

# The Rise of Cloud Computing: Minding Your P's and Q's (and K's)

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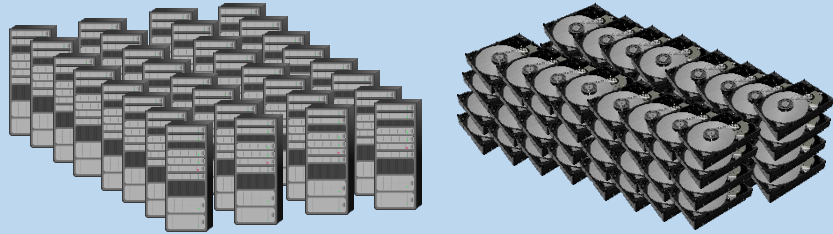
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The views expressed by the authors are not intended to represent the official views of the Institutions with which they are affiliated. Sichel is grateful for financial support from the Bureau of Economic Analysis and the National Telecommunications and Information Administration.

# Information Technology Landscape: 2017

## Cloud Service Providers



Amazon

Google

Microsoft

## Software & Content Providers

Salesforce.com

Netflix

Oracle

Youtube

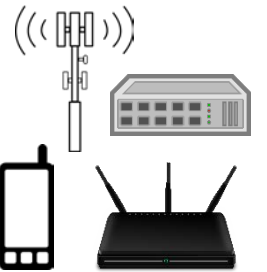
ADP

Facebook

## Electronics Key



Computing

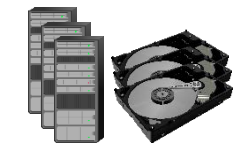


Communications



Entertainment

## Internet Service Providers



Datacenter



Firms



Office



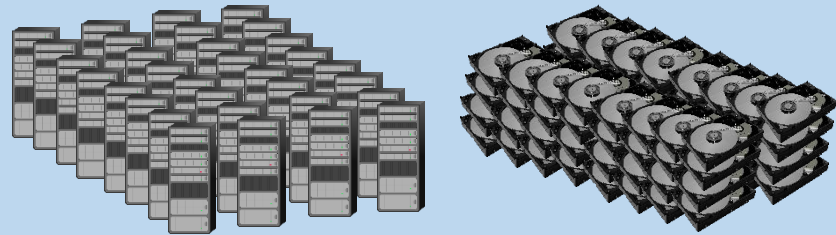
Mobile Users



Households

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## Compute, Storage, & Platform Services

### Internet Service Providers



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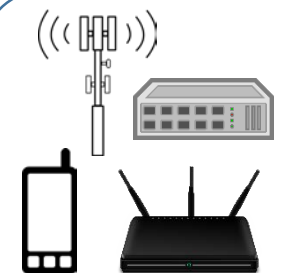


Households

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Computing

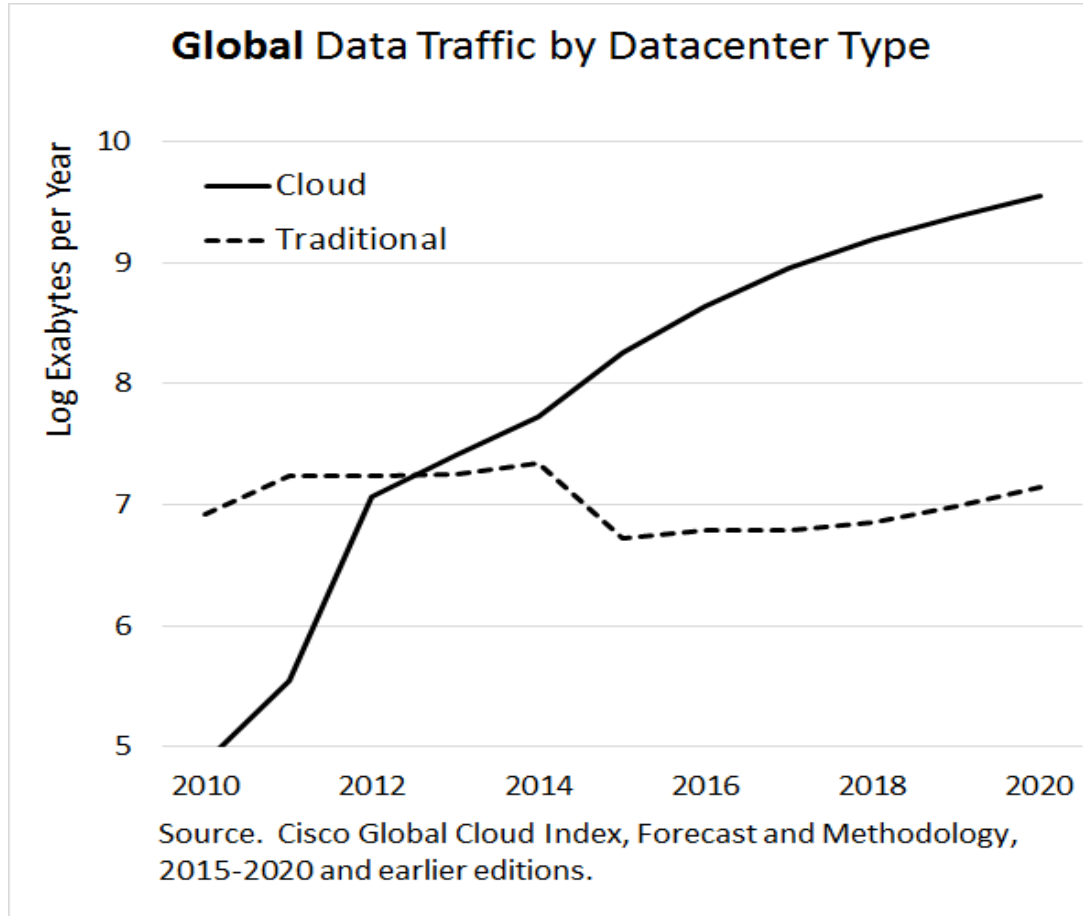


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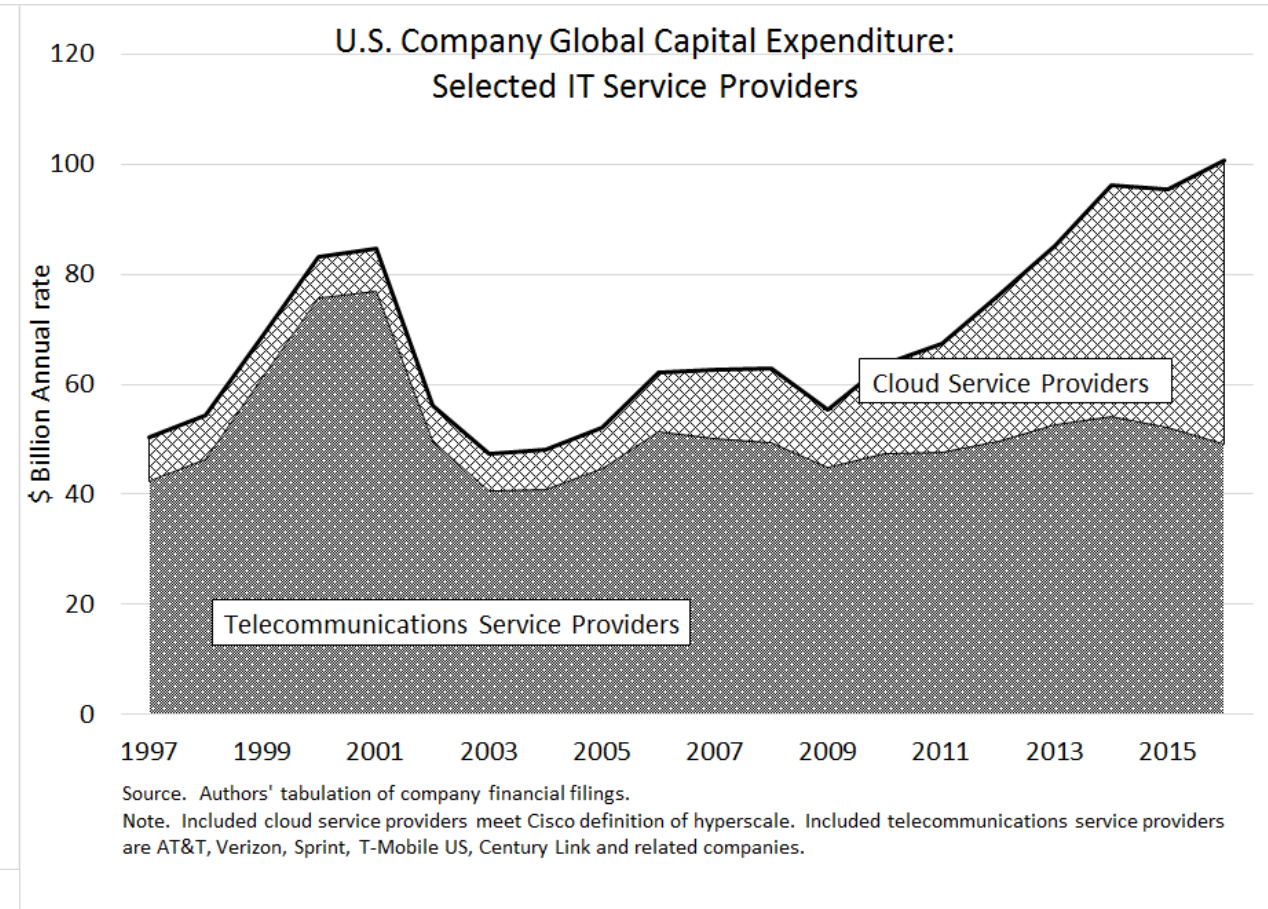
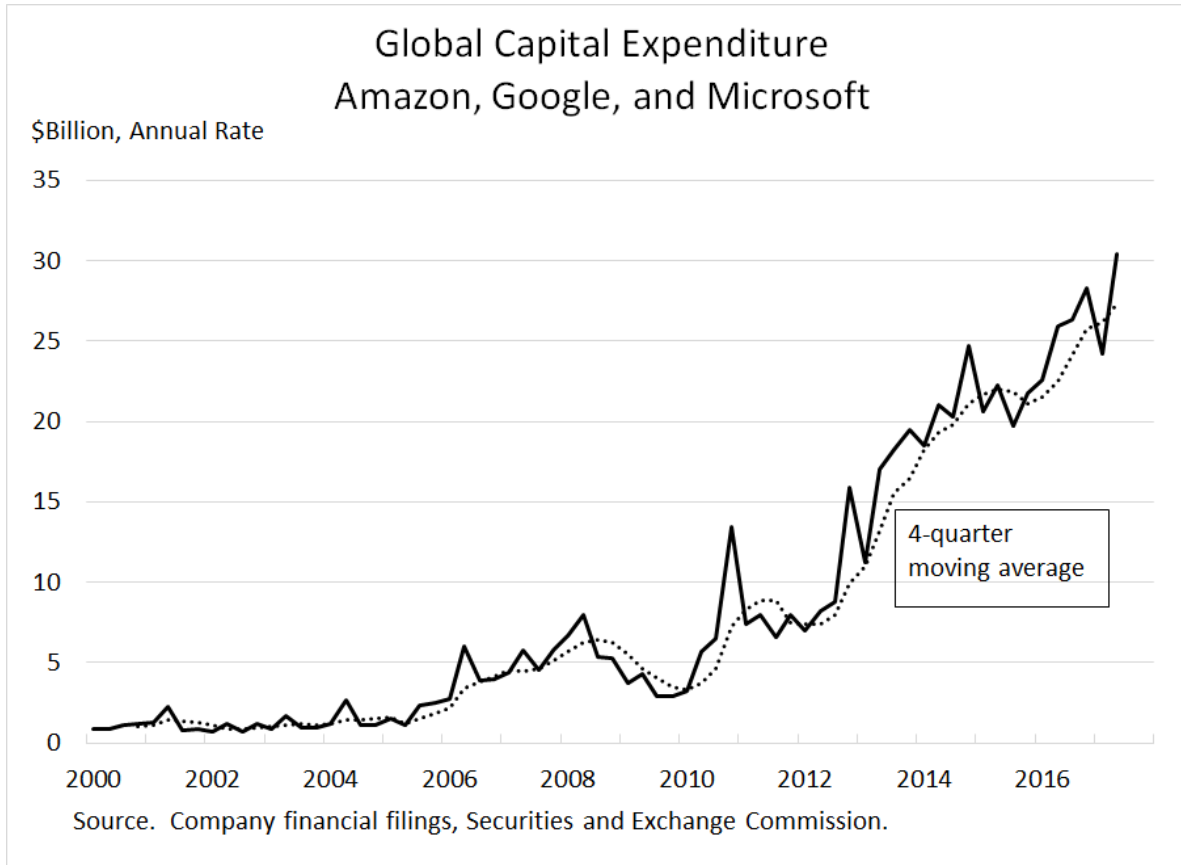
# Q's: How prevalent is cloud computing?



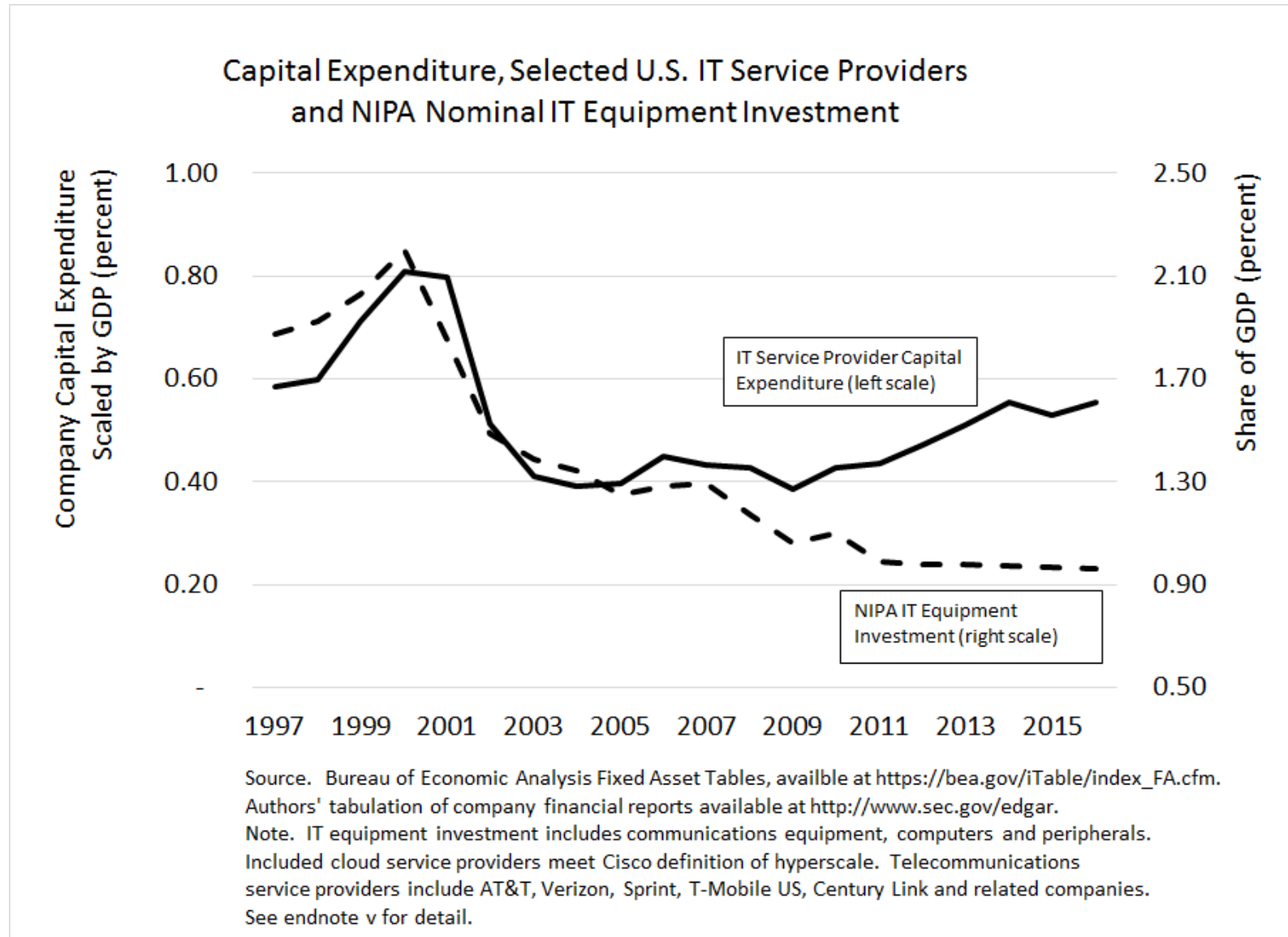
## Global Share of IT Services

- Global cloud services revenue:
  - \$48 billion (2017Q3, annual rate) Synergy Research Group
- Total IT services
  - \$931 billion (2017) Gartner forecast.
  - Includes application services, business processing services, and infrastructure services (cloud)

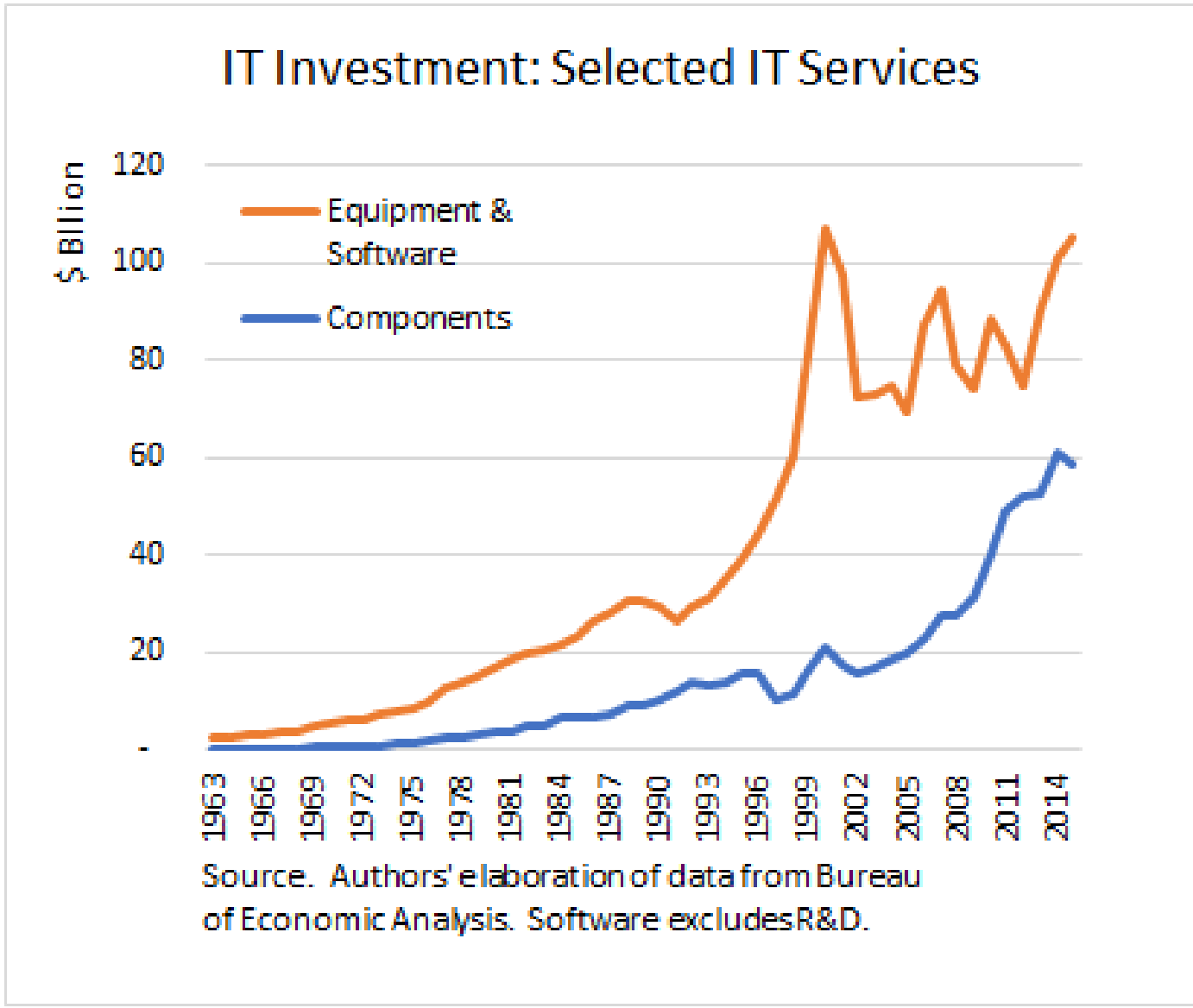
# K's: Investment by Major Cloud Providers



# K's: Is cloud investment in the national accounts?

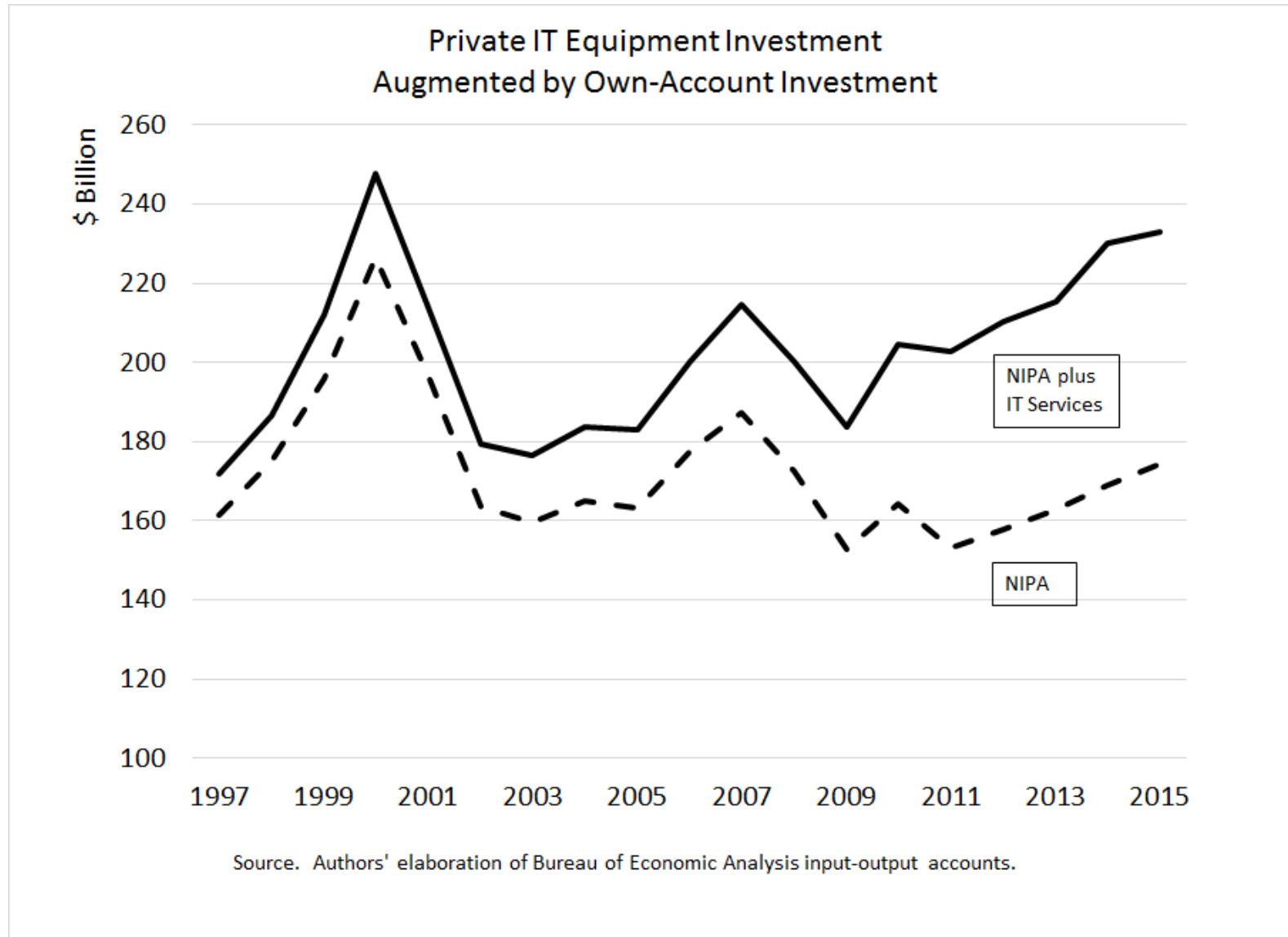


# K's: Cloud providers making own IT equipment?



- Selected NAICS Industries**
- 514** Data processing, internet publishing, other info. services
  - 5415** Computer systems design and related services
  - 511** Publishing industries, except internet (includes software)

# K's: (Speculative) Own-account investment changes the recent IT investment story





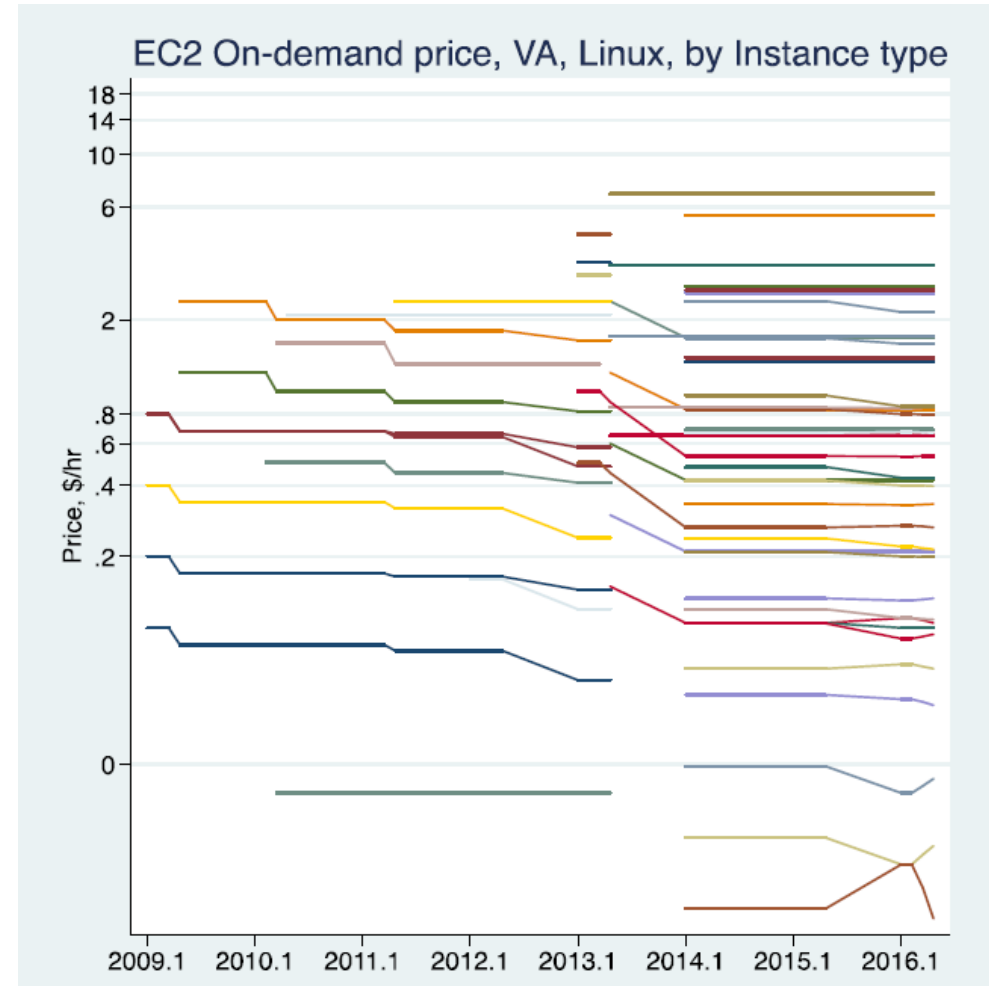
# P's: Data on cloud services

- Prices and characteristics
  - Scraped using the Web Archive
  - 3 products each from 3 vendors
    - Amazon (2009-2016)
    - Microsoft (2014-2016)
    - Google (2014-2016)
- Cloud Service Products
  - **Compute** (renting virtual machines)
  - **Storage** (renting storage)
  - **Database** (user-developed apps)

Amazon Observations 2013-2016	
Product	Prices
Compute	4,079
Database	5,340
Storage	445

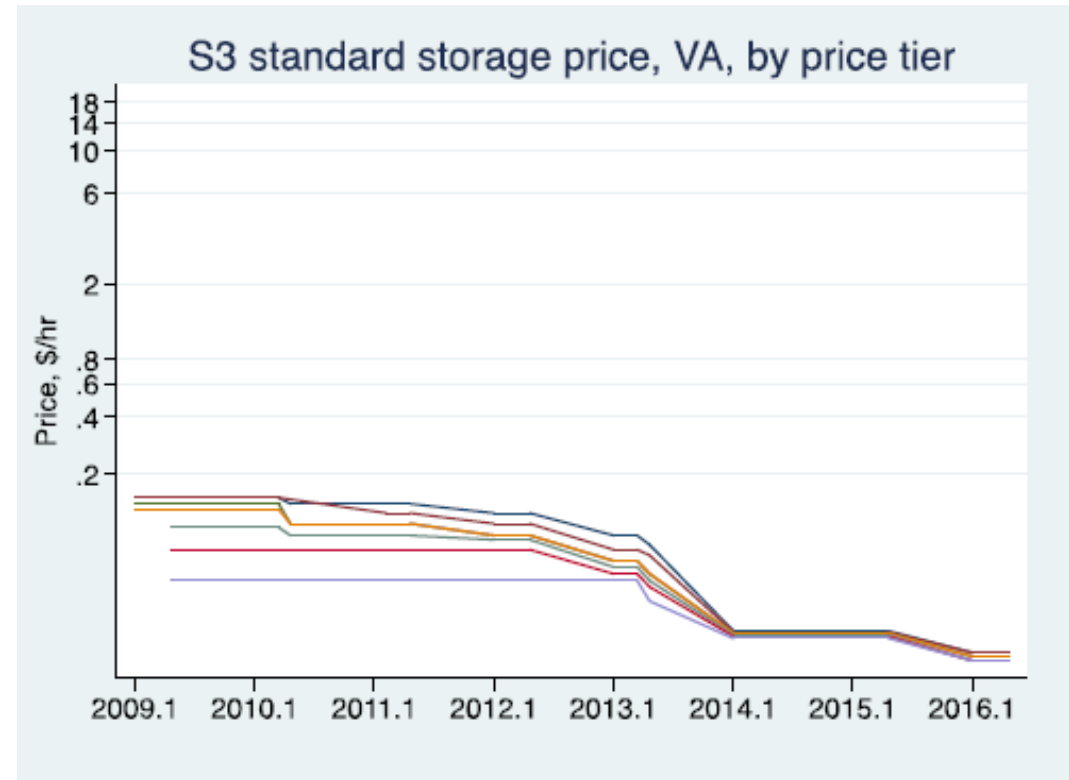
# P's: Compute services

- Amazon “EC2”
- Hedonic adjacent-quarter regressions
- Controls:
  - Processor power
  - Memory
  - Storage
  - *fixed effects* for region, operating system, bus width, solid state drive



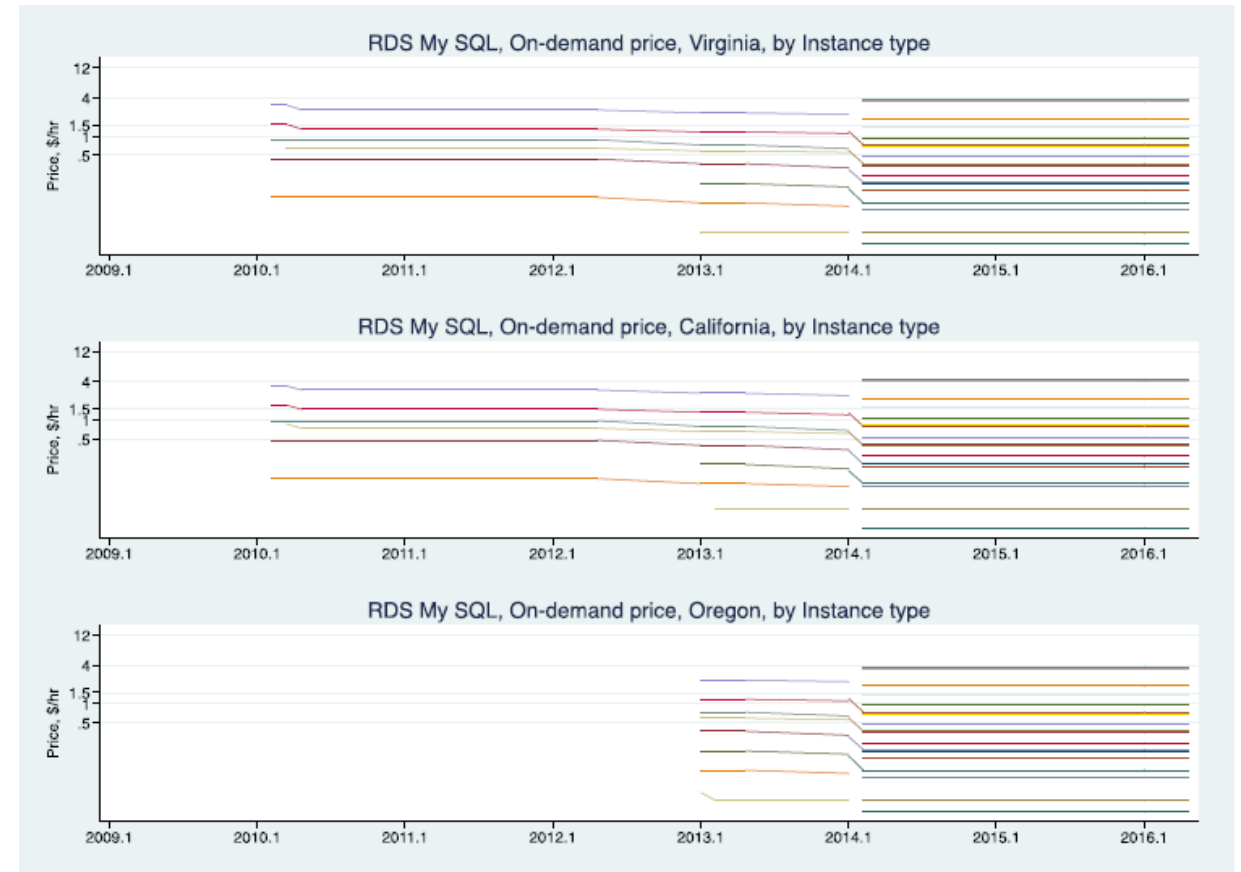
# P's: Storage services

- Amazon “S3” (simple storage solution)
- Matched-model
- Models distinguished by
  - Volume
  - Access speed
  - Region



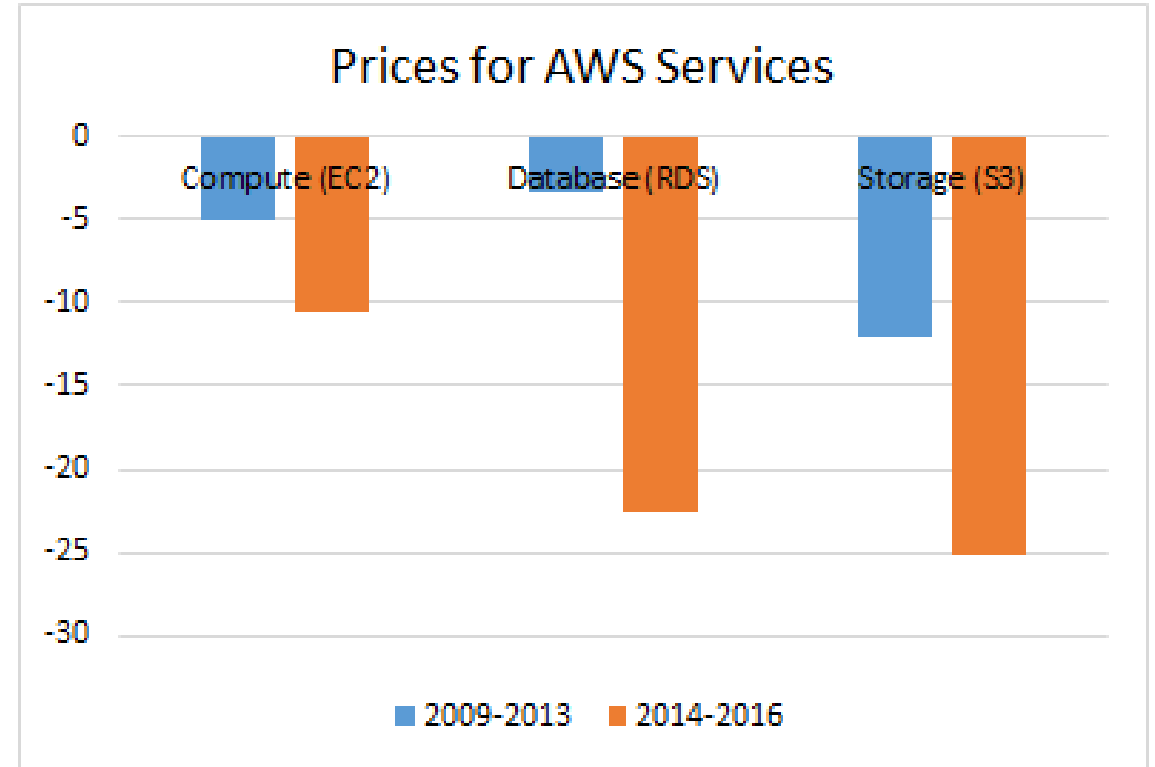
# P's: Database services

- Amazon RDS
- Hedonic adjacent-quarter regressions
- Controls
  - Processor power
  - Memory
  - Input-output
  - *fixed effects* for region, type of database software



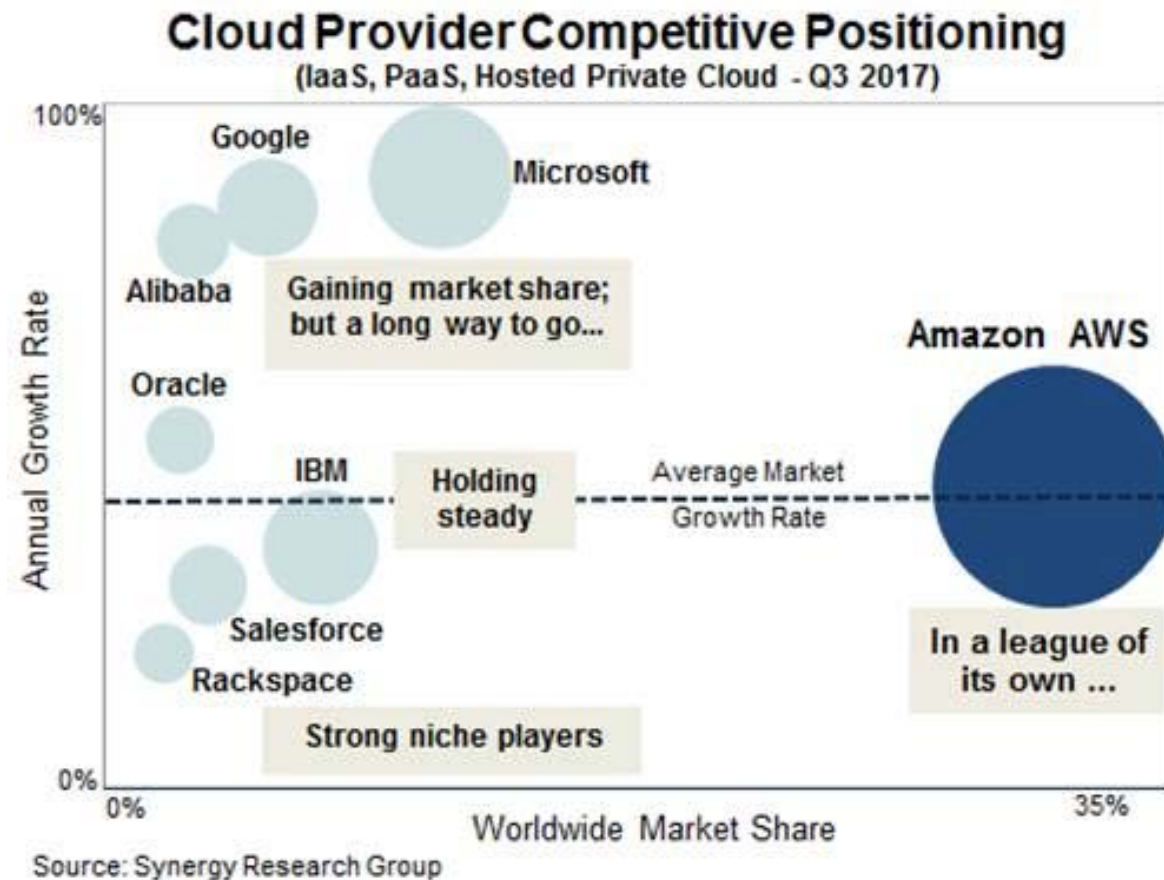
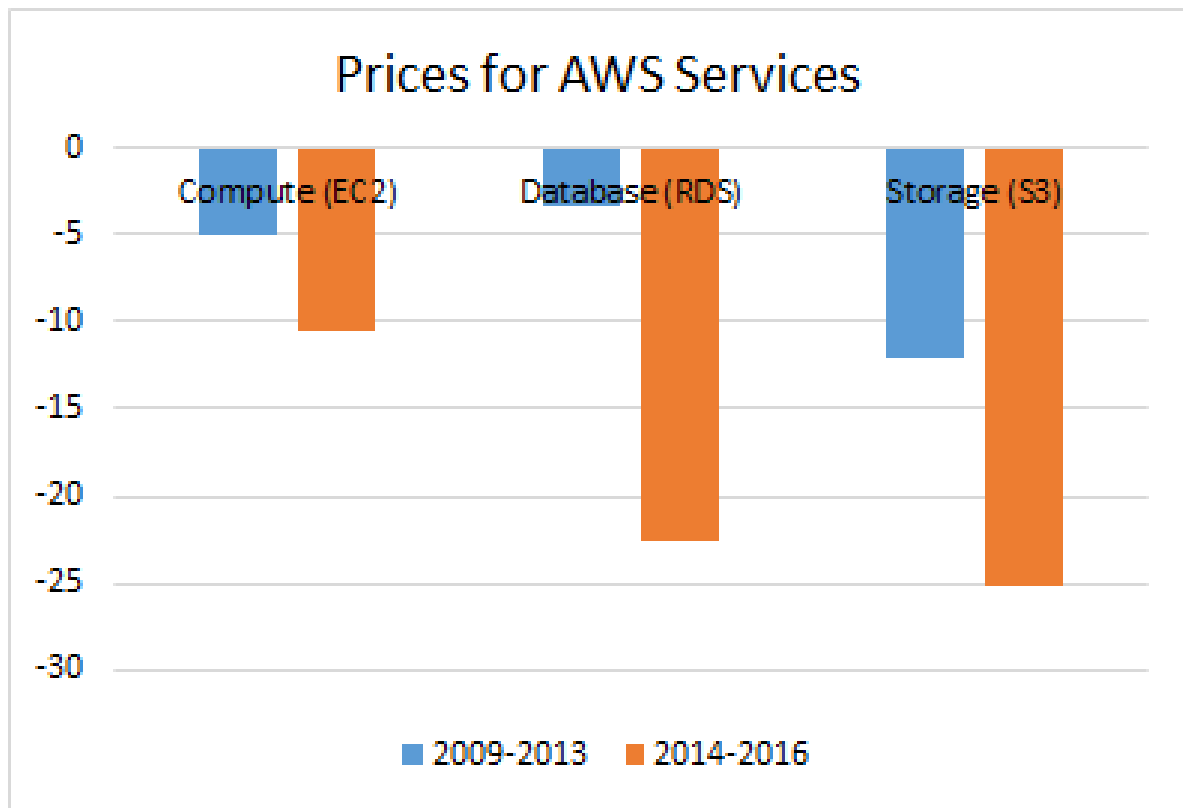
# P's: Acceleration since entry of Microsoft, Google

Prices for AWS Cloud Service Products (percent change, annual rate)		
	2009-2013	2014-2016
Compute (EC2) <i>Google</i>	-5.1	-10.5 <i>-11.4</i>
Database (RDS)	-3.3*	-22.6
Storage (S3)	-12.1	-25.1



\* Sample for RDS starts 2010:Q2

# P's: The Role of Amazon

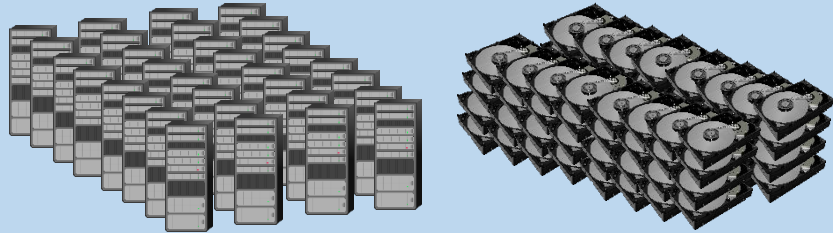


# Summary

- P's: Rapid cloud service price declines
  - Indicates continued technical progress in IT
  - Matters for sources-of-growth analysis (how important is IT?)
- Q's: Volume of cloud services relatively small
  - Early in the adoption cycle?
  - Adoption depresses equipment investment (initially)
- K's: Capital spending by cloud companies is enormous
  - Comparable to 1990s telecom boom.
  - IT investment may be understated in national accounts
  - Greater K deepening => future productivity gains?

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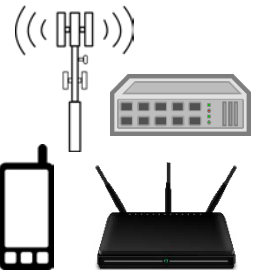
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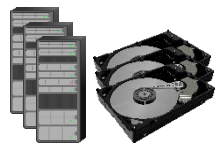
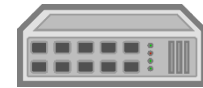
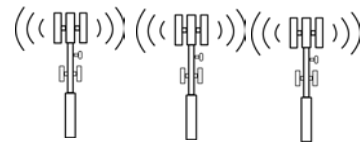
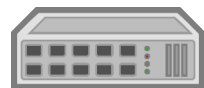
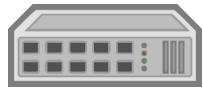


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