

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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- Economists believe technical change is responsible for economic growth and a major cause of business cycles

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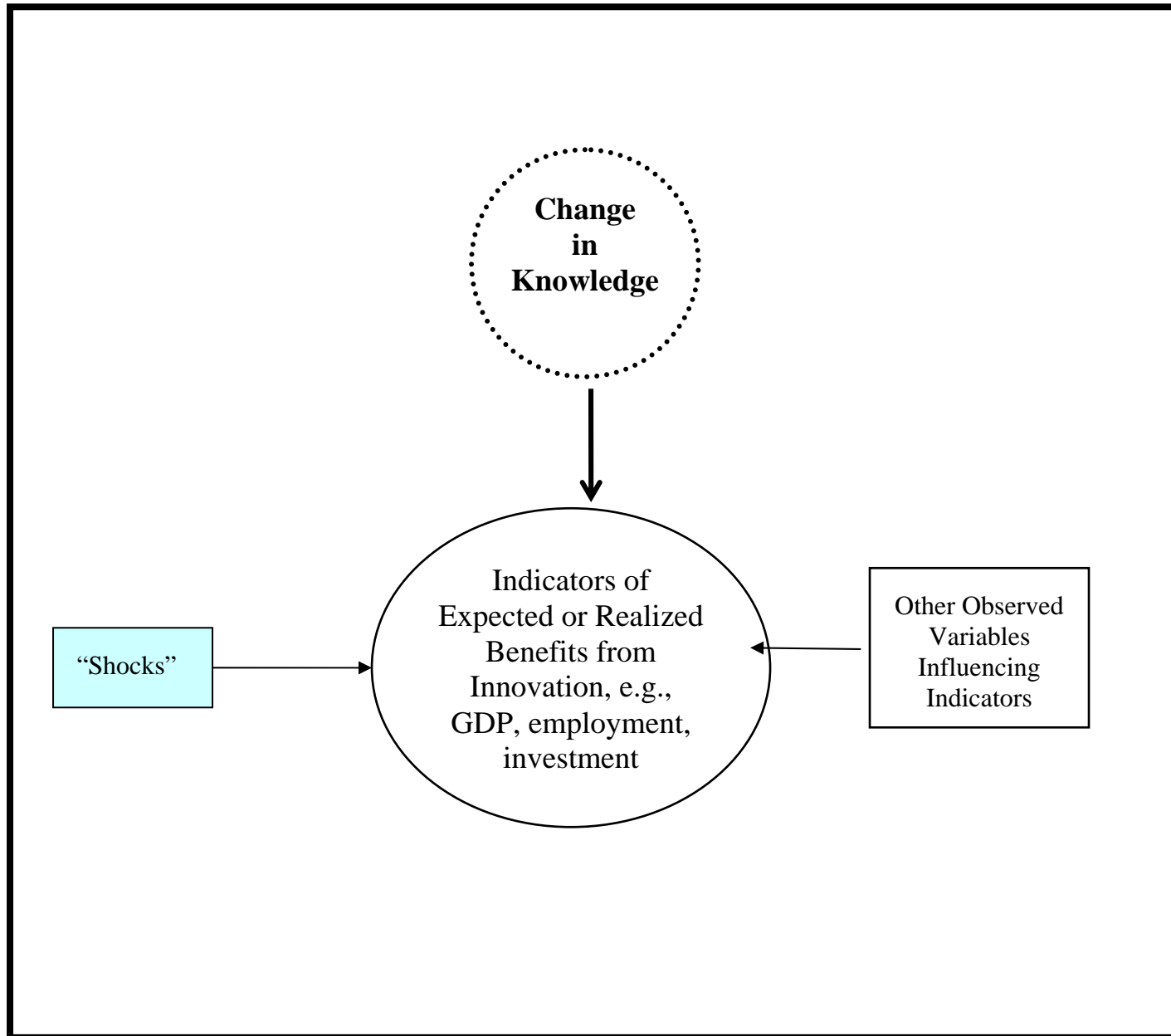
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- Economists believe technical change is responsible for economic growth and a major cause of business cycles
- Without good measures, we can't test these theories
- Without good measures, we can't determine what areas of technology are growing rapidly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

How Does Technological Change Affect the Economy?

How Does Technological Change Affect the Economy?



Previous Direct Measures of Technological Change

In Economics:

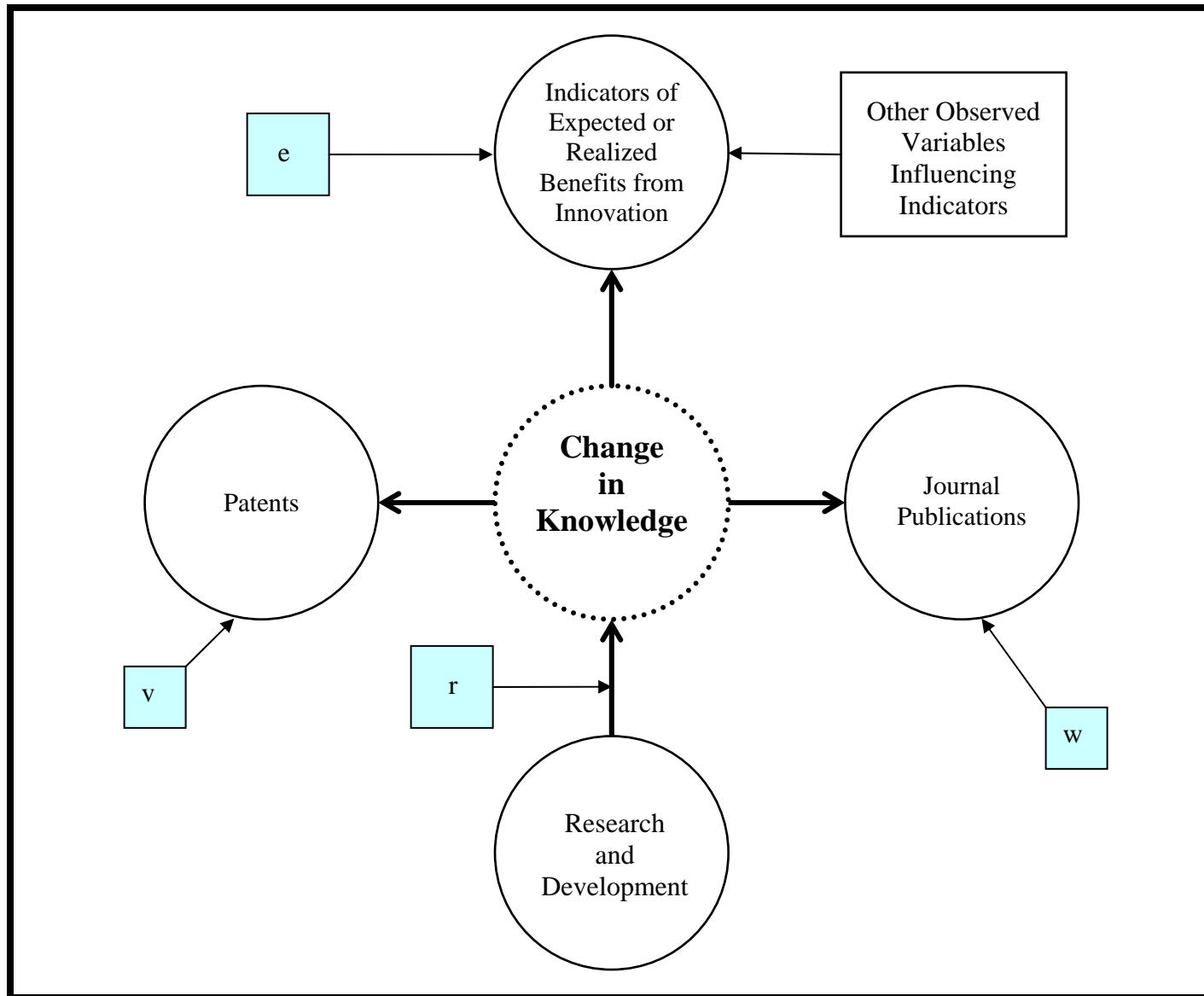
- a. Patents and Patent Citations
- b. R&D expenditures
- c. Major Innovation Counts

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

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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

Measure: R&D Intensity

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- So should R&D expenditures in Industry

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3. Knowing the date of changes in R&D intensity tells you nothing about the timing of a new product/processes release
⇒ even longer and more variable lags than patents

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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- 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 ?

An ideal indicator would:

1. Be available at least yearly

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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

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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

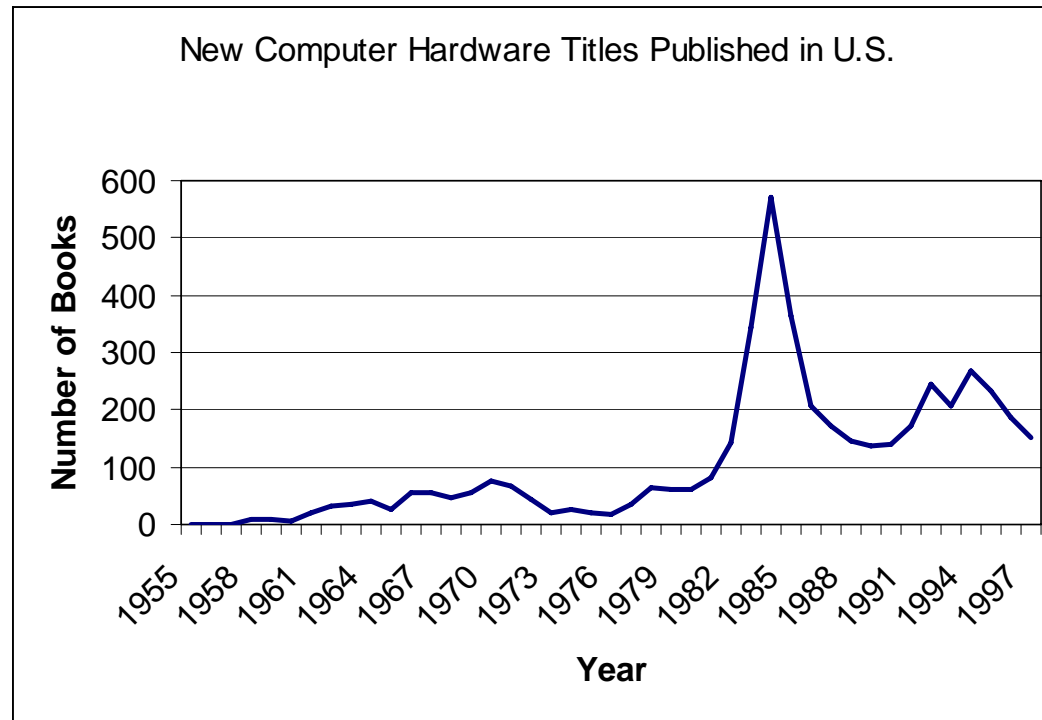
<i>Invention</i>	<i>Date of Invention</i>	<i>Date of Innovation</i>	<i>Date of Commercialization</i>	<i>Book Date</i>
Insulin	1889	1922	1922	1922
Neoprene/Duprene	1906	1932	1932	1937
Nylon	1927	1938	Dec. 1939	1939 (1940 in english)
Penicillin	1922	1941	1943	1943
Radio	1887	1922	1922	1910 (1922)
Streptomycin	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: 1st commercial transistor computers

1959: beginning of second generation of computers

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

1970-74: 1st 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 1st 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

Small innovation/Sector specific technology



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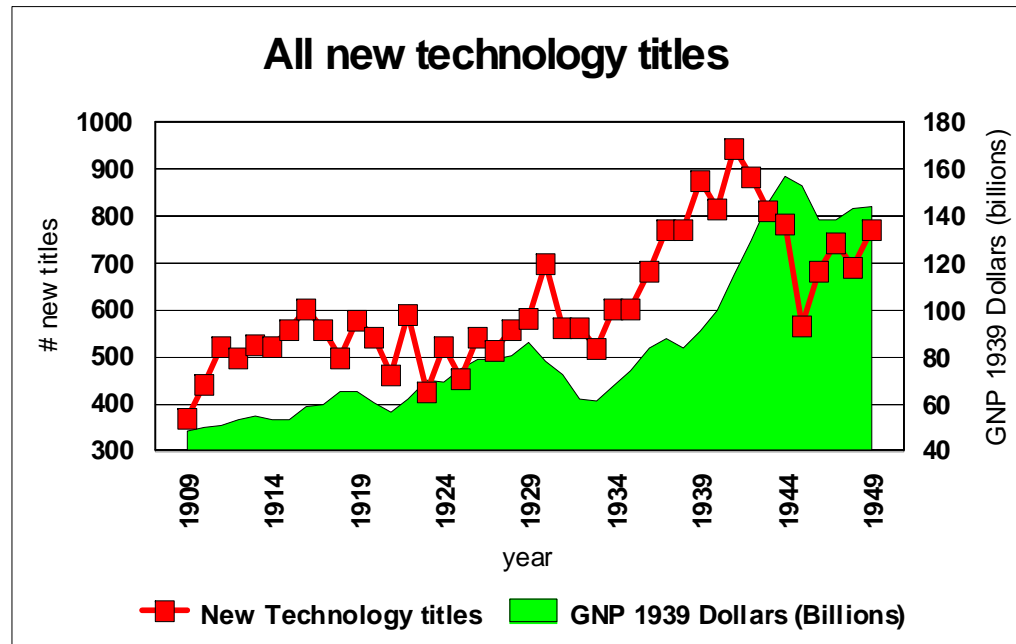
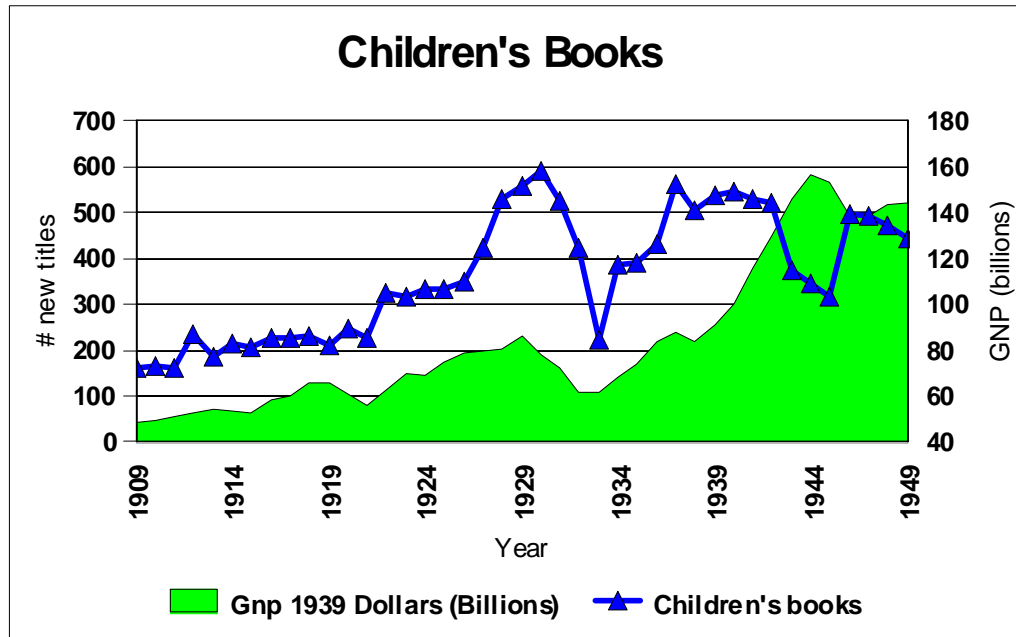


Less books

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

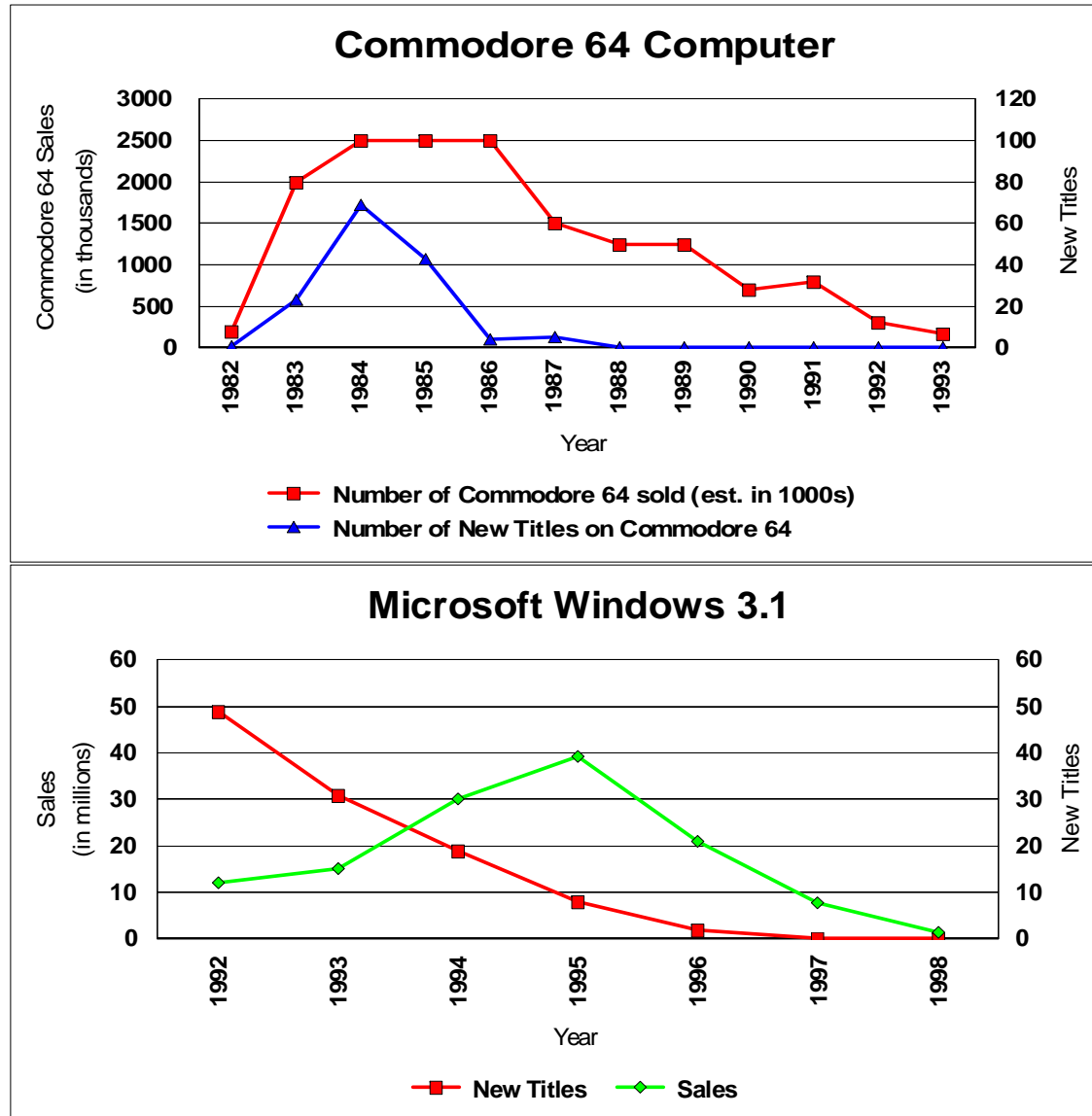
Do our technology indicators simply track trends in the publishing industry?

NO



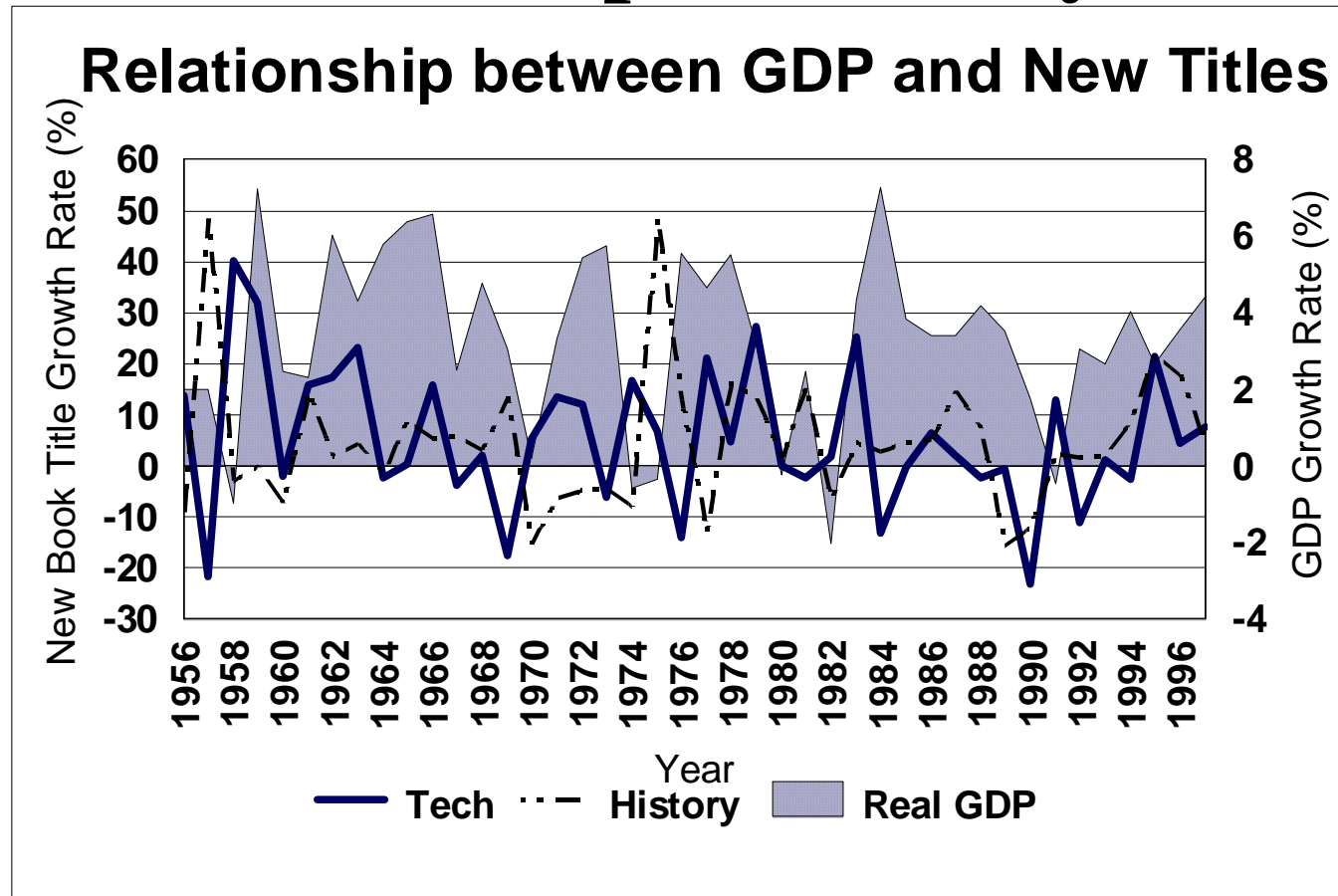
Source: M. Alexopoulos and J. Cohen, 2009. "Volumes of Evidence: Examining technical change last century through a new lens"
University of Toronto Working Paper

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)

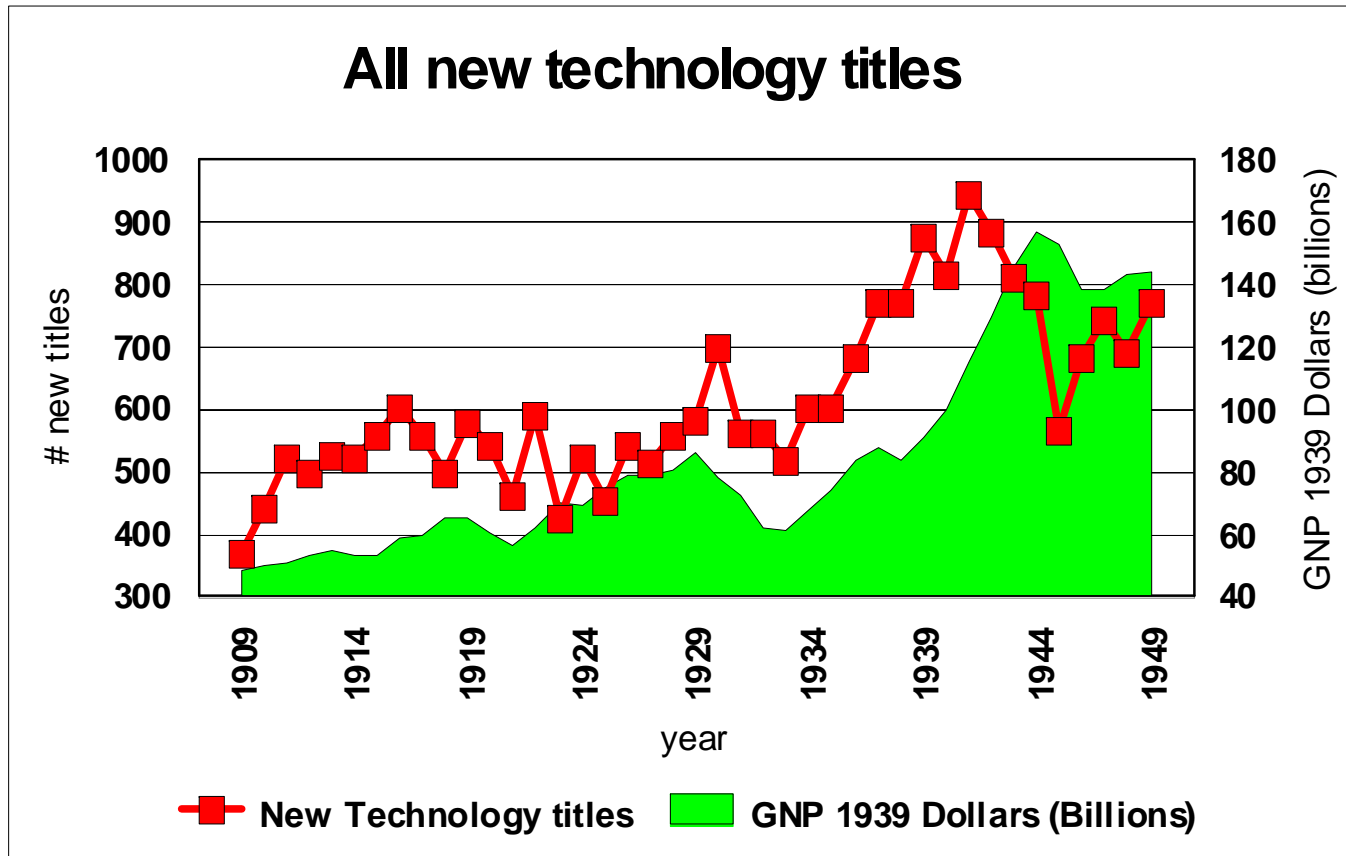


Source: M. Alexopoulos, "Read all about it!! What Happens following a technology shock?" Forthcoming American Economic Review

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

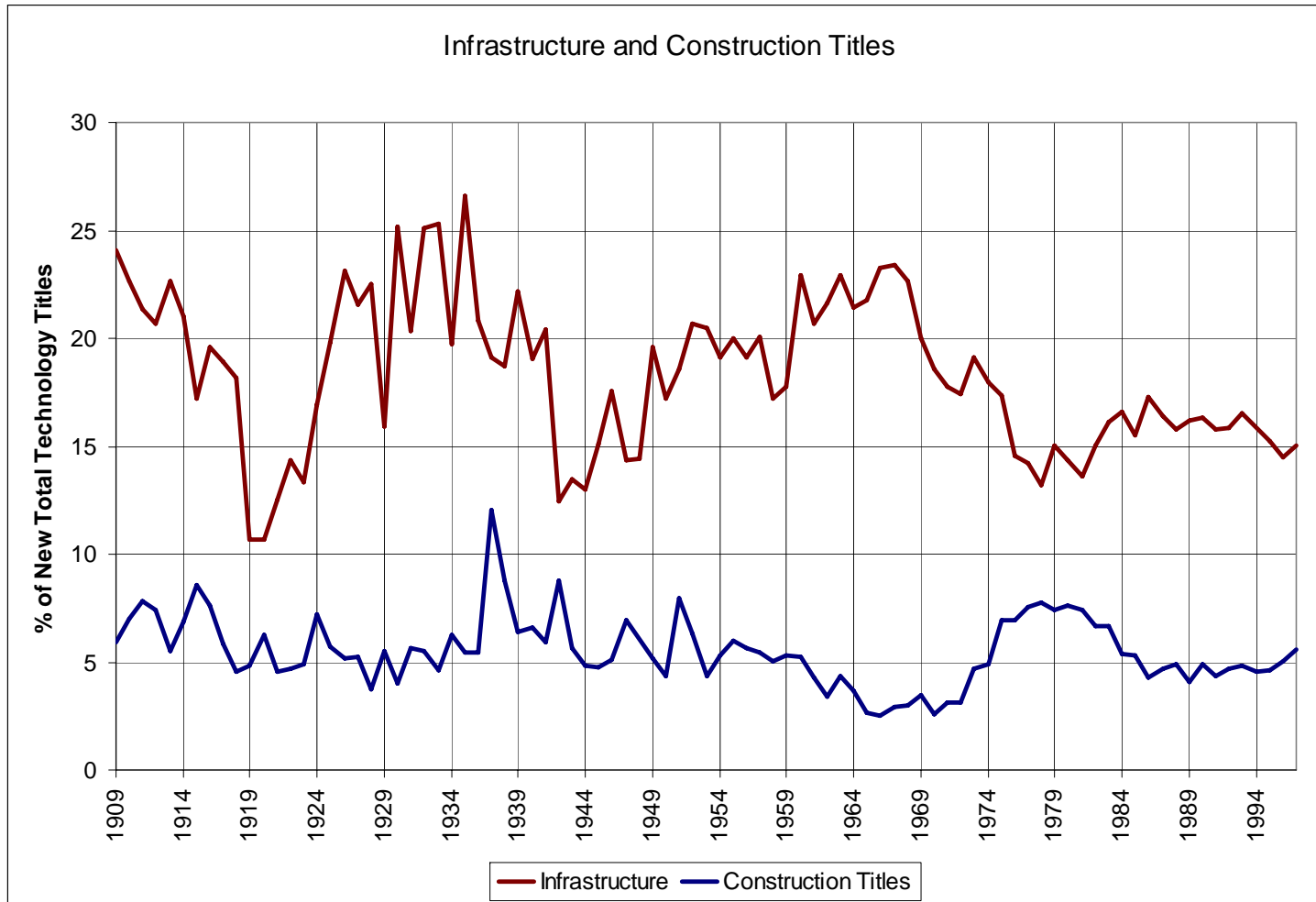
**Was the 1930s really a technologically
progressive decade?**

It Was!!

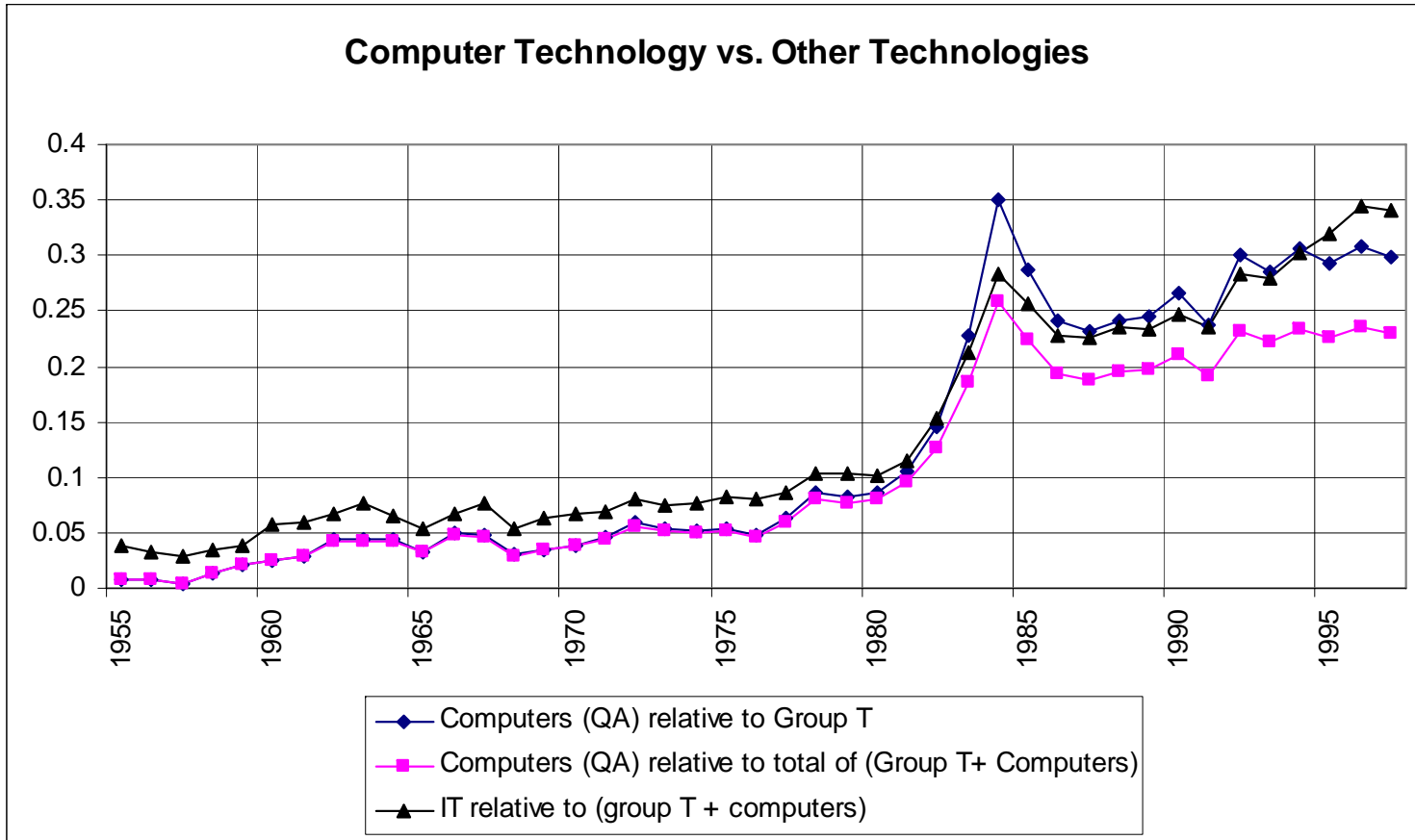


Source: M. Alexopoulos and J. Cohen, 2009. "Measuring our ignorance one book at a time: New indicators of technical change, 1909-1949" [Journal of Monetary Economics](#)

Application #3: Documenting Waves of Innovation

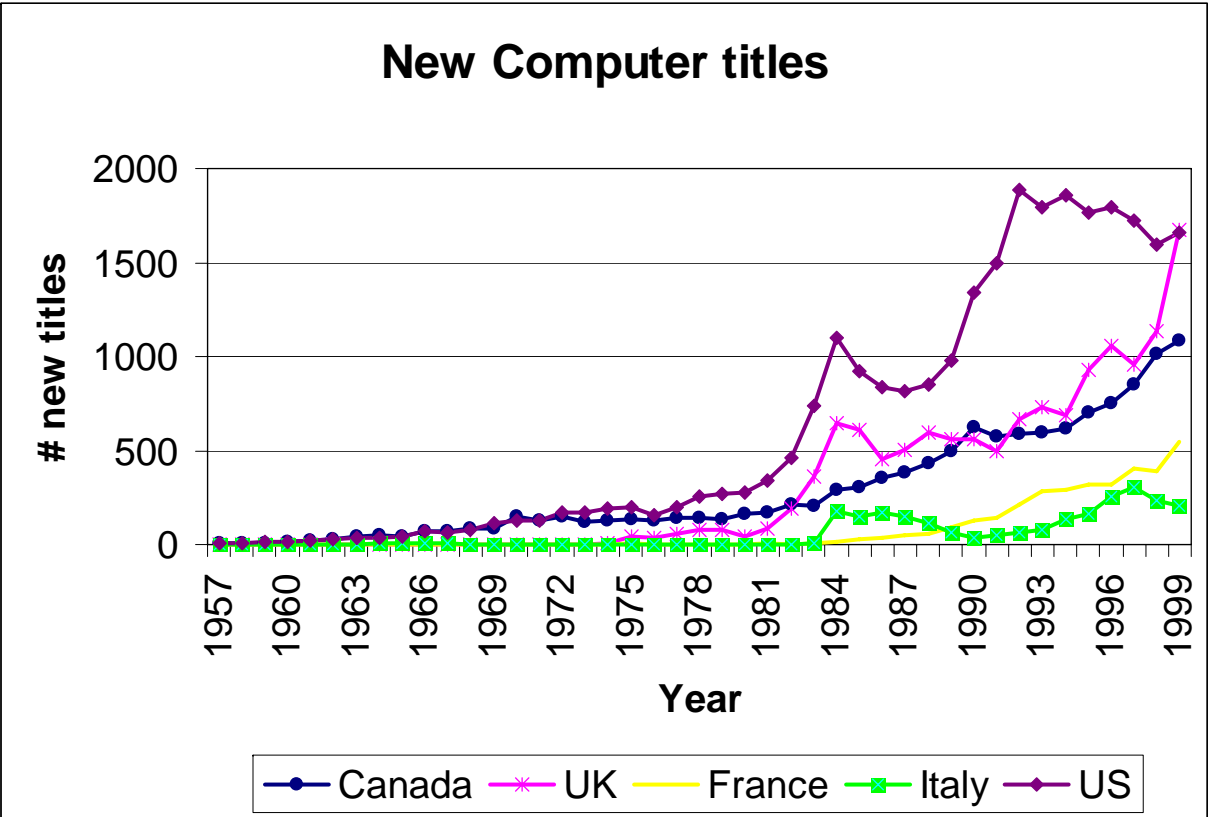


Source: M. Alexopoulos and J. Cohen, 2009. "Volumes of Evidence: Examining technical change last century through a new lens" University of Toronto Working Paper



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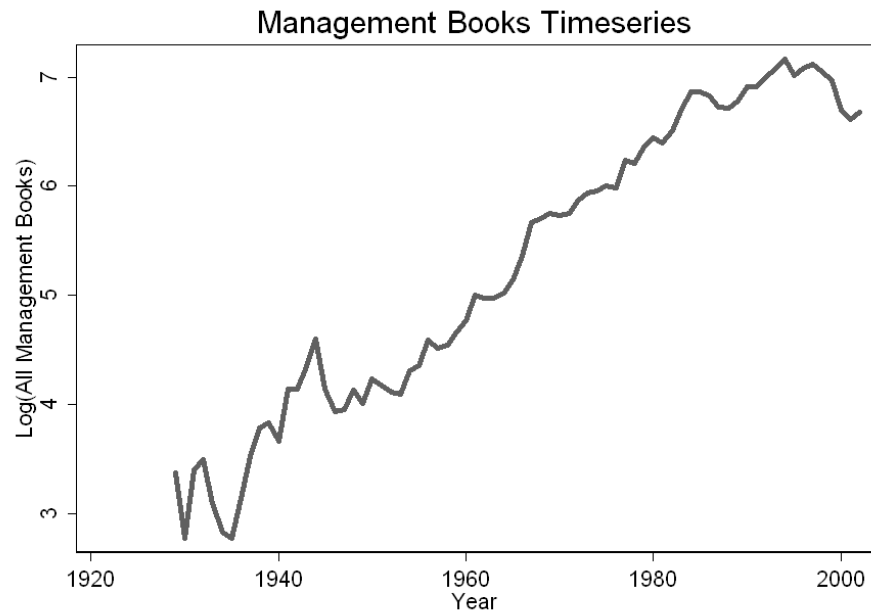
Application #4: Cross-country Studies



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

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

Application #8: Creating measures for regional jurisdictions (Using WorldCat information)

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

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- 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:

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American Economic Review

Alexopoulos, Michelle, 2008. "Extra! Extra! Some positive technology shocks are expansionary!," *Economics Letters* 101(3): 153-156

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