

# A microeconomist looks at productivity

A view from the Valley

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These slides do not necessarily represent the view of the author's employer.

## GDP ≠ welfare

Even though everyone agrees GDP is not intended to be a measure of “welfare”, it is often used as a proxy for “standard of living”.

- “...a measure for **standard of living**: average real **gross domestic product (GDP)** per capita”
- “...productivity and **living standards**”
- “...GDP per capita as yardstick for **living standards.**”
- “...Measuring **living standards** with GDP per capita”

# Problems with GDP as welfare measure

GDP = value at **market prices** of all **final** goods and services **produced** in a given **country** in a given time period.

- **Market prices:** does not measure **unpriced goods** such as leisure, household production, free goods, most quality improvements, open source software, etc.
- **Final:** excludes intermediate goods and services, such as **marketing**, embedded software, quality, etc.
- **Produced:** welfare depends on **consumption**, not **production**
- **Country:** with **global supply chains**, the location of production is often not clear

# Problems that are particularly important now

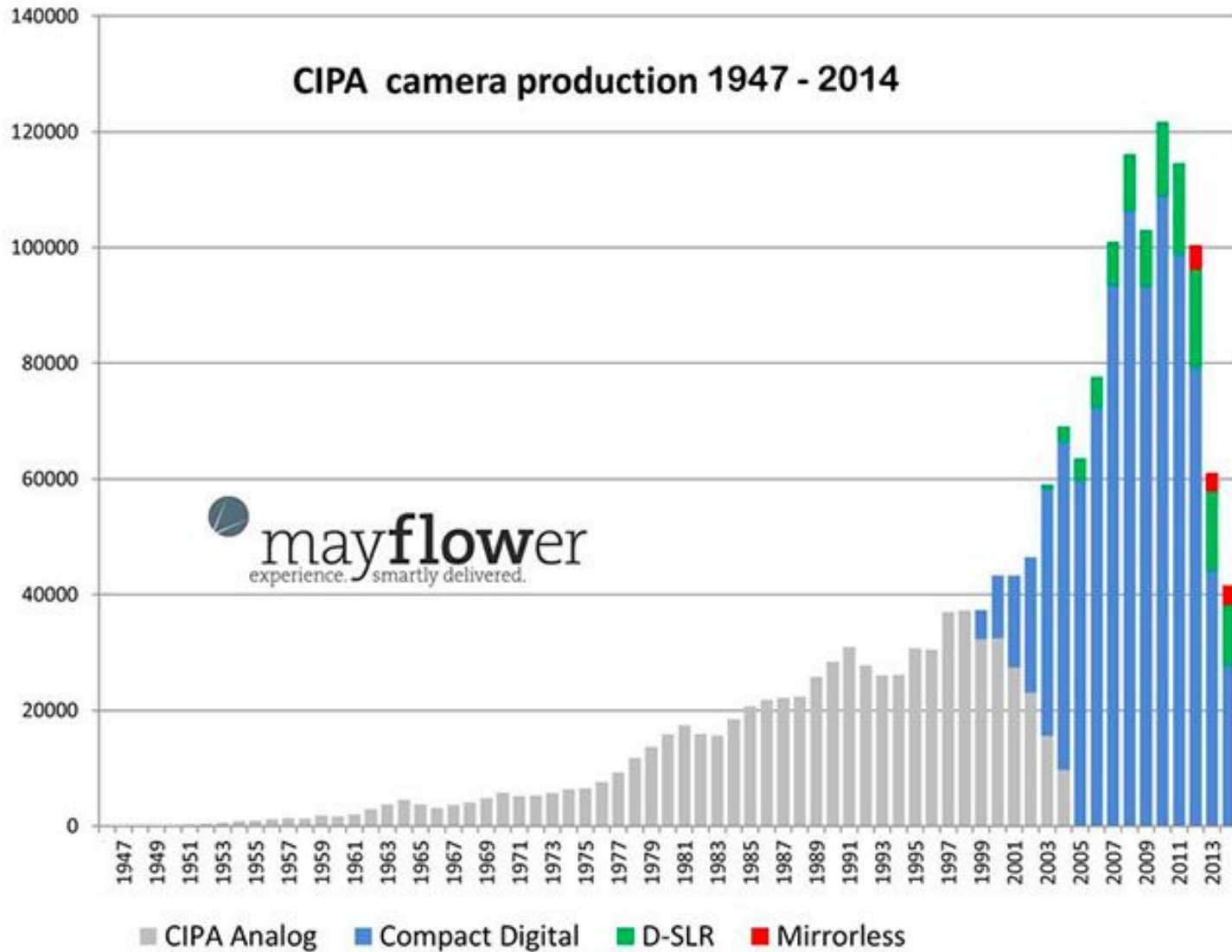
- Unmeasured quality change
- Non-monetary transactions
- Global supply chain
- Semiconductors

Quality changes

# Product improvements: photos

- **Photos** taken worldwide
  - 2000: [80 billion photos](#) [easy to measure]
  - 2015: 1.6 trillion photos [20 times as many]
  - Price per photo has gone from 50 cents to 0 cents.
- Increase doesn't show up in productivity measures since...
  - Price index for photography includes price of (**film, developing, cameras**) all of which are **vanishing**
  - Photos are mostly **shared, not sold** (non-monetary transaction)
  - GDP went *down* when cameras were absorbed into smartphones
  - (No quality adjustment applied to smartphones)

# Camera production



# Non-monetary transactions



# Product improvements: GPS systems

- Vehicular monitoring systems for **trucking** in late 90s, early 2000s.
  - Price of GPS system was over \$1000
  - Productivity growth in trucking was twice aggregate productivity growth
- GPS systems for **households**
  - First, price of GPS devices fell to a few hundred dollars then became free
  - **GDP went down** when GPS systems were absorbed by smartphones

## Product improvements: smartphones

A **mobile phone is a substitute** for a camera, a GPS, a land line, a game machine, an ebook reader, a computer, a movie player, an audio player, a map, a password generator, a fitness monitor, an alarm clock, a web browser, a calculator, a recording device, video camera, etc.

Building these capabilities into smartphones **reduced GDP** due to reducing sales of special purpose devices and the lack of quality adjustment for smartphones.

When price goes down, real **GDP may increase** ... until the price hits zero at which point the product is **taken out of GDP!**

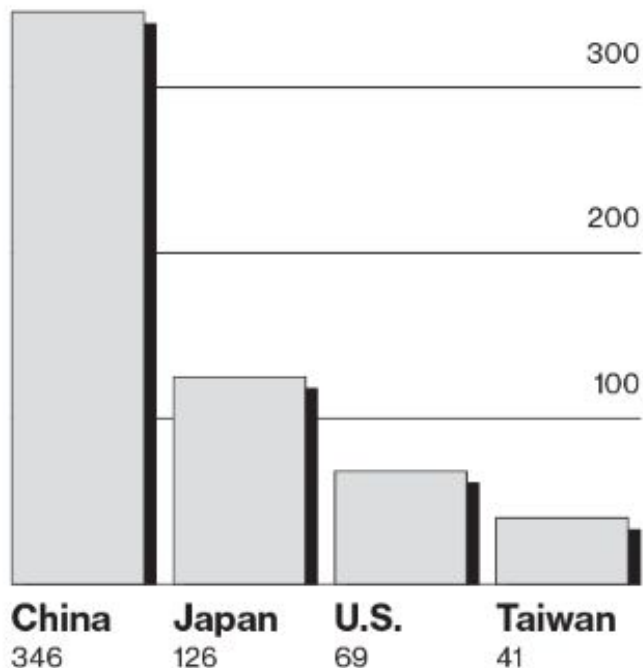
Makes sense for “economic activity”, doesn’t make sense for “standard of living” People *love* their smartphones...

# Global supply chain

# Where is the iPhone made?

- Cupertino? Design, engineering, software, marketing.
- Shenzhen? Foxconn labor and parts from 28 countries.
- Labor cost for assembly is \$5-\$10

Apple has suppliers in 28 countries ...



## 766 suppliers including...

- **Screen:** made by Corning, facilities in Kentucky, South Korea, Japan and Taiwan, cost: \$20
- **Processor:** designed by Apple, manufactured by Samsung and TSMC (Taiwan)
- **Cellular modem:** designed by Qualcomm, outsourced to Germany, Singapore, New York, Vermont, cost: \$15
- **Low value parts:** mostly Asia

Konstantin Kakes, "[The All-American iPhone](#)", Technology Review, June 2016.

# GDP international accounting

- GDP is about what is produced in a **single country**.
- But nowadays products are produced in **many countries**
- What is produced where and what is “market value”?



# Phone designed in US, produced in China, consumed in France: scenario 1

Standard GDP accounting: do not impute a price for export of software or engineering plans. (Though software does count as a domestic investment.)

1. US export design/software	0 to China
2. Manufacturing cost	150 in China
a. US parts	?? [screen, chips]
b. Foreign parts+labor	?? [low value]
3. Import finished device	350 to France
4. Retailing	50 in France
5. Retail cost	400 in France

## Export finished iPhone from China to France

- Counts as \$350 of export from China to France but this could be thought of as:
  - \$200 of software exports from US to France
  - \$150 parts from elsewhere (e.g Japan, US, Korea)
- Where does the \$200 of plans and software show up in US GDP?

# Android phones: 80% of mobile phones sold

- Android's operating system is **open source**
  - US GDP counts **Android OS at zero**
  - US GDP counts **Android hardware at ~ zero** since it is designed abroad (assembled using US parts and IP)
- So quality adjustment for smartphones won't show up in GDP anyway
  - mostly foreign hardware
  - free US open source software
- **Total mobile phones sold worldwide = \$400 billion**
  - **Smartphone software** is (perhaps) **\$200 billion of US exports to ROW** in terms of "value"
  - Equals 1% of US GDP or about half of trade deficit



# Summing up

## Smartphones

- People love their smartphones
- Smartphones reduced sales of special-purpose devices
- Quality adjustment of smartphones should in principle offset the reduced sales of special-purpose devices

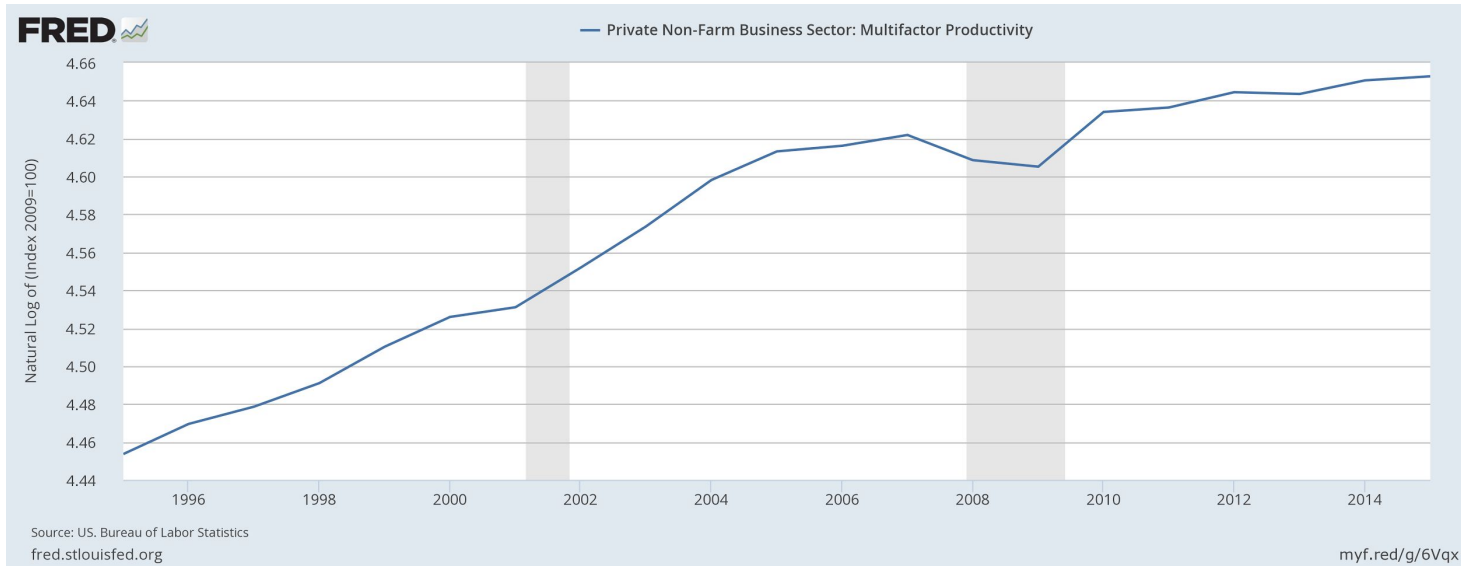
## Imports

- Smartphone hardware is mostly imported
- Android software is open source and has zero price
- Treatment of iOS software is unclear
- Conclusion: big loss in measured GDP due to smartphones!
- Despite all that love and US software!

# Factoryless production is not just high tech

- Semiconductors
- Vehicles (\$4,000)
- Consumer electronics (\$1,600)
- Furniture (\$746)
- Toys (\$740)
- Clothes: (\$1,700)

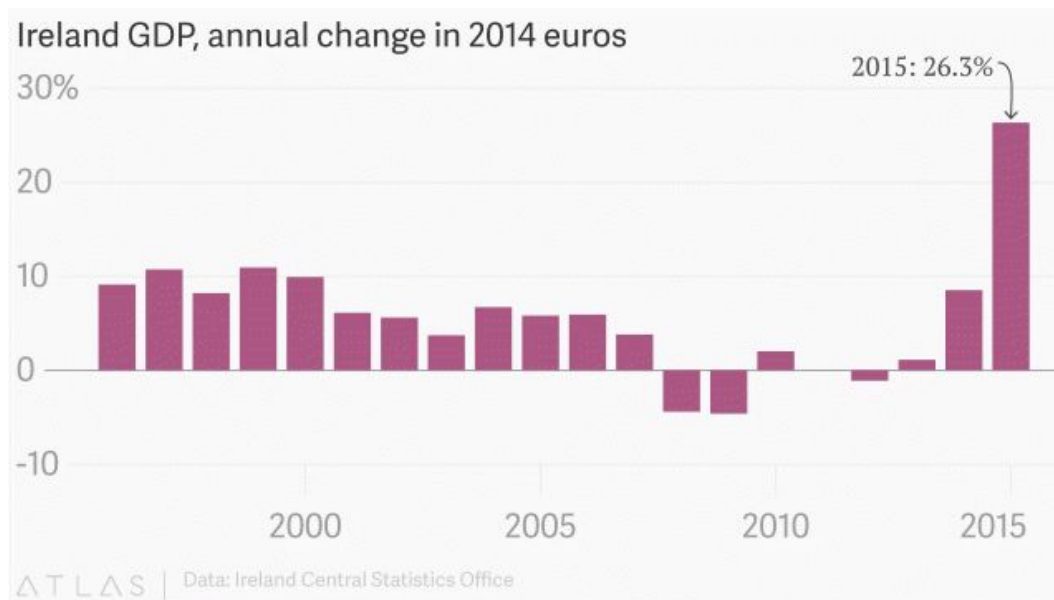
# Chinese imports and MFP (logs)



# Country where IP is held is relevant

IP may be created in one country but held elsewhere. The **Irish economy grew by 26%** in 2015 due to huge rise in [investment and net exports](#), caused in part by inversions. Pharma previously exported from US may now be exported from Ireland.

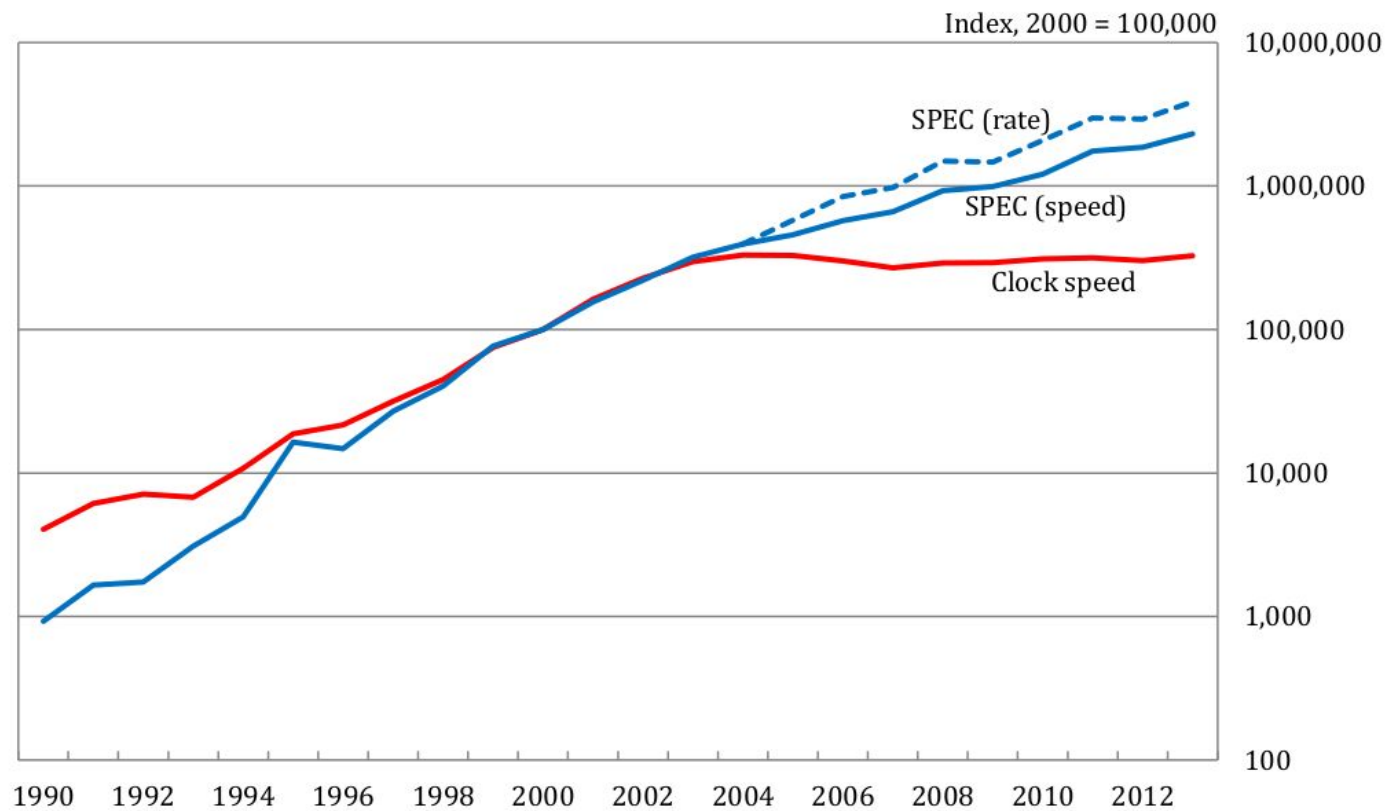
## Irish GDP



# Semiconductors

# Quality change?

Figure 1: Desktop MPU Performance Measures



Source. Authors' calculations using data provided by Unni Pillai and performance information from Intel price lists and SPEC corporation.

# Semiconductors

“This slowdown in the rate of decline is puzzling in light of evidence that the performance of microprocessor units (MPUs) has continued to improve at a rapid pace.” Byrne, Oliner, Sichel [2015].

- Intel pricing policies
- Multicore CPUs (8% v 43% improvement)
- **Data centers and multiprocessing**
- **GPUs and special purpose chips**