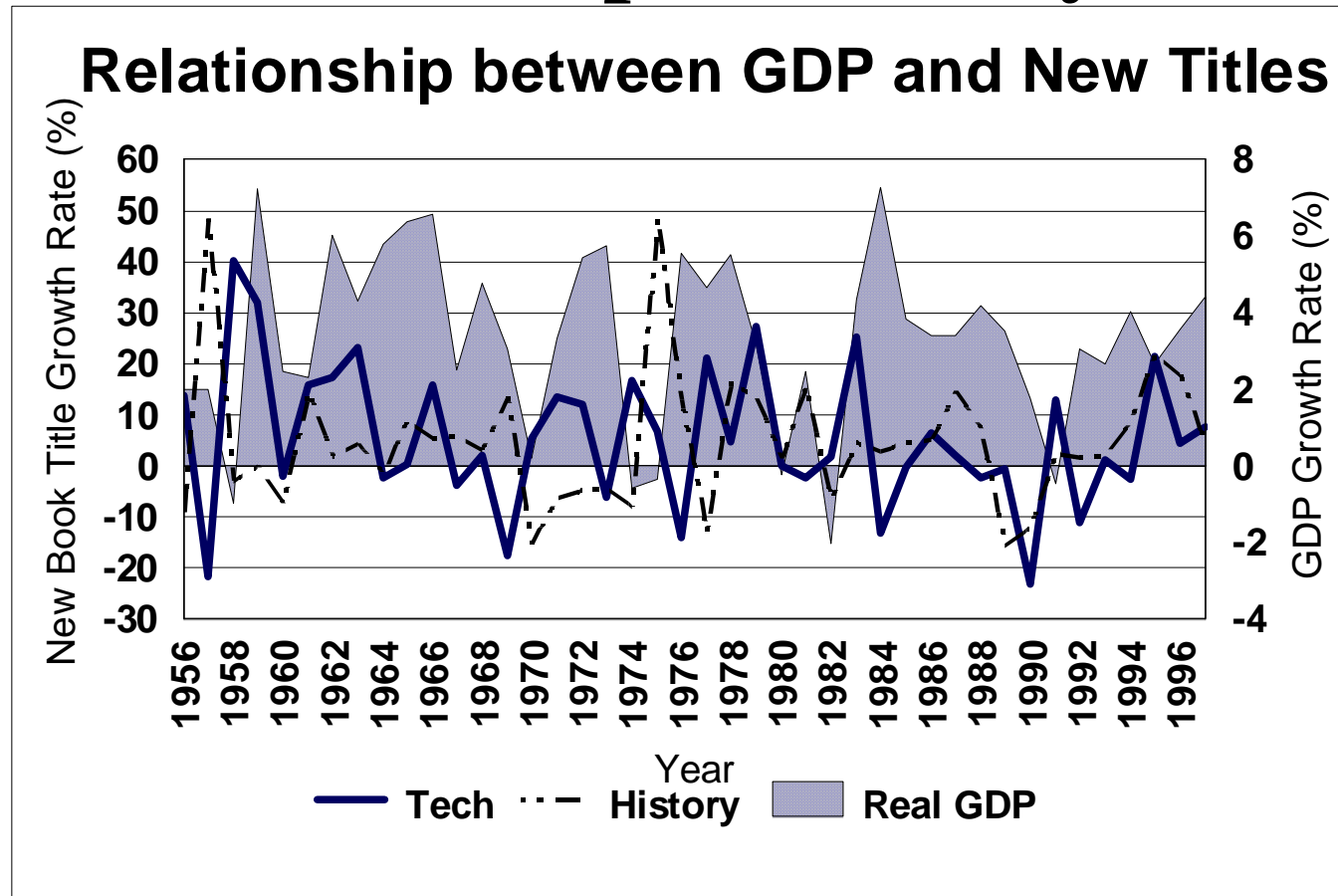
# The new indicators do not simply track diffusion of a product/process



Source: M. Alexopoulos, "Read all about it!! What Happens following a technology shock?" Forthcoming American Economic Review



# Application #1: Relationship between technical change and GDP (or productivity)

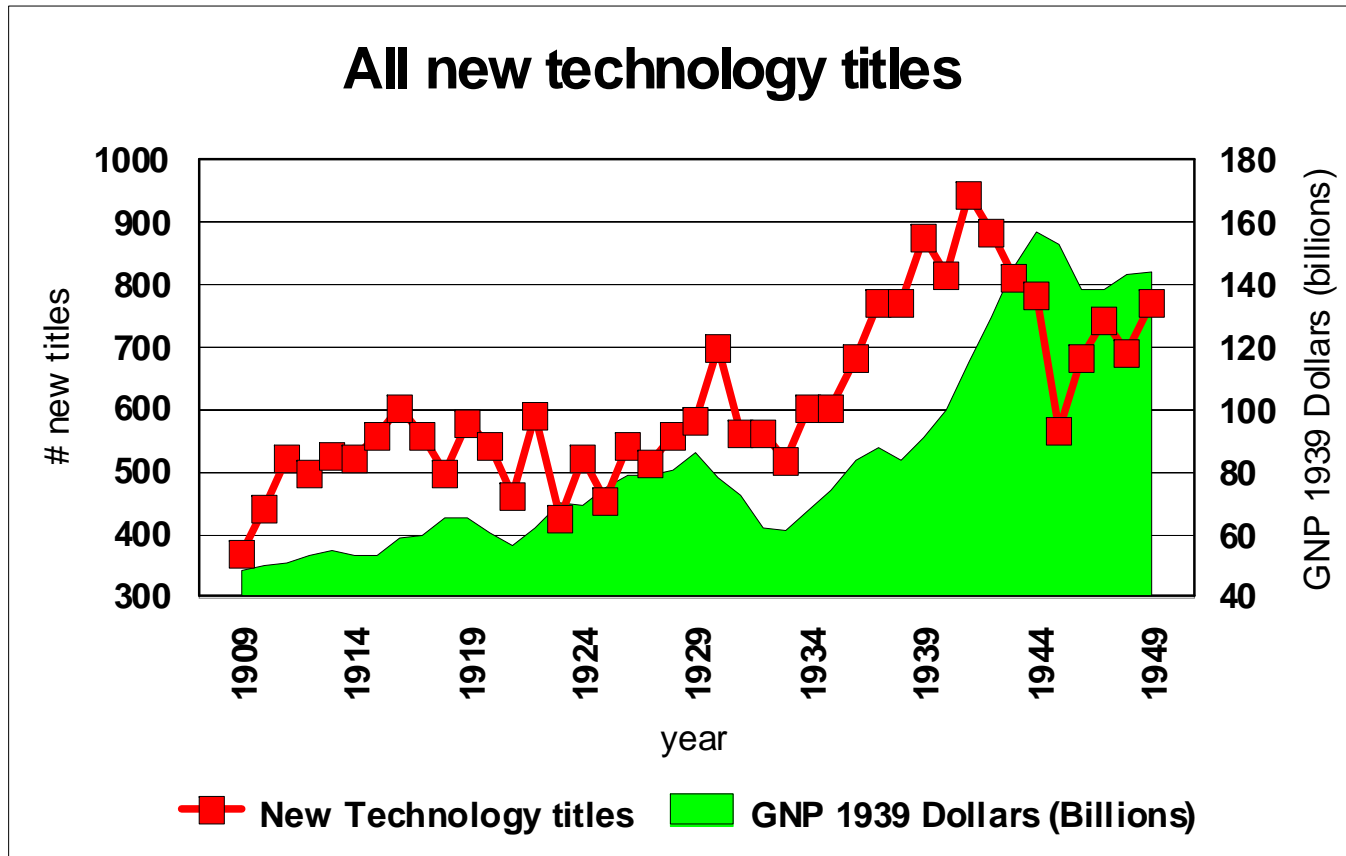


Source: M. Alexopoulos, "Read all about it!! What Happens following a technology shock?" Forthcoming American Economic Review

**Application #2:  
Can answer questions like:**

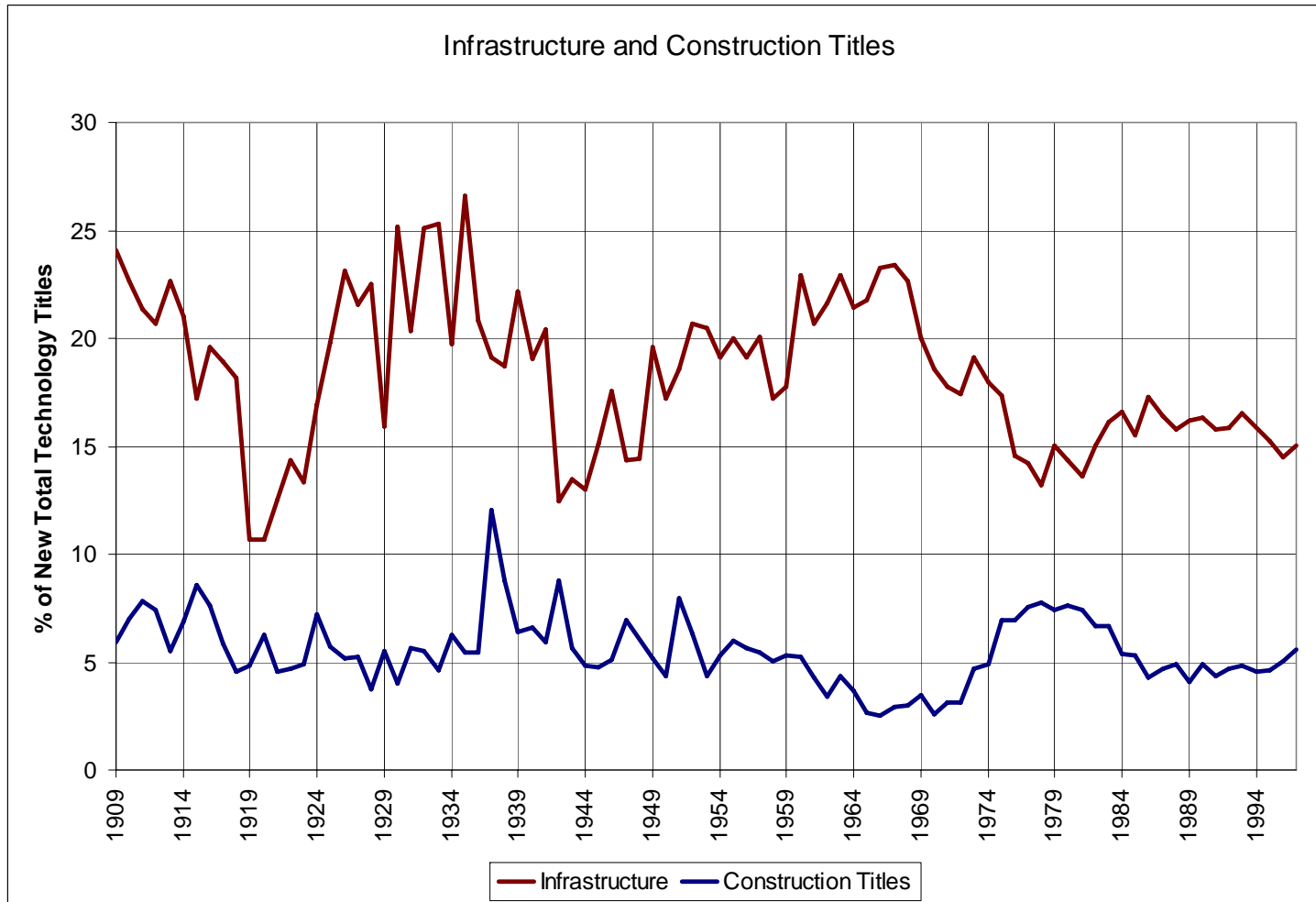
**Was the 1930s really a technologically  
progressive decade?**

# It Was!!

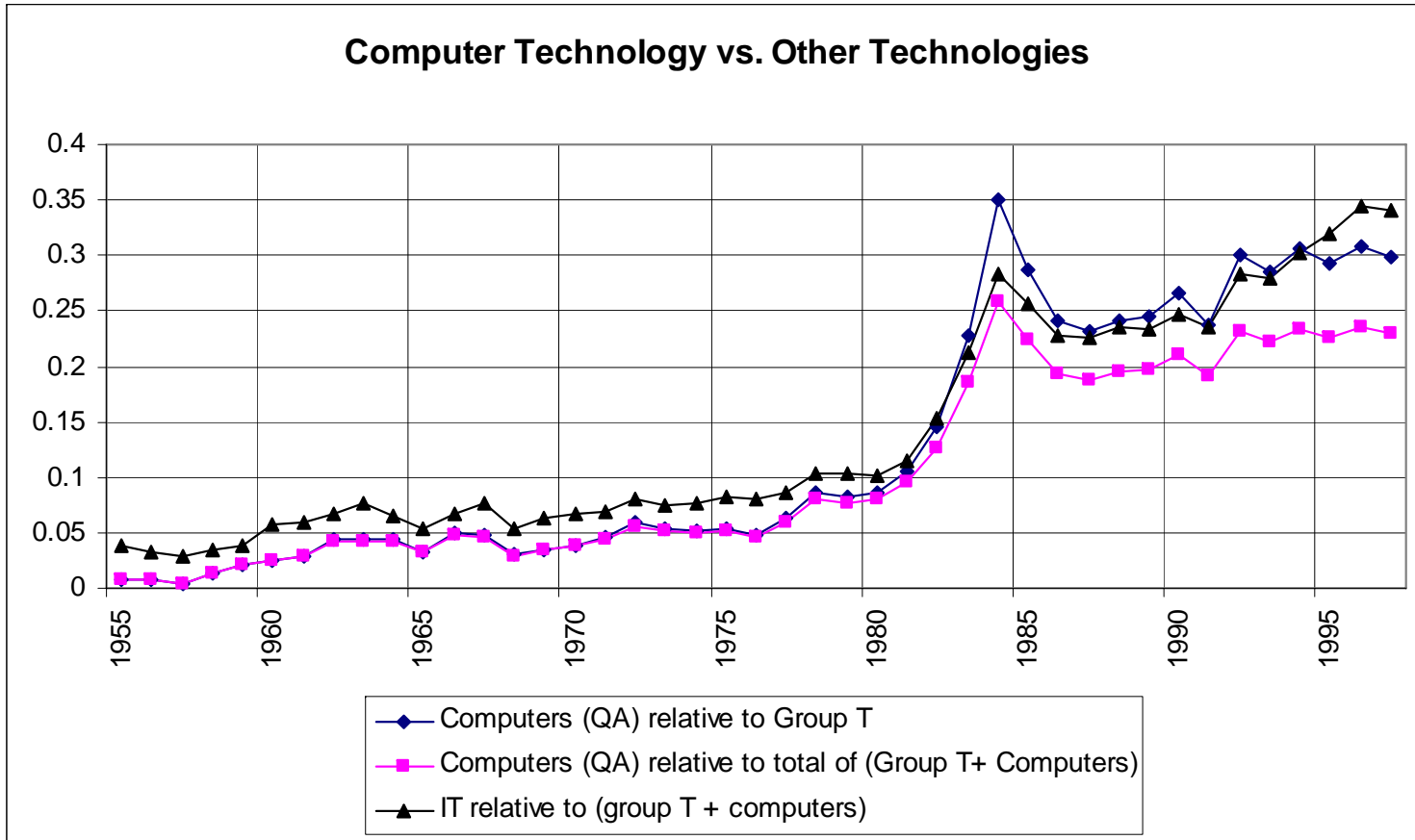


Source: M. Alexopoulos and J. Cohen, 2009. "Measuring our ignorance one book at a time: New indicators of technical change, 1909-1949" [Journal of Monetary Economics](#)

# Application #3: Documenting Waves of Innovation

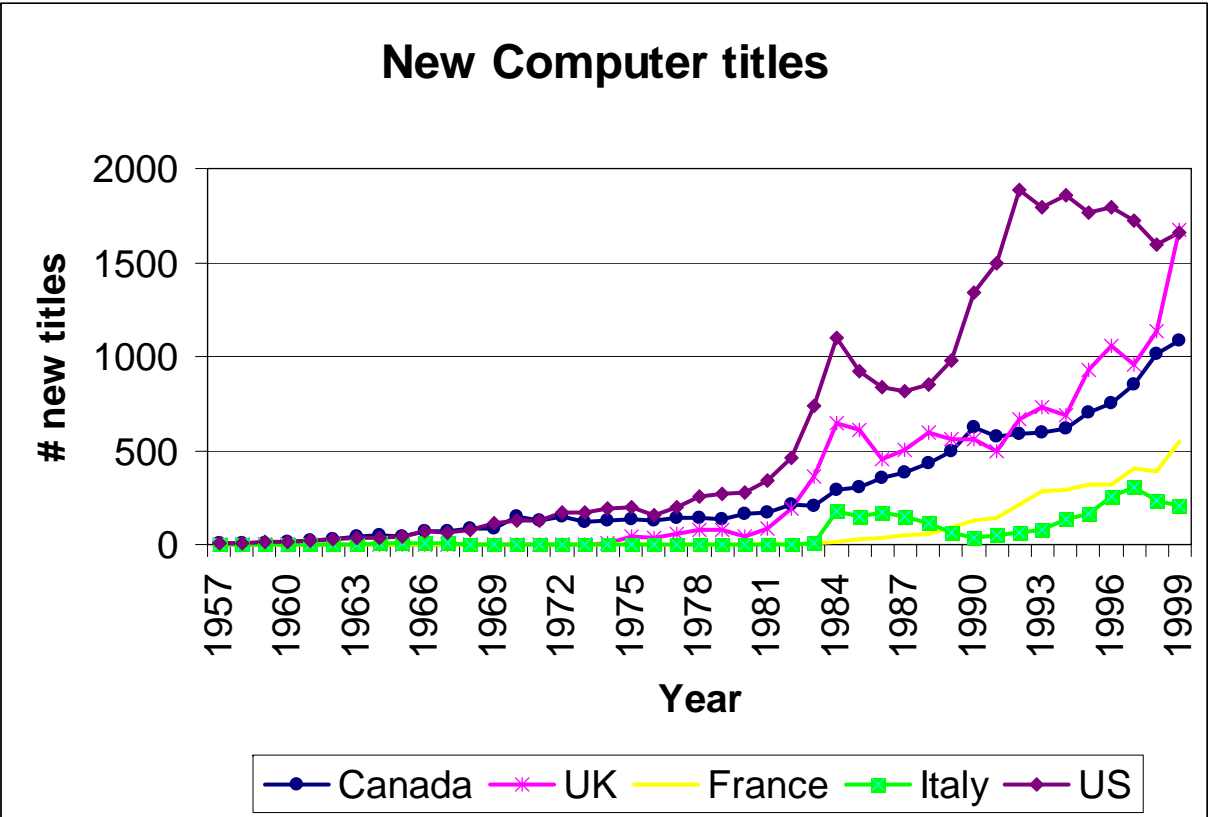


Source: M. Alexopoulos and J. Cohen, 2009. "Volumes of Evidence: Examining technical change last century through a new lens" University of Toronto Working Paper



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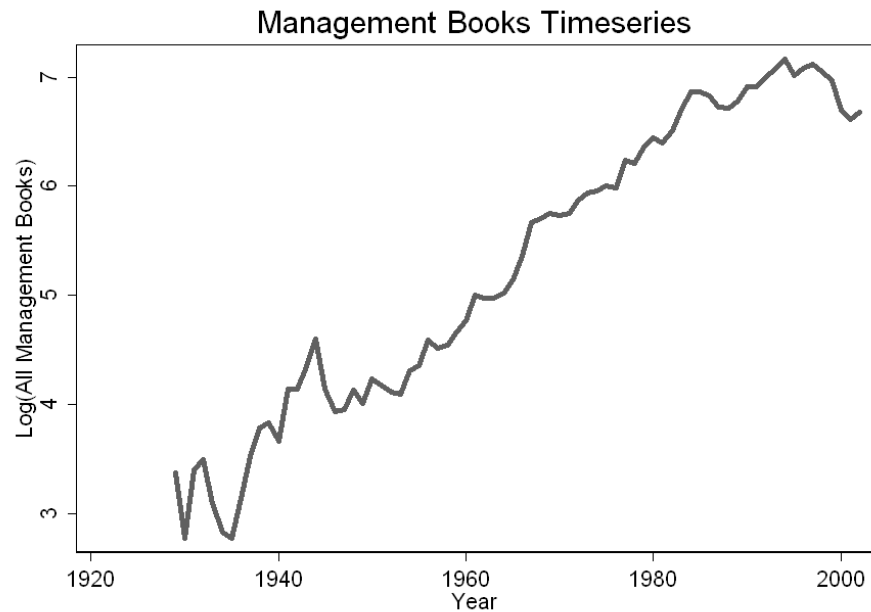
# Application #4: Cross-country Studies



Source: Authors Calculations

# **Application #5: Exploring quantitative Links between Science and Technology**

# Application #6: Measuring changes in intangible technologies (e.g., Management) and determining its effect on the economy



Source: M. Alexopoulos and T. Tombe. 2010. "Management Matters", University of Toronto Working Paper



# **Application #7: Creating measures for regional jurisdictions (Using WorldCat information)**

\*Measure of technical or scientific advancement may proxy for different technologies used in areas

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- may help explain geographic variation in innovation, development, employment and income

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\*Creating measures of diversity and openness, based on holding in other areas (language, art, music, religion) etc)

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\*Creating measures of diversity and openness, based on holding in other areas (language, art, music, religion) etc)

- useful in evaluating claims such as diversity and openness helps spawn innovation (see e.g., R. Florida's work on the creative class)

# Ongoing work: Second Generation Indicators

(based on WorldCat database)

- Second generation indicators weight titles by the numbers of libraries in a country that hold the item
- Requires holding information for a large sample of libraries
- This new weighting helps distinguish important and influential advances

# Main Message

\*\*Direct measures of Technological change based on printed material are useful for determining the impact of technological change and technology shocks on the economy

# Strengths of New Book Indicators

- Quantitative measure with fairly long time series
- Large MARC record databases (such as Library of Congress and WorldCat)
- Can link of book data to economic and financial data at the industry level
- Records contain detailed information on editions, country of publication, subject information, source of information, and year of copyright
- Since it is expensive to produce and market books, new titles are published when the publishers believe there is a market for it
- Average time to release new book on technology/Computers is 6 months
- Books should be related to technological advancement and knowledge

# Strengths of New Book Indicators

- Gives more weight to major technological advances
- Although changes in the number of books published can be affected by changes in the book industry, pattern of new books published in other fields (e.g., literature, history, music, etc) can help identify what impact these changes have



# **Weaknesses of New Book Indicators**

- Not all forms of technological advancement will be captured by books.
- Books may be misclassified by cataloguers

Questions and Comments Welcome

## References:

Alexopoulos, Michelle. Forthcoming "Read all about it!! What happens following a technology shock?"

*American Economic Review*

Alexopoulos, Michelle, 2008. "Extra! Extra! Some positive technology shocks are

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Alexopoulos, Michelle and Jon Cohen. 2009. "Volumes of Evidence: Examining Technical Change Last

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