Accounting for Innovation in Consumer Digital Services: Implications for economic growth and consumer welfare

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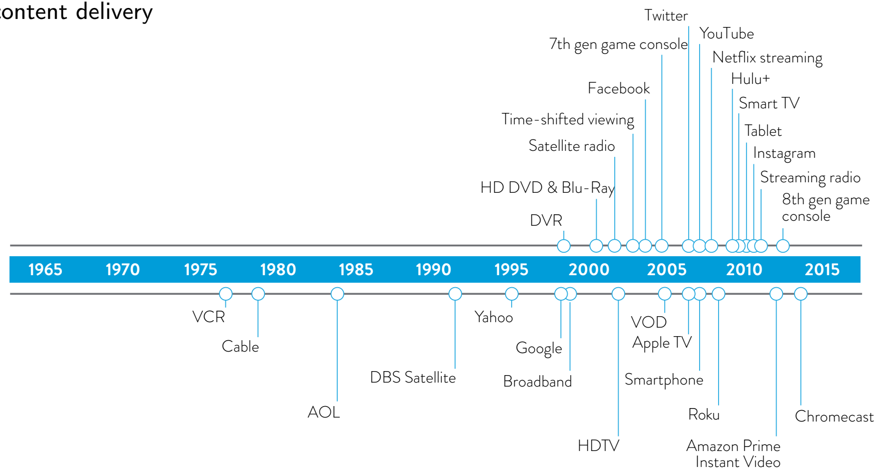
Slow productivity a puzzle in view of consumer digital innovation ...

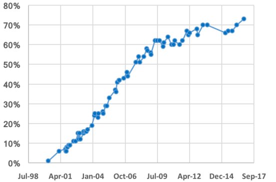
Timeline of innovations in consumer content delivery



Source: Nielsen (2014).

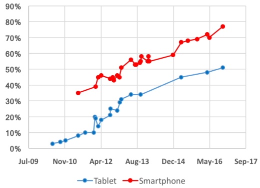
Household digital network use has increased dramatically since 2000

Indicators of U.S. Consumer Digital Capital Use



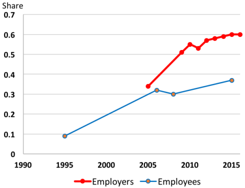
Source. Pew Center on the Internet.

(a) Broadband Use



Source. Pew Center on the Internet.

(b) Mobile Device Use



Source. Employers offering telework: Society of Human Resource Managers. Employees ever telecommuted: Gallup Polls.

(c) Prevalence of Telework

A lot of quality change in content delivery devices

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Will capitalizing consumer digital goods capture consumer digital innovation, esp. innovations in content delivery, in national accounts?

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- Account for consumers' intensity of use of digital devices
- Address demand complementarity between network access services (i.e., paid services) and imputed services obtained via ownership of digital gizmos

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- Use quality-adjusted prices for digital devices
- Account for consumers' intensity of use of digital devices
- Address demand complementarity between network access services (i.e., paid services) and imputed services obtained via ownership of digital gizmos
  - Imputed services are an estimate of what has come to be called “free goods"

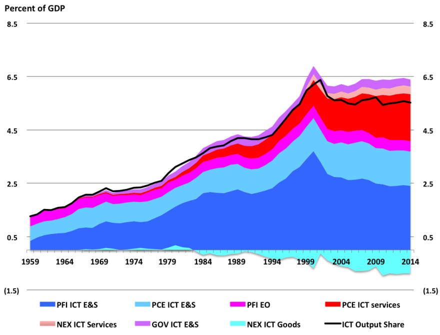


Figure: U.S. ICT Final Output Share

- Relabeling household consumption as investment doesn't change GDP
- But imputing service flows from that capital raises GDP
- Gauging by the PCE investment share—1.3 percent of existing GDP—the impact is large
- . . . and will punch above its weight if the new output posts real price declines

Methods

- Consumer digital services reflects not only their use of digital devices but also their take up of network access services.
- The typical business model for access services is a *subscription*. Households pay a monthly fee in return for continuous access to a range of delivery modes, e.g., broadband, smartphone, cable TV, etc.
- Demand complementarity between the use of devices and use of access services raises both possibilities and challenges for measurement
  - Exploit the degree to which each access mode is utilized to obtain a measure of use intensity
  - Services quality for each access mode (a delivery process) is, then, this use intensity

Digital capital services

- Define $\lambda =$ a factor of proportionality representing the average use intensity of consumer digital stocks, where $\dot{\lambda} \neq 0$ is a disequilibrium phenomenon
- Measure imputed household digital service flows $P^{S_T^H} S_T^H$ in the standard way, i.e., via user cost expression $(\overline{\rho} + \delta_T^H) P^{I_T^H} K_T^H$,
  - where $P^{I_T^H}$ is a quality-adjusted asset price index for digital stocks
- Log price change for consumer digital capital services is $\dot{P}^{S_T^H} = \dot{P}^{I_T^H} - \dot{\lambda}$
  - Suggests trends in household use rates influence consumer's willingness-to-pay for digital access equipment

Digital access services

- Producer perspective: services are denoted as $P^{O_T^B} O_T^B$, where $\frac{O_T^B}{N}$ is the potential quantity of services offered per user (or plan), and $\frac{P^{O_T^B} O_T^B}{N}$ is the average price of a plan.
- Consumer perspective: payments for subscription plans are $P^{C_T^B} C_T^B$ where C_T^B is the quantity of services *consumed*.
- Define the quantity of access services consumed as consumer Internet Protocol traffic (IP), in which case $C_T^B = IP$, and the price index for purchased digital access services is $P^{C_T^B} = \frac{P^{O_T^B} O_T^B}{IP}$.

Digital access services, continued

- It also follows that we can link λ, the average use intensity of consumers digital capital, to access services as follows: $\lambda = \frac{C_T^B}{N} = \frac{IP}{N}$
- This measure of λ absorbs a chain of utilization margins, the most subtle of which is that, depending on the nature of the applications run by consumers, the number of unduplicated hours consumers devote to connectivity will not necessarily translate one-for-one to IP traffic.
  - Other margins include that the number of users may differ from the number of plans; the number of devices may be greater than the number of users, and hours per plan and per device and per user may change over time.
- The combined changes in the various margins of use—the $\dot{\lambda}$ that enters (disequlibrium) changes in the consumer digital capital services price—is the difference between the price index for access services and the average price paid:

$$\dot{\lambda} = \dot{P^{C_T^B}} - (\dot{\frac{P^{O_T^B} O_T^B}{N}}) \ .$$

Implementation

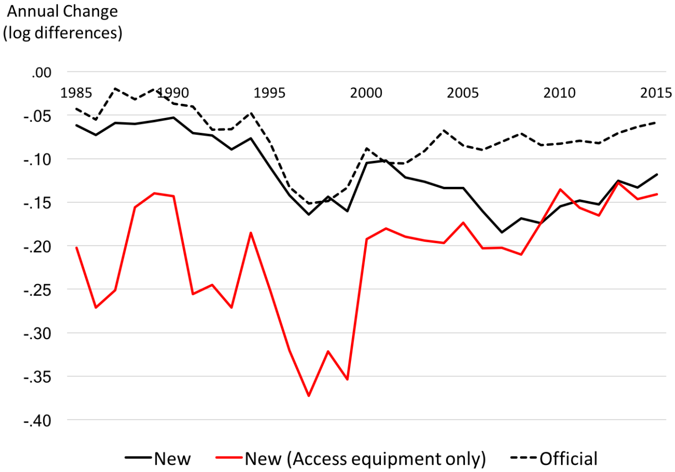
- Focus on 14 detailed product classes of consumer digital goods (TVs, computers, cameras, etc.)
  - All products are capitalized
  - Quality-adjusted asset price change is estimated for all products (based in part on Byrne and Corrado, 2015, 2017)
  - Capital services prices for a subset, termed “network access equipment", are adjusted for use intensity.
- Develop price index for access services from 5 categories of service: internet access, smartphone, subscription video-on-demand, conventional cellular phone, cable TV)
  - We have IP data traffic for the first three types of services; grows very fast, especially mobile data IP traffic.
  - We use hours for cable TV and assume 24 hours for conventional cellular phone (i.e., no use adjustment).

Results

Price change for consumer digital assets

Declines in official price index are understated after 2000

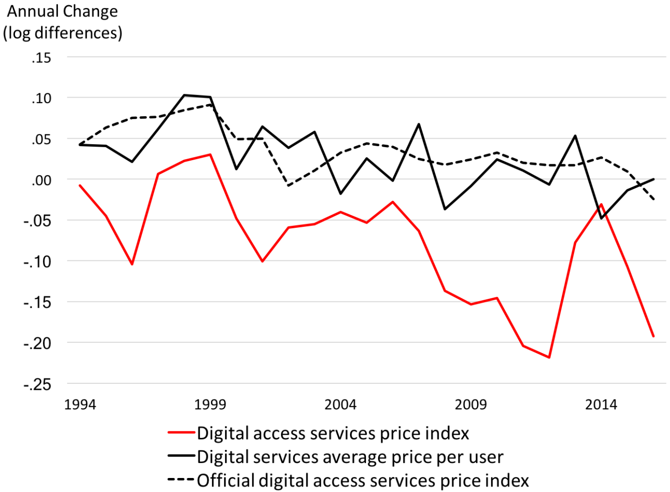
Access equipment price declines slow after 2000



Price change for consumer digital access services

Declines in official price index are understated by 10 ppts, on average, after 2005

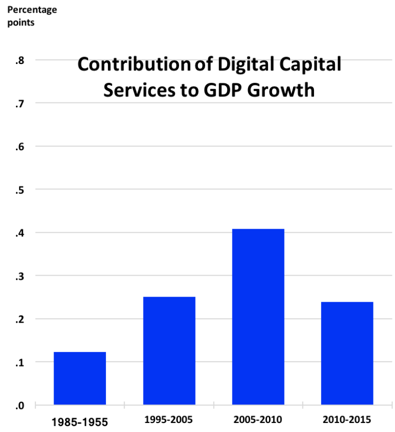
Implied $\dot{\lambda}$ contributes additional -6 ppts to consumer capital services price change after 2005

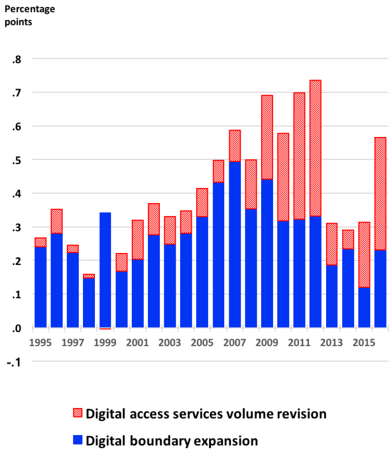


Results show a sizeable impact on U.S. real GDP growth

New consumer digital services measures (both series) add .7 ppts per year since 2005

Swing in post-2005 growth is .2 ppts per year





Implications for Consumer Surplus and Productivity

Methods imply large consumer surplus from innovations in content delivery

Equivalent to 16 percent of the change in DPI that occurred between 2005 and 2015.

- Cannot look at individual innovations or compute Harberger-type triangles
- But can use new series to compute CS from continuing commodities as $.5(\Delta P_T^{S_T^H} \Delta S_T^H) + .5(\Delta P_T^{C_T^B} \Delta C_T^B)$
- Kick comes because we are measuring consumption and using quality-adjusted price measures

Table 7: **Consumer Surplus from Innovations in Digital Content Delivery, billions of dollars**

	1995 to 2005	2005 to 2015	Acceleration (2) - (1)
	(1)	(2)	(3)
1. Consumer surplus	381.7	1,074.8	693.1
2. Capital services	349.7	784.9	435.2
3. Access services	31.9	289.9	257.9
Fraction of ΔDPI:			
4. Consumer surplus	.10	.27	.16
5. Capital services	.09	.20	.10
6. Access services	.01	.07	.06

NOTE: DPI is disposable personal income, adjusted to include imputed digital capital income. The fractions in column 3 are calculated relative to the 2005 to 2015 change in DPI.

Productivity and Concluding Remarks

Large productivity impact—about .6 ppt per year contribution to long-term growth in output per hour (computed assuming $\dot{\lambda} = 0$)

- The household has been an important locus of the ongoing ICT revolution and arguably the most visible in recent years.
- Are national accounts missing consequential output and income associated with the innovations in consumer content delivery that have taken place?
  - Capitalizing long-lived consumer purchased of digital goods
  - Accounting for their increased use as content delivery devices
  - Capturing quality change in digital goods prices
  - . . . would all appear to be necessary to avoid significant bias to GDP.
- Capturing this "hidden" consumer services innovation—like the "hidden" cloud services innovations in the business realm—has notable productivity implications
  - For an analysis of the long-term productivity implications of cloud and related ICT services, see Byrne and Corrado, *International Productivity Monitor* 33 (Fall 2017).

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