GLOBAL DIGITAL TRANSFORMATION

LECTURE 5 – COMPUTING BOUNTY

TOMASZ JANOWSKI
GDAŃSK UNIVERSITY OF TECHNOLOGY, POLAND
DANUBE UNIVERSITY KREMS, AUSTRIA

COURSE

1.	BACKGROUND	What is digital transformation about?
2.	LANDSCAPE	What is the global adoption of digital transformation?
3.	INNOVATIONS	What are the cases of digital transformation?
4.	FEATURES	What features define digital transformation?
5.	BOUNTY	What benefits can digital transformation deliver?
6.	SPREAD	How unequal are the benefits of digital transformation?
7.	WINNERS	Who benefits most from digital transformation?
8.	IMPACT	What is the impact of the bounty and spread?

CONTEXT

Outstanding features the second machine age:

1. sustained exponential improvement in most areas of computing,
2. extraordinarily large amounts of digital information, and
3. recombinant innovation.

Exceeding recent expectations with no foreseeable limits in sight.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

THE BEGINNING

The advances we have seen so far:

1. cars that can drive themselves,
2. useful humanoid robots,
3. speech recognition and synthesis,
4. three-dimensional printers,
5. quiz champion computers, etc.

are not the crowning achievement of the computer age.

They are just warming acts, with more impressive inventions on the way.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

THE FOUNDATIONS

The exponential, digital and recombinant powers of the second machine age has made possible two most important inventions in our history:

- the emergence of real, useful artificial intelligence AI and
- the connection of most people on the planet via a common digital network.

Either of them would fundamentally change our growth.

When combined, they are more important then anything since Industrial Revolution.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

AIM

The aim of this lecture is to introduce the benefits offered by the second machine age to individual, corporations and the entire society.

What is covered:

- technological foundations,
- productivity improvements,
- beyond productivity improvements, and
- how to measure improvements in the second machine age.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
4. NEW METRICS FOR THE SECOND MACHINE AGE

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
   - 1.1 THINKING MACHINES
   - 1.2 BILLIONS OF INNOVATORS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
4. NEW METRICS FOR THE SECOND MACHINE AGE

THINKING MACHINES

Machines that can complete cognitive tasks are even more important than the machines that can accomplish physical tasks.

Today's thinking machines are starting to demonstrate improved abilities in:

- pattern recognition
- complex communication
- natural language processing
- machine learning
- computer vision
- simultaneous localization and mapping.

Soon, pieces of AI will be working on our behalf, often in the background, helping us perform tasks ranging from trivial to substantive to life changing.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

APPLICATIONS OF THINKING MACHINES

Trivial applications:

- recognizing friends' photos
- recommending products

Substantive applications:

- automatically driving cars on the road
- guiding robots in warehouses
- matching jobs and job seekers

Life-changing applications…

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO – A DAY IN THE LIFE WITH ORCAM MYEYE 2

Source: https://www.youtube.com/watch?v=jx2zOrCTvcA

AUTOMATED MEDICAL DIAGNOSIS AND TREATMENT

Huge amounts of information involved in modern medicine – a human doctor would need 160 hours of reading weekly to keep up with relevant literature.

IBM, Memorial Sloan-Kettering Cancer Center and the Cleveland Clinic are working to build Dr. Watson.

The supercomputer is trained to:

- sit on top of all of the world's high-quality published medical information,
- match it against patient's symptoms, medical histories and test results, and
- formulate diagnosis and treatment plan.

Dr. Watson will be used to augment physicians clinical expertise and judgment.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO: HOW IBM WATSON LEARNS

Source: https://www.youtube.com/watch?v=ymUFadN_MO4

QUESTIONS

1.	What are the thinking machines? What are they capable of?
2.	From your experience, provide trivial applications of thinking machines.
3.	From your experience, provide substantive applications of thinking machines.
4.	From your experience, provide life-changing applications of thinking machines.

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
   - 1.1 THINKING MACHINES
   - 1.2 BILLIONS OF INNOVATORS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
4. NEW METRICS FOR THE SECOND MACHINE AGE

POPULATION GROWTH AND SOCIAL WELL-BEING

With the exception of climate change, virtually all environmental, social and individual health indicators have improved over time even as human population has increased.

These improvements are not despite but because there are more people that in total have more good ideas to improve our individual and societal well-being.

Our good ideas and innovations will:

- address the challenges that arise,
- improve the quality of our lives,
- allow us to leave more lightly on the planet, and
- help us take a better care of one another.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

POPULATION GROWTH AND SOCIAL WELL-BEING

It is your mind that matters economically as much or more than your mouth or hands.

In the long run, the most important economic effect of population size and growth is the contribution of additional people to our stock of useful knowledge.

And this contribution is large enough in the long run to overcome all the costs of population growth.

Julien Simon

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

RECOMBINANT INNOVATION

Both theory and data bear out this insight.

Theory of recombinant innovation stresses how important it is:

- to have more eyeballs look at the challenges,
- to have more brains think about how existing innovations (building blocks) can be rearranged to meet them, and
- to have more people filter and improve the innovations of others.

Data on everything from air quality to commodity prices to levels of violence show humanity's remarkable ability to meet its challenges.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

LACK OF IMAGINATION?

The main fuel to speed the world's progress is our stock of knowledge and the brake is our lack of imagination.

Julien Simon

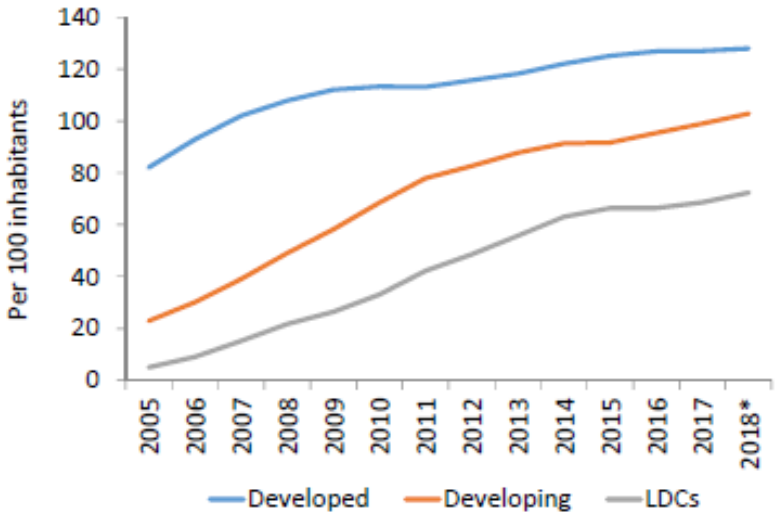
Until recently, the main impediment to progress has been part of the world population not having effective ways to access the world's stock of knowledge or adding to it.

This is changing, fast...

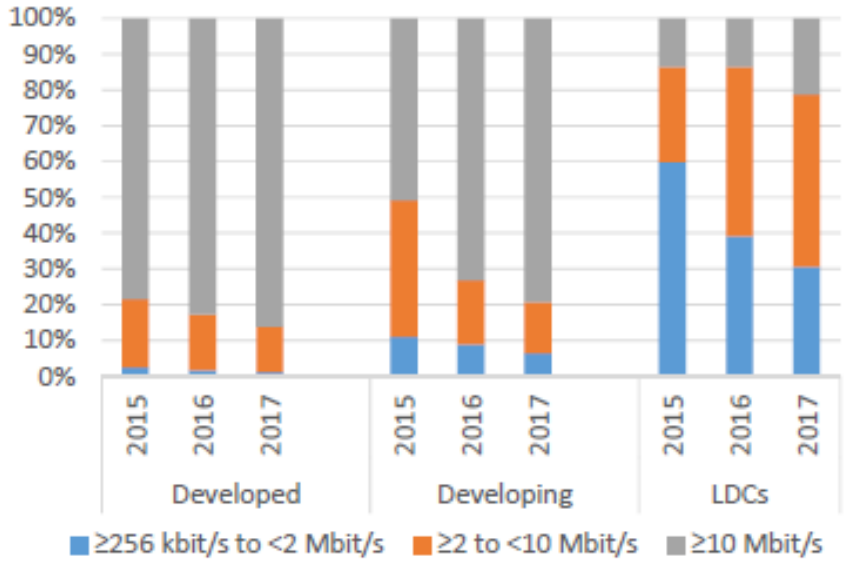
Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

DEVELOPED VERSUS DEVELOPING WORLD IN THE DIGITAL SPACE

Mobile-cellular subscriptions



Fixed broadband subscriptions



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

DEVELOPMENT THOUGH MOBILE TELEPHONY

Study by the economist Robert Jensen of coastal villages in Kerala, India where the fishing was the main industry, carried out between 1997 and 2001.

Data was taken both before and after mobile phone service was introduced.

Documented changes:

- fish prices stabilized immediately after phones were introduced
- even though prices dropped on average, profits increased due to waste elimination when fish was taken to the market with enough supply for the day
- the overall economic well-being of buyers and sellers improved
- improvements were tied to the phones themselves

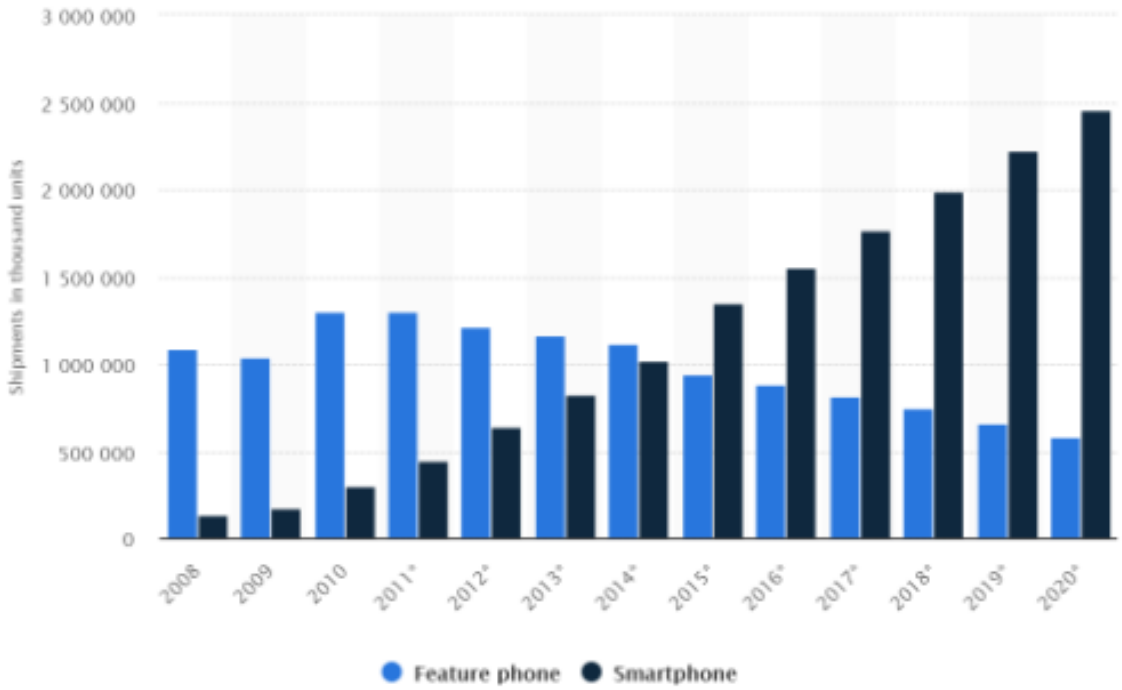
Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

FEATURE PHONES VERSUS SMARTPHONES

Increasing share of smartphones sold.

Even feature phones are able to take pictures and videos, brown the web, run applications, etc.

This shift is due to continued performance improvements and cost declines in both mobile phone devices and networks.



Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

Source: https://www.statista.com/statistics/225321/global-feature-phone-and-smartphone-shipment-forecast/

THE EFFECT

Bringing billions of people into the community of potential knowledge creators problem solvers and innovators.

People with connected smart phones anywhere in the world have access to most of the same communication resources and information. They can:

- search the web
- browse Wikipedia
- attend online courses
- share their insights on blogs, Facebook and Twitter
- conduct sophisticated data analysis using cloud resources, etc.

They can be full contributors in the work of innovation and knowledge creation.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

DIGITAL TRANSFORMATION IMPROVING OUR WORLD

Until recently, rapid communication, information acquisition and knowledge sharing were limited to the planet's elites.

Now they are much more democratic and egalitarian, and getting more so all the time.

Based on the power of recombinant innovation, this will boost human progress.

The second machine age will feature countless instances of machine intelligence and interconnected brains working together to understand and improve our world.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO: THE ROLE OF ICT IN DEVELOPMENT

Source: https://www.youtube.com/watch?v=7xJSlKDgSqA

QUESTIONS

1.	How is population growth improving individual and societal well-being?
2.	How is recombinant innovation relying on population growth?
3.	What has been the main impediment to progress thus far?
4.	How can mobile technology turn people into innovators and knowledge creators?
5.	What is the effect of global digital transformation on innovation and knowledge?

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
4. NEW METRICS FOR THE SECOND MACHINE AGE

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
   - 2.1. LABOR PRODUCTIVITY
   - 2.2. COMPLEMENTARY INNOVATIONS
3. BEYOND PRODUCTIVITY GROWTH
4. NEW METRICS FOR THE SECOND MACHINE AGE

LIVING STANDARDS

Vast amounts of statistics analysis and prediction concerning trends in interest rates, unemployment, stock prices, deficits, and other indicators.

One trend is standing out, in the US, the rate of GDP growth per person has been 1.9% per year since early 1800s, this means doubling living standards every 36 years.

Economic growth is important:

- if the GDP of the United States grew 0,5% faster each year than predicted, the US budget problem would be solved without any changes to policy
- slower growth, however, would make it significantly harder to close the deficit let alone increase spending on a new initiative or lower taxes

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

CAUSES OF PRODUCTIVITY GROWTH

What drives increases in GDP per person?

Part comes from using more resources but most from increasing our ability to get more output from a given level of inputs, i.e. increases in productivity.

Working more hours does not increase productivity – while we once worked over 60 hours per week, the average work week is 35 hours while living standards are higher.

Increases in labor and capital input could not explain most of the increases in total output of the economy – it would take us 11 hours of labor per week today to produce as much as we produced in 40 hours in 1950.

Productivity growth is due to innovations in technology and techniques of production.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

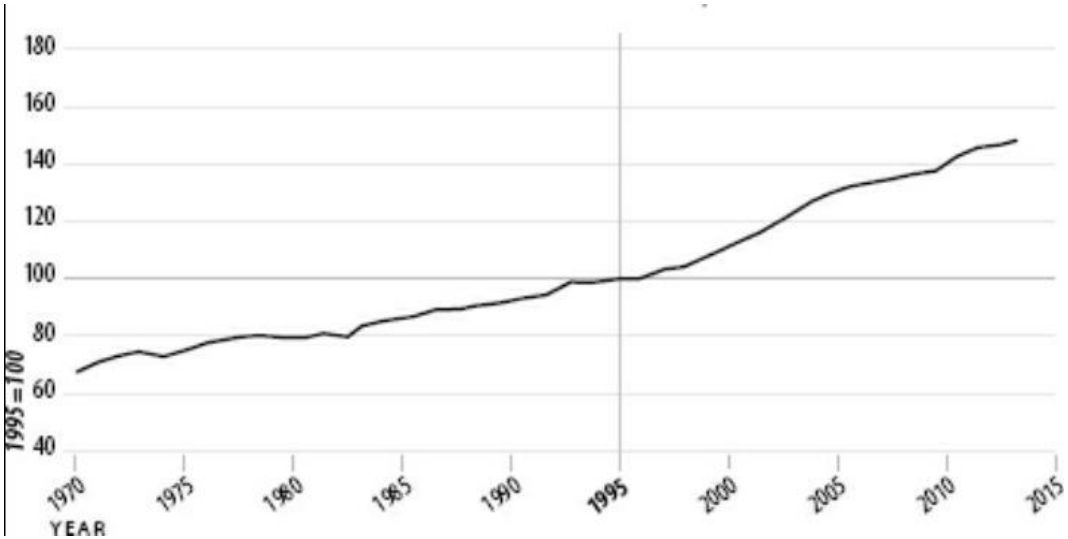
PRODUCTIVITY GROWTH AND SLOWDOWN

Productivity improvements were particularly rapid in the 1940s, 50s and 60s as the benefits drawn from the technologies of the first machine age started to materialize.

However, in 1973, productivity growth slowed down. The slowdown seemed to coincide with the early days of the computer revolution.

We see the computer age everywhere accept in productivity statistics.

Bob Solow, 1987



Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

PRODUCTIVITY GROWTH AND IT

In 1993, computers were still a small share of the economy and complementary innovations where needed before GPTs like IT had a real impact.

Still, the biggest users of IT were dramatically more productive than their competitors.

By mid 90s these benefits were big enough to become visible in the overall economy, which experienced a general productivity surge.

The major share of these gains is due to the power of IT.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

LABOR PRODUCTIVITY IN TWO ERAS

Drawing analogy:

- slowing down of productivity 1970s and the subsequent speed up 20 years later
- introduction of electricity to factories in the 1890s with labor productivity growth only taking off 20 years later

The technologies involves were very different but the underlying dynamics are similar.

The slow start and subsequent acceleration of productivity growth in the electricity area match well with the speed up at the beginning the 1990s.

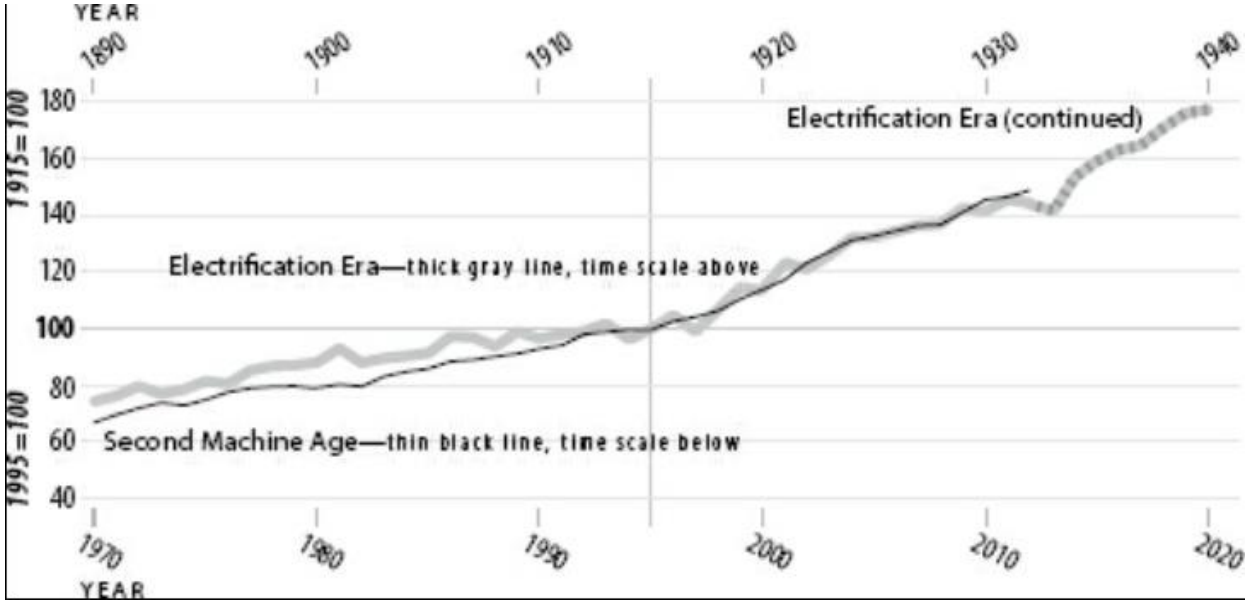
Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

LABOR PRODUCTIVITY IN TWO ERAS

GPTs like IT always need compliments and coming up with them can take years or decades.

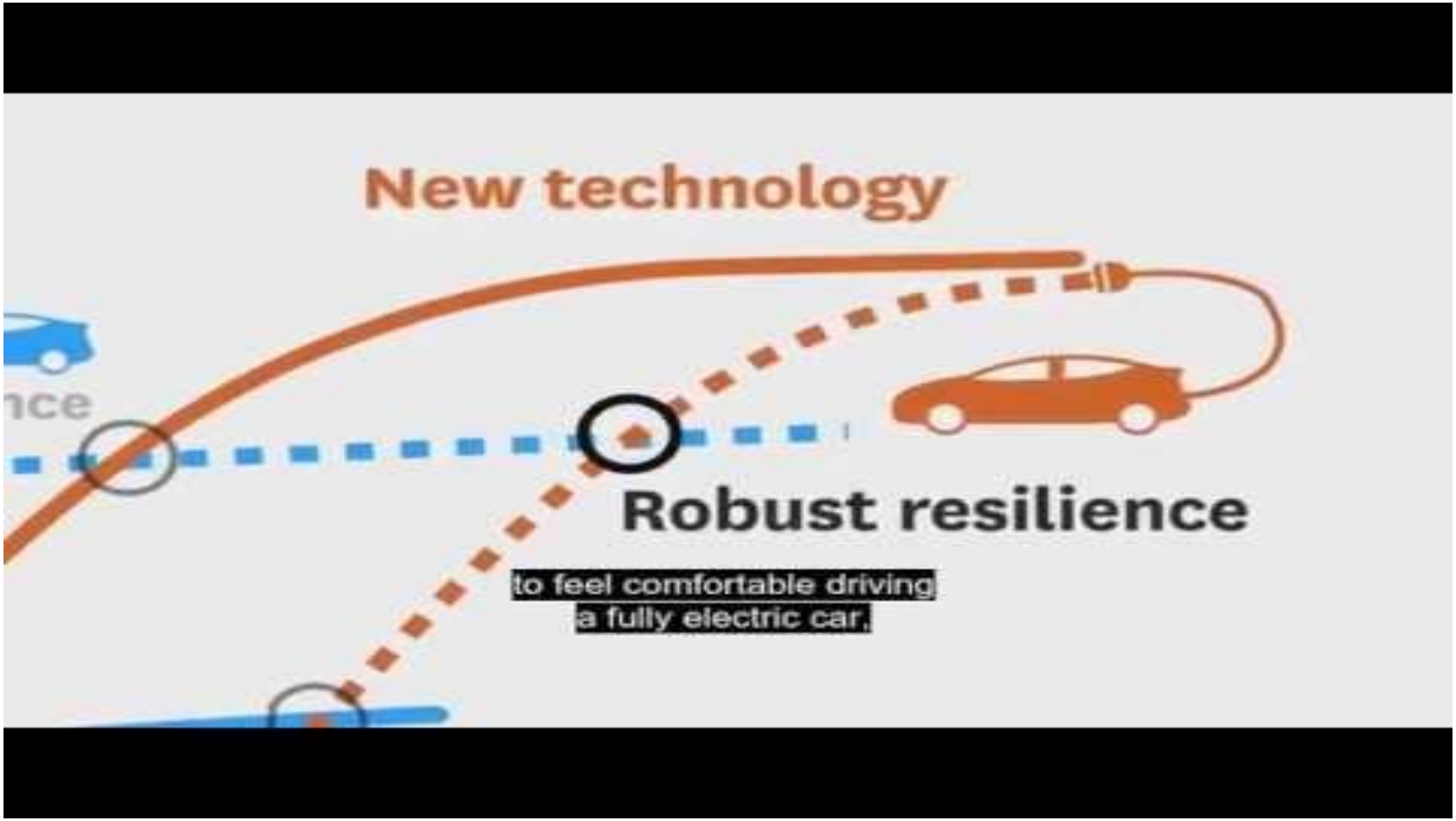
This creates lags between the introduction of the technology and the productivity benefits.

We can see this clearly from electrification and computerization.



Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO: WHY BETTER TECHNOLOGY CAN BE SLOWER IN ADOPTION?



Source: https://hbr.org/video/5155033576001/why-better-technology-can-be-slower-to-take-off

QUESTIONS

1.	What are the long-term trends in living standards and GDP growth?
2.	What are the main causes of productivity growth?
3.	What is the correlation between productivity growth and the IT use?
4.	How to explain the productivity slowdown in 1890s and 1970s?
5.	What factors influence the substitution of the old by new technology?

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
   - 2.1. LABOR PRODUCTIVITY
   - 2.2. COMPLEMENTARY INNOVATIONS
3. BEYOND PRODUCTIVITY GROWTH
4. NEW METRICS FOR THE SECOND MACHINE AGE

ELECTRIFICATION ERA - STEAM ENGINE-POWERED FACTORIES

The most important complementary innovations were business process changes and organizational inventions that made new technologies possible.

Steam engine-powered factories:

- Power was transmitted via a large central axle, which in turn drove a series of pulleys, gears and crankshafts.
- If the axle was too long, the torsion involved would break it, so machines needed to be clustered near the power source; the more power needed, the closer
- Industrial engineers put equipment on the floors above and below the central steam engine to minimize the distances involved.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

ELECTRIFICATION ERA - FIRST ELECTRICITY-POWERED FACTORIES

When factories first electrified, they retained similar layout and organization to those that were powered by steam engines:

- Engineers bought the largest electric motors they could find and stuck them where the steam engines used to be. Even new factories followed the same design.
- There was less smoke and less noise but the new technology was not always reliable and the overall productivity did not improve.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

ELECTRIFICATION ERA - REFINED ELECTRICITY-POWERED FACTORIES

30 years passed, long enough for the original managers to retire and be replaced by a new generation of managers.

New factories started to look much like those we see today:

- a single story spread out over an acre or more
- instead of a single engine, each piece of equipment had its own small motor
- instead of putting the machines closest to the source of power, the layout was based on the flow of materials
- productivity on the resulting assembly lines doubled or tripled

Subsequent innovations – lean manufacturing, steel mini-mills, Total Quality Management, Six Sigma principles, etc. continued boosting productivity.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

COMPUTERIZATION ERA – WORLD WIDE WEB

As with earlier GPTs, significant organizational innovations are required to capture the full benefits of the second machine age technologies.

For example:

- Tim Berners-Lee's invention of the World Wide Web in 1989 initially benefited only a small group of particle physicists.
- Due to digitization and networks that spread the diffusion of ideas, complementary innovations are happening faster that they did in the electrification age.
- Less than 10 years later, entrepreneurs found ways to use the Web to reinvent publishing and retail.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

COMPUTERIZATION ERA – ENTERPRISE SYSTEMS

Large enterprise-wide systems adopted by companies in the 1990s had a huge impact on productivity by making possible a wave of business process redesign.

For example:

- Walmart introduced systems that shared point-of-sale data with suppliers.
- This enabled the introduction of complementary process innovations like vendor managed inventories, cross-docking and efficient consumer response.

This helped drive dramatic increases in the entire retail and distribution industries, accounting for much of the additional productivity growth.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

COMPUTERIZATION ERA – IT INVESTMENT SOARING

IT investment soared in the 1990s when many companies upgraded their systems to take advantage of the Internet, implement enterprise systems and avoid the Y2K bug.

Innovations in semiconductors took huge leaps, so the surging spending on IT delivered more rapidly increasing levels of computer power.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

COMPUTER USE VERSUS PRODUCTIVITY

A large portion of the acceleration through 2000 can be traced to the sectors of the economy that produced or intensively used IT equipment and software.

Also industries that were heavy users of IT tended to be more productive through 1990s, while falling in those sectors that did not use IT extensively.

Correlation between computers and productivity also occurs at the level of firms: those using more IT have higher productivity and faster growth then their competitors.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

PROCESS INNOVATION

The first five years of the 21st century focused less on computer hardware and more on diversified set of applications and process innovations.

The case of CVS:

- Prescription drug ordering process was the source of customer frustration.
- The process was pre-designed and simplified by embedding its steps in the enterprise-wide software system.
- Thus the company managed to replicate the process in over 4,000 locations, dramatically boosting customer satisfaction and profits.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

COMPLEMENTARY INVESTMENTS

It takes on average 5 to 7 years before for productivity benefits of computers are visible in the productivity of the firm making the investments.

This reflects the time and effort required to make other complementary investments.

For every dollar of investment in computer hardware, companies needs to invest up to another nine dollars in software training and business process redesign.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO - SMART MANUFACTURING INNOVATION

Source: https://www.youtube.com/watch?v=g6S-Qfrsfmw

QUESTIONS

1.	What are the key complementary innovations for new technology adoption?
2.	Explain complementary innovations in the electrification era.
3.	Explain complementary innovations in the computerization era.
4.	What evidence exists to relate computer use and productivity growth?
5.	What factors influence the substitution of the old by new technology?

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
4. NEW METRICS FOR THE SECOND MACHINE AGE

BEYOND GDP

The gross national product does not including the beauty of our poetry or the intelligence of our public debate. It measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion. It measures everything, in short, except that which makes life worthwhile.

Robert F. Kennedy

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

MEASURING ECONOMIC ACTIVITY

When President Hoover was trying to understand what was happening during the Great Depression and design a program to fight it:

- a comprehensive system of national accounts did not exist,
- he had to rely on sources of data like freight car loadings, commodity prices, and stock price indexes, and
- these gave only an incomplete and often unreliable view of economic activity.

The first set of national accounts was established in 1937.

The resulting set of metrics helped illuminate many changes that transform the economy throughout the 20th century.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

NEW METRICS FOR THE SECOND MACHINE AGE?

As the economy has changed so too must have our metrics.

More and more of what we care about in the second Machine Age is ideas, not things; mind, not matter; bits, not atoms; interactions, not transactions.

The irony is that in many ways we actually know less about the sources of value in the economy that we did 50 years ago.

Much of the change has been invisible, a huge layer of the economy unseen in the official data, income statements or balance sheets of companies:

- free digital goods
- the sharing economy
- intangibles
- changes in relationships, etc.

They are having a big effect on our well-being, calling for new organizational structures, new skills, new institutions, new values.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VALUE OF DIGITAL GOODS

Bits are created at virtually zero cost, transferred almost instantaneously worldwide, and a copy of a digital good is exactly identical to the original.

This leads to very different economics and some special measurement problems.

When a business traveler calls home to talk to her children via Skype that may have zero to GDP but it's hardly worthless.

How do we measure the benefits of goods or services that were unavailable with any price in previous years?

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

WHAT GDP LEAVES OUT

Despite all the attention it gets from the economists, journalists and politicians, GDP, even if it were perfectly measured, does not quantify our welfare.

The trends in GDP and productivity growth covered earlier are important but insufficient to measure our overall well-being, and not even our economic well-being.

Trends in the official economic statistics not only underestimate our bounty but are becoming increasingly misleading in the Second Machine Age.

We can do a better job of understanding our basic economic progress by considering some of the changes in the goods and services that we are able to consume.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

CASE OF WIKIPEDIA

Wikipedia has over 50 times as much information as Encyclopedia Britannica, premier compilation of knowledge for most of the 20th century.

Like Wikipedia but unlike Botanica, much of the information and entertainment available today is free.

Because it has a zero price, Wikipedia is virtually invisible in the official statistics, it adds value to the economy but no dollars to the GDP.

Because productivity data is in turn based on GDP metrics, the availability of free goods does not move the productivity dial.

There is little doubt however that such goods have real value.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

CASE OF ONLINE MUSIC

Music is also hiding itself from our traditional economic statistics:

- Sales of music on physical media declined from 800 million units in 2004 to less than 400 million units in 2008.
- Over the same time, total number of units purchased still grew, reflecting an even faster increase in the purchases of digital downloads.
- Digital streams such as iTunes, Spotify or Pandora also came to prominence.
- The purchase data don't reflect the even larger number of songs that was shared, streamed and download for free.

There is quantitative evidence that the overall quality of music has not declined, it is higher than ever. You are listening to more and better music than ever before.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

CASE OF ONLINE MUSIC

How did music disappear?

The value of music has not changed, only the price.

From 2004 to 2008, the combined revenue from sales of music dropped from 12.3 billion to 7.4 billion, a decline of 40% or 30% including digital sales.

Similar economics apply elsewhere:

- reading the New York Times online at a reduced price instead of physical copy
- using Craigslist instead of the classified ads
- sharing photos via Facebook instead of mailing prints around

Analog dollars are becoming digital pennies.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO

Source: https://www.youtube.com/watch?v=aqz3DaisBz8

QUESTIONS

1.	Which elements of the digital economy are invisible in official economic statistics?
2.	Why are digital goods difficult to measure within traditional economics?
3.	Explain how such difficulties apply to online music.

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
   - 3.1. FREE GOODS
   - 3.2. TIME MACHINE
   - 3.3. CONSUMER SURPLUS
   - 3.4. NEW GOODS AND SERVICES
   - 3.5. REPUTATIONS AND RECOMMENDATIONS
   - 3.6. INTANGIBLE ASSETS
4. NEW METRICS FOR THE SECOND MACHINE AGE

FREE GOODS SUPPRESSING GDP

The proliferation of free products even pushes GDP downwards.

If the cost of creating and delivering an encyclopedia to desktop is a few pennies instead of thousands of dollars, then you are certainly better off.

But these decrease in cost lowers GDP even as our personal well-being increases, leaving GDP to travel in the opposite direction to our true well-being.

A switch to using:

- a free texting service like Apples iChat instead of SMS
- free classified ads like Craigslist instead of newspaper ads
- free calls like Skype instead of a traditional telephone service

can make billions disappear from company's revenues and the GDP statistics.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

MEASURING ECONOMIC GROWTH THROUGH GDP

Economic welfare is only loosely related to GDP.

Unfortunately many economists, journalists, and the general public still using GDP growth as a synonym for economic growth:

- if each additional unit of production creates a similar increment in well-being,
- counting up how many units were produced, as GDP does, would be a fine approximation of welfare.

For much of the 20th century, this was a fair comparison.

With a greater volume of digital goods introduced each year that do not have a dollar price, these traditional GDP heuristic is becoming less useful.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

MEASURING ECONOMIC GROWTH IN INFORMATION ECONOMY

In information economy, more people than ever are using Facebook, Amazon, Netflix, Google, etc. with thousands of new digital goods introduced each year.

The information sector's contribution to the economy as the sum of the sales of:

- software,
- publishing,
- motion pictures,
- sound recording,
- broadcasting,
- telecommunications and
- information and data processing services.

These account for just 4% of our GDP today almost precisely the same share of GDP as in the late 1980s before the World Wide Web for even invented.

The official statistics is missing a growing share of the value created in our economy.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO – DOES TECH CONTRIBUTE TO GDP?

Source: https://www.youtube.com/watch?v=aq8HapQU3tI

QUESTIONS

1.	How is the provision of free digital goods included in GDP metrics?
2.	What is the direct contribution of the information sector to the economy?
3.	Why is this insufficient to capture economic value in the information age?

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
   - 3.1. FREE GOODS
   - 3.2. TIME MACHINE
   - 3.3. CONSUMER SURPLUS
   - 3.4. NEW GOODS AND SERVICES
   - 3.5. REPUTATIONS AND RECOMMENDATIONS
   - 3.6. INTANGIBLE ASSETS
4. NEW METRICS FOR THE SECOND MACHINE AGE

WOULD YOU RATHER …?

Can we improve on GDP as a measure of well-being?

“Would you rather” game:

- Suppose that you have a shopping catalog listing of all the goods and services available from any seller in the economy in 1912 at the same prices as 1912.
- Would you rather shop exclusively in that catalog with no other choices, or would you rather pay today's prices for a full selection of today's goods and services?

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

WOULD YOU RATHER …?

To make the comparison less difficult:

- Pick two recent catalogs from 1993 and 2013.
- If you had $50,000 to spend:
  - Would you rather be able to buy a brand-new 1993-model car at 1993 prices or order a 2013 car and pay 2013 prices?
  - Would you rather be able to buy the bananas, contact lenses, chicken wings, shirts, chairs, banking services, airline tickets, computers, gasoline and other goods and services that were available in 1993 at 1993 prices?
  - Or would you rather buy the equivalent 2013 basket of services at 2013 prices?

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

DIFFERENT CATEGORIES OF GOODS AND SERVICES

Different categories of goods and services:

- Bananas or gasoline have not changed much qualitatively since 1993, so the only difference to consider is the price.
- Other goods, though, especially second machine age goods like online information or mobile phone capabilities, changed a lot in quality, so the real quality-adjusted price may have fallen even as the nominal price has increased.
- A lot of new goods, especially digital goods, that didn't exist before.
- Many older goods and services have been discontinued or degraded, e.g. it is hard to find a 1993 vintage personal computer, or a gas station with the attendance routinely wash your windshields for no charge.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

QUANTITY INDIFFERENCE TO TWO CATALOGUES

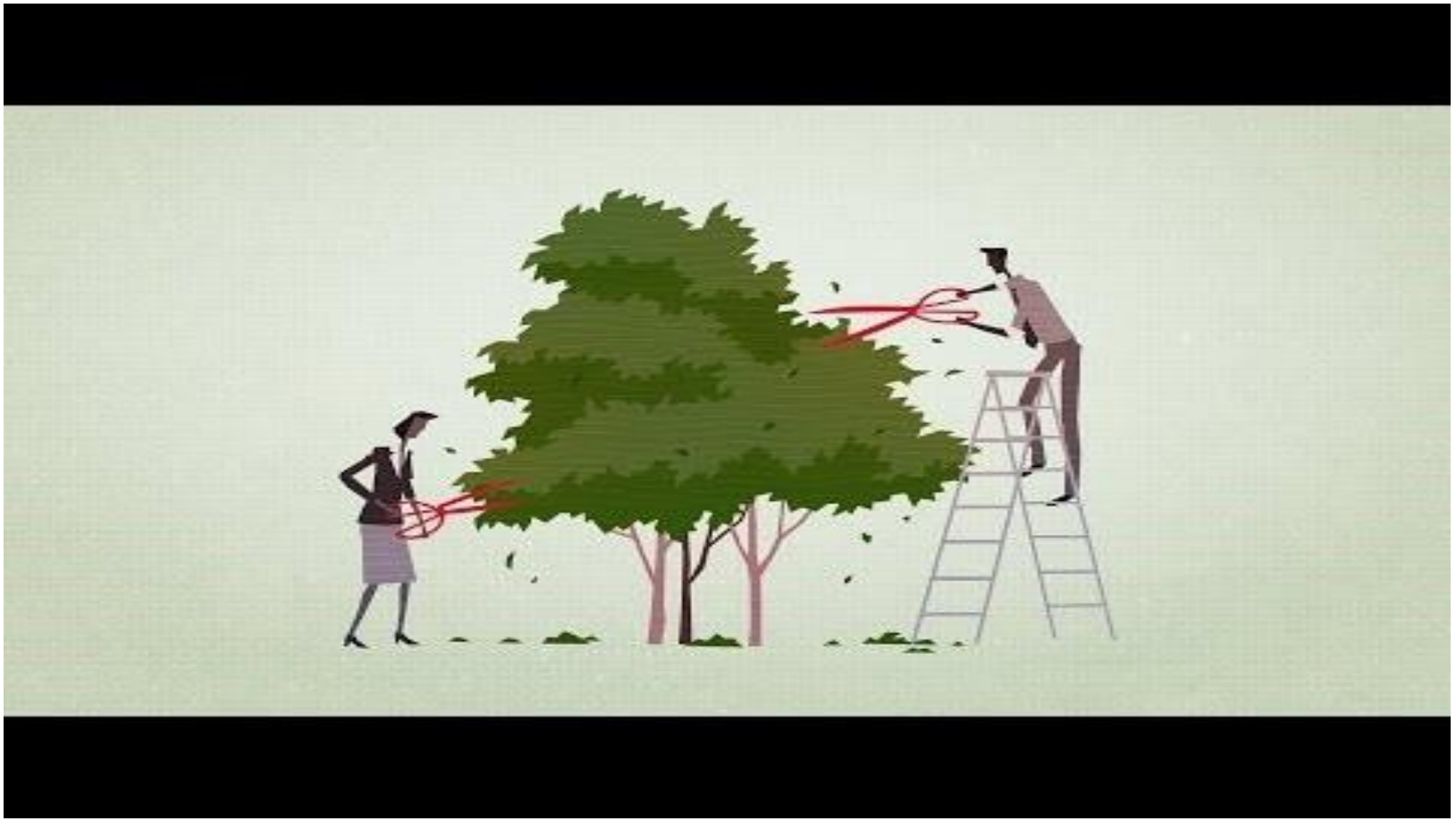
Once you pick which catalog you would like, the next step asks how much money you would expect to become indifferent for shopping between the two catalogues.

- If you would have to be paid 20% to make you just as happy shopping from the new catalog as from the old catalog, then the overall price index has increased by 20%.
- If your income has not changed, then the erosion of purchasing power translates to an equivalent fall in your standard of living.
- Similarly, if your income increased faster than the price index, then your standard of living is increasing.

This approach is the basis for how most governments calculate changes in the standards of living. But the data is always drawn from market transactions where money changes hands. The free economy is not factored in.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO – HOW CAN COUNTRIES MEASURE THE WELL-BEING OF THEIR CITIZENS?



Source: https://www.youtube.com/watch?v=4PkD4JebMAY

QUESTIONS

1.	Describe different situations of products' valuation over time.
2.	Describe the "would you rather…" game to measure economic well-being.
3.	How do most governments calculate changes in the standards of living?

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
   - 3.1. FREE GOODS
   - 3.2. TIME MACHINE
   - 3.3. CONSUMER SURPLUS
   - 3.4. NEW GOODS AND SERVICES
   - 3.5. REPUTATIONS AND RECOMMENDATIONS
   - 3.6. INTANGIBLE ASSETS
4. NEW METRICS FOR THE SECOND MACHINE AGE

CONSUMER SURPLUS

And alternative approach to measuring well-being is calculating consumer surplus generated by goods and services.

- Consumer surplus compares the amount a consumer would have been willing to pay for something to the amount they actually have to pay.
- If you would pay $1 to read the morning newspaper but instead you get it for free, then you just gained $1 of consumer surplus.
- The rapidly growing consumer surplus from price declines in computers increases economic welfare by about $50 billion each year.
- However, replacing a paid newspaper with an equivalent free information service would increase consumer surplus while decreasing GDP.
- While appealing conceptually, consumer surplus is difficult to measure.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

ATTENTION ECONOMY

When the product studied is already free, looking at price declines doesn't work.

However, even when people don't pay with money, they still give up something valuable when that they use the internet: their time.

No matter how rich or poor we are, each of us gets 24 hours in a day. In order to consume YouTube, Facebook, or email, we must pay attention.

Between 2000 and 2011, we nearly doubled the amount of leisure time spend on internet – confirming the value of the time spent online to other forms of activity.

By considering the value of users time and comparing leisure time spent online to time spent in other ways, Internet creates $2,600 worth of value for users each year.

None of these shows up in the GDP statistics but if it had, the GDP and productivity growth would have been about 0.3% higher each year.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

TIME SAVINGS

Value at work is created by saving time, not extending online time during leisure.

How much time is saved from Google searches?

- A random sample of Google queries, such as “In making cookies, does the use of butter or margarine affect the size of the cookie?”
- Answer the questions with Google and without Google, e.g. in the library.
- On average, it took 22 minutes to answer the query without Google (not counting travel time to the library) but only 7 minutes to answer question with Google.
- Multiplying 15 minutes saving across all queries made by average worker and using the average hourly wage gives $500 per worker per year.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

WORK VERSUS PLAY

The strict distinction between work and play or input and output that economists make is not always so clear.

The billions of hours people spend uploading, talking, and commenting on photos on Facebook creates value for their friends, family, and even strangers.

Yet these hours are uncompensated, so presumably the people doing this ‘work’ find it more intrinsically rewarding then the next best use of their time.

In 2012, users collectively spent about 200 million hours each day on Facebook, much of it creating content for other users to consume.

None of this is counted in our GDP statistics as either input or output, but these kinds of zero-wage and zero-price activities still contribute to our welfare.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO: ATTENTION ECONOMY

Source: https://www.youtube.com/watch?v=H-fHXju6Xf0

QUESTIONS

1.	What is consumer surplus? Prove an example.
2.	What is the attention economy about? Provide an example.
3.	How much time can be saved by using Google search?

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
   - 3.1. FREE GOODS
   - 3.2. TIME MACHINE
   - 3.3. CONSUMER SURPLUS
   - 3.4. NEW GOODS AND SERVICES
   - 3.5. REPUTATIONS AND RECOMMENDATIONS
   - 3.6. INTANGIBLE ASSETS
4. NEW METRICS FOR THE SECOND MACHINE AGE

ZERO OR INFINITY

In the early days of the 1990s internet boom, a joke circulated that there were only two numbers in the new economy: zero or infinity.

- A big part of the value in the new economy has come from the reduction in the price of many goods to zero.

- On the other end, price drops from infinity to a finite number for new goods.

  - Suppose Warner Brothers makes a new movie and you can watch it for $9. Has your welfare increased?

  - Before the movie was conceived, cast, filmed, and distributed, you couldn't buy it at any price, even infinity.

  - In a sense, paying just $9 is a large price reduction from infinity, or whatever maximum price you would have been willing to pay.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

NEW GOODS AND SERVICES

We now have access to all sorts of new services that never existed before.

Much of the increasing our welfare comes not just from making existing goods more cheaply but from expanding the range of goods and services available.

77% of software companies report the introduction of new products each year and internet retailing has vastly expanded the set of goods available to most consumers.

With a few clicks, over 32 million books can be found or purchase at amazon.com. By contrast, the typical physical bookstore has about 400,000 titles and even the largest Barnes & Noble store in New York City stocks only 250,000 titles.

Similar increases are observed in the online selection of other product categories such as videos, music, electronics, and collectibles.

Every time a new product is made available, it increases consumer surplus.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VALUE OF NEW GOODS AND SERVICES

One way to think about the value created is to imagine that the new product always existed, but only at such a high price that no one could buy it.

Make it available is like lowering the price to a more reasonable level.

For the overall economy, the GDP numbers miss the value of new goods and services added to the tune of about 0.4% of additional growth each year.

Remember that productivity growth has been in the neighborhood of 2% per year for most of the past century so the contribution of new goods and services is huge.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

QUESTIONS

1.	What does it mean that the economy has only two numbers – zero and infinity?
2.	How to measure the value of new goods and services added to the economy?

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
   - 3.1. FREE GOODS
   - 3.2. TIME MACHINE
   - 3.3. CONSUMER SURPLUS
   - 3.4. NEW GOODS AND SERVICES
   - 3.5. REPUTATIONS AND RECOMMENDATIONS
   - 3.6. INTANGIBLE ASSETS
4. NEW METRICS FOR THE SECOND MACHINE AGE

IMPACT OF LOWER SEARCH AND TRANSACTION COSTS

Digitalization also brings a related by subtle benefit to the vast array of goods and services that already exist in the economy.

Lower search and transaction costs mean faster and easier access and increased efficiency and convenience.

For example:

- The writing site Yelp collects customer reviews to help diners find nearby restaurants in the quality and price ranges they seek.

- The reservation service OpenTable then let them book a table.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

REPUTATIONS AND RECOMMENDATIONS

In aggregate, digital tools like these make a large difference.

In the past:

- ignorance has protected the inefficient lower-quality sellers from being unmasked by unsuspecting consumers, while
- geography limited competition from other sellers.

With the introduction of structured comparison sites, airline travel, banking, insurance, car sales, motion pictures, and other industries are being transformed by consumers' ability to search for and compare competing sellers.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

IMPACT OF ONLINE REPUTATIONS AND RECOMMENDATIONS

No longer can a seller:

- of substandard services feed on the stream of ill-informed consumers, or
- be insulated from remote competitors who can deliver more for less.

The increased transparency:

- helped smaller independent restaurants compete with bigger chains,
- customers can more quickly find quality food via recommender sites,
- reducing reliance on brand names' expensive marketing campaigns.

The intangible benefits delivered by the sharing economy – better matches, timelines, customer service, increase convenience – are poorly measured with GDP.

Another way in which the true growth is greater than the standard data suggest.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO: MANAGING YOUR ONLINE REPUTATION

Source: https://www.youtube.com/watch?v=w7qEbPVw3hA

QUESTIONS

1.	In what ways are the search costs lowered in the digital economy?
2.	What barriers existed in the traditional economy due to the high search costs?
3.	What is the impact of online recommendations/reputation on economic behavior?

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
   - 3.1. FREE GOODS
   - 3.2. TIME MACHINE
   - 3.3. CONSUMER SURPLUS
   - 3.4. NEW GOODS AND SERVICES
   - 3.5. REPUTATIONS AND RECOMMENDATIONS
   - 3.6. INTANGIBLE ASSETS
4. NEW METRICS FOR THE SECOND MACHINE AGE

INTANGIBLE ASSETS

Just as free goods rather than physical products are an increasingly important share of consumption, intangibles also make up a growing share of the economy's assets.

Production in the second machine age depends less on physical equipment and structures and more on the four categories of intangible assets:

- intellectual property,
- organizational capital,
- user-generated content, and
- human capital.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INTANGIBLE ASSETS: INTELLECTUAL PROPERTY

Intellectual property includes patents and copyrights.

The rate of patenting has been increasing rapidly since the 1980s, and all the types of intellectual assets have also grown.

In addition, a lot of research and development is never formalized as intellectual property but is still very valuable.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INTANGIBLE ASSETS: ORGANIZATIONAL CAPITAL

Organizational capital includes:

- new business processes
- techniques of production,
- organizational forms, and
- business models.

Effective uses of the new technologies of the second machine age almost invariably require changes in the organization of work.

For instance:

- when companies spend millions on computer hardware and software for a new enterprise resource planning system,
- they typically also include process changes which outlast such investment, but
- which are 3-5 times as costly as the original investments.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INTANGIBLE ASSETS: ORGANIZATIONAL CAPITAL

Yet:

- why the hardware and software spending generally shows up as additions to the nation's capital stock,

- the new business processes, are generally not counted as capital.

Correct accounting for computer-related intangible assets would add over $2 trillion to the official estimates of the capital assets in the economy.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INTANGIBLE ASSETS: USER-GENERATED CONTENT

User-generated content is a smaller but rapidly growing category of intangible assets.

Uses of Facebook, YouTube, Twitter, Instagram, Pinterest, etc.

- not only consume free content and gain consumer surplus
- but also produce most of the content.

The latter include:

- 300 hours of video are uploaded to YouTube every minute.
- 350 million new photos are uploaded each day on Facebook.
- Reviews on sites like Amazon, TripAdvisor or Yelp.
- Rating of reviews is used to sort reviews and present the best content first, etc.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INTANGIBLE ASSETS: USER-GENERATED CONTENT

Hardware and software companies compete to improve the productivity of user-generated content activities.

For example, smartphones and apps now include easy or automatic tools for posting photos on Facebook.

User-generated content has value to all users, it can be treated as yet another type of intangible asset which is added to our collective wealth.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INTANGIBLE ASSETS: HUMAN CAPITAL

The biggest category of intangible assets is human capital.

The many years that we all spend:

- in schools learning skills like reading, writing, and arithmetic, as well as
- additional learning that happens on the job and
- additional learning done on our own

makes us more productive and, in some cases, is intrinsically rewarding.

It is also a contribution to the nation's capital stock.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INTANGIBLE ASSETS: HUMAN CAPITAL

The value of human capital in the United States is 5 to 10 times larger than the value of all the physical capital in the country.

Human capital has not always been this important to the economy:

> The man whose whole life is spent in performing a few simple operations … has no occasion to exert his understanding. Adam Smith, 1776

Investment in human capital will be increasingly important as a routine tasks become automated and the need for human creativity increases.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INTANGIBLE ASSETS AND GDP

Important as intangible assets are, the official GDP ignores them.

User-generated content, say, involves unmeasured labor creating unmeasured assets that are consumed in hundred of ways to create unmeasured consumer surplus.

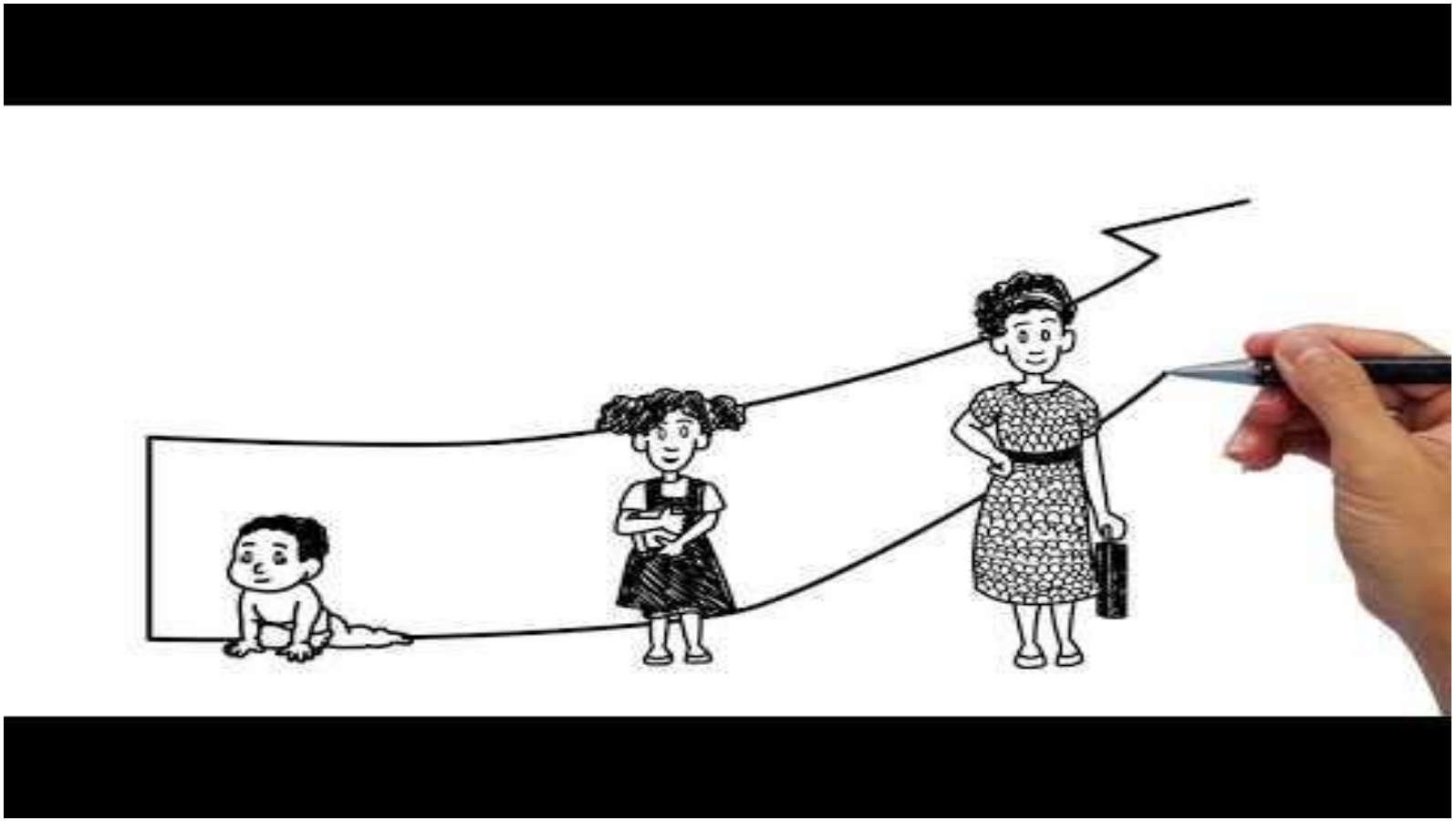
In recent years, experimental satellite accounts are being used to track some of the categories of intangible assets in the US economy.

For instance, the account created by the Bureau of Economic Analysis estimates that:

- investment in R&D capital accounted for about 2.9% of GDP and
- has increased economic growth by about 0.2% per year between 1995 and 2004.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO: HUMAN CAPITAL INDEX



Source: https://www.youtube.com/watch?v=iCUIAQkOwKw

QUESTIONS

1.	What do we mean by intangible assets?
2.	What types of intangible assets exist in the digital economy? Provide examples.
3.	Which intangible asset has the largest economic impact and why?
4.	What is the human capacity index?

OUTLINE

1. TECHNOLOGICAL FOUNDATIONS
2. PRODUCTIVITY GROWTH
3. BEYOND PRODUCTIVITY GROWTH
4. NEW METRICS FOR THE SECOND MACHINE AGE

INNOVATION IN ECONOMIC METRICS

Joseph Stiglitz:

> The fact that GDP may be a poor measure of well-being, or even of market activity, has of course, long been recognize. But changes in society and the economy may have heightened the problems, at the same time that advances in economics and statistical techniques may have provided opportunities to improve our metrics.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INNOVATION IN ECONOMIC METRICS

A fundamental principle of management is that what gets measured, gets done.

Modern GDP accounting was certainly a huge step forward for economic progress, they are among the greatest inventions of the 20th century.

But the rise in digital innovation means we need innovation in our economic metrics:

- If we are looking at the wrong signals, will make wrong decisions and get the wrong outputs.
- If we measure tangibles only, then we won't catch the intangibles that will make us better off.
- If we don't measure pollution and innovation, then we will get too much pollution and not enough innovation.
- Not everything that counts can be counted, and not everything that can be counted counts.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

EXISTING METRICS

The new metrics will differ both in conception and execution.

We can build on some of existing surveys and techniques, e.g.

- The human development index uses health and education statistics to fill in some gaps in official GDP statistics.
- The multidimensional poverty index uses 10 different indicators such as nutrition, sanitation and access to water to assess well being in developing countries.
- Childhood death rates and other health indicators are recorded in periodic household surveys like the demographic or health surveys.
- Gross national happiness, well-being index, etc.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

HARVESTING DIGITAL DATA

The biggest opportunity for new measurements is in using the extraordinary volume, variety and timeliness of digital data, e.g.

- Daily measurement of online prices from around the world to create an inflation index that is far timelier and reliable than the data gathered via monthly surveys.
- Using satellite mapping of nighttime artificial light sources to estimate economic activity in different parts of the world.
- Assessing the frequency of Google searches to understand the changes in unemployment and housing.

Harnessing this information will produce a leap in our understanding of the economy, just as it has changed marketing, manufacturing, finance, retailing, and virtually every other aspect of business decision-making.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

ASKING RIGHT QUESTIONS

As more data become available and as the economy continues to change, the ability to ask the right questions will become even more vital.

We must think about what it is we really value, what we want more of, and what we want less off. GDP and productivity growth are just means to an end.

- Do we want to increase consumer surplus? Then lower prices and more leisure time might be signs of progress, even if they result in a lower GDP.

- Many of our goals are non-monetary. We shouldn't ignore economic metrics, but neither let them crowd out other values because they are more measurable.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

ASKING RIGHT QUESTIONS

In the meantime:

- we need to bear in mind that the GDP and productivity statistics overlooked much of what we value, even when using a narrow economic lens.

What's more:

- the gap between what we measure and what we value grows every time we gain access to a new good or service that never existed before, or

- when existing goods become free as they so often do when they are digitized.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

VIDEO: NEW ZEALAND IS FOCUSING ON THE WELL-BEING OF ITS PEOPLE, NOT JUST ECONOMIC GROWTH

Source: https://www.youtube.com/watch?v=coYQEBMjdco

QUESTIONS

1.	What is the impact of wrong economic measurement?
2.	How is digital data helping conduct new economic measurements?
3.	What questions should be asked from new measures of the economy?

THANK YOU FOR YOUR ATTENTION

Tomasz Janowski

tomasz.janowski@pg.edu.pl