

A historical black and white photograph of a busy city street, likely New York City, showing a horse in the foreground and a street scene with buildings and people in the background. The text is overlaid on the right side of the image.

**THE GREAT
HORSE MANURE
CRISIS OF
1894**

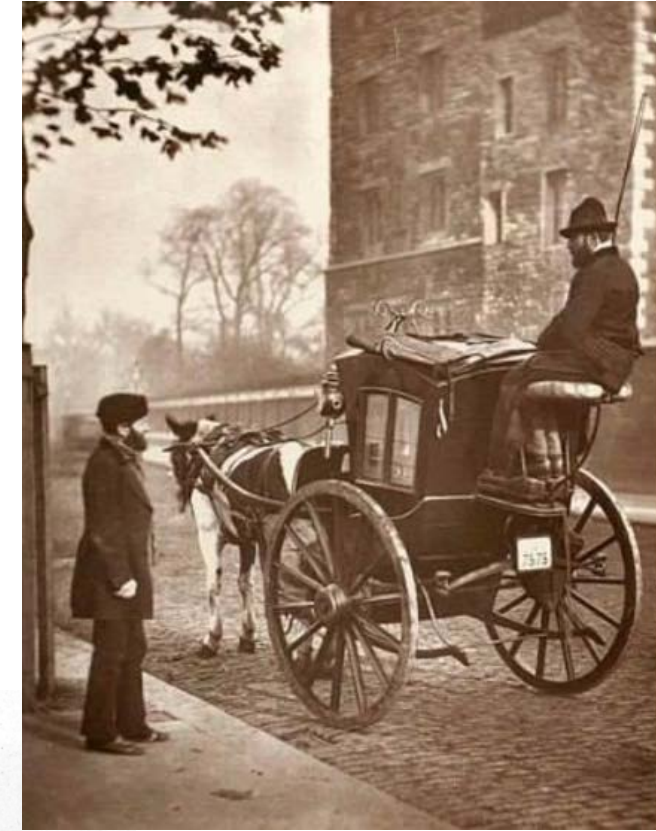
Is Technology the Seed of the Next Global Crisis?

Campbell R. Harvey
Duke University and NBER

Revised March 21, 2018

Horses

- Late Victorian England, 3.3 million working horses
- 1893 there were 300,000 working horses in London



Horses

- Each horse producing 15-35 lbs of manure every day
- About 4,000 tons left on the streets every day
- Not just the manure, the average life of a working horse was 2-3 years – so many carcasses abandoned on the streets

Horses

- 1894 Times of London:
“In 50 years, every street in London will be buried under nine feet of manure.”



Horses

- 1915 London:
No horses used for trams or cabs
- The motor carriage is the technological disruption

DISPENSE WITH A HORSE



and save the expense, care and anxiety of keeping it. To run a motor carriage costs about $\frac{1}{2}$ cent a mile.

THE WINTON MOTOR CARRIAGE

is the best vehicle of its kind that is made. It is handsomely, strongly and yet lightly constructed and elegantly finished. Easily managed. Speed from 3 to 20 miles an hour. The hydrocarbon motor is simple and powerful. No odor, no vibration. Suspension Wire Wheels. Pneumatic Tires. Ball Bearings.  Send for Catalogue.



Horses were disrupted by technology

- Minimal impact on labor
- Drivers switched to taxis - motorized carriages
- Stable hands pumped gas at service stations
- The main losers were the horses: UK working horse population plummets to 25,000

Two views of technology

The Dark View

Karl Marx (*Das Kapital*, ch. 15
“Machinery and Modern Industry”)

- Technology is an instrument of the capitalist to increase profit at the expense of labor
- Technological advances will lead to mass unemployment

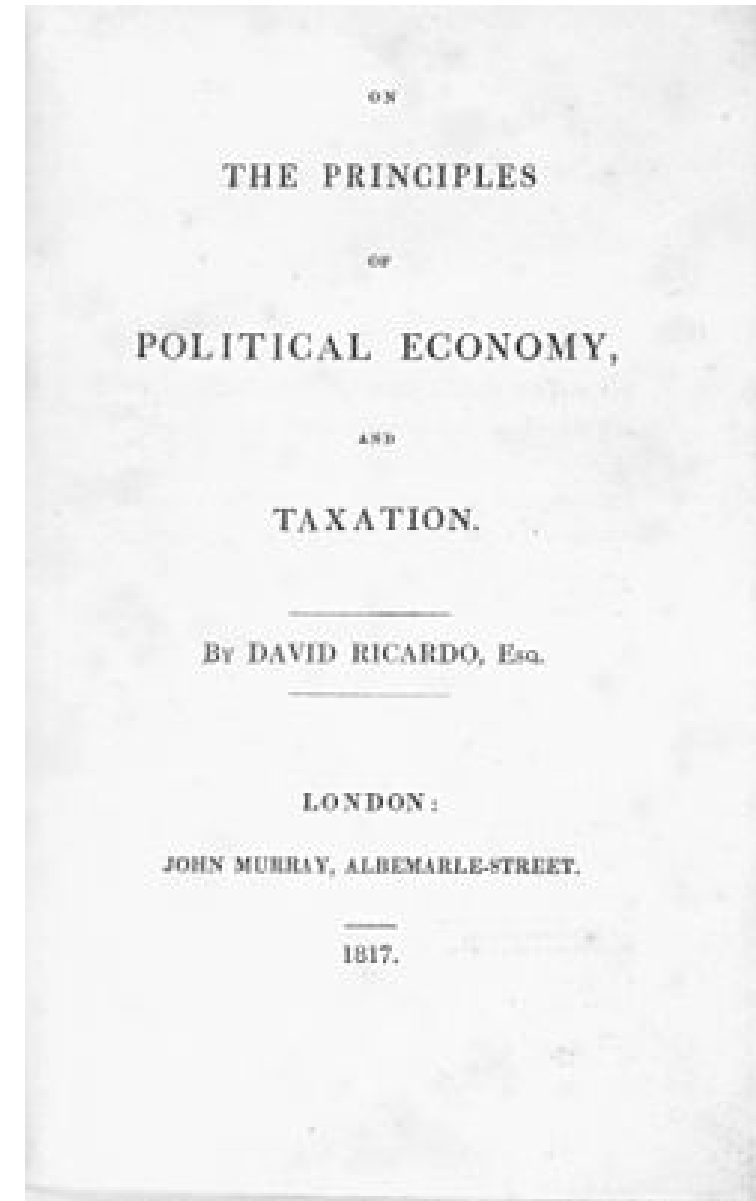


Two views of technology

The Dark View

This was not just Marx's view

- David Ricardo expresses a similar view in chapter 31 “On Machinery” in his famous *The Principles of Political Economy and Taxation*
- Also, John Stuart Mill and Thomas Robert Malthus!



Two views of technology

The Bright View

Empirical evidence began to shape a more nuanced view

- Technological change can lead to short-term disruptions but there is no evidence of long term effects on employment
- For example, 100 years ago over 50% of the U.S. population worked on farms; today it is less than 2% (yet much more food is produced and it is cheaper)

Two views of technology

The Bright View

Empirical evidence began to shape a more nuanced view

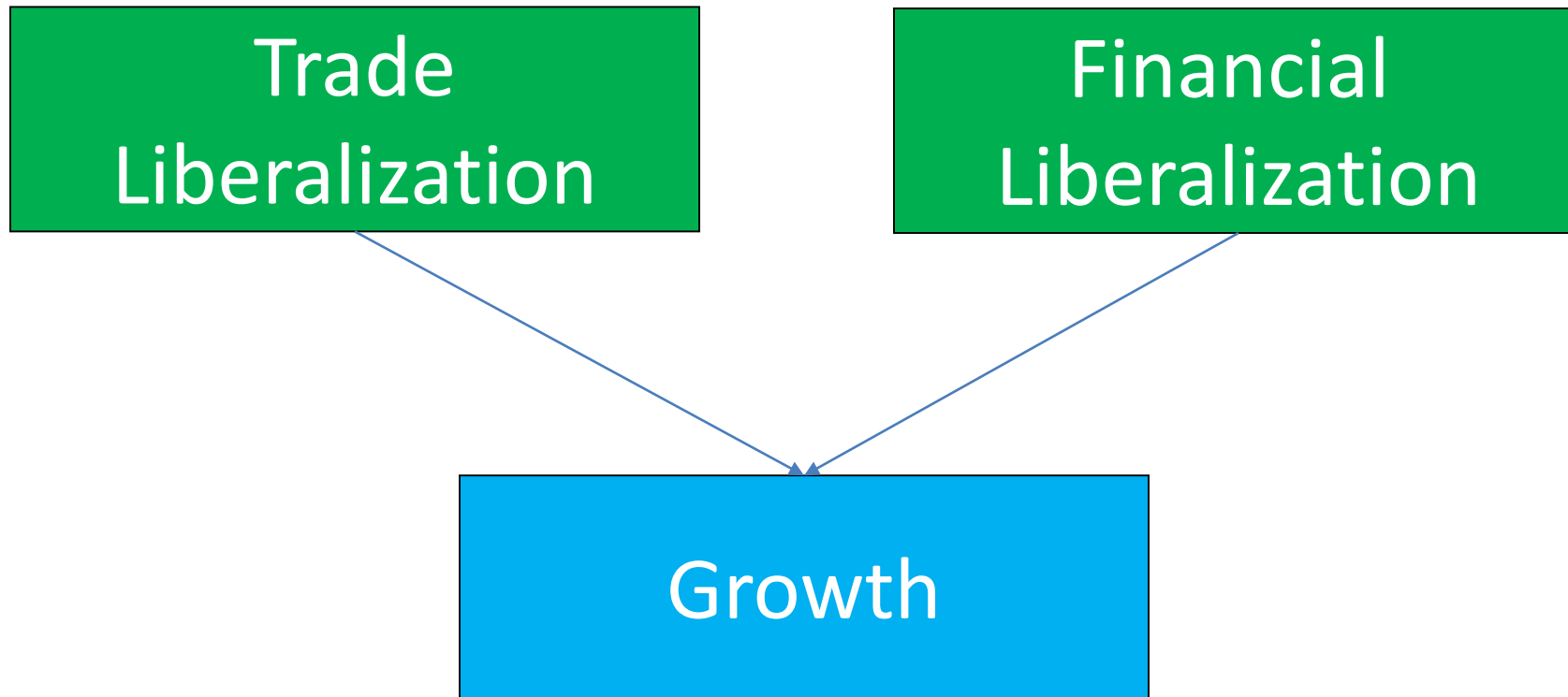
- Three basic ideas:
 - It is crucial to take the benefits of technology into account when predicting the impact on the economy and labor specifically
 - Labor is mobile and will eventually find new jobs
 - Different technologies have different demographic impacts, e.g., the tractor displaced relatively unskilled labor while the computer displaced skilled labor

Globalization and technology

Historically, technology has made goods and services more portable leading to increased trade

- Increased trade generally associated with increased growth

Traditional View of Globalization



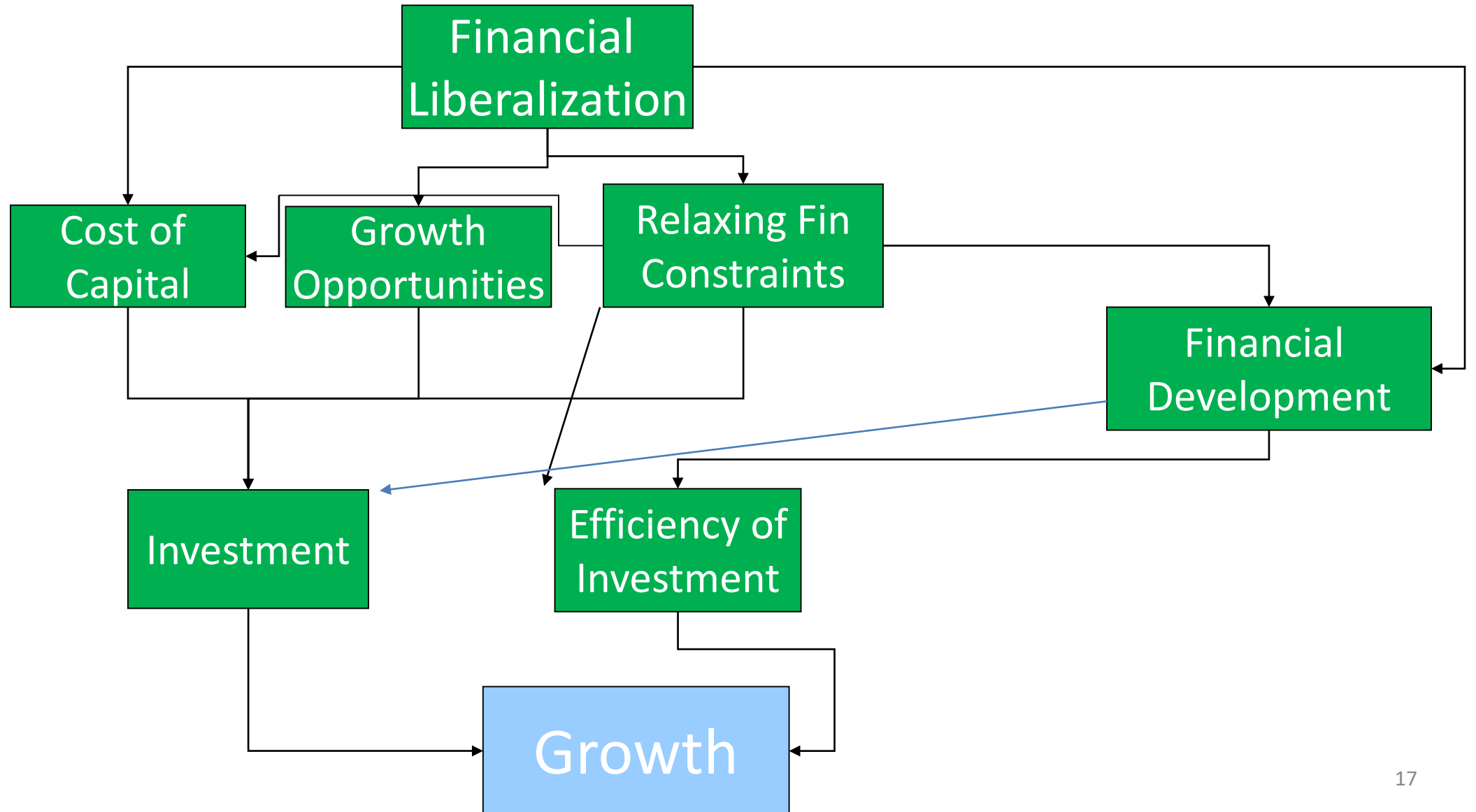
Trade Liberalization

- Reduction in barriers to trade (tariffs and non-tariff barriers)
- Regulatory harmonization (e.g., EU)
- Trade includes not just goods and services but labor
 - Labor includes both cheaper labor from immigrants and the outsourcing of labor to emerging markets

Trade Liberalization

- Near universal agreement from economists beginning with David Ricardo (1817) that trade has positive impact on average growth

Financial Liberalization



Financial Liberalization

- Bekaert, Lundblad and Harvey (2005) estimate average real GDP growth increases by 1% p.a. after financial liberalizations
- This effect independent of trade and capital account liberalizations
- Effect is more dramatic in countries already endowed with high quality institutions

Financial Liberalization

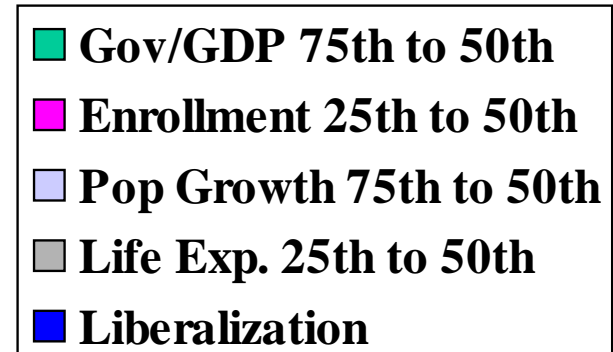
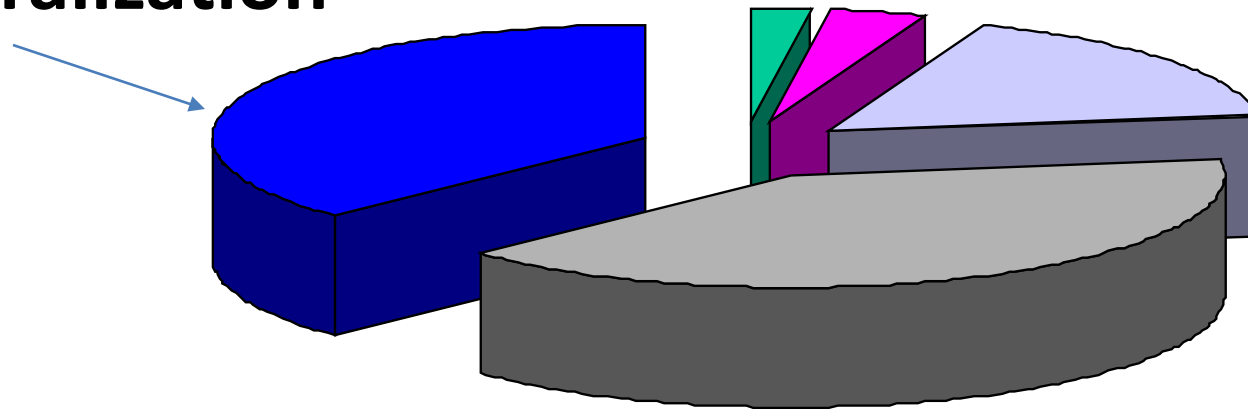
Mechanism is simple:

- Financial markets open up and international investors enter seeking diversification opportunities
- Prices rise and the cost of capital decreases
- Lower cost of capital means increased investment (more projects have positive NPV)
- More investment associated with higher employment
- All this leads to higher growth

Financial Liberalization

- Consider economic impact of improvements plus a equity market liberalization

Liberalization



Total Growth = 3.02%

Financial vs. Trade Liberalization

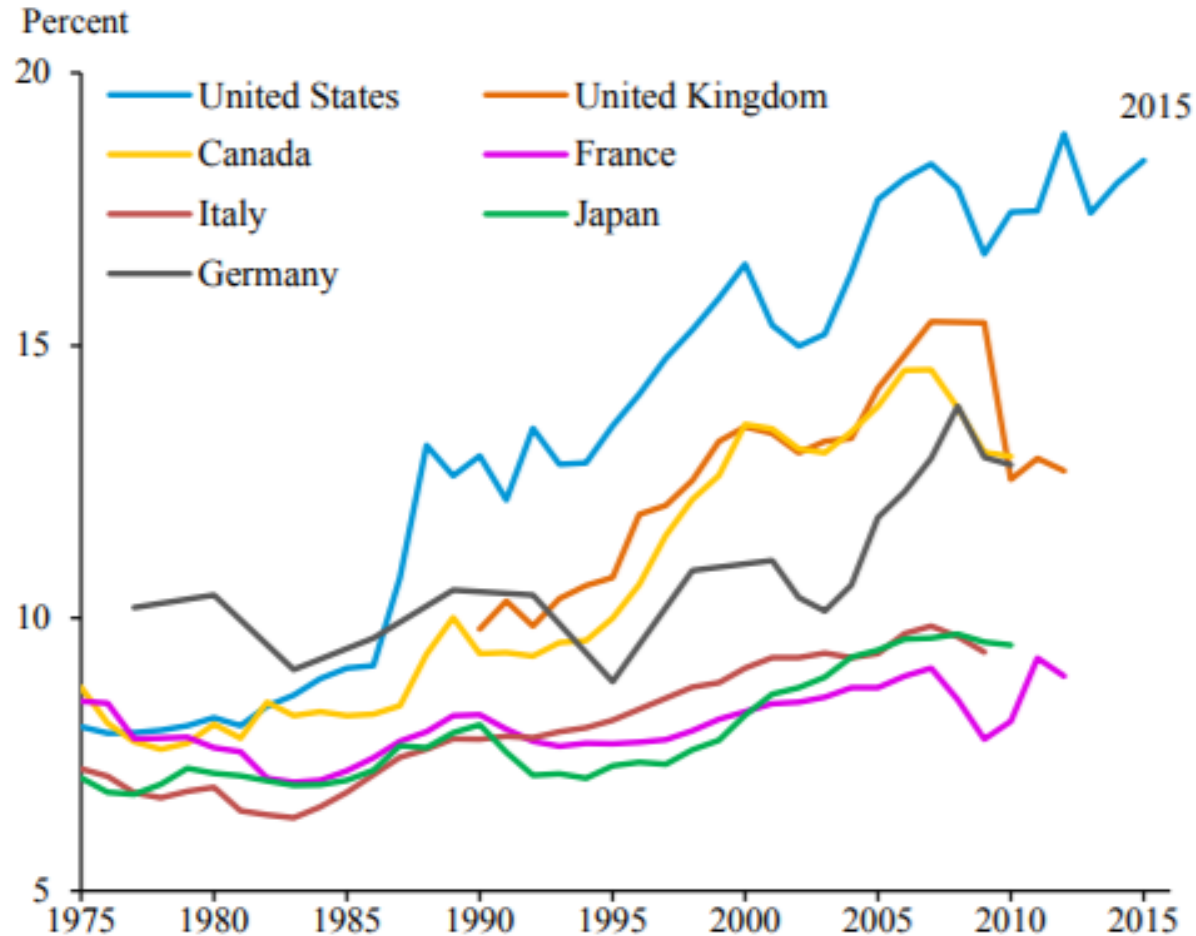
Financial liberalization more likely to help local firms

- Reduces financial constraints
- Promotes financial development
- Makes more local investment projects viable
- Allows local investors to diversify their portfolios internationally (by sharing risk, it means there is a greater chance that local risky projects will be undertaken)

Unequal Benefits of Globalization

Figure 1-17

Share of Income Earned by Top 1 Percent, 1975–2015



Source: World Wealth and Income Database.

Unequal Benefits of Globalization

Jeff Bezos' wealth is now equal to 2.3 million Americans'

David Carrig, USA TODAY Published 3:29 p.m. ET March 6, 2018 | Updated 7:53 a.m. ET March 7, 2018



But this metric looks at 2.3 million “median” Americans

Unequal Benefits of Globalization

The three richest people in the US – Bill Gates, Jeff Bezos and Warren Buffett own as much wealth as the bottom half of the US population, or 160 million people.

Unequal Benefits of Globalization

Unintended consequences



WORLD

**'BREXIT' CAMP SEIZES ON HIGH U.K.
MIGRATION FIGURES**

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Unequal Benefits of Globalization

Unintended consequences



WORLD

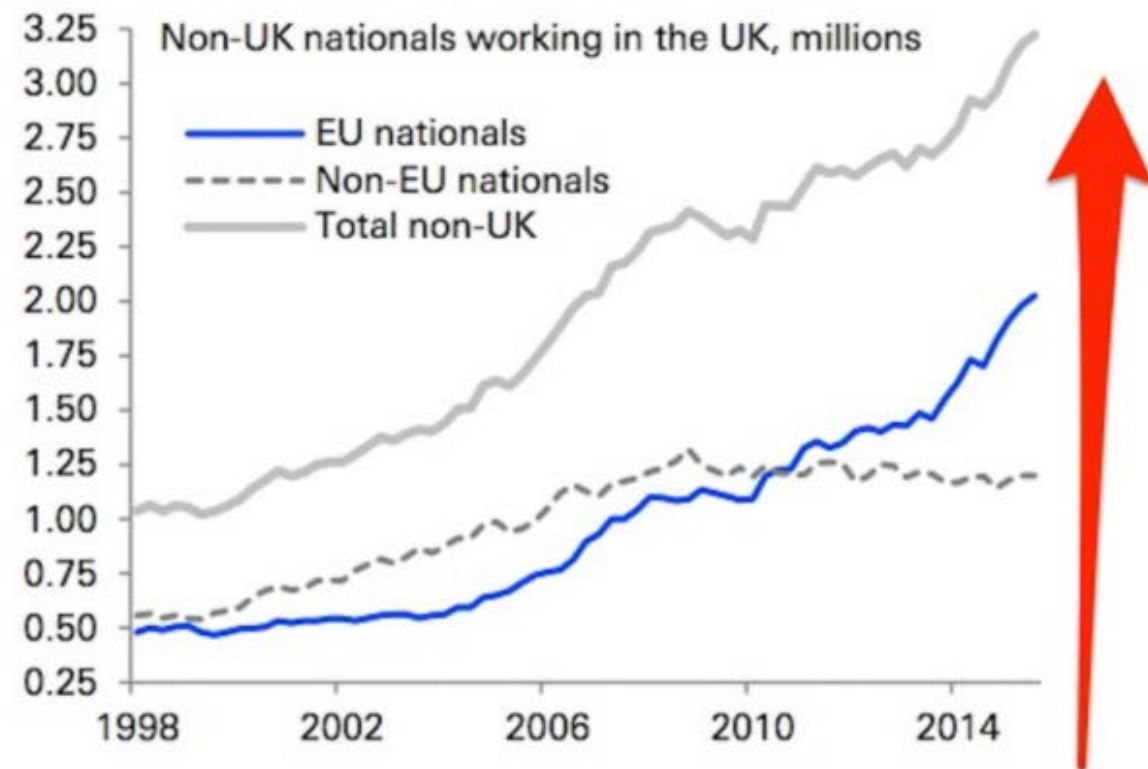
'BREXIT' CAMP SEIZES ON HIGH U.K. MIGRATION FIGURES

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Unequal Benefits of Globalization



Figure 1.9: Rise in non-UK nationals largely due to EU



Source: Deutsche Bank, ONS



Exploding UK immigration helped drive 'Brexit' vote

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Unequal Benefits of Globalization

- Outsourced labor and immigration are but a side-show in a much more important force: Technology



Unequal Benefits of Globalization

- In contrast to outsourced labor and immigration, there is nothing policy makers can do to stop or slow the impact – you can't prevent a company from buying a machine

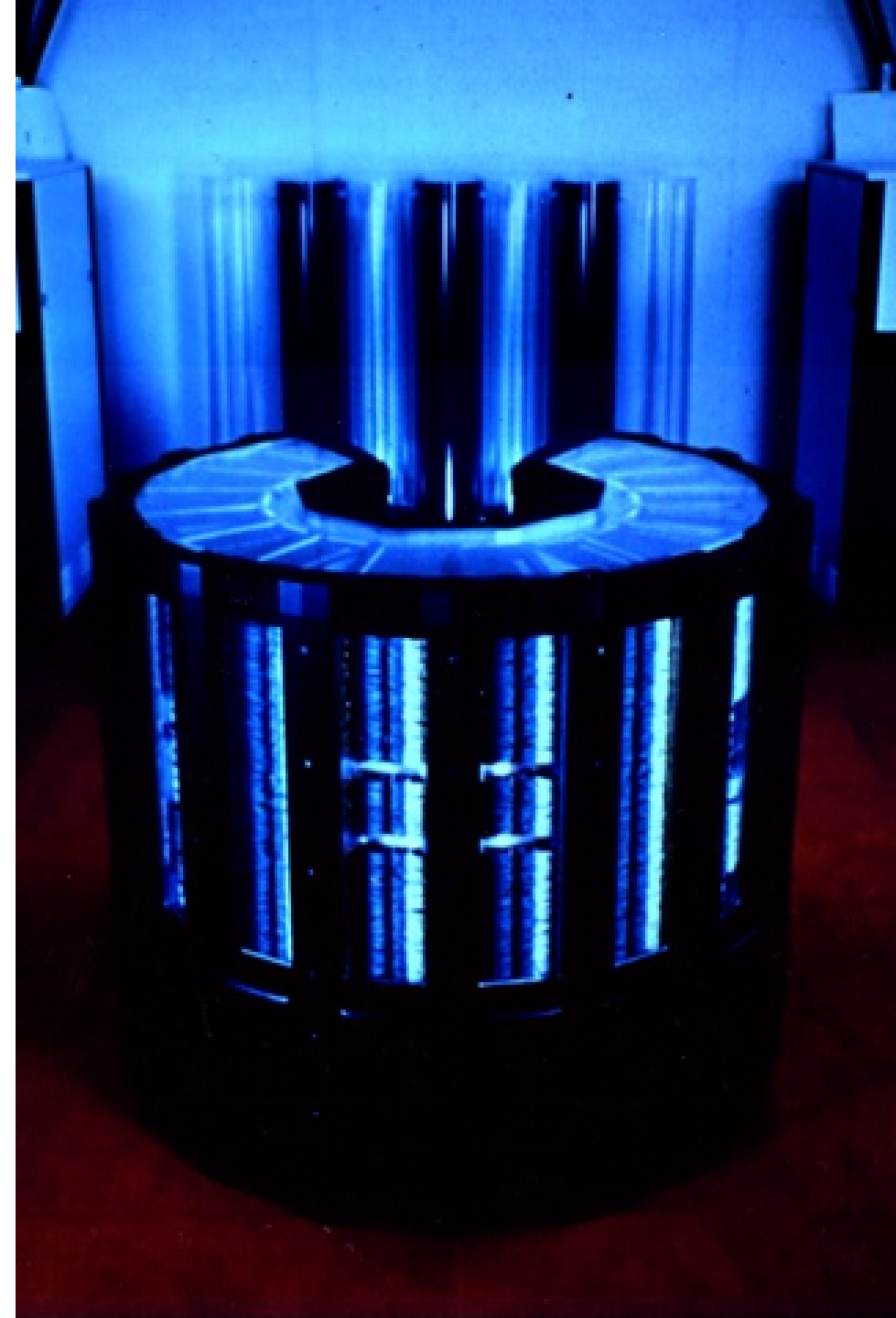


Rise of the Machines

Cray 2 is the world's fastest supercomputer: 1985-1990

- CPU: 1.9 GFLOPs*
- Weight: 5,500 pounds
- Cost: \$32 million (current \$)

*1 billion floating point operations per second



Rise of the Machines

2017 iPhone X:*

- 250 GFLOPs
- 256 GB storage
- 4.7 oz
- \$900

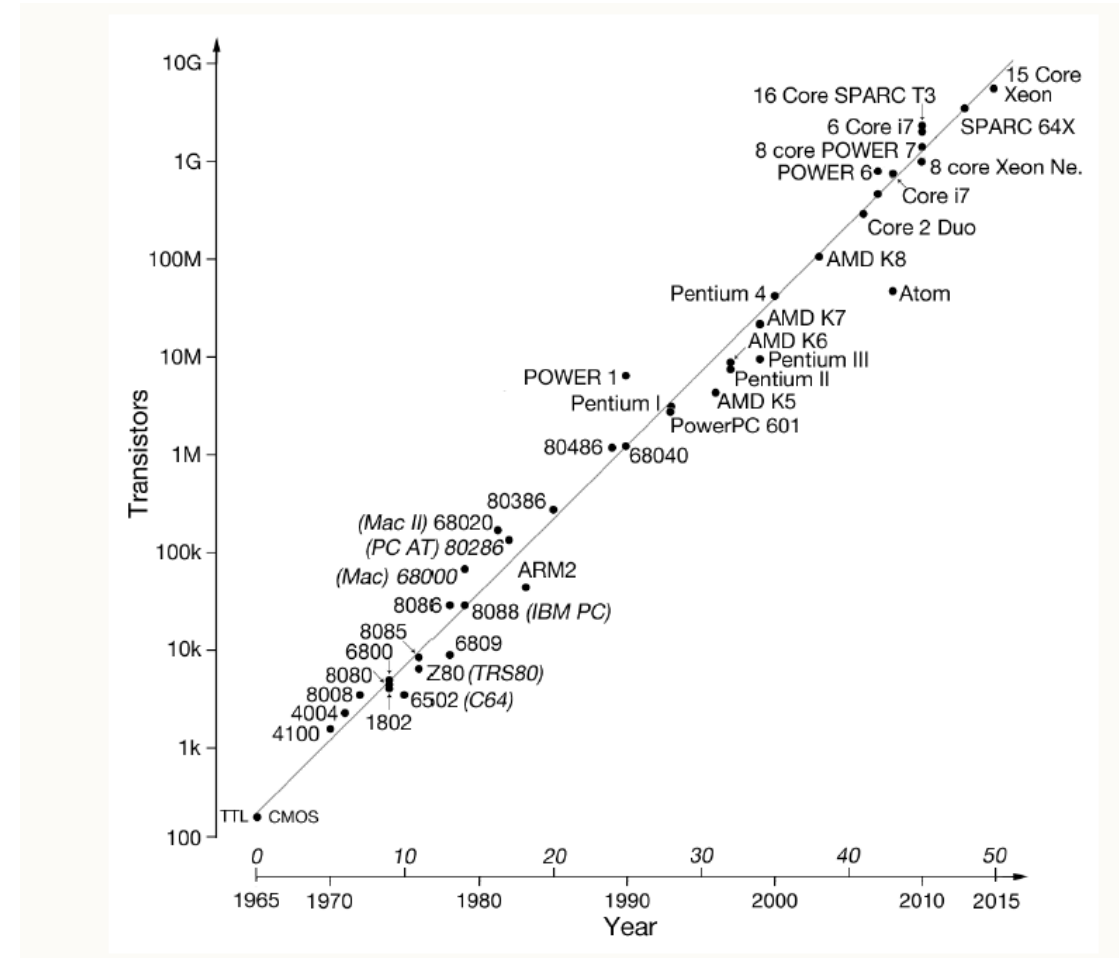


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*A11 Bionic. Also note the Apollo guidance system had only 4K of RAM.

Rise of the Machines

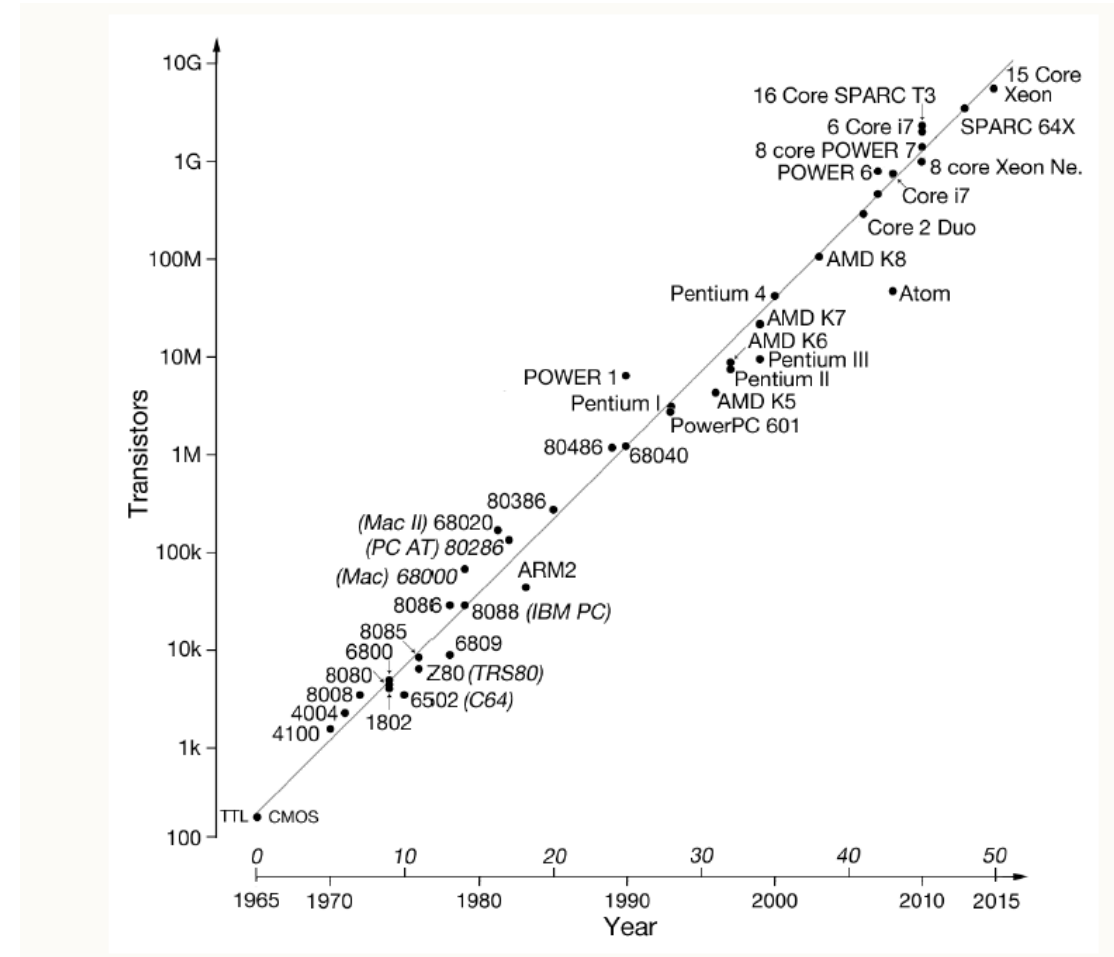
Revolution #1: Computing Power



Rise of the Machines

Revolution #1: Computing Power

In contrast to most applications, the future is very easy to forecast



Rise of the Machines

Revolution #2: Data generation and storage

Cost per GB

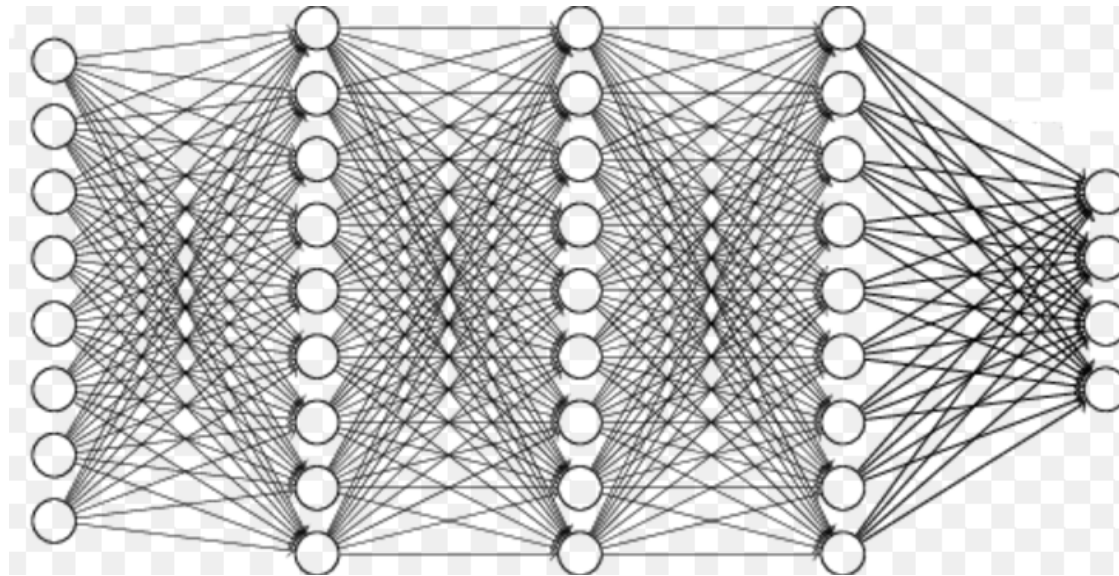
- 1981 - \$300,000
- 1987 - \$50,000
- 1990 - \$10,000
- 1994 - \$1,000
- 1997 - \$100
- 2000 - \$10
- 2004 - \$1
- 2010 - \$0.10
- 2017 - \$0.01

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Rise of the Machines

Revolution #3: Methods

- Maturing of combined methods from statistics, computer science, engineering and mathematics



New View of Globalization

Trade
Liberalization

Financial
Liberalization

Technology

Growth

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graph TD; A[Trade Liberalization] --> D[Growth]; B[Financial Liberalization] --> D; C[Technology] --> D;
```

How Technology Impacts Finance and Growth

Key initiatives:

- P2P Financing
- Robo-advising and Asset Management
- Blockchain and Smart Contracting
- Machine learning

P2P Finance

Landscape:

- P2P Lending
- Crowdfunding
- Payments and New Banks

P2P Finance

Implications:

- Makes it possible to for entrepreneurs to obtain financing that was not possible in the past
- Allows the unbanked to join the world of Internet commerce
- Large swath of skilled employees in traditional banking will be displaced.

Robo Asset Management

Landscape:

- Algorithm gives low cost advice to a retail investor based on an algorithm that selects a “diversified” portfolio that matches the investor’s risk preferences
- Not just for the retail investor – many institutional investors turning to systematic trading algorithms for asset management

Robo Asset Management

Implications:

- Hundreds of thousands of financial advisors will be out of a job
- Large shake out of asset management industry with thousands of 'mom and pop' asset management companies closing because they are unable to compete with the large companies that have invested in big data and machine learning

Blockchain and Smart Contracting

The opportunity:

- Imagine a world where transactions costs are near zero, the integrity of the transaction can be quickly verified, the transaction happens almost immediately, and the system is secure from outside attack. This is the blockchain opportunity.

Blockchain is a Ledger

A very special ledger...

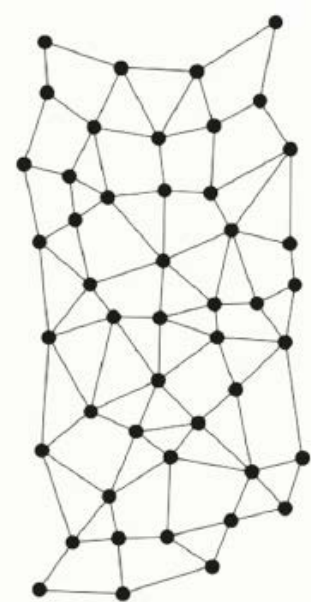
- Quickly and easily accessed and shared by many -- distributed
- Various levels of transparency depending on application
- Immutable (you can only add to it – you cannot alter history)



Centralised (A)



Decentralised (B)

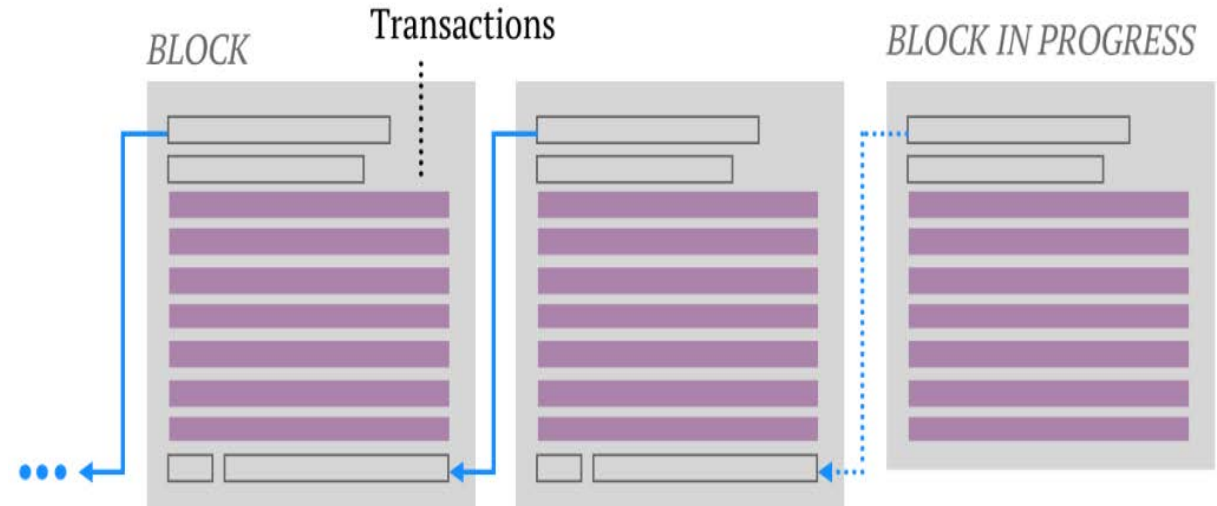
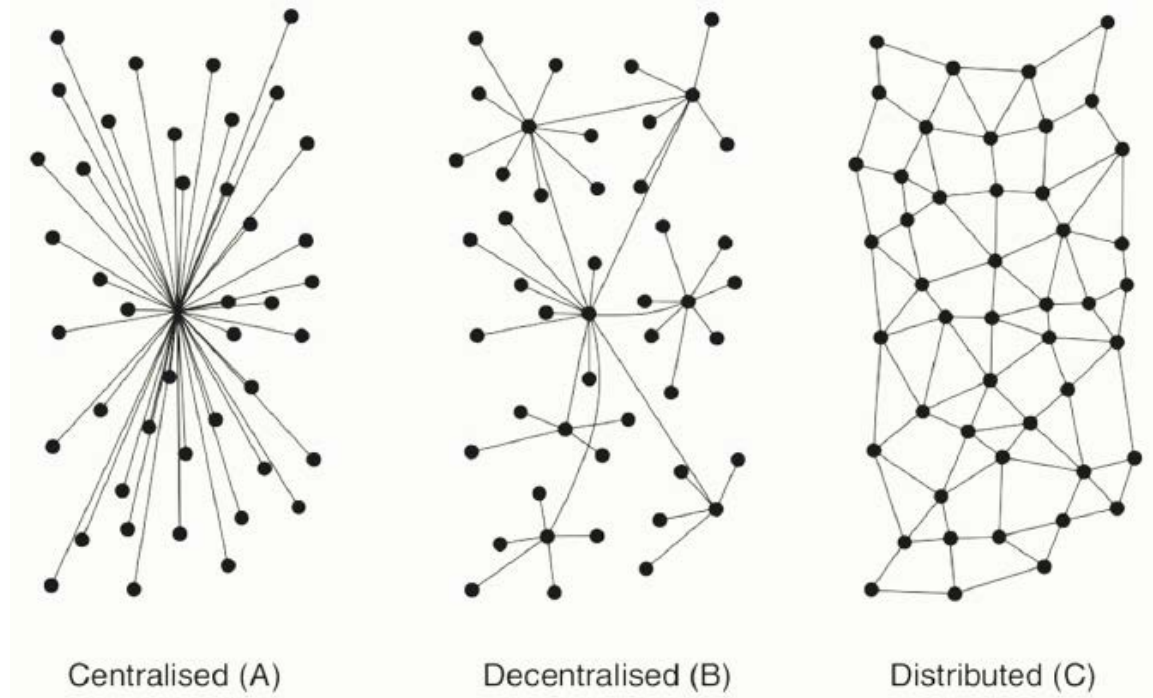


Distributed (C)

Blockchain is a Ledger

A very special ledger...

- Quickly and easily accessed and shared by many -- distributed
- Various levels of transparency depending on application
- Immutable (you can only add to it – you cannot alter history)
- Cryptographically secured



What can Blockchain Technology do?

Solves many problems

- Verification of ownership (quickly check the immutable history recorded on a blockchain to see if someone owns something)
- Efficient exchange of ownership (direct transactions *without a middle person*, everybody treated the same whether customer, retailer or banker).

Blockchain is about more than Finance

Driving transactions cost to near zero has many implications

- Enables micropayments (enables pay for view, listen, mobile communication, email, Internet, continuous dividends)
- Disrupts traditional banking and investment banking
- Widespread use in companies for supply chain
- Unprecedented security
- Protection (and monetization) of individual identity

Machine Learning

Four forces:

- Open source software
- Growth of big data
- Computing power and the rise of GPU
- AI and Machine Learning

This Time is Different

Let's continue to play through the history of the automobile



This Time is Different

Technological change is not new:

- Taxi drivers disrupted by Uber
- Taxi drivers sign up with Uber

This Time is Different

Technological change is not new:

- Taxi drivers disrupted by Uber
- Taxi drivers sign up with Uber
- Where do they go next?



This Time is Different

Technological change is not new:

- 13.1 million Americans work in transportation related jobs
- 4.6 million in the for hire

https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/transportation_economic_trends/ch4/index.html

This Time is Different

Where will they go?

This Time is Different

Where will they go?

- Not here!
- Many studies have shown that retraining fails after age 30



Software Engineer - Machine Learning

Uber

San Francisco, CA

via Uber

Full-time



Software Engineer - Machine Learning

Uber

Palo Alto, CA

via Uber

Full-time



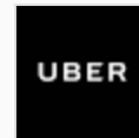
**Data Scientist - Machine Learning
Global Intelligence**

Uber

San Francisco, CA

via Uber

Full-time



**Machine Learning Systems
Engineer - Routing**

Uber

San Francisco, CA

The Losers

Unskilled and medium skilled workers in developed markets:

- Very difficult to retrain
- Lost generation will cause political problems (we have just seen the beginning)
- Crucial to train the next generation so there is not a second lost generation which could be very toxic

Who are the Winners?

- The UK Foreign Secretary has taken a lot of criticism:
 - “16 per cent of our species have an IQ below 85, while about 2 per cent have an IQ above 130”
 - 2% represents about 1.3 million people in UK



Who are the Winners?

- 2% represents about 20 million people in developed markets

Who are the Winners?

- 2% represents about 20 million people in developed markets
- 2% represents 100 million people in emerging markets



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Who are the Winners?

- Potential to liberate a vast amount of human capital
- Unleashing this amount of human capital is historically unprecedented



Takeaways

Technology will play a key role in next wave of globalization

- Easy to forecast yet we tend to ignore the implications
- We can no longer afford to manage the “average”. Yes, growth will increase – but it will not be good for everyone
- It is crucial that policy makers, corporate leaders, and educators develop a strategy to deal with the inevitable

Humans Beware

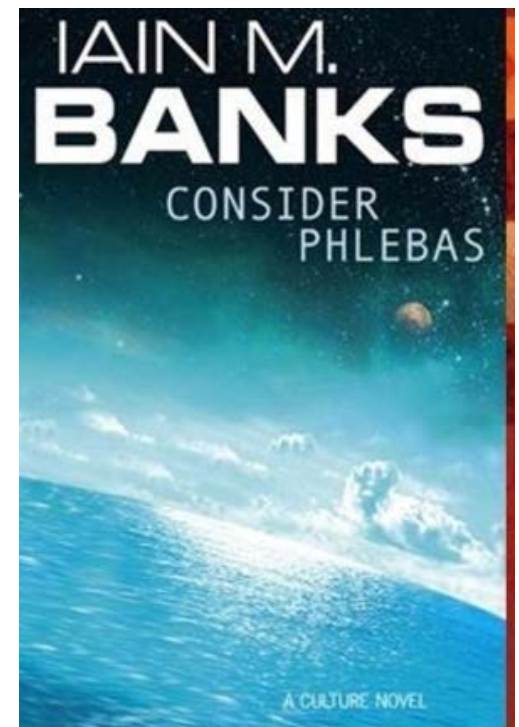
We need to avoid the fate of Phlebus the Phoenician

Humans Beware

*O you who turn the wheel and look to windward,
Consider Phlebas, who was once handsome and tall as you.*

Humans Beware

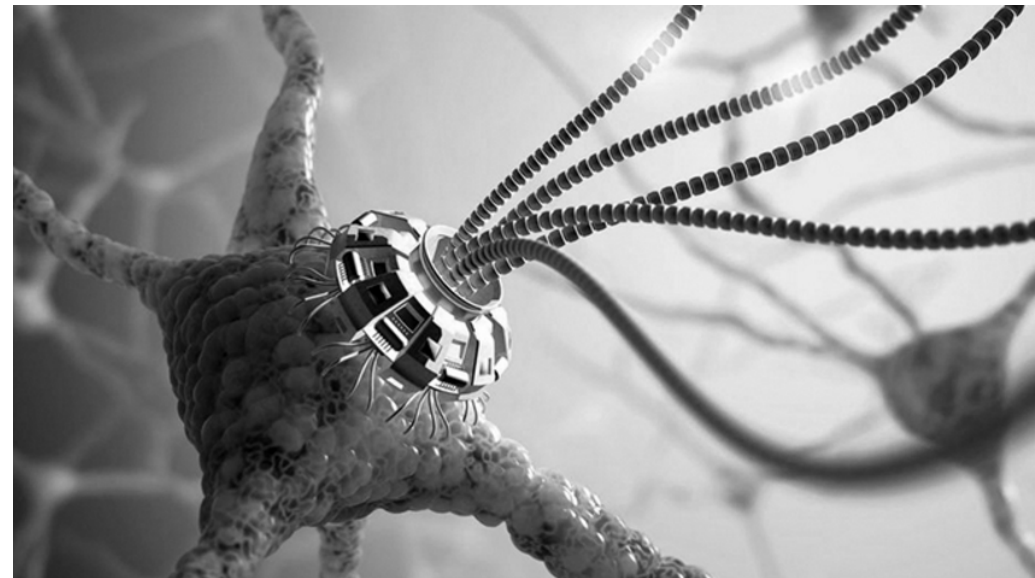
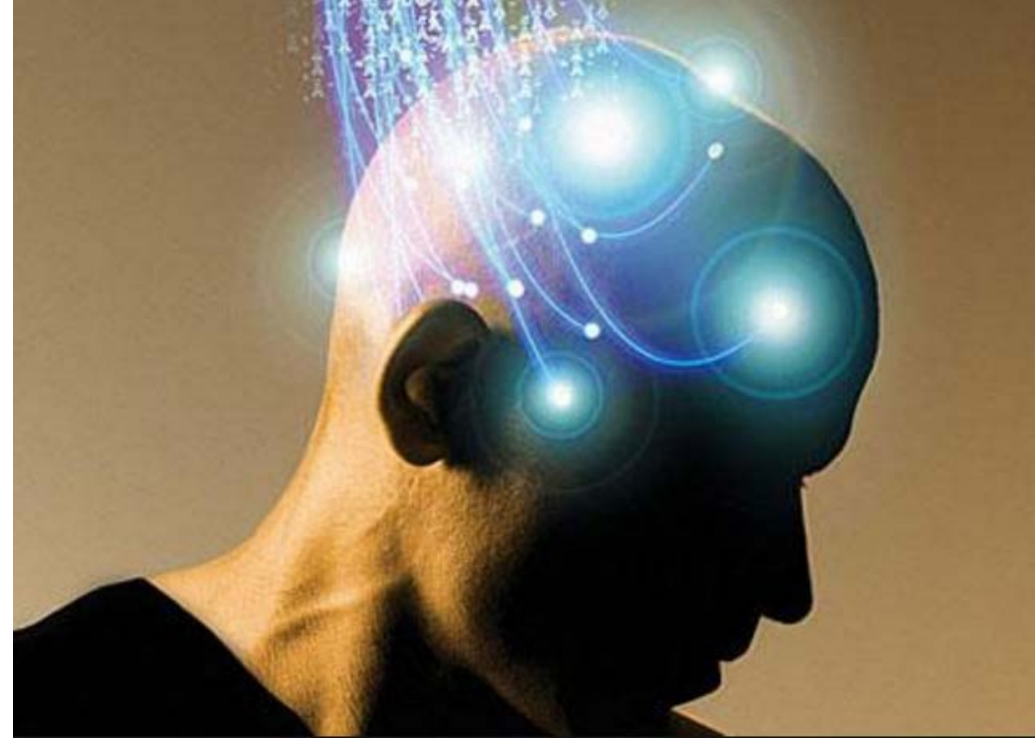
- 2016 Elon Musk on Neural Lace:
“If you assume any rate of advancement in AI, we will be left behind by a lot. ... Even in the benign situation in AI, we would be so far below them in intelligence we would be a pet – like a cat.”



Humans Beware

We are already cyborgs

- There is no where to hide



Humans Beware

THE WALL STREET JOURNAL.

TECH

Elon Musk Launches Neuralink to Connect Brains With Computers

Startup from CEO of Tesla and SpaceX aims to implant tiny electrodes in human brains

By *Rolfe Winkler*

March 27, 2017 3:24 p.m. ET



<https://www.youtube.com/watch?v=ZrGPuUQsDjo>

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Materials Available on Request

- Campbell R. Harvey, [The Blockchain Identity](#)
- Campbell R. Harvey, **Technology and Investment Management**
- Campbell R. Harvey, **Emerging Markets in a Globalizing World**

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Supplementary Material