Digital Economy Measurement

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The views expressed here are not represented to be the views of the Federal Reserve Board of Governors. Nor are these remarks a characterization of the current economic outlook or the state of monetary policy.

Motivation

Digitalization is top of mind for many observers of the economy.

- Since the mid-20th century, information technology (IT) innovation has driven down the cost of gathering, storing, transforming, and transmitting information.
- Firms and households have responded by using more IT. The economy has become more digitalized.
- This phenomenon is central to our understanding of the role of **innovation** in **productivity** and **economic growth** in the post-war era.

Are recent developments simply a continuation of a longstanding trend or are we witnessing another "IT boom"?

An array of measurement challenges make it difficult to bring statistics to bear on such questions. We review these challenges and the state of efforts to overcome them in this chapter.

What is the digital economy?

Informally, "the digital economy" is a reference to a set of companies and concepts.

Fig. 1: Digital Economy Companies

Fig. 2: Digital Economy Concepts

Note: Word clouds created with *R* (R Core Team, 2021) supplemented with *wordcloud* (Fellows, 2018), available at https://CRAN.R-project.org/package=wordcloud
Source: Companies and concepts frequently mentioned in *Harvard Business Review* articles with "digital economy" in the title, 2015-2019.

A framework for studying the digital economy

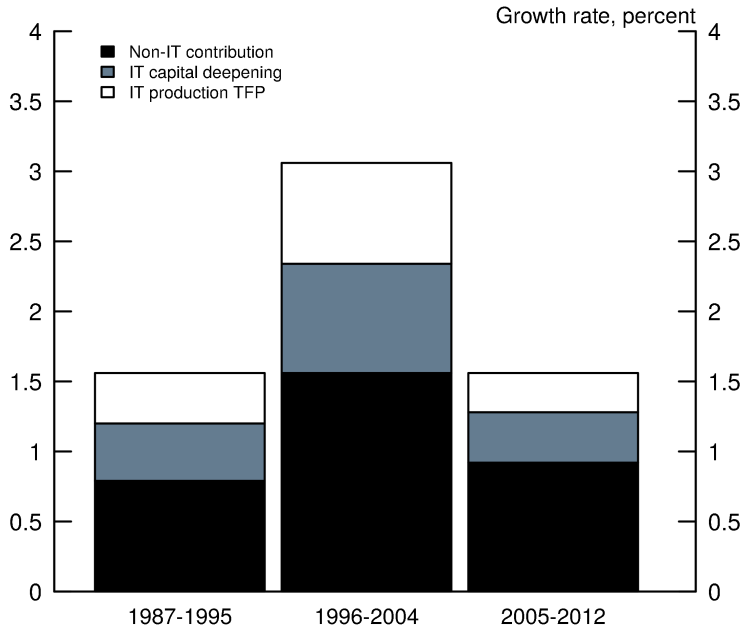
Formally, the contribution of the digital economy can be studied in a growth accounting framework.

IT contributes to productivity—output per hour worked—through

- More efficient IT *production*
- The *use* of IT in all sectors

Historically, the digital economy has accounted for a substantial share of aggregate growth and productivity.

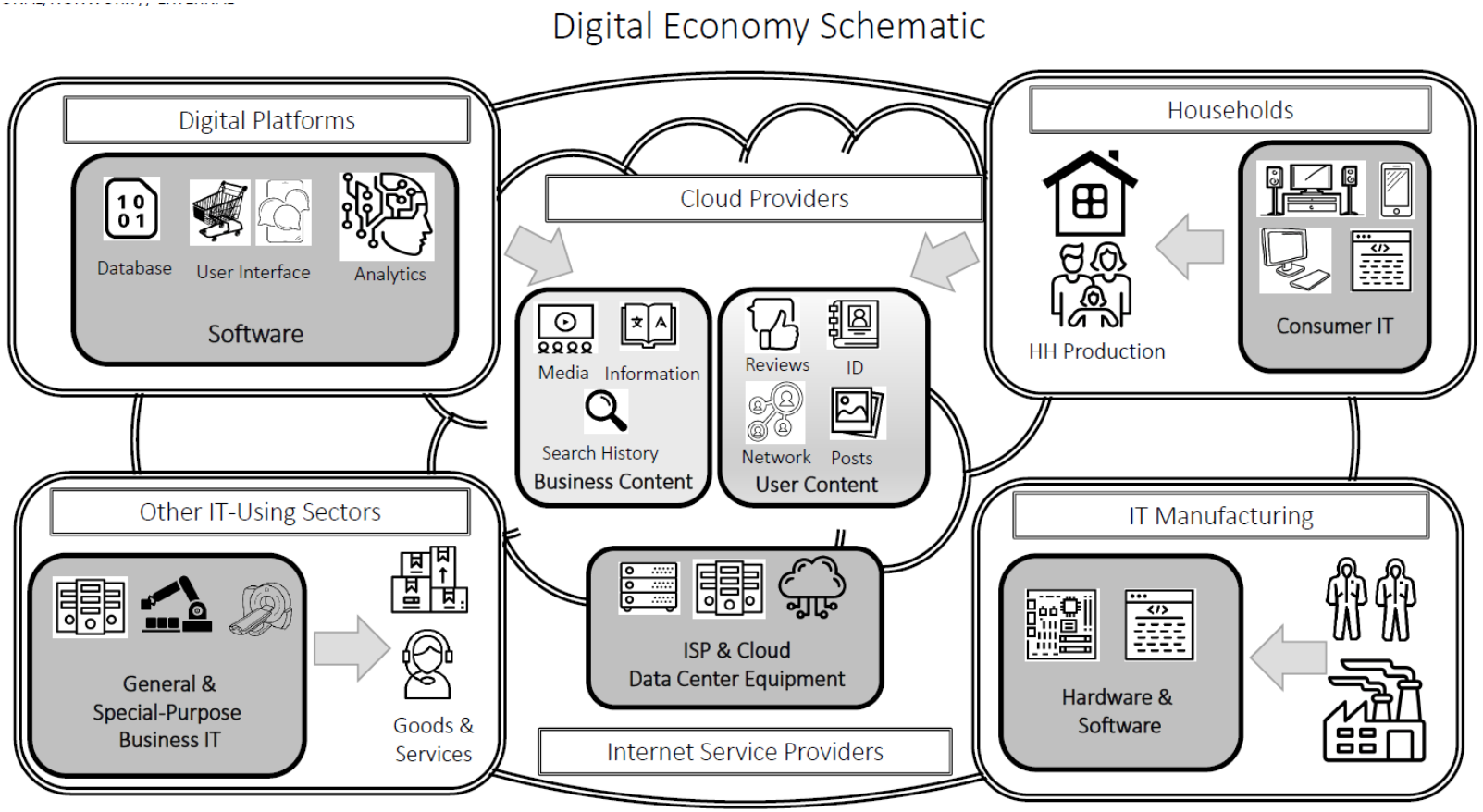
Fig. 3: Digital Growth Accounting



Note: Non-IT contribution is aggregate productivity unexplained by IT capital use and production.
Source: Byrne, Oliner, Sichel (2014).

Types of IT production and use

To quantify these effects, we measure the production and use of a wide array of IT capital types.



Source: Author's depiction.

Practical Measurement Challenges

Concrete challenges encountered in this exercise include

- **Accounting for quality change**: New IT products often embody substantial changes in quality. Careful attention to measuring inflation is needed.
- **Consistency across products**: Some products (smartphones, for example) have data with sufficient detail to support good measurement, others (MRI machines, for example), do not. This made lead to spurious differences in output growth.
- **Consistency across statistical programs**: Differences in data quality can cause inconsistencies across measurement of key economic flows (consumption, imports, investment).

Accounting for Quality Change: Matched-Model Indexes

Highly granular (e.g. model level), high-frequency data are needed to capture quality change in price statistics...

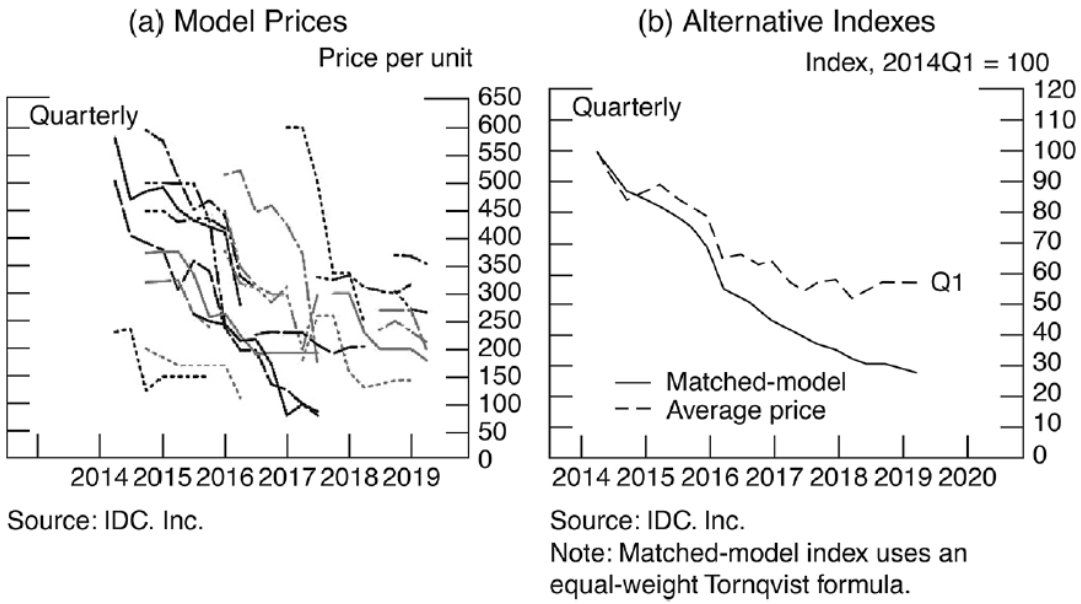


Fig. 5.4 Smartphone price cascade and index calculation

Note: Figures use models produced by the top three Android operating system smartphone manufacturers, sold in the United States, with initial prices between $200 and $600. Each line in the figure on the left represents the price evolution of a different model of phone.

Accounting for Quality Change: Matched-Model Indexes

... and frequent refresh of the sample of models used in price index construction is needed.

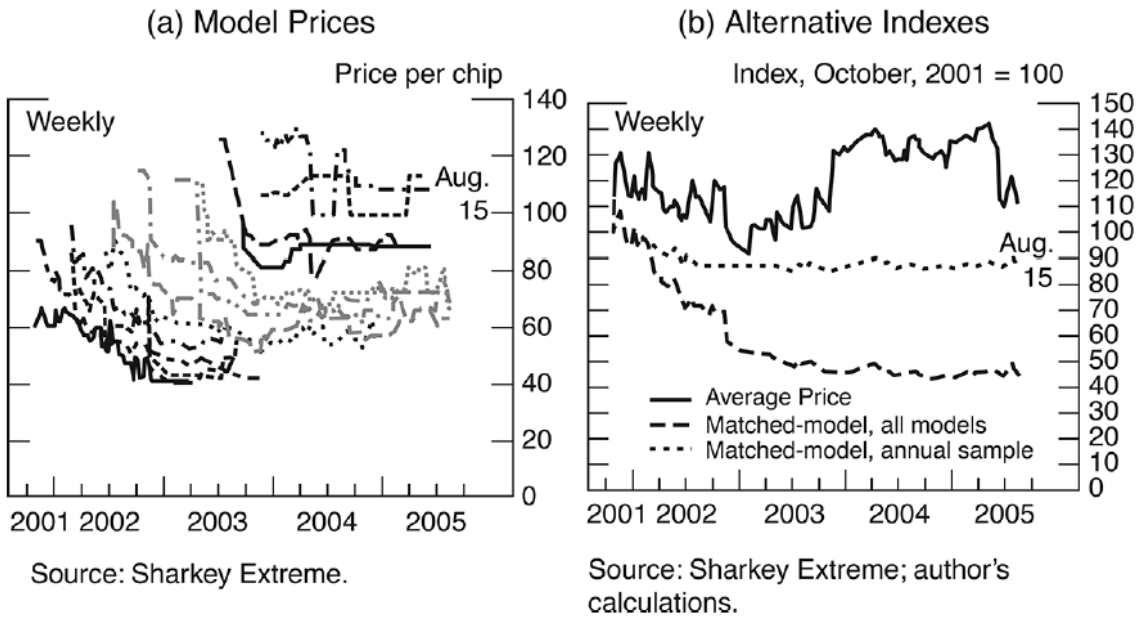


Fig. 5.5 Effect of sample updating frequency on microprocessor price indexes

Accounting for Quality Change: Hedonic Indexes

Hedonic indexes are another good option, but only if the correct characteristics are used to adjust for quality.

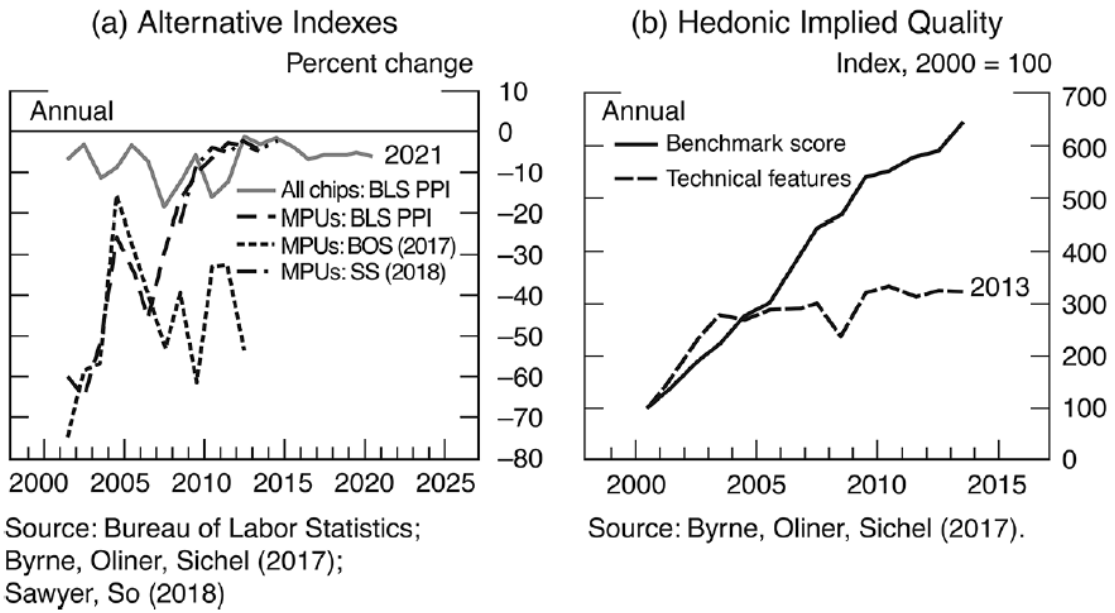


Fig. 5.10 MPU price index quality adjustment

Note: In 2015, BLS stopped publishing a separate price index for MPUs due to confidentiality concerns. In the figure on right, implied quality is constructed from hedonic regression coefficients and average characteristics for Intel microprocessors.

Consistency Across Product Types

As the composition of U.S. IT manufacturing industry has shifted toward special-purpose equipment (electro-medical devices, military & aerospace equipment), measurement has become more difficult.

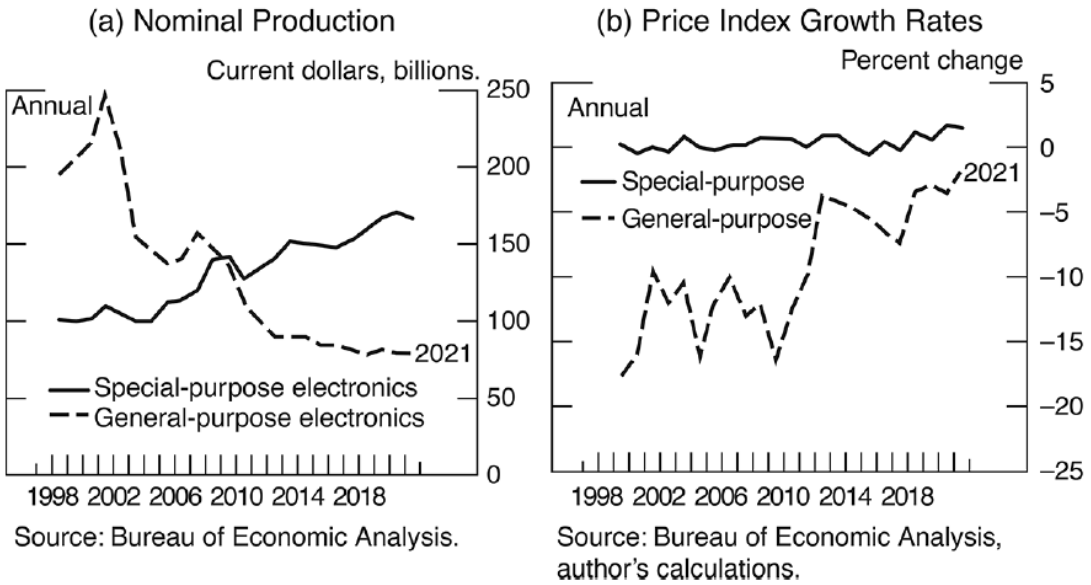
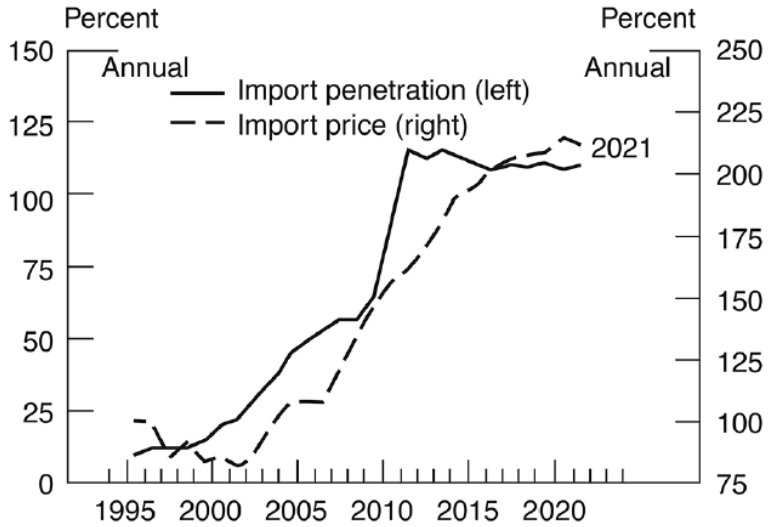


Fig. 5.9 US general-purpose and special-purpose electronics production

Note: The general-purpose price index is a Törnqvist aggregate of computer and peripheral equipment and communications equipment from BEA's underlying detail tables on gross output by industry. The special-purpose index contains navigational, measuring, electromedical, and control instruments manufacturing.

Consistency Across Statistical Programs

Using different data collection programs for different prices can lead to curious results.



Source: Bureau of Labor Statistics: Census Bureau.

Fig. 5.15 Computer import penetration and prices

Note: Computer import price is the ratio of the computer import price index to the computer (domestic) producer price index. Import penetration is the ratio of imports to imports plus domestic production less exports.

Measurement and the Productivity Slowdown

The productivity slowdown is an example of the practical importance of these measurement issues to our understanding of the macroeconomy.

Table 5.2 **Adjustments to the aggregate labor productivity slowdown, by industry (percentage points)**

Industry	Primary Issues	Adjustment
IT hardware equipment	Quality adjustment, in-house production	0.02
Semiconductors	Quality adjustment, embedded systems	–0.07
IT intangibles software	Quality adjustment, in-house production	0.08
Product design	"Factoryless" manufacturing	–0.02
Data	User and item information	unknown, likely positive
IT services telecom	Quality adjustment, utilization	0.12
Web	"Free" content	unknown, likely positive
Total adjustment	*(A moderately smaller slowdown)*	0.13 plus data investment and service effects

Source: Author's judgmental assessment as described in the text.

Note: Slowdown estimated between the 1996–2004 and 2005–2015 period. A positive adjustment figure represents raising the second period's productivity growth rate relative to the first.

Summary

The chapter on the digital economy and the volume as a whole identify ongoing measurement challenges and suggest directions for improvement.