



A COLLABORATION WITH



ESCoE Research Seminar

Cloud Computing and National Accounting

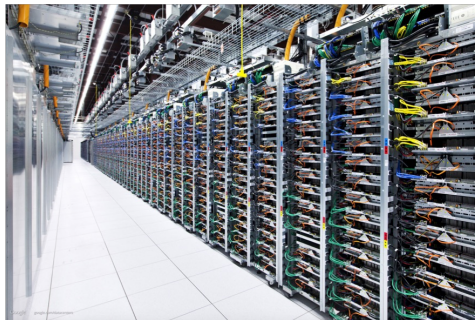
Presented by Diane Coyle (Cambridge University, ESCoE) and
David Nguyen (NIESR, ESCoE)

16 October 2018

What will not be in the cloud?

salesforce

NETFLIX



- ➊ Intro: What is the cloud and why use it
- ➋ Trends in capital formation
- ➌ Implications for productivity and GDP
- ➍ Use of cloud services (by sector and firm size)
- ➎ Cloud services providers in the UK
- ➏ Prices and quality over time
- ➐ Implications for trade

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What is cloud computing

- Software and computing services supplied by large providers from remote data centres.
- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)
- Private cloud
- Public cloud
- Hybrid cloud

Pros and cons for users of cloud services

Advantages:

- ① Cost savings
- ② Flexibility and scalability
- ③ Global accessibility
- ④ Functionality and performance
- ⑤ Reliability and security

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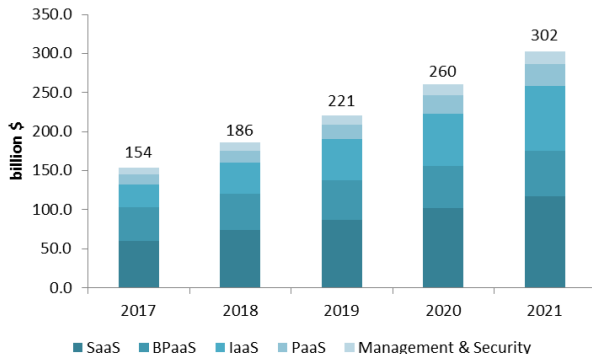
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Barriers:

- ① Data security
- ② Localisation requirements and latency
- ③ Data portability (vendor lock-in)
- ④ Organisational change
- ⑤ Local support

Cloud computing - a growing phenomenon



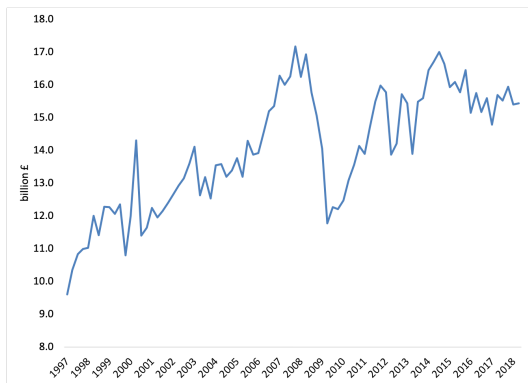
Notes: Global public cloud service revenue forecast. Source: Gartner, April 2018

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Capital formation in the UK

ICT and other Machinery & Equipment. Q1-2017 to Q2-2018

- Decline in real investment since 2015. Correlates with expansion of cloud service providers in the UK.



Notes: CVM, seasonally-adjusted, reference year = 2016. Source: ONS

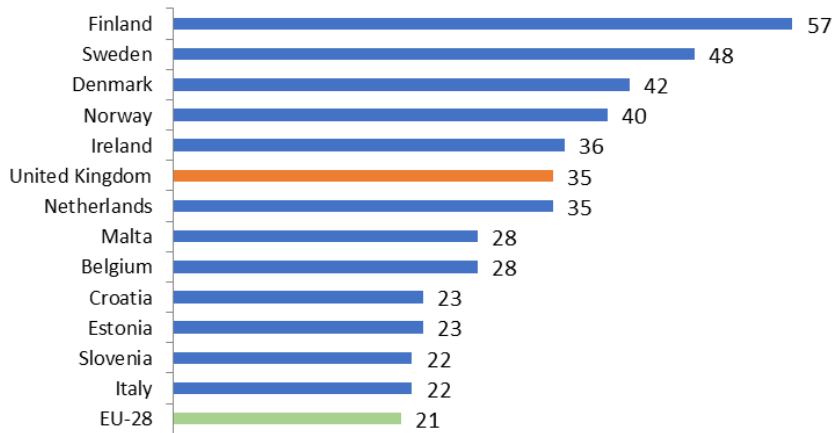
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Implications for productivity and GDP

- Cloud services do not require on-premise hard- or software
- Reduction in business investment, partially offset by data centre investment
- Shift from capital account to operating expense
- Prices / volumes of purchases needed for double deflation
- Implications for net trade figures (detachment of where online service is created, used, hosted) Example: Netflix

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Nordics lead the way, UK in upper quartile

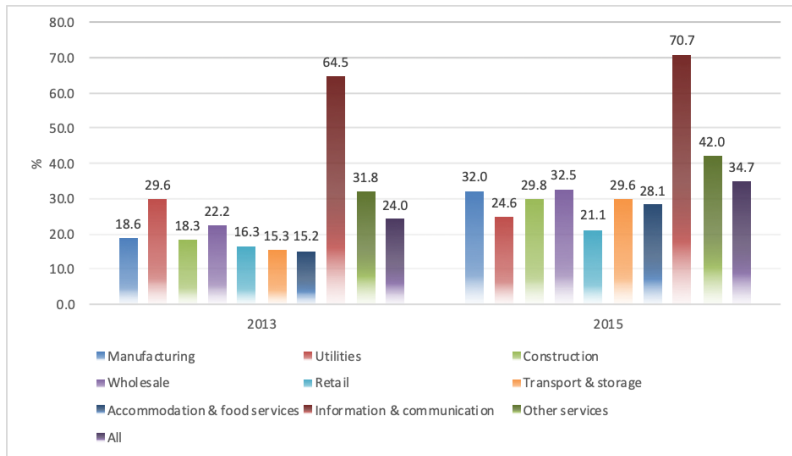


Notes: Firms in 2015 with 10+ employees outside financial sector. Shows countries above EU average.

Source: Eurostat, January 2018

Different adoption rates across sectors

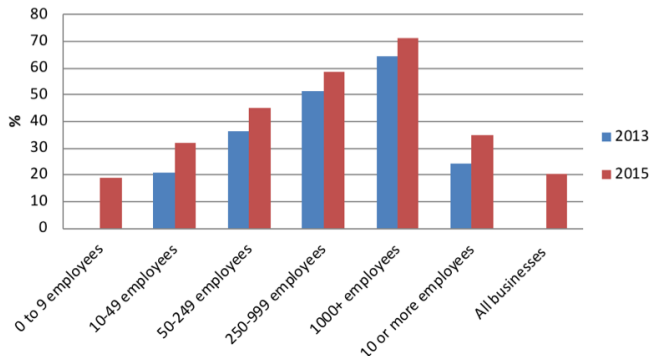
Proportion of businesses buying cloud services in the UK



Source: E-Commerce Survey, ONS

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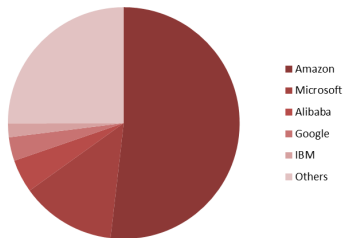
Proportion of businesses buying cloud services by firm size



Source: E-Commerce Survey, ONS

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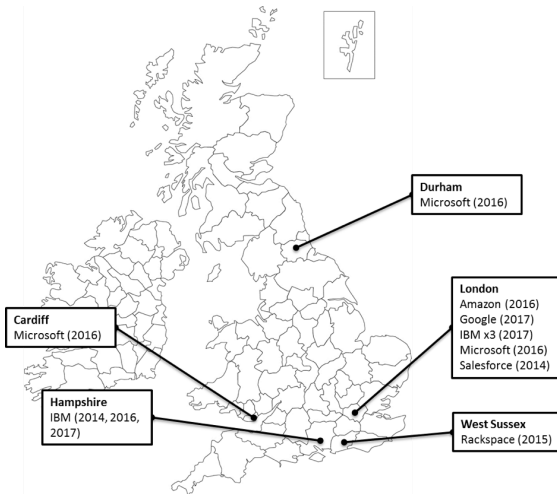
Infrastructure as a Service: A \$24bn global market



Source: Gartner, August 2018

- "Processing, storage, networks, and other fundamental computing resources" (NIST, 2011).
- AWS controls 52% of global IaaS market in 2017.
- Also market leader in the UK by large margin.
- First UK data centre opened in London in December 2016.

Infrastructure as a Service: A \$24bn global market



Source: Authors based on company websites and press releases

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Constructing a price index for cloud services

The basics:

- 1 Prices are listed online.
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- ② Revenues in principle easy to collect by statistical offices.
 - More difficult if service is imported (more on this in full paper).

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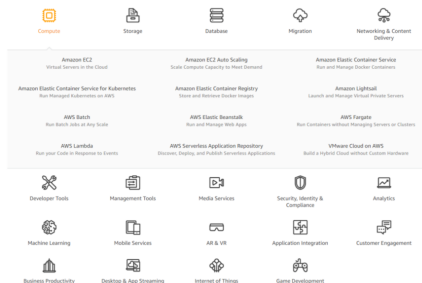
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Three issues (discussed in turn):

- ① Multiple products.
- ② No expenditure weights.
- ③ Continuous quality improvements.

1. Multiple products; and 2. No weights



Source: AWS website, August 2018

- AWS has 21 products categories and 144 different products.
- Microsoft Azure lists 399 products and Google 108.
- Collecting prices for all not feasible.
- Weights would help but not available.
- 2nd Watch: AWS S3 (storage) and EC2 (compute) most used products in 2017.

3. Accounting for product quality

Example: The "quality" of EC2 products over time.

- First introduced as "M1 instance" in August 2006 (Dublin). Followed by M3 in 2012, M4 in 2015 and M5 in 2017.

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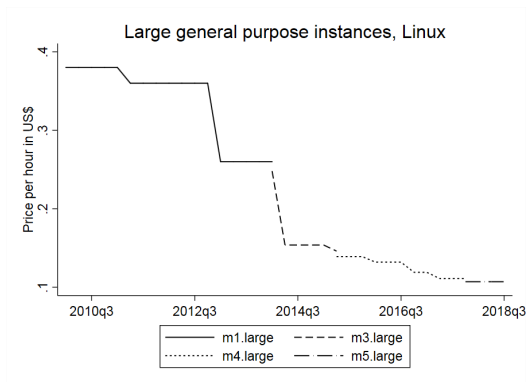
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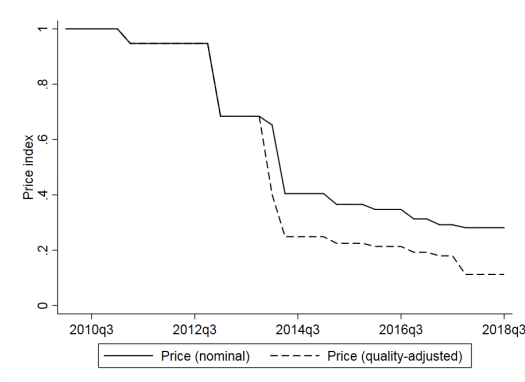
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- Number of 'EC2 Computing Units (ECU)' increased for each product (e.g. for 'General Purpose Large' from 4 to 10)
- However, number of virtual CPUs or memory constant.
- What happened? Better processors with more FLOPS (e.g M3 'Sandy Bridge' led to 50% improvement over M1).

Nominal prices are declining



- Trend similar to other instance types (small, x.large, ...).
- Also Google's compute products look similar (see full paper).
- Prices declined by 72% over 35 quarters.

Quality-adjusted prices declining more rapidly



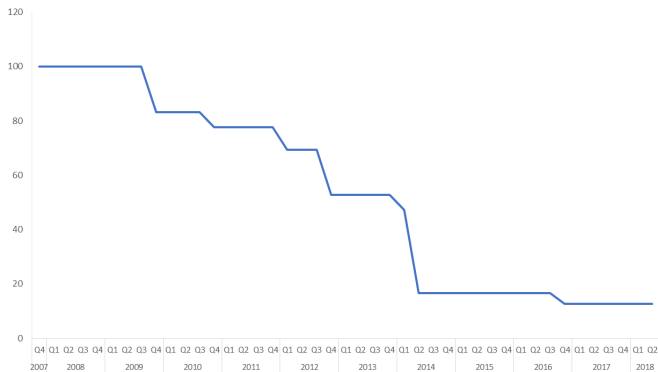
- Quality-adjustment not relevant pre-2014, but from Q1-2014 adjusted prices fall more rapidly.
- Price index dropped by 83% over 35 quarter (!).
- This is 11 percentage points above nominal price (25 for Windows).

Quality-adjusted prices declining more rapidly

Instance class	Operating system	Start quarter	End quarter	Total quarters	Total price drop		Average quarterly drop	
					Nominal	Adjusted	Nominal	Adjusted
Small	Windows	Q1-2010	Q4-2013	16	24.17%	24.17%	1.51%	1.51%
	Linux				31.58%	31.58%	1.97%	1.97%
Medium	Windows	Q1-2012	Q1-2015	13	41.84%	61.23%	3.22%	4.71%
	Linux				57.29%	71.53%	4.41%	5.50%
Large	Windows	Q1-2010	Q3-2018	35	58.54%	83.42%	1.67%	2.38%
	Linux				71.84%	88.74%	2.05%	2.54%
Xlarge	Windows	Q1-2010	Q3-2018	35	58.54%	77.89%	1.67%	2.23%
	Linux				71.84%	84.98%	2.05%	2.43%
2Xlarge	Windows	Q1-2013	Q3-2018	23	59.39%	65.94%	2.58%	2.87%
	Linux				61.09%	67.37%	2.66%	2.93%
4Xlarge	Windows	Q2-2015	Q3-2018	14	20.72%	30.47%	1.48%	2.18%
	Linux				23.02%	32.49%	1.64%	2.32%
10Xlarge	Windows	Q2-2015	Q3-2017	10	19.12%	19.12%	1.91%	1.91%
	Linux				20.14%	20.14%	2.01%	2.01%
12Xlarge	Windows	Q4-2017	Q3-2018	4	0.00%	0.00%	0.00%	0.00%
	Linux				0.00%	0.00%	0.00%	0.00%
16Xlarge	Windows	Q3-2016	Q3-2017	5	16.82%	16.82%	3.36%	3.36%
	Linux				15.95%	15.95%	3.19%	3.19%
24Xlarge	Windows	Q4-2017	Q3-2018	4	0.00%	0.00%	0.00%	0.00%
	Linux				0.00%	0.00%	0.00%	0.00%

- Computed this index for 10 instances types and 2 operating systems.
- Overall, adjusted prices fall more rapidly (up to 5.5% per quarter)

Also storage prices declining rapidly (S3, AWS)



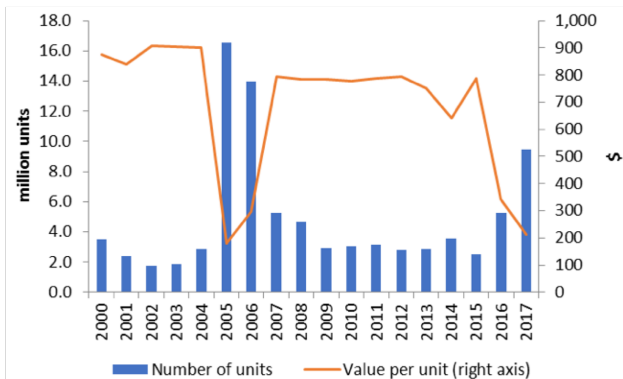
- Quality-adjustment less relevant for Storage products, as quality not main factor.
- Nominal prices for S3 (standard storage, Dublin) dropped by 87%.

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Implications for trade in goods and services

- Physical location of data and computing process detached from creator, user, owner, regulator
- Also across borders: Review trade in services and goods (substitutes?)
- Goods: Import of servers (HS847150)
- Services: Use analyst 'cloud shift' rates to attribute imports to cloud (COMTRADE and ONS ITIS)

UK imports of servers



- 1 Recent surge in 2016 and 2017 (expansion of AWS, Microsoft, Google?)
- 2 Unit prices declining (bulk buy? unbranded servers?)

Method 1: Service imports in COMTRADE

- Imports of "Computer and information services"
- Similar to Berry & Reisman (2012), US International Trade Commission
- \$14.5bn in 2016 (7% of total service imports), \$1.3bn in 2000
- UK cloud market: 71.3% SaaS, 17.6% IaaS and 11% PaaS
- Cloud shift: 25% SaaS, 7% IaaS, and 6% PaaS
- $(0.713 \times 0.25 + 0.07 \times 0.176 + 0.06 \times 0.11) \times \$14.5\text{bn} = \$2.86\text{bn}$

Method 2: Services imports in ITIS

Number	Question	Related cloud service	Value 2016
19	Imports of 'Copyrighted literary works, sound recordings, films, television programmes and databases' without transfer of ownership; including 'any computer programmes or databases that are copyrighted'	SaaS	\$4.679bn
22	Imports of 'Telecommunication services'; incl. e-mail, business network services, teleconferencing, internet backbone services, internet access services, and online access services; excl. database services	SaaS, PaaS, IaaS	\$4.947bn
26	Imports of 'Information services'; incl. database services, and web search portals	SaaS, PaaS, IaaS	\$1.041bn
6	Imports of 'Accountancy, auditing, bookkeeping and tax consulting services'	BPaaS	\$1.070bn

- ① Using the same calculation we get value of \$2.73bn
- ② Comparable to \$2.86bn based on aggregated COMTRADE data

Conclusion

- ① Digitalisation leads to physical detachment of data and computation processes: creation, ownership, use
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- ③ Need better data on: capital investment and revenues of cloud providers, business expenditure by cloud product, data flows by data centres.
- ④ Related to broader question of 'usefulness' of growth accounting when looking at general purpose technologies, such as cloud computing.

This presentation has been entirely created in the cloud using Overleaf.

Questions?