Is the Information Technology Revolution Over?*

Dan Sichel
Wellesley College and NBER

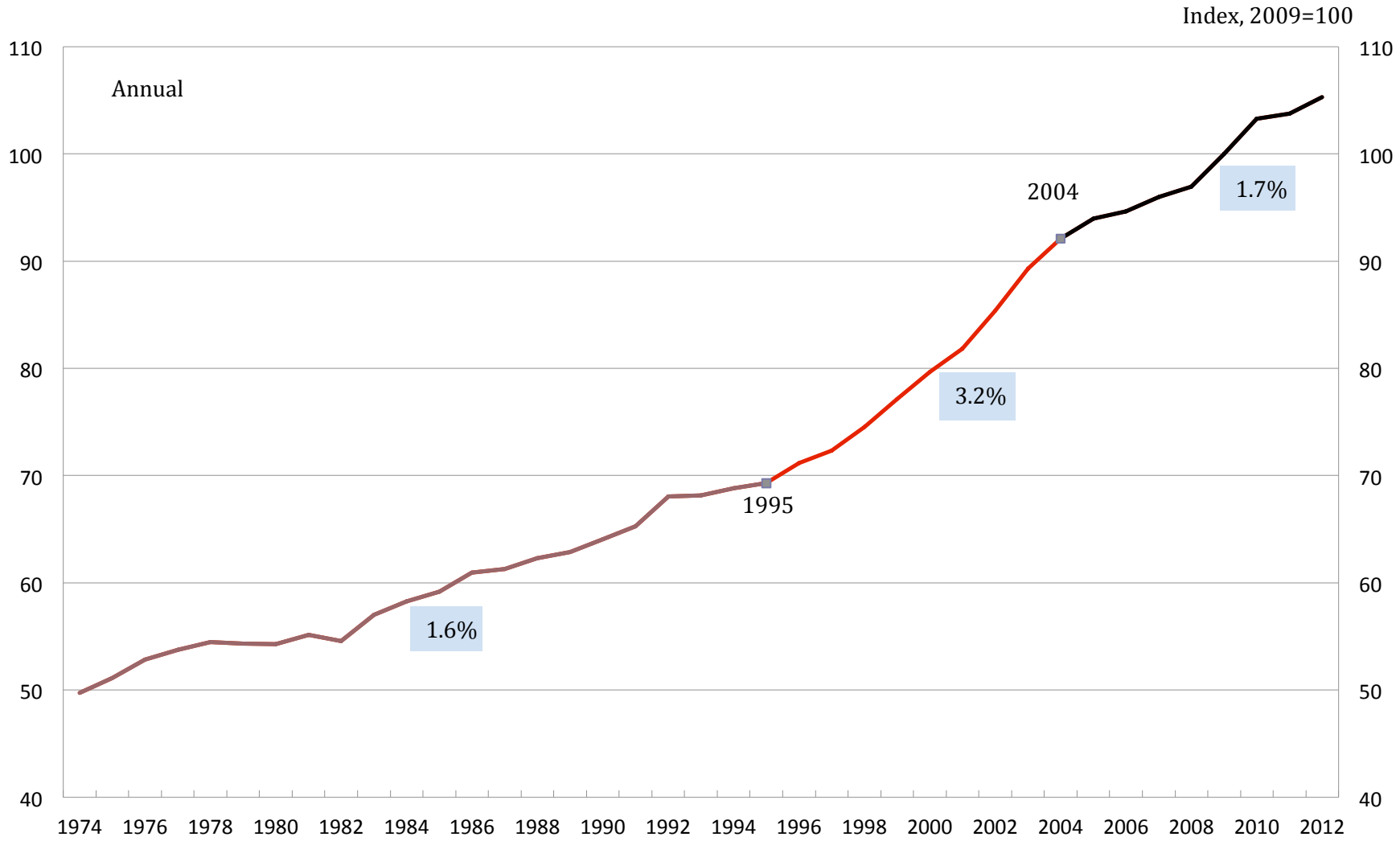
Presented at UNSW Economic Measurement Group Workshop
Sydney Australia
November 28-29, 2013

Today's Talk

- Results based on recent research with ***David Byrne*** (Federal Reserve Board) and ***Stephen Oliner*** (UCLA and American Enterprise Institute).*
  - *"Is the Information Technology Revolution Over?"* http://www.csls.ca/ipm/ipm25.asp
  - *Also, see "The GPT Behind IT: What is Happening to Semiconductor Prices?"*

* The views express are those of the authors alone and should not be attributed to the Board of Governors of the Federal Reserve or other members of its staff.

U.S. Labor Productivity, Nonfarm Business Sector



Source: Bureau of Labor

Why did productivity growth in the U.S. slow after 2004?

- Housing bubble and financial crisis?
- Secular stagnation? Slowdown in innovation?
- End of ICT revolution?
  - Focus for today
  - Three types of evidence
    - Growth accounting
    - GPT: Semiconductors (IARIW-UNSW paper from Tuesday)
    - Steady-state projections

Growth Accounting

- **Decomposition of output/hour *("use of IT")***

$$\dot{Y} - \dot{H} = \sum_j \alpha_j^K \left(\dot{K}_j - \dot{H} \right) + \alpha^L \dot{q} + M\dot{F}P,$$

- **Decomposition of MFP growth *("production of IT")***

$$M\dot{F}P = \sum_i \mu_i M\dot{F}P_i + \mu_S M\dot{F}P_S,$$

Types of Capital

- IT hardware
  - Computers and peripheral equipment
  - Communication equipment
- Intellectual property products
  - Software
  - R&D spending
  - Entertainment, literary, and artistic (ELA) originals
- Other capital
  - All equipment other than IT
  - Nonresidential structures and rental housing
  - Inventories
  - Land

Data and Related Issues

- Data cover 1974-2012 for the nonfarm business sector.
- Rely heavily on data published by BLS and BEA.
- Have incorporated major revision of GDP data from this summer
  - Added R&D and ELA originals
  - BEA and BLS haven't yet published much of the detailed data needed for our analysis. Approximated missing data.
- Use dual approach with prices to estimate sectoral MFP growth.

Selected Contributions to Growth of Output per Hour

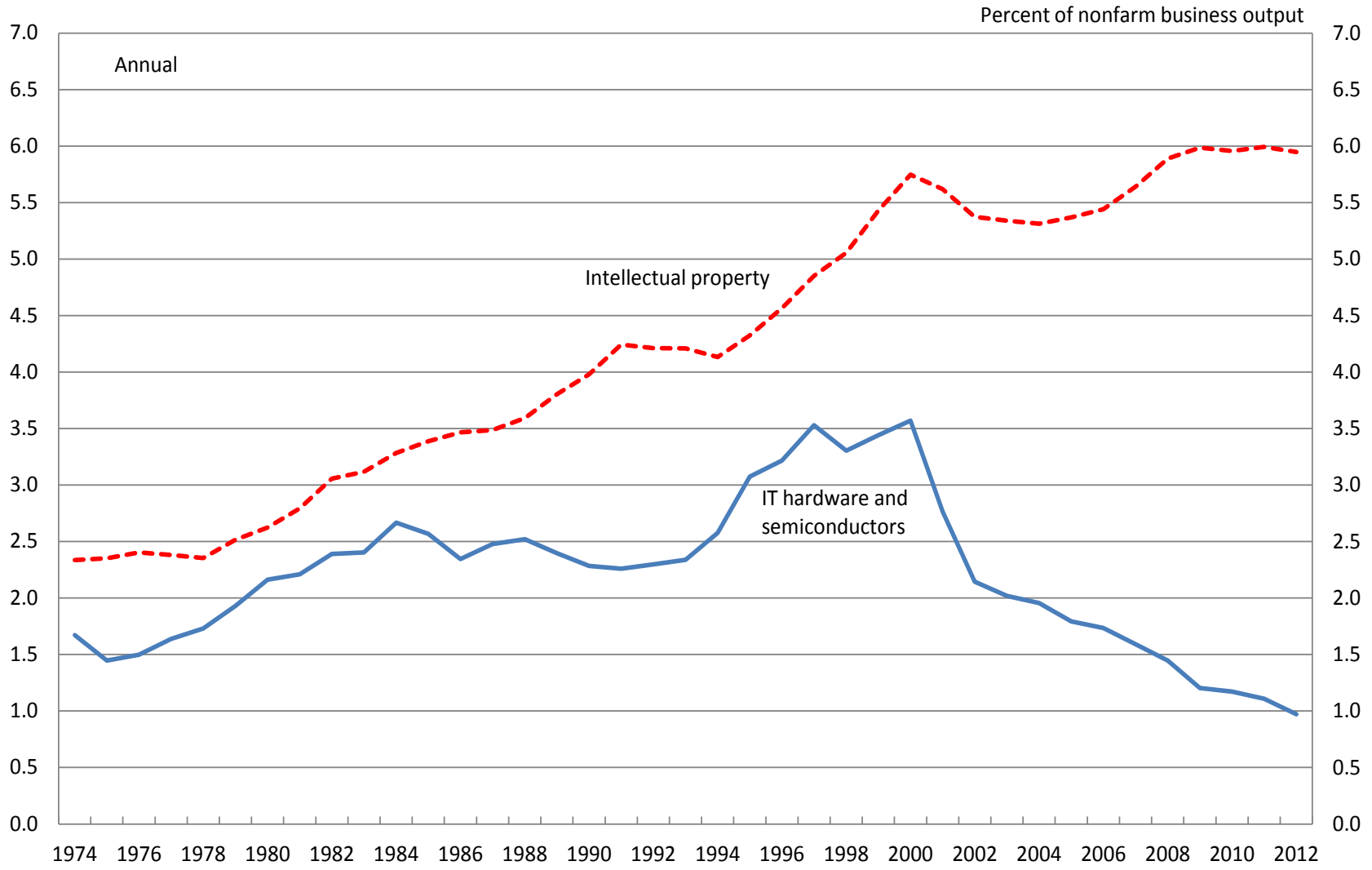
	1974-1995	1995-2004	2004-2012
Growth of output per hour (percent)	1.58	3.16	1.67
Contributions[a] (percentage points)			
Capital deepening	**.85**	**1.39**	**.82**
IT hardware	.28	.52	.18
Intellectual property	.24	.37	.25
Other	.33	.49	.39
MFP	**.41**	**1.56**	**.39**
IT hardware and semiconductors	.30	.59	.20
Intellectual property	.06	.13	.08
Other sectors	.06	.85	.12
Labor composition	.25	.21	.31

Note: NFB sector. Detail may not sum to totals because of rounding.
a. Excludes the effects of cyclical influences on MFP growth.

IT Hardware and Semiconductors

- Contributions of MFP growth in production of IT hardware and semiconductors declined dramatically.
    - Slower pace of MFP growth in these sectors
    - Decline in US output shares for these sectors

Current-dollar Output Shares



Source. Authors' calculations.

Detail, Capital Deepening
Contributions to output/hr (percentage points)

	1974-1995	1995-2004	2004-2012
Intellectual property	**.24**	**.37**	**.25**
R&D	.05	.06	.07
ELA originals	.02	.03	.02
Software	.17	.28	.16
IT hardware	**.28**	**.52**	**.18**
Computer hardware	.21	.39	.10
Communication equipment	.07	.13	.08

Note: Detail may not sum to totals because of rounding.

Detail, MFP Growth (percentage points)

	1974-1995	1995-2004	2004-2012
Intellectual property			
R&D	.38	1.25	-.08
ELA originals	.48	1.47	2.04
Software	5.63	3.72	2.40
IT hardware and semiconductors			
Computer hardware	15.4	14.0	8.5
Communication equipment	5.6	6.8	3.5
Semiconductors	26.3	44.3	26.4
NFB	.41	1.56	.39

Note: Detail may not sum to totals because of rounding.

Steady-State Projections

- Use a multi-sector growth model to translate assumptions for underlying pace of technical advance (MFP) in each sector into growth rate of output/hour.

- Similar to single-sector Solow model.

$$\dot{Y} - \dot{H} = \sum_i \left[\left(\alpha_i^K / \alpha^L \right) \left(\dot{MFP}_i + \beta_i^S \dot{MFP}_S \right) \right] + \dot{q} + \dot{MFP},$$

$$\dot{MFP} = \sum_i \mu_i \dot{MFP}_i + \mu_S \dot{MFP}_S.$$

Growth Model Parameters

- Choose plausible lower- and upper bound values
  - Historical record
  - Judgment
  - Details in appendix table of paper

Key parameters

- MFP growth in ICT. Set relative price change:
  - Lower bound is **0.8** times average from 1974-2012
  - Upper bound is **1.2** times average from 1974-2012

- MFP growth outside of ICT
  - Lower bound = rate from 2004-2012 = **0.06 pct pt**
  - Upper bound = 2/3 of rate from 1996-2004 = **0.62 pct pt**

- Labor composition: 0.0 – 0.14 pct pt.
  - Range around Jorgenson's estimate of 0.07 pct pt
  - Compared with 0.34 pct pt from 2004-2012

Steady-State Results for Growth in Output per Hour

- Results for alternative parameter values:
  - **Lower-bound: 0.88% per year**
  - **Upper bound: 2.82% per year**
  - **Midpoint: 1.80% per year. Baseline scenario in the paper.**
- Baseline outlook compared to history:
  - A touch **faster** than 2004-2012 rate
  - About ½ percentage point **slower** than average since 1889
- Baseline outlook compared to other forecasts:
  - In about the middle of the range.
  - Lowest is Gordon at 1.55%; highest is CBO at 2.1%

Steady-State Decomposition of Growth in U.S. Labor Productivity
Non-farm Business Sector

	History 2004-12	SS: Baseline	SS: 2nd Wave
%ch (Y/L)	1.56	1.80	
Cap deep	.74	1.03	
Lab comp	.34	.07	
MFP	.48	.70	
IT	.29	.38	
Other	.05	.33	

Trends in Semiconductor Technology and Prices

- IARIW-UNSW paper
- Measures of technical progress in semiconductors indicate continued rapid progress.
- Hedonic price index suggests price declines have been about 30 percent per year (in contrast to PPI which shows almost no price decline).
- Suggests innovation in ICT could continue at a substantial pace.

Second-Wave Scenario

- Syverson (2013): productivity gains from electricity in fits and starts.
- Second-wave: combined benefit from "big data" and mobile devices.
- Use steady-state machinery to analyze a more optimistic outlook.
  - Boost MFP growth in ICT-producing sectors (by assuming moderately faster declines in prices of ICT goods).
  - Assume spillover benefits raise MFP growth in other sectors (by raising annual growth from 0.35% to 0.6%).
- **Second-wave alternative: 2.5% growth in output per hour.**

Steady-State Decomposition of Growth in U.S. Labor Productivity
Non-farm Business Sector

	History 2004-12	SS: Baseline	SS: 2nd Wave
%ch (Y/L)	1.56	1.80	2.47
Cap deep	.74	1.03	1.34
Lab comp	.34	.07	.07
MFP	.48	.70	1.06
IT	.29	.38	.46
Other	.05	.33	.60

Conclusions

- ICT contributions to productivity growth much smaller since 2004.
- Baseline steady-state outlook for labor productivity growth of 1.8%.
- But, growth outlook not set in stone.
  - Second ICT wave is possible.
    - Continued semiconductor technical advance and price decline.
  - Future brighter if sensible action on education, R&D, immigration, infrastructure, and fiscal issues.
- **No, ICT revolution is not over.**