
Global Trends to 2035

Economy and Society



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Abstract

This study maps and analyses current and future global trends in the fields of economics and society, covering the period to 2035.

Drawing on and complementing existing literature, it summarises and analyses the findings of relevant foresight studies in relation to such global trends.

It traces recent changes in the perceived trajectory of already-identified trends and identifies significant new or emerging trends.

It also addresses potential policy implications of such trends for the European Union.

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List of acronyms

AI	Artificial Intelligence
AMD	Advanced Micro Devices
AMECO	Annual Macro-Economic Database
ARM	Advanced RISC (Reduced Instruction Set Computing) Machine
ASC	Advisory Scientific Committee
BAMF	German Federal Office for Migration and Refugees
BEA	Bureau of Economic Analysis
BRICS	Brazil, Russia, India, China and South Africa
CEECs	Central and Eastern European Countries
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
CPTPEU	Comprehensive and Progressive Agreement for Trans-Pacific Partnership for European Union
CPU	Central Processing Unit
DDL	Distributed Deep Learning
DG EPRS	Directorate-General for European Parliamentary Research Services
EMEs	Emerging Market Economies
EPO	European Patent Office
ESPAS	European Strategy and Policy Analysis System
ETC	European Emissions Trading System
EV	Electrical Vehicles
FDI	Foreign Direct Investment
FLOPS	Floating Point Operations Per Second
FRED	Federal Reserve Economic Data
GDP	Gross Domestic Product
GPU	Graphics Processing Unit
IAB	Institute for Employment Research
IBM	International Business Machines Corporation
ICE	Internal Combustion Engines
ICT	Information and communications technology
IPC	International Patent Classification
JPO	Japan Patent Office
M&A	Merges and Acquisitions
MaGE	Macroeconomic General Economic (model)
MEDAM	Mercator Dialogue on Migration and Asylum

MFN	Most Favoured Nations
MIT	Massachusetts Institute of Technology
NDC	Nationally Determined Contributions
NIC	Newly Industrializing Countries
NREL	National Renewable Energy Laboratory
NVIDIA	Northeastern Vermont Development Association
PISA	Programme for International Student Assessment
PPP	Purchasing Power Parity
PPS	Purchasing Power Standard
PV	Photovoltaic
PwC	PricewaterhouseCoopers
R&D	Research and Development
RQC	Russia Quantum Center
SOEP	Socio-Economic Panel
SOEs	State Owned Enterprises
TFP	Total Factor Productivity
TIMSS	Trends in International Mathematics and Science Study
TPP	Trans-Pacific Partnership
TPU	Tensor Processing Unit
UNFCC	United Nations Framework Convention on Climate Change
USPTO	United States Patent and Trademark Office
WTO	World Trade Organisation

Executive summary

Two trends that appear well established at the global level are:

- i) continuous, if slow and gradually decelerating, population growth and
- ii) a rapid economic convergence of emerging markets, implying a considerable relative decline of the EU.

The combined effect of these two trends is that there is a real possibility that by 2035 the EU-27 will not be among the three biggest economies – even if per capita growth continues to increase slowly in Europe. A further implication of this shrinking relative weight of the European economy is that for most Member States the internal market might become less important than the global market, thus strengthen centrifugal forces ('no Brexit without China').

Uncertainty about the future global economic order arises less from the predictable shifting weights than from different views of the relative roles of the government and markets in the two emerging large powers, India and China.

Globalisation

Globalisation in the traditional sense (trade volumes relative to GDP) might have peaked. Given the likely dominant role of China, the major uncertainty concerning the global economic system relates to two of its policy choices, both pertaining to the degree of state control over the economy:

- a) At present, the major assault on the global trading system comes from an erratic US President. But in the longer term, the survival of the open and multilateral global trading system will depend on whether China will choose to become a fully-fledged market economy or whether the 'guiding role' of the Communist Party, which has now been enshrined also for all private corporations, will continue to remain paramount. It is difficult to imagine a global trading system in which the largest economy is subject to extensive state control.
- b) The degree to which the US dollar remains the dominant global reserve currency will depend on the degree of capital market opening permitted by the Chinese authorities over the next decade or so. Accepting free capital movements carries a substantial cost for the Chinese authorities, as they would thus lose control over the exchange rate, which would considerably complicate their control over the economy.

Growth

The rapid growth of emerging economies should not represent a problem for the EU economy (which has already adjusted to China). An expanding middle class and continuing high levels of investment in emerging economies should even benefit European industry, which specialises in high quality investment and consumer goods.

We find that tangible benefits in terms of productivity from the undoubtedly rapid advances in information technology (IT) have so far proven elusive. However, there are strong arguments that they might materialise in the medium term.

The EU's fragmented internal market for IT services is likely to constitute a handicap in a sector dominated by 'winner takes all' competition. Without a major effort to increase expenditure on R&D in some key technologies, it is thus likely that the European economy will continue to fall behind in this area, relative to both the US and China.

Energy and climate change

Recent years have seen further significant falls in the cost of renewable energy, mainly for photovoltaic solar and offshore wind. The cost of storage has also fallen rapidly, mitigating the drawback of the intermittent nature of these power sources. The key uncertainty at present is whether these cost reductions will continue. Until now, price reductions have concerned core technical elements (wafers in photovoltaic installations and in battery production), but system costs include many other elements for which reductions appear more difficult. These 'soft' costs are particularly important for residential applications and are thus likely to impede the emergence of a de-centralised power generation system. The exact date of 'peak oil' (demand) remains uncertain, but it seems likely that competition for hydrocarbon resources will be mitigated. Increases in oil prices will be limited by the fairly elastic, and price-sensitive, supply from unconventional sources.

By 2035, the evidence that the climate is changing should have become even more compelling, and the associated costs should be apparent. However, policy might find itself in a bind because the vast new global capital stock accumulated in today's emerging economies (not only in terms of coal fired power generation, but also housing and transport infrastructure) might make it very expensive to shift to a low carbon economy. The EU is unlikely to play more than a secondary role in global climate policy because its own emissions should have fallen to less than one tenth of the global total.

EU internal dynamics

Over the last two decades, there has been considerable east-west convergence in the EU-27, but not north-south within the eurozone. However, problems in the future might not be along these known fault lines, but between countries, which can benefit from new technologies because of strong domestic governance (most importantly high-quality education) and those where knowledge accumulation and generation is weak. Research on the limits to longer-term convergence in the US confirm the key role of education and investment in R&D even within a very integrated economy. Our scenarios are based on these elements, which make a continuation of slow growth and gradual convergence the most likely outcome.

Inequality is widely perceived as an increasing problem. However, we find that that the EU evidence is very different from that in the US, where one finds a continuous trend increase in inequality. In Europe, by contrast, no such trend can be found. Over the last two decades one finds very different experiences across Member States in terms of inequality, with some increase, but also falls in others. Moreover, different indicators give a different picture. In sum, the data does not confirm the impression of a generalised trend increase in inequality throughout the EU.

1 Introduction

This study aims at offering a solid background for the key questions and (known) unknowns regarding global trends as we look forward to 2035. While some trends identified in the ESPAS report (2015) and the CEPS study (2013) have remained relevant, others have shifted considerably, making this study more than just an update of the 2030 reports.

This chapter introduces the overarching issue using a variant of the five major economic and social trends identified in the 2015 ESPAS Global Trends Report as a starting point:

1. A richer and older human race,
2. A more vulnerable process of globalisation, with an uncertain leadership,
3. A transformative industrial and technological revolution,
4. A growing nexus of climate change, energy and competition for resources,
5. Changing power, interdependence and fragile multilateralism.

These five mega-trends led to the projection that the world will tend towards a more multi-polar system, driven by economic growth in emerging and developing economies (notably China), with the centre of gravity shifting away from the established developed economies, like the US and the EU.¹

This study first assesses whether there are reasons to believe that these trends will change, whether any new trends have emerged in recent years meaning that the conclusions derived do not hold anymore. Then it evaluates the economic and social impact of the updated trends on the EU under alternative scenarios and discusses its policy implications. For this purpose, we identify major developments and events since 2013 (base year for the ESPAS Report) that could have significantly affected the trajectory of the above trends or could have spurred new ones. We are aware of the cognitive trap of placing too much emphasis on high-profile events, which could later turn out to be mere noise, and avoid this pitfall paying attention to longer-term trend development and inter-dependencies between different trends as well as by combining different methodologies, such as quantitative research, interviews and text analysis.

Based on the review of recent literature, stylized facts based on macro data and evidence from text analysis, we find that relative to 2013 there is:

1. Little indication that catch-up growth in emerging market economies (EMEs) will slow down materially. The growth potential in OECD countries is more uncertain. Data exhibit no clear trend in inequality in Europe. Perceived rising inequality might be driven by the relative decline of the middle class in advanced countries.

¹ For earlier studies emphasising some of these trends, see National Intelligence Council (US) (2008), Wilson D. et al. (2011), Ward, K. (2011) and PwC (2011).

2. A more vulnerable process of globalisation, still led by an 'economic G3'? Vulnerability is likely to be overwhelmingly driven by structural factors. By 2035, it might be more accurate to speak of G3, G2 or even G1: China first, the USA second and the EU a distant third, and possibly even displaced from that position by India.
3. A transformative industrial and technological revolution. There is no doubt that this trend will continue with changes occurring very fast, but it remains very difficult to measure its effects on society and the economy, and hence to predict its future direction and implications. Currently, Big Data combined with AI (Artificial Intelligence) and Blockchains are at the core of such processes. This was not the case five years ago, and it is not clear whether this will still be the case in a decade. The measurable impact of these changes on the economy has so far been limited.
4. In 2035, the global energy system will still be dominated by fossil fuels. However, rapid advances in alternative energy generation and storage could mean a high proportion of power generation using renewables in OECD countries (and China). This might mean less competition for 'old' resources like oil and gas. Today, there is more debate about 'peak oil' in demand, than in supply (as was the case 5-10 years ago).
5. Changing power, interdependence and fragile multilateralism. The ongoing inter-dependence through FDI means that there is little danger of a collapse in global trade. But the forces maintaining an open and multilateral trading system are declining as new powers emerge. The position of China might be key in two areas. A continuation of the primacy of the Communist Party even over the private sector is difficult to reconcile with an open trading system and WTO rules. Moreover, the Renminbi can emerge as a competitor to the US dollar as a global reserve currency only if the Chinese authorities allow full convertibility of their currency.

The study is organised around the five key trends identified above, which are analysed separately in Chapters 2 to 6. Each Chapter contains two elements: the discussion of major developments and events since 2013 that could have affected a corresponding, previously predicted key trend (or created a new one) and the description of major updates of continuing trends. Chapter 7 is devoted to investigating income and wealth inequality as well as changes in the labour share of income.

Chapter 8 illustrates the findings of the text analysis. Chapter 9 is devoted to the analysis of the economic and social impact of the updated trends on the EU and provides a scenario analysis for the 2035 around two themes: convergence and growth within the EU. Chapter 9 concludes and discusses policy implications.

2 Demographics and Growth

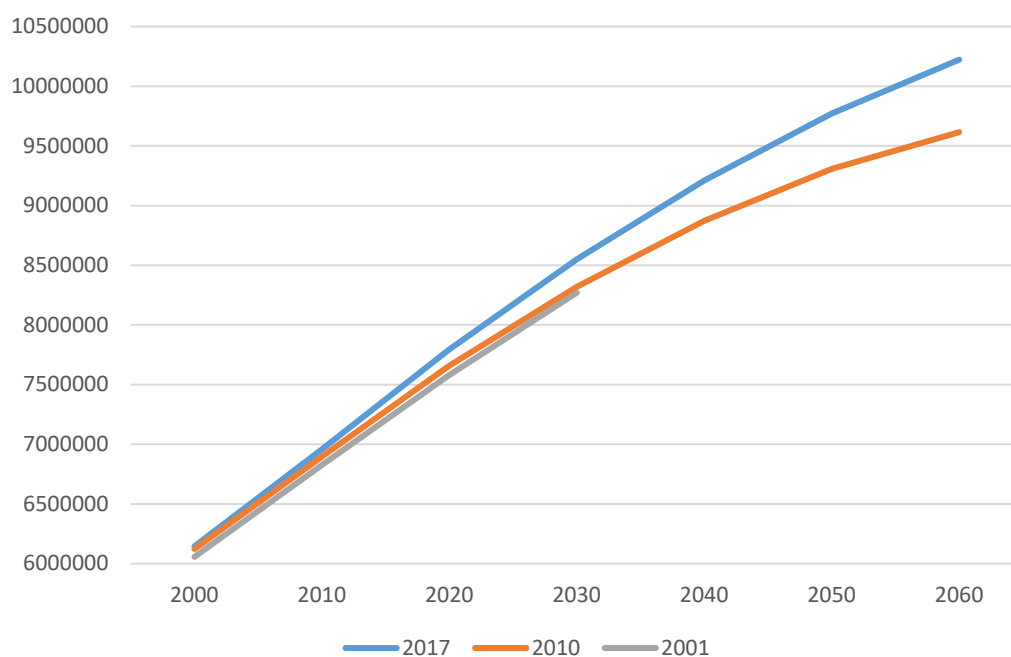
2.1 Demographics

2.1.1 Global population growth to continue

The most recent population projections suggest that global population growth will continue, albeit at a moderate pace. The UN forecast used in CEPS (2013) contained three variants, the lowest one of which implied that global population might already stop increasing around 2035.

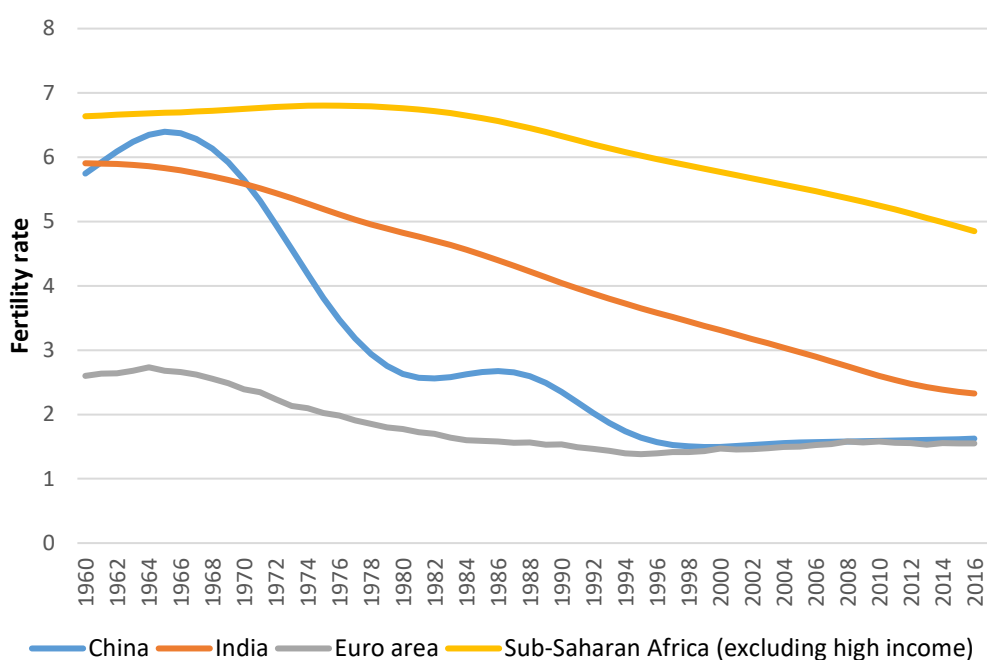
However, more recent forecasts do not confirm the lower projections for global population. The medium variant of the latest available UN projections predicts global population will rise to over 8.7 billion by 2035, and to continue to grow after that point at somewhat less than 1% per annum, with no peak until the end of the century. The increase between today (roughly 7.2 billion) and the expected value for 2035 would be around 1.5 billion, nearly equivalent to the population of China or India. Almost all of this increase would be outside OECD countries and East Asia.

Figure 1. Global population projections, different vintages



Source: UN.

It is worth underlining that this continuing expansion of global population is not driven in any way by the end of the 'one child policy' in China. As this policy only ended a few years ago, it is too early to arrive at a definitive judgement of its significance. However, there has been no immediate rebound in the birth rate since the policy ended. The fertility rate in China seems now close to that of the euro area and that of other East Asian countries, suggesting that government policy cannot do much to reverse deep underlying socio-economic trends. Sub-Saharan Africa and India are the main areas with above-replacement fertility.

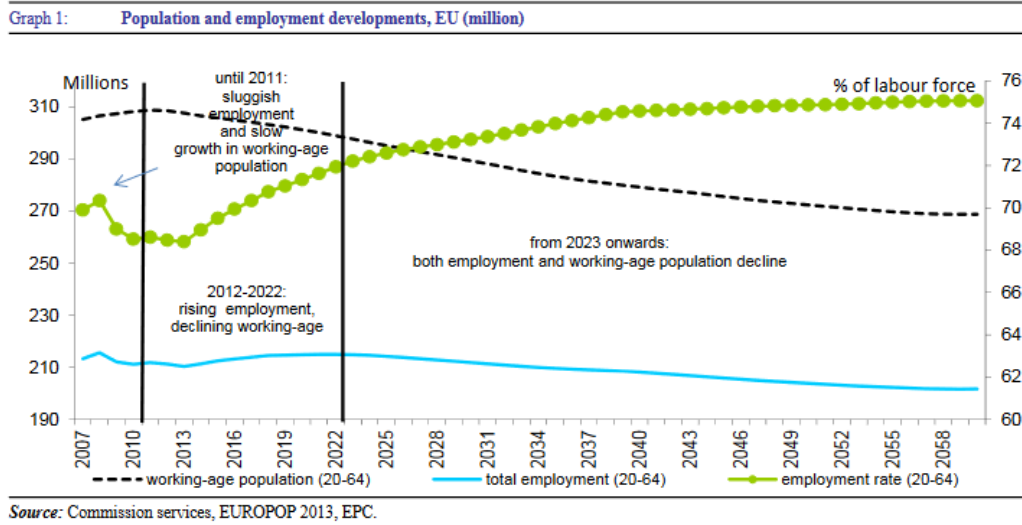
Figure 2. Long-term evolution of fertility

Source: World Bank.

2.1.2 Ageing

Low fertility rates coupled with a continuous increase in longevity leads of course to an increase in the old-age-dependency ratio (see EPRS 2016a). In Europe, the impact of this trend on the ratio of workers to pensioners has so far been partially neutralised by the increase in the labour force participation rate. However, this might not be possible in the future. The 2015 Ageing Report of the European Commission provides an in-depth overview of ageing-related costs in the EU. Figure 3 below summarises the relevant demographic assumptions. This report predicts that a rising labour force participation rate could offset the decline in the working age population until about 2022, but that total employment would start to fall after that date, thereby increasing the pressure on pension systems.²

² The adjustment of labour force in the direction of offsetting the effects of ageing could be used as evidence against the idea that ageing societies require increasing demand for inward labour migration. However, such argument is valid only to the extent the objective is the sustainability of the pension system. In the long term, it is population growth that contributes to GDP growth. It is for this purpose that immigration remains relevant.

Figure 3. Population and employment forecasts for the EU

The overall increased cost of all aspects of ageing (including health care) is estimated at around 2% of GDP by 2060, with only a fraction of the impact effective by 2035. The Commission's report points out that there are a number of ways in which ageing affects government expenditure and that the inter-linkages between them have to be taken into account (for example less generous pensions systems might lead to higher labour force participation rates).

Other countries with similar demographics are likely to experience similar impacts, somewhat more severe in the case of Japan, and less severe in the case of the US.

It is often argued that China will have similar difficulties with ageing as Europe (or the US) because its fertility rate is even below that of most OECD countries. Some authors³ have argued that China is 'getting old before getting rich'. However, one has to keep in mind that an increasing old-age-dependency ratio is politically much easier to manage if the economy is growing (or has grown at a high pace in the preceding period). In this case, the income of retirees could be high relative to their last salary, but low relative to average wages. Pensioners might thus be content with a low replacement rate or moderate pension increases.

2.2 Global growth: from G7 to E74?

2.2.3 Recent developments and near-term outlook

Nothing over the last five years suggests that the trend towards a richer human race will be derailed. There is no indication that global growth will suddenly stop. However, one needs to distinguish between (today's) leading economies, i.e. largely the OECD club, and the emerging economies.

³ Among others, Johnston (2012).

⁴ Group of Seven (G7) is a group of the largest advanced economies consisting of Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. E7, "Emerging 7", is the seven countries China, India, Brazil, Mexico, Russia, Indonesia and Turkey, grouped together because of their major emerging economies.

Table 1 below compares recent growth performance and the latest predictions of the IMF for the next five years. Growth in advanced economies has stabilised at 1.4% in advanced economies over the last four years and is expected to continue at that pace for the next few years. By contrast, growth in the rest of the world (i.e. emerging markets and developing economies) is expected to accelerate from 3.1% to 3.6%. Most of this acceleration is due to a composition effect. Few countries are actually expected to accelerate, but the weight of China, which is expected to continue to grow at a fast rate, has increased considerably and is forecast to increase further.

Table 1. Average real per capita growth rates

	2013-2017	2018-2022
Advanced economies	1.4	1.4
Emerging market and developing economies	3.1	3.6

Source: IMF.

The last years have seen some revival of growth even in the euro area economy, but most projections continue to predict a (near term) potential growth rate of around 1%, which is one percentage point below that of the US.

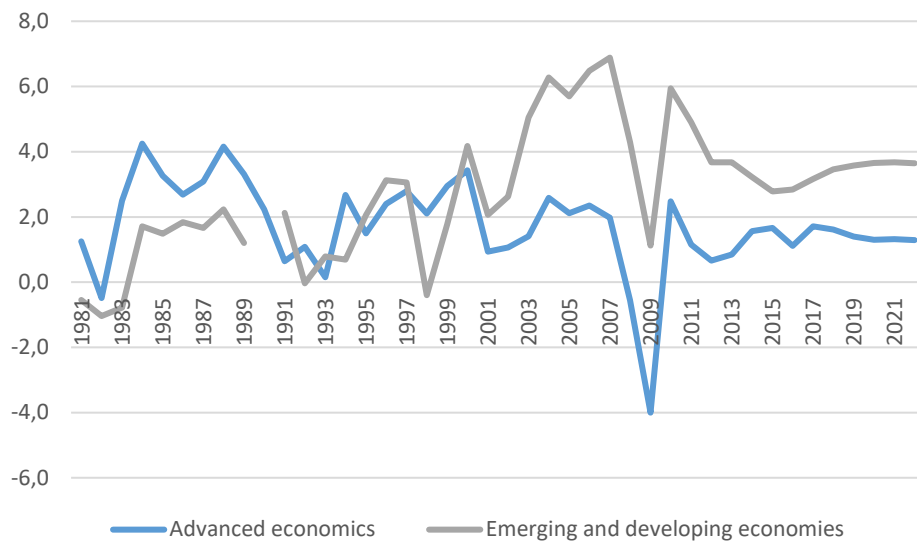
One unanticipated recent development is that the drivers of growth in China have become somewhat less imbalanced. Growth is no longer driven by exports and investment. Domestic savings have diminished and the external surplus has almost disappeared, with the current account now at only around 1% of GDP, while domestic consumption expanded.

The fact that the growth rate of India has accelerated has attracted much less attention, but it indicates the potential emergence of another large economy, rivalling the EU in size by 2035.

2.2.4 The medium term outlook

The last decades have witnessed a very rapid narrowing of the income differentials between OECD countries and what used to be called developing countries. Almost all available projections and forecasts assume that this trend will continue into the indeterminate future.

While until the end of the 1990s, the per capita growth rate of OECD economies was, most of the time, at least as high, if not higher, than that of the rest of the world, this changed in the following years mostly driven by China in the early stage, and then Asia in general. While the contribution of Africa to the convergence process has always been very limited.

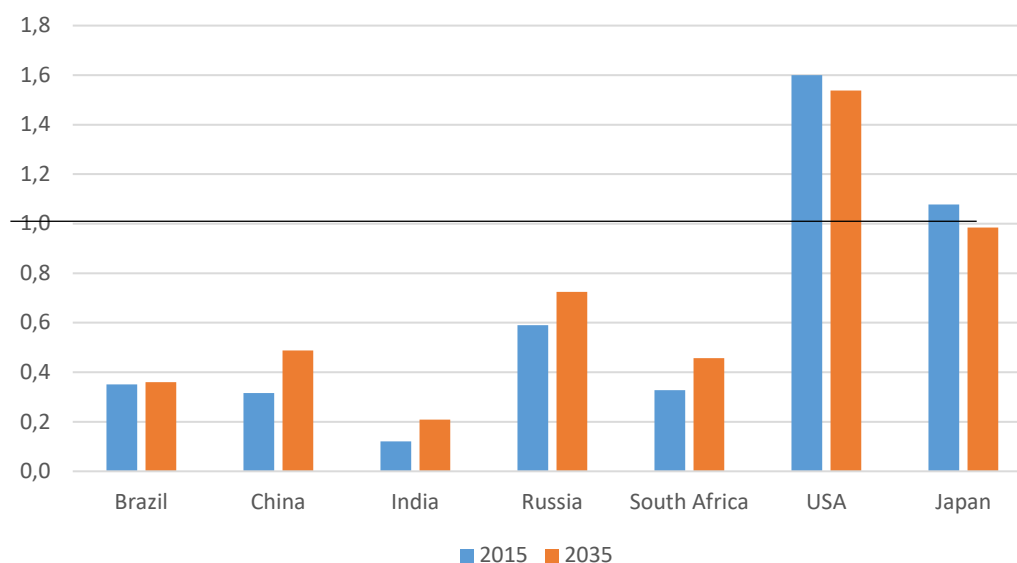
Figure 4. Growth rates of GDP per capita

Source: IMF.

The substantial growth differential of the last two decades resulted from the combination of somewhat lower growth in OECD countries and, above all, a considerable acceleration of growth in most of the rest of the world.

The reasons for both of these changes are not well understood. It is thus difficult to identify the factors that could lead to a revival in growth for the OECD and what factors would cause a slowdown in today's emerging economies. The apparent contradiction between the impression of accelerating technological progress and the slow-down of productivity growth in developed economies will be discussed further in Chapter 4.

Naturally, there are large differences within the emerging and developing economies. This is also reflected in the predicted GDP per capita in the world of 2035. As shown in Figure 5, looking at the BRICS, only Russia will have a GDP per capita above half that of the EU (in PPS). Brazil is predicted to remain at its current level of GDP per capita relative to the EU. China will double its GDP per capita from currently 10,000 USD to 21,000 USD by 2035, but still remain at just below 50% of the EU value. Likewise, India will achieve a substantial relative improvement, reaching 20% of EU average income.

Figure 5. GDP per capita (PPS), relative to the EU⁵, 2035

Source: Authors' elaboration on OECD, CEPS (2013) and UN population forecasts.

Despite substantial growth rates in Sub-Saharan Africa, the GDP per capita (on average) will remain low. Nevertheless, for some countries the speed of convergence to the EU average is similar to that of India. For example, heavyweights Nigeria and Egypt are expected to reach, respectively, 5-10% and 15-20% of EU average income by 2035. In essence, among the major emerging and developing economies, the catch-up process is predicted to continue while the gap itself will remain substantial.

Prospects for long-term convergence

There exist many projections of long-term growth rates. Some are based on mere extrapolation of the past; others predict using models, but must then make assumptions about the key drivers of growth.

Most model-based projections of long-term growth rely on two key factors of production, namely physical and human capital, combined with an overall efficiency factor, which is equated with knowledge. CEPS (2013) used one such model, which emphasises investment and education. In this model, secondary education is the key to catch-up growth of poorer nations, which can then import knowledge from advanced countries to drive rapid growth from a low level. The closer a country gets to the technological frontier, the more it would need to rely on indigenous innovation, which requires higher tertiary education.

Education, in different forms, is usually assumed to constitute a key variable in enabling rapid growth. Levels of schooling are increasing everywhere, but the 'pay off' in terms of economic growth appears to vary a great deal (see Box 1).

⁵ EU average includes only: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

Box 1. "Where has all the education gone?"

Pritchett (2000) starts from the observation that the highly educated have much higher earnings almost everywhere. If one were to apply this uniformity to the observed increase in the years of schooling throughout many developing and advanced countries, one would expect very strong growth, especially in countries where the upgrading of the average level of schooling has been strongest. However, Pritchett (2000) finds that this is often not the case.

One explanation of this seeming paradox could be that in rent-seeking societies, the higher productivity generated by more education is wasted in 'directly unproductive activities' (a term coined by Anne Kruger). According to this view, the higher educated might just waste their higher human capital in a struggle for control over rents. This struggle for control could be worse than a zero sum game since it ties up resources, which could otherwise be used productively. The canonical example for such rents are profits from mineral extraction. This would be another manifestation of the 'resource curse' or 'Dutch disease' as it suggests that higher education might contribute little to growth in economies dominated by resource extraction. This is confirmed by our own observation that resource exporting countries tend to grow more slowly. The evidence used by Pritchett (2000) predates the strong acceleration of growth in EMEs around the turn of the century. Data from the last two decades might show a somewhat different picture for EMEs, but the question of why the massive upgrading of education levels in many of the old EU Member States has not led to an acceleration of growth remains.

Turner (2018) provides a provocative response to this question. He argues that 'zero sum' activities have become increasingly important in modern developed economies, especially in the services sector. Legal and accountancy services, some financial trading, regulators, etc. constitute examples where a better educated workforce might not lead to higher welfare. Better defence lawyers on both sides of a case might lead to the same outcome. The same might happen between regulators and the representatives of the regulated industry (banking, insurance, telecoms, utilities, etc.). The underlying thesis is that, as modern societies become more productive, they have to devote a larger share of labour resources to the distribution of income, which is inherently a zero-sum activity.

Moreover, differences in the quality of education, as measured by standardised tests, are very high between most EMEs and the OECD, with the exception of China and East Asia in general. However, an increase in the quantity of schooling (e.g. years of schooling) should still increase productivity and lead to higher growth as long as differences in quality do not change significantly over time. For the few countries for which longer term comparisons are available, one finds little change in the quality of schooling.

Baldwin (2016) provides one explanation for the process of global convergence, namely a massive transfer of technology and knowhow, made possible by advances in information technology (ICT). Box 2 provides more details. Given that ICT technology continues to improve, maybe even at an accelerating pace (see chapter 4 below), this view would suggest that convergence should continue for some time.

Box 2. The Great Convergence

The growth projections for 2035 reported here reflect what Baldwin (2016) calls the 'Great Convergence'. This term views the preceding century, during which the developed world pulled away from the rest (the Great Divergence), as a temporary phenomenon that was based on an initial advantage in terms of technology that was reinforced by economies of scale which made it more efficient to locate manufacturing close to existing industrial clusters.

The data on the relative growth rates presented above show that indeed, until about 1980, the world was dominated by the G7; and there was no convergence since developed economies often grew faster than poorer countries.

In his book, Baldwin argues that the world is being changed by a 'colossal, one-way flow of technology from mature to emerging economies'.

Rapid growth in emerging market economies has been made possible by US, German and Japanese offshoring firms distributing their know-how in the form of FDI, thereby allowing local production to soar, initially based on offshored stages of production. According to Baldwin, this transfer of knowledge (and the offshoring it enabled) was rendered possible by advances in information technologies, which allowed large manufacturing firms to coordinate different stages of production, which have to be executed in a coordinated way in locations that might be thousands of miles apart.

In this view, there is no reason why growth in emerging economies should not continue as long as the transfer of knowledge continues. With continuing advances in information technologies, the transfer of knowledge could actually accelerate. From this point of view, the Great Convergence should continue into the indeterminate future.

We would add that the transfer of knowledge by itself is not sufficient for convergence. The knowledge can only be applied if there is a sufficient local supply of labour that can understand and implement instructions from the headquarters. Moreover, there needs to exist a minimum infrastructure to transport components as well as final products back and forth and additionally a minimum of legal and political certainty that foreign owned factories will not be expropriated, and contracts will be respected.

This foundation to make knowledge transfer profitable is becoming increasingly available as the level of education of the workforce improves rapidly in many emerging economies and infrastructure investment in these places continues at a relatively high level.

Growth spurts, commodity exports and the BRICS

Pritchett and Summers (2013) have drawn attention to the fact that growth tends to be unstable; and that most 'growth spurts' have petered out before the country could reach high income status. They maintain that the key 'regularity' of growth is 'regression to the mean'. This is based on their finding that if one compares growth rates across countries for subsequent decades there is very little correlation. Countries that grew particularly fast during one decade do not show a tendency to grow faster during the next decade.

One reason for this instability of growth rates over time might be that growth in many emerging economies had been driven by commodity prices, which have been very unstable over the last decades.

This hypothesis is confirmed by the data if one looks separately at two different groups of countries: a) commodity exporters, and, b) all others, i.e. countries that export mainly manufactured goods.

The dividing line between commodity and industrial exporters was taken to be the share of manufacturing goods in overall exports (of goods). We find that about 65 countries (out of the 123 for which data is available), accounting for a little over a quarter of the global population, depend mainly on commodity exports in their international trade relations. For this group of countries, there is indeed little persistence in growth. Only one EU member country classifies as a commodity exporter, namely Greece. This dependence on commodity exports might be one of the reasons why the adjustment programme of that country did not produce the desired effect, namely to general rapid export growth through lower wages. Commodity exports are not very sensitive to cost, especially labour costs.

However, growth is fairly persistent for the remaining 58 manufacturing exporters. The correlation coefficient between the average growth rates over the ten years up to 2006 and the average growth rates over the following 10 years (2007-2016) was almost 60%. After the financial crisis, average growth rates are lower, but the countries that grew faster before the crisis also tend to have higher growth after the crisis. The euro area countries that experienced a prolonged recession after the sudden stop to capital inflows in 2007/8 thus constitute an exception, rather than the rule.

The difference between commodity exporters and other emerging market economies is also significant for their overall growth prospects. Economists use the concept of 'beta convergence' to measure catch-up growth. This concept posits that poorer countries should exhibit more dynamic growth than richer countries and hence should converge to a higher level of GDP. This assumes that in one country per capita GDP growth negatively depends on the initial level of income. Beta-convergence is a corollary of the neoclassical theory of economic growth, which assumes that capital can move freely and its allocation is driven by returns, which are diminishing on the level of accumulation of capital. Economies with little capital and know-how, have easier avenues to increase productivity than economies closer to the technological frontier. In growth models (see Section 2.2.7 for an exposition), this is captured by the idea that investment has declining returns to scale: the more capital is available per worker, the less any additional unit of capital will contribute to increasing output.

Table 2 presents the results from a simple application of this approach, namely the results from a regression in which the average per capita growth rate over the period 1991-2016 is a function of the (logarithm of the) starting level of income per capita. This standard regression is augmented with the share of manufacturing in total exports. The result indicates a strong convergence process since poorer countries initially tend to grow faster. This finding is not surprising and has been found in many studies. In the results below, the estimated coefficient implies that a doubling of the initial GDP per capita leads to a lower growth rate of about half a percentage point (0.44).

Table 2. Convergence at the global level and manufacturing exports

	<i>Coefficients</i>
Intercept	6.89***
Initial GDP per capita (in ln)	-0.44***
Manufacturing exporter dummy	0.02***
OECD dummy	0.32
China dummy	5.65***
Obs. 123	

Source: own calculations based on WB data.

Note: cut-off for manufacturing exporter is 50% of exports. The dependent variable is the growth rate over the period 1991-2016.

Note2: *** p<0.01, ** p<0.05, * p<0.1

A second result is that a high share of manufacturing tends to accelerate growth, and countries that are mainly commodity exporters grow more slowly (given any initial GDP per capita). The estimated coefficient implies that as the share of manufacturing in exports goes from zero to 100%, the trend growth rate increases by one full percentage point.

But some argue that catch-up will become more difficult for the 'late comers' because the continuing advancement of automation has increased the skill requirement of 'entry level' manufacturing more quickly than the education levels of many emerging economies.⁶

It is also apparent from this table of regression results that the growth of China has been considerably higher, by over 5 percentage points, than one would have expected given its initial income (and even taking into account the preponderant share of manufacturing goods in its exports). This underscores once more the uniqueness of the case of China, with its persistently high growth rates. By contrast, OECD countries show relatively much lower growth, which is consistent with their already high income (technically speaking, the associated dummy variable is not significant).

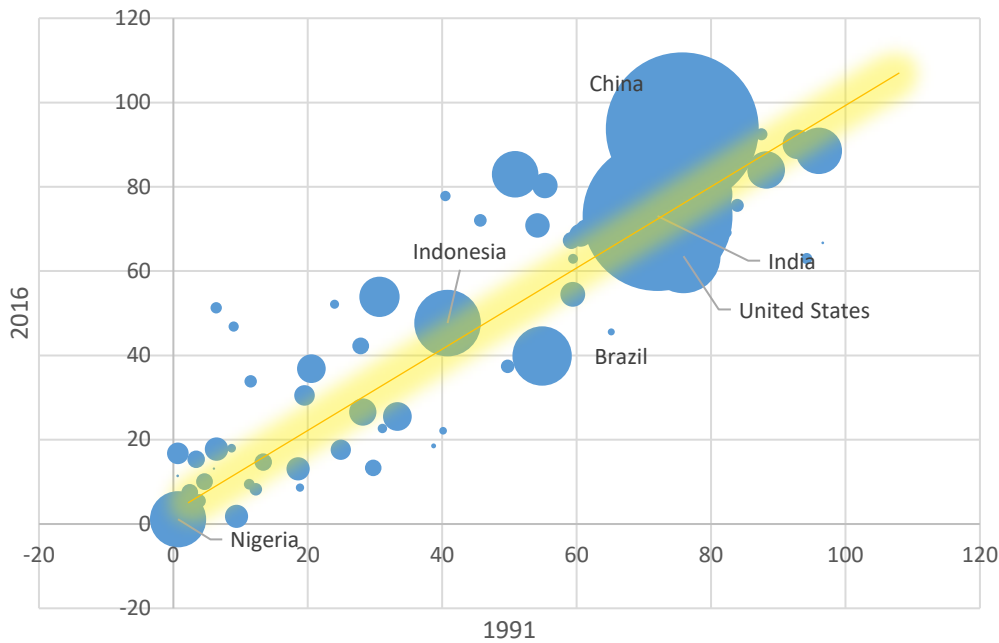
Finally, few countries 'graduate' from commodity to manufacturing exports, as shown in Figure 6 below. This figure shows the share of manufacturing in exports for 1991 and 2016, with the size of the bubble indicating the population in 2016. It is apparent there is a strong correlation between the values in 1991 and 25 years later. The most emblematic case is Nigeria, where in 1991 the share of merchandise export was nearly zero and today it is in the same situation. Countries below the 45° line are those for which manufacturing has become less important over time. This includes for example the US, which tends to export more agricultural commodities and energy today than a quarter of a century ago.

Given that a high dependency on commodity exports is associated with lower growth, it is positive that the most populous countries (India and China) are both specialised in manufacturing. Sub-Saharan Africa, by contrast, provides the opposite example of a region (exemplified by its largest

⁶ "Emerging market catch-up set back 'decades' – Slowdown hits hopes of closing income gap with US and other rich countries, says World Bank", FT, June 7, 2016.

country, Nigeria) of a dependency on commodity exports, which seems to be associated with lower and less stable growth.

Figure 6. Merchandise exports as % of total exports (bubble: pop 2016)



Source: World Bank.

This difference of growth prospects between commodity and industrial exporters is also the main reason that the 'BRIC' grouping does not make sense. In contrast to India and China, Brazil and Russia both depend on commodity exports. During the commodity price boom of the first decade of this century, the latter two countries also had high growth rates, but this growth was not sustainable when commodity prices reversed.

Box 3. BRICS no longer?

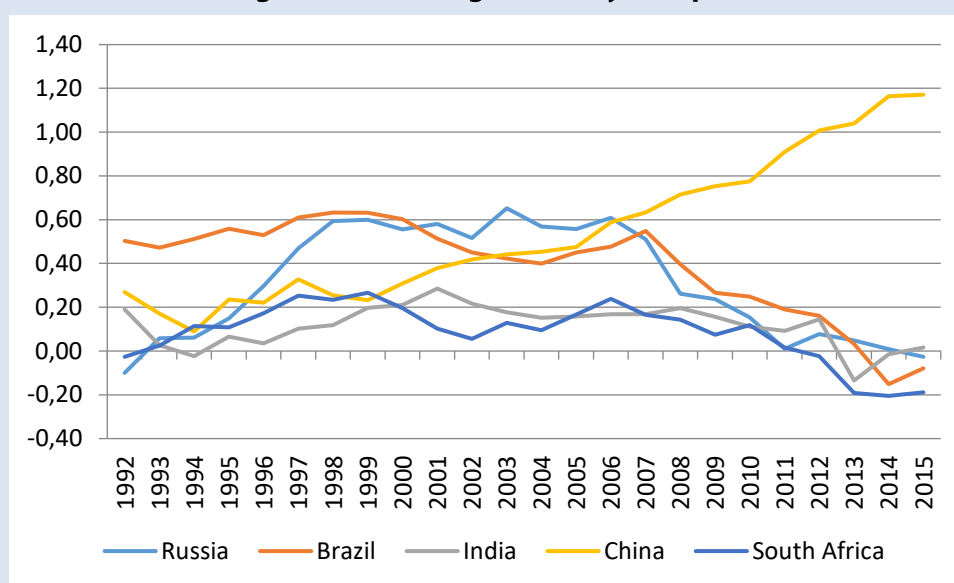
The BRIC grouping (Brazil, Russia, India, China) was coined around the turn of the century as the largest and most promising set of emerging markets. South Africa was later added, resulting in 'BRICS'. Until the global financial crisis, it seemed that this group would share a bright future as growth rates were high and the economies seemed to be modernising in other respects as well (opening financial markets, for example). However, after the financial crisis, and even more after the end of the commodity price boom, the growth rates of Brazil, Russia and South Africa fell sharply, and have remained low since then while that of China has remained elevated. The slowing down of the three resource exporters could have expected given our result that commodity exporters tend to grow more slowly.

More in general, the deep underlying differences within this group can also be seen in the index of economic complexity (see Hidalgo and Hausmann, 2009) which measures the “knowledge intensity of an economy by considering the knowledge intensity of the product it exports”.⁷

The figure below shows that of the BRICS, only one country stands out in terms of the knowledge intensity of its exports: China. Moreover, China shows a continuous improvement over time, whereas all the other members of the BRICS group have fallen back in recent years. The relative bad performance of India, which is not a commodity exporter, casts some doubts on the level of income the country will eventually be able to achieve.

The key overall conclusion is that by 2035 the BRICS is likely to have disappeared as group.

Figure 7. Knowledge intensity of export



Source: Hidalgo and Hausmann (2009).

Will the two giants continue to catch up?

The key issue for any longer-term forecast for the global economy therefore concerns China and India: can they maintain their current growth rates?

As mentioned above, human capital constitutes an increasingly important factor of production as a country advances from very low to medium or even high levels of income per capita. This is one area where China in particular has made great progress. With regard to the education of its youth, the

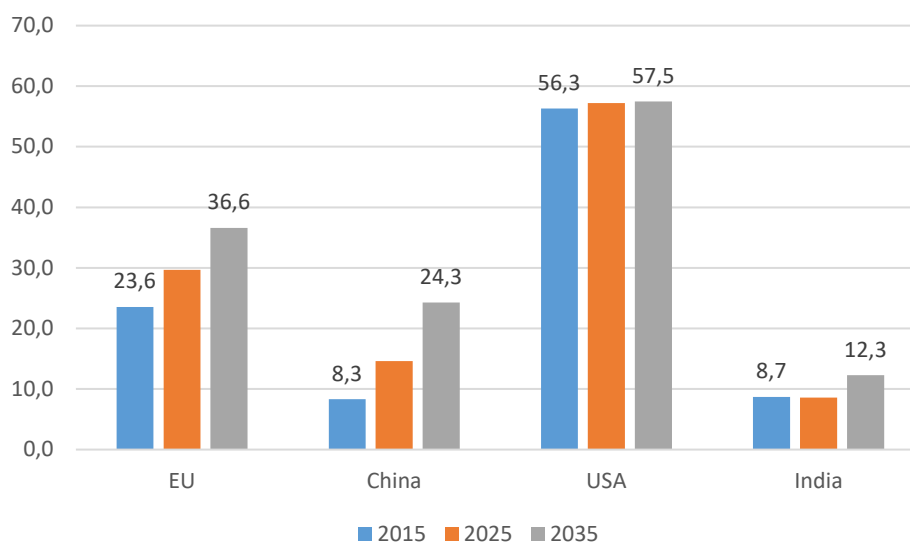
⁷ The ranking can be found at <https://atlas.media.mit.edu/en/rankings/country/eci/>

country has already achieved the goal the EU has set itself for 2020, namely that 40% of the 25-35 cohorts have attended university. However, the low birth rates documented above mean that the working age population is renewing itself rather slowly. This is why the increase in the share of workers with a tertiary education is somewhat limited.

Figure 8 below shows the projections from the updated Barro-Lee database for the four candidates to be among the biggest three economies in 2035. In relative terms, China shows the biggest predicted increase as the ratio of those with tertiary education almost triples, increasing from 8.3% to 24.3%. The EU shows also considerable progress, seeing the percentage rising from 23.6% to 36.6%. The US, by contrast, shows little progress as it seems to have reached a ceiling with over 56% of its working age population already having (at least some) tertiary education. India remains far behind, although its starting point (in 2015) is not much different from that of China. This shows the extraordinary effort currently being undertaken in China to upgrade the human capital of its population through a 'massification' of the access to university education. CEPS (2013) had already described the beginning of this process.

Education is of course not only a question of quantity, but also quality. However, the quality of tertiary education is very difficult to assess in a comparable way. For secondary education, the OECD provides an indicator based on international comparative student testing scores, namely the PISA⁸. In this indicator, China scores extremely high when results are based on four large cities. Results for a larger and more representative sample from schools across the country have been lower, but still at the top level globally, confirming the impression of a very high standard throughout the country. India, by contrast, has refused to participate in all global testing exercises. The partial participation of two Indian states in one such exercise put Indian pupils at the very bottom of all participating countries (see CEPS (2013) for more details).

Figure 8. Share of tertiary education in working age population



Source: Barro Lee updated dataset.

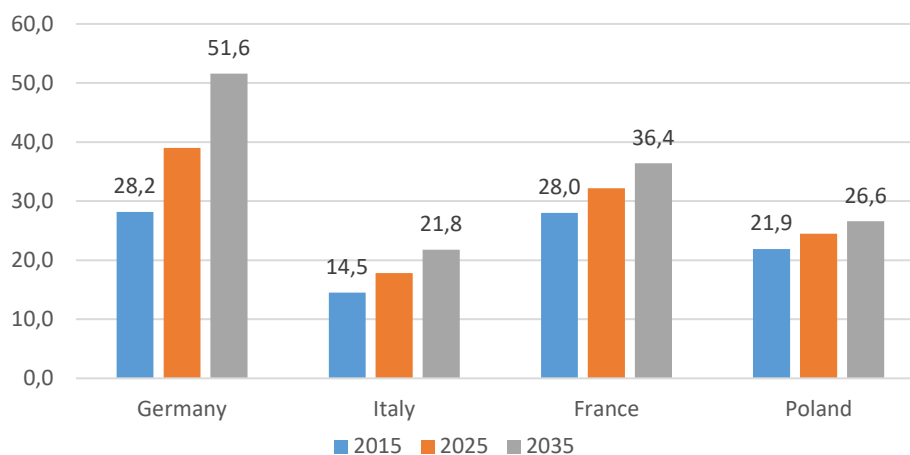
Note: EU is calculated as the unweighted average of the major old EU countries (Germany, France and Italy).

The EU average reported in the global comparison above hides of course considerable differences among Member States. These are highlighted below for four cases: the three largest euro area

⁸ See <http://www.oecd.org/pisa/data/>

countries and Poland as the biggest among the new Member States from CEEC. Whether this might be one of the factors driving divergence within the EU will be discussed below.

Figure 9. Share of tertiary education in working age population, selected EU countries



Source: Barro-Lee updated dataset.

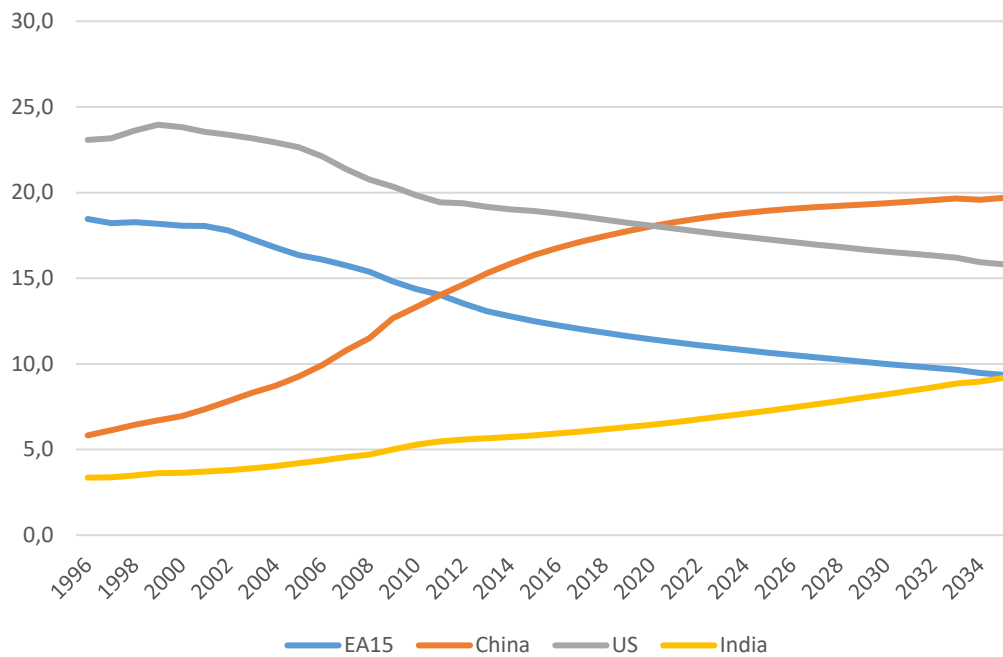
The data on human capital investment thus suggest considerable catch-up potential for China even beyond middle-income levels.⁹ For India, the very long-term potential to approach closer to the technological frontier is less clear, but given its extremely low starting point in terms of income per capita, this should not be a limiting factor for growth in a 2035 perspective.

Competing projections

There exist a number of forecasts/projections for growth of major economies over the next decades. In this section, we will show some of them. Nevertheless, some results have not changed. One common prediction is that China will become by far the largest economy by 2035. However, and this is seldom noted, the share of China in the global economy might peak around 2035 as its own growth falls, whereas other emerging markets continue their catch up. India might grow to a similar size as the EA. Given the margin of error even the EU could thus lose its place among the G-3.

One source of detailed projections is the OECD, whose predictions are summarised below.

⁹ We do not discuss separately investment in physical capital, which was covered in CEPS (2013), as there has been no material change in investment rates in India, China or most other emerging markets over the last years.

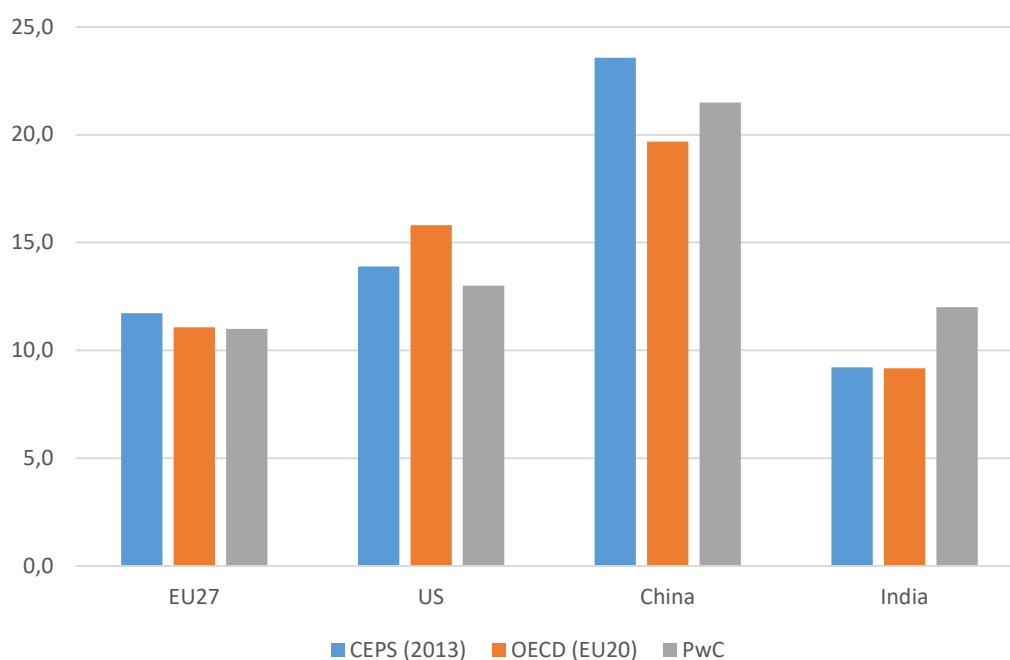
Figure 10. Projections for shares in the global economy at PPP

Source: Authors' calculation based on OECD data

Note: OECD shares adjusted to reflect shares of global economy based on CEPS (2013).

Various consultancies also provide long-term scenarios, though usually with little detail on how the results were obtained. We show here the findings of a study by PwC (2017) for comparison purpose.

Figure 11 below shows projections, from three different sources, for the US, EU, China and India, in 2035, in terms of their respective shares in global GDP at purchasing power parity (or rather a common purchasing power standard, PPS). The large differences emphasize the important of the underlying assumption and model calibration (see for example the analysis by Fontagné and Fouré, 2017).

Figure 11. Global shares in GDP, PPS, in 2035

Source: OECD, PwC (2017) and CEPS (2013).

Note: In CEPS (2013) estimates stop at 2030. OECD data available only for EU aggregate consisting of EU member states that are part of the OECD.

Given the considerably different results in the different forecasts, it might be better to formulate the outlook for the biggest economies by 2035 in the form of ranges, as percent (of world GDP):

1. China: 20-24
2. US: 13-16
3. EU: 11-12
4. India: 9-12.

Three of the ranges do not overlap and suggest that, by 2035, there should be a clear rank order with China first by some margin, the US second and two contenders for third place: the EU and India. Most projections imply therefore that the weight of the EU-27 economy will be about one-half of that of China and one third smaller than that of the US. By 2035, it might thus not be appropriate to speak of a G-3, but rather of a G-1,2,3, in which the EU is the smallest element, possibly even surpassed by India.

This is of course valid only under the assumption that growth rates are relatively stable over time. Based on section 2.2.4, this is more likely in view of the fact that these economies are not commodity exporters but export manufactured products and high rates of physical investment are coupled with a continuous upgrading of the skill level of the population.

What growth model?

Most of the projections for growth mentioned above rely on the simple Solow type model in which output is a function of the amount of labour and capital employed in the economy. This model implies that if one compares two economies, one of which has double the amount of capital and

labour than the other, it should also be the case that it produces twice the output. However, it is apparent that often economies that are similar in terms of the size of the workforce and the amount of capital available per worker have a very different output level.

One differentiating factor could be the quantity and quality of education of the workforce. This is why more sophisticated growth models also contain years of schooling as a rough indicator of the human capital embodied in the workforce. However, as mentioned above these factors can only very partially explain differences in productivity.

The differences in productivity, after having accounted for human and physical capital, represent the overall productivity with which factors of production are combined. This is called 'total factor productivity' (TFP). For the standard Solow model, TFP was taken as exogenous, and increasing at a steady rate because of the continuous accumulation of knowledge.

The 'new growth models' proposed by Romer (1986) argue that the accumulation of knowledge does not fall from the sky, but depends instead on the resources employed in activities such as R&D (see **Box 4** for a comparison of the two models). This approach formalises the common sense notion that firms will spend more on R&D and are more likely to find innovations when this promises increases in profit opportunities. The key aspect of this approach is that new ideas can be used by anybody, as technically speaking they are non-rival: a new approach to produce a cheaper battery can be used by many firms at the same time. This also implies that the incentive to invest in R&D should increase with the size of the market. This applies in particular to software. Developers will be more willing to invest their time to develop a new 'app' if they know it can be used by a billion of consumers than if it can be used by 'only' millions. This would imply that innovation activity should be stronger in large economies and it should accelerate as the economy grows.

However, the key issue is then whether or not ideas can be copied. If there is no protection of intellectual property rights, private enterprises will not invest enough in R&D since they cannot get the full benefit. The government should thus subsidise innovation, at least in a closed economy.

This approach also has implications for international trade since any new idea developed at home might also be used abroad. If the world economy is integrated, innovation activity should accelerate (and productivity growth with it). However, in this case, governments in a small open economy might no longer be willing to finance innovation because a large part of the benefits of domestically subsidised innovation might accrue to foreigners. On the other hand, if there is strong protection of property rights, firms might have the right incentives to invest, but new ideas might not be used by everyone if the market for property rights does not work well.

Overall, this new approach would imply that a large economy, like China, might naturally have a stronger innovation activity than smaller emerging markets (or those that are internally fragmented like in India). The EU market is integrated for most goods, but in the service sector many hurdles remain. This might be one of the reasons why the big social media and other tech firms started in the US. Consumer protection will remain a national competence for a long time, so this handicap of a fragmented market in services is likely to persist well beyond 2035.

Box 4. New theories of growth: Solow versus Romer?

The neoclassical theory of economic growth developed by Solow in the 1950s posits that differences in standards of living across countries are associated with different amounts of physical capital. However, physical capital only explains about one-third of the variation in income per capita across countries. The remaining two-thirds are driven by so-called total factor productivity (TFP). The Solow model emphasises that income per capita increases with the amount of machinery and equipment per worker, but less than proportionately. So while in the initial phase of development, capital accumulation generates high growth, an increasing capital stock will deliver less and less additional growth. The prediction of diminishing returns to capital was the main insight of the Solow model. According to this idea, advanced economies, where the existing stock of capital is high, additional capital investment will deliver smaller growth impulses.

The neoclassical theory has been challenged in the 1980s by Romer (1986) and the so-called new economic (or endogenous) growth theory. Romer relaunched the growth literature with a model of increasing returns in which there is a stable positive equilibrium growth rate that results from endogenous accumulation of knowledge, which he views as the main source of TFP growth. This was a quite radical break with the existing literature, in which technological progress had largely been treated as completely exogenous (for instance in Solow).

The Romer model can be viewed as an equilibrium model of endogenous technological change in which long-run growth is driven primarily by the accumulation of knowledge by forward-looking, profit-maximising firms. In contrast to physical capital, which can be produced from output, new knowledge is assumed to be the product of a research technology that exhibits diminishing returns. However, investment in knowledge generates a natural externality: new knowledge created by one firm can have a positive externality on the production possibilities of other firms. This happens because knowledge cannot be perfectly patented or kept secret and because it is a non-rival good, meaning that the use of knowledge by one person or firm does not impede its use by another.

A key result of this reasoning is that the production of goods (consumption and capital), which is a function of the stock of knowledge and other inputs, exhibits increasing returns. Doubling the amount of capital and labour would double the output. However, doubling the amount of labour and capital and knowledge will yield an output that is more than twice as large as before.

The end-result is that there might be increasing returns to scale even if there are diminishing returns to scale in the production of knowledge.

The model implies that over time knowledge will grow without bounds. It is the combination of the two assumptions that ensures a competitive equilibrium and leads to an equilibrium with positive growth.

2.3 World income distribution

There is a widespread consensus that, in the last two decades the growing performance of emerging market economies has been accompanied by an expansion of the middle class, whereas in developed economies 'rising inequality' or hollowing out of the middle class has been a growing concern (see EPRS' Global Trends, 2017). Income distribution thus appears to evolve in different ways in emerging and developed economies (see chapter 6 about inequality in advanced economies).

The middle class is indeed expanding in emerging economies, as a large share of people gets out of poverty. This does not necessarily mean that inequality is falling in these countries. Economic

growth also pushes part of the population above the 'middle class' threshold and if part of the gains is concentrated in the hands of few, also inequality increased.

This might have been the case in India, leading to reports about the lack of a middle class in India¹⁰ However, the quality of income data for this subcontinent is very poor and hence it is very difficult to verify the accuracy of this claim. Inequality would have to rise to extreme levels if the income of the poorer did not increase at all while GDP per capita increases by 5% per annum.

Recent data suggest that this has been the experience of China. The IMF¹¹ indicates that after more than two decades of spectacular economic growth, millions of people were lifted out of poverty but growth has not benefited all equally. China has moved from being moderately unequal in 1990 to being one of the world's most unequal countries. The IMF work points to rapid technological change and industrialization as well as differences in wages and educational attainment between urban and rural areas as the main causes of rising inequality. Unless adequate policies are put in place the trend is unlikely to reverse, if anything it could get worse.

It should be added that growth in emerging markets (combined with technological progress) might have increased inequality domestically and also had an unintended political consequence in advanced economies: populism, understood as political revolt of the 'white Western male' against the loss of economic and political dominance. The following chapter will document the rise of emerging economies, especially China, not only in economic terms but also in terms of human capital and the complexity of the economy.

In Europe, populism has also been fed by another phenomenon: immigration. Over the last decade, migration (often irregular) has increased, with the number of refugees increasing most strongly. In recent times, after the big refugee influx, the motives of those trying to enter the EU illegally seem to be shifting towards the economic side, with a large proportion of the arrivals in Europe seemingly using the asylum system as an entry ticket to Europe.

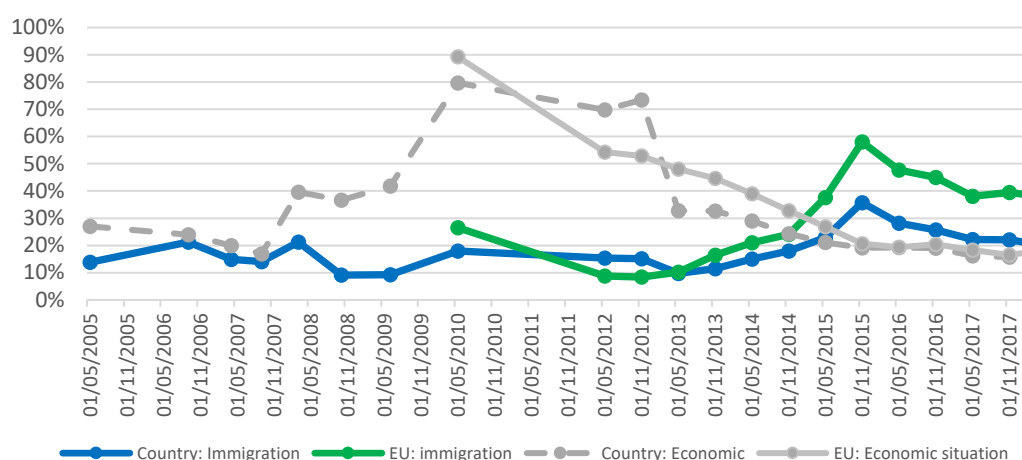
2.4 Immigration in the EU

Immigration constitutes at present a dominant problem for the EU, or at least one of the most salient and contentious issues. Massive irregular arrivals to the EU in a short period of time (2014-16), together with emotional media coverage and political discussions at the highest levels contributed to the rise in public concerns about immigration (see

¹⁰ See for instance The Economist of January 11, 2018: "The elephant in the room – India's missing middle class. Multinational businesses relying on Indian consumers face disappointment").

¹¹ https://blogs.imf.org/2018/09/20/chart-of-the-week-inequality-in-china/?utm_source=GDPR&utm_campaign=2a2fa1ea0b-EMAIL_CAMPAIGN_2018_09_21_08_52&utm_medium=email&utm_term=0_7c51e322b7-2a2fa1ea0b-278658053

Figure 12. Concerns about immigration in the EU (based on answers to the EU barometer question about important issues facing a country / the EU)



Source: [EU Barometer](#).

Does this rise in concerns indeed represent apprehension about long-term consequences of the recent and future immigration flows in the EU; or does it merely reflect a ‘news effect’, which will gradually fade away with the decline in arrivals? After all, at the end of 2017, the concerns about immigration at the country level were not much more prevalent than in 2008 or 2010.

A certain consensus regarding the effects of and future developments in EU immigration has been reached, at least, in academic and expert circles.

First, even though the 2014-16 inflow of asylum seekers was unprecedented, it was still rather small relative to the employed population, even in the most affected countries. Therefore, the tangible economic and social effects of this recent immigration wave are likely to be low in aggregate.

Second, and in contrast to the first statement, the political impact is often portrayed as severe, in particular, when referring to the apparent association between the 2014-16 inflow of asylum seekers and the rise of populist parties in a number of EU Member States.

Third, looking forward, the main concerns of massive irregular immigration to the EU relate to Sub-Saharan Africa, which continues to face high birth rates in an environment of poor institutions and failing education and infrastructure systems. Yet, when examined in more detail, a more nuanced picture emerges behind each of these three statements.

Trends in irregular and regular migration to the EU

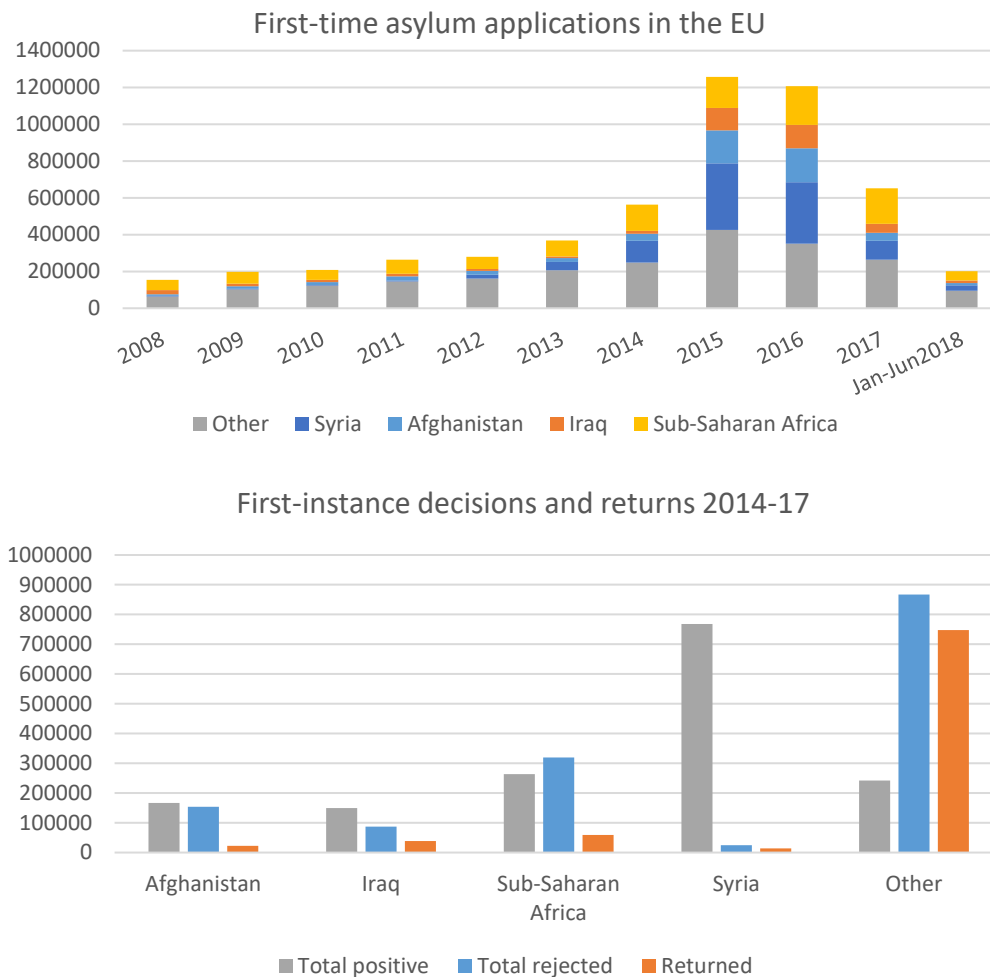
From 2014 to December 2017, the EU Member States accepted almost 3.7 million first-time asylum applications, three times more than from 2010 to 2013 (Figure 13). About 1.6 million asylum seekers were granted some sort of international protection. Nationals of Syria, Afghanistan, and Iraq accounted for 45% of all applications from 2014 to 2017 and 68% of all positive decisions.¹² Another important group – nationals of Sub-Saharan Africa¹³ – represented 20% of applicants and 16.5% of

¹² Eurostat.

¹³ Sub-Saharan Africa: Angola, Benin, Botswana, Burkina Faso, Burundi, Cape Verde, Cameroon, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Republic of the Congo, Cote d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome

all positive decisions. The increase in the number of beneficiaries of international protection in the EU is also reflected in the data on residence permits issued (Figure 14): permits for the reason of international protection fall under the 'Other' category, which increased by more than 40% between 2010-13 and 2014-17.

Figure 13. Asylum applications, positive decisions and rejections in the EU in 2008-2017



Note: The category 'Other' includes mainly asylum applicants from Balkan countries, which face high rejection, but also high effective return rates.

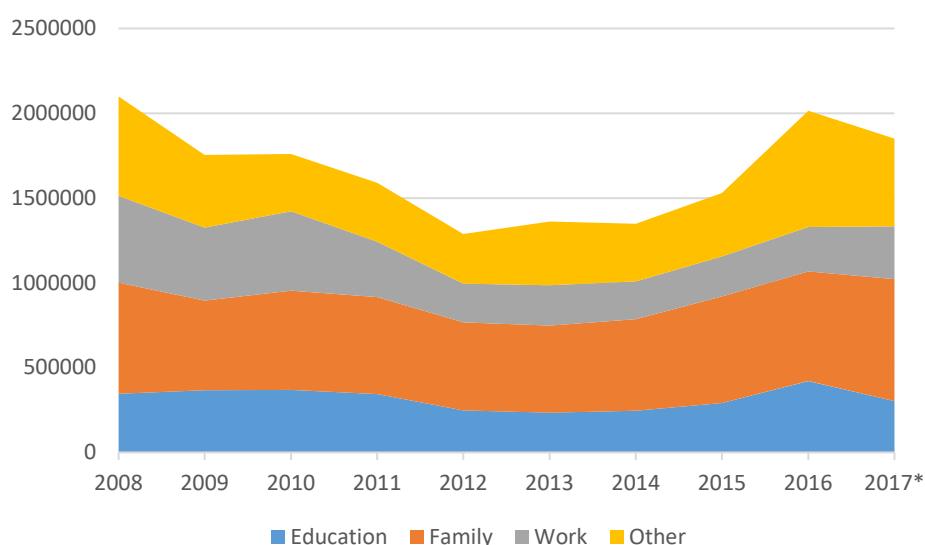
Source: Eurostat.

Regarding regular immigration, the number of permits for work reasons (with a duration of at least twelve months) decreased by 18% in 2014-17 compared to 2010-13. This was mainly driven by lower labour demand (in particular, in Spain and Italy) and the opening of labour markets to intra-EU migrants from Bulgaria and Romania. Among EU Member States, Poland represents an important exception: over 2014-2017, the country issued more than 1.5 million new work permits to the Ukrainian citizens. Most of these work permits, however, were short-term (up to one-year stay) and are, thus, not reflected in Figure 14.

and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, and Zimbabwe (World Bank definition).

Family reunification increased by about 16% in 2014-17 relative to 2010-13. However, since 2014, it is possible to observe a disproportionate increase in family reunification for Syrians: for instance, in 2017, family residence permits issued to Syrian nationals amounted to about 50,000 and represented 7% of all family residence permits issued by EU Member States. While part of this increase could be due to family reunifications initiated by the already established Syrian diaspora, the most recent family migrants already relate to a large extent to asylum seekers from the 2014-16 inflow.¹⁴

Figure 14. Issued residence permits (duration at least 12 twelve) by EU Member States in 2008-17 by reason of migration



Source: Eurostat. Data for 2017 is preliminary (Austria and Portugal have not yet reported). The data include permits for a duration of stay over 12 months.

Thus, the observed increase in the number of immigrants in the EU from 2014 to 2017 was due mainly to the inflow of asylum seekers. At the same time, regular immigration in most EU Member States either remained stable or decreased, with the exception of Poland that issued over one million short-term work permits to Ukrainians.

The economic and social impact of the 2014-16 refugee wave on the EU is likely to be small...

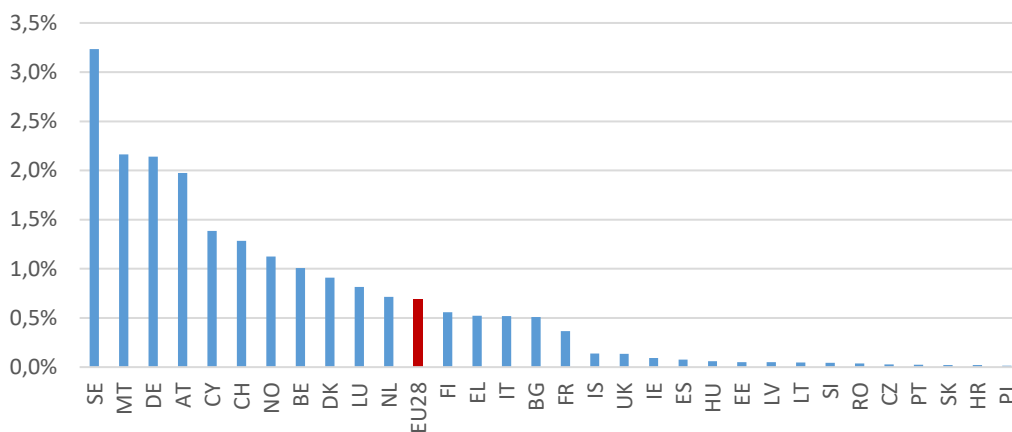
Existing research on past and the most recent refugee inflows usually finds zero or marginal effects on receiving economies (see, for instance, Clemens and Hunt, 2017 and OECD, 2018 for an overview; Staehler et al., 2017 and MEDAM, 2018 for Germany). In the first years following arrival, labour market participation of refugees is weak.¹⁵ The chances that refugees will fill so called 'labour shortages' or,

¹⁴ This could be seen, for instance, from the change in main destination countries of Syrian family migrants: in 2016, most family migrants went to the same destinations that hosted the largest numbers of asylum seekers from Syria.

¹⁵ According to the IAB-BAMF-SOEP Survey (2016), 57% of male asylum seekers and refugees were employed or actively searched for a job in their year of arrival; this number increased to 65% and 71% after one and two years respectively. At the same time, only 8% of male asylum seekers and refugees were employed in the year of arrival. After two years, this number increased to 25%. For women, the figures are smaller by far: labour

on the contrary, exert strong pressure on labour markets by competing for jobs are therefore slim in the short term. Moreover, in the medium and longer term, an immigration shock usually entails a variety of economic effects, which attenuate each other (e.g. not only labour supply, but also labour demand increases as immigrants consume goods and services; while immigrants are substitutes to some native workers, they can complement others; with time, firms adjust to the change in the workforce). It would be even more illusionary to imagine that recent refugees could substantially alleviate the 'ageing' problem: apart from lower participation rates in the short-run, refugees will also acquire their own pension rights as they work and age in the EU. Lastly, relative to the overall population, refugee inflows are small. Even if we consider the large recent wave and the most affected countries – Germany, Austria, and Sweden – the share of recognised refugees (i.e. those with prospects of staying) relative to the employed population does not surpass 3.5% (see Figure 15).

Figure 15. Refugees (recognised over 2014-17) as a share of the EU employed population



Note: We count as 'recognised refugees' all asylum seekers (all age groups) with a positive first-instance decision on the application. We calculate the share to the employed population as of 2017, aged between 15 and 64.

Source: Eurostat.

Even though the net fiscal redistribution to the refugee population might be positive, especially in the first years following arrival (due to higher public costs for housing, education, or health and lower public per capita revenues), the relatively small size of the refugee inflow limits possible effects on the welfare state. Aiyar et al. (2016), for instance, estimate that, in 2016, the short-term fiscal costs related to asylum-seekers and refugees constituted about 1% of GDP in Sweden and 0.3% of GDP in Germany and Austria. It is plausible that annual fiscal costs for EU member states will decrease in the longer term (provided no further major inflow of asylum seekers occurs), as more refugees from the 2014-16 wave enter the labour market and start contributing themselves.¹⁶

force participation – 34% in the year of arrival, 36% after one and 37% after two years; employment – less than 8% two years after arrival.

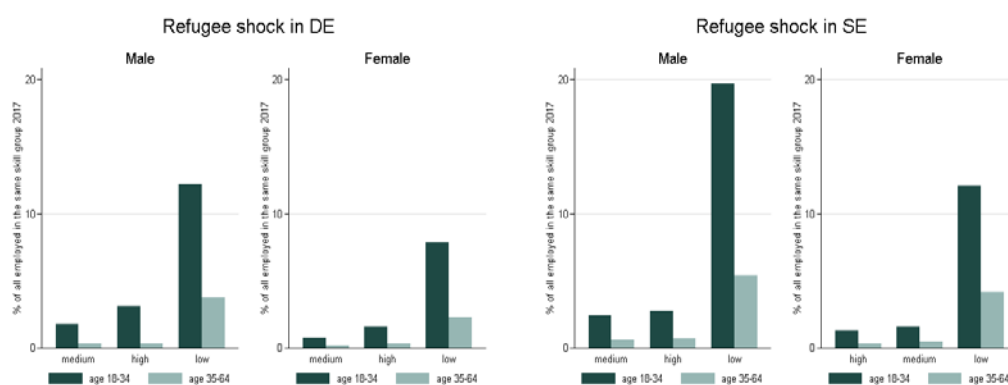
¹⁶ Fiscal costs may well stay high if refugees (and members of their families) remain out of the labour force or stay in low-paid occupations. It should be also acknowledged that estimation of fiscal impacts is complicated due to the necessity to account for multiple factors, feedback effects, and uncertainty about the relevant time horizon.

...but

There are at least three potential challenges related to the 2014-16 refugee wave that might lead to important consequences in the future: i) overrepresentation of low-skilled men among recent refugees; ii) future inflow of family migrants; iii) high number of rejected asylum applicants coupled with low effective return rates. While these challenges will still play out locally or affect only certain groups of the native population, they are likely to draw wider public attention and, hence, could have strong political repercussions.

The recent refugee inflow has been to a large degree homogeneous (Barslund et al., Forthcoming and OECD, 2018). According to the IAB-BAMF-SOEP 2016 survey in Germany, low-skilled men and women account for more than 50%.

Figure 16. 'Refugee shock' within a skill group (by age, gender, and education) in Germany (DE) and Sweden (SE)



Note: In numerator: refugees, 18-34 and 35-64 years old, recognised over 2014-17 in Germany/Sweden. In denominator: employed population, 15-34 and 35-64 years old, as of 2017 in Germany/Sweden. Slight misalignment in age groups is due to data availability. Low-skill – Isced 0-2 (up to secondary school); medium-skill – Isced 3-4 (vocational degree); high-skill – Isced 5-6 (university).

Source: Barslund et al. (Forthcoming) using IAB-BAMF-SOEP Survey, 2016 refugee sample and Eurostat.

Low-skilled men aged between 18 and 34 represent over 30% of all arrivals. Thus, in terms of the potential labour market impact, the 'refugee shock' is mainly concentrated in one skill group. Within this group immigrants/refugees can be important: In Sweden, low-skilled young male refugees recognised from 2014 to 2017 amount to almost 20% of the employed from the same skill group. In Germany, this number is over 12%. Among the native population of these countries, low-skilled young men represent a relatively small group.

Such concentration is risky especially if labour markets are segmented and low-skilled young refugees compete for jobs mainly with the native population or other immigrants of the same age, gender, and education. Notably, the unemployment rate among this skill group is over 2.5 times higher than that of the EU average (19% vs. 7.8% as of 2017).¹⁷ This is also a group likely to be considerably affected by import competition from developing countries and technological change. In this way, upgrading the skills of both refugees and of the native population (at least to medium-

¹⁷ Eurostat, lfsa_urgaed. Unemployment rates of young (15-39 years old) low-skilled men vs. unemployment rates of all individuals between 15 and 64 years old.

skill) would be a critical step towards avoiding negative longer-term outcomes, either in the form of high unemployment among refugees or strong pressure on the vulnerable group of the native population – both of which foster negative public attitudes toward refugees.

Future inflows due to family reunification may amount to 13-27% of the working age refugee inflow from 2014-16 (OECD, 2018). For Syrian refugees, the OECD predicts a future family inflow equal to 50% of the Syrian refugee wave. Qualitative studies often emphasise negative impacts of family separations and contend that family reunification can result in substantial increases in quality of life and possibly better labour market outcomes for immigrants.¹⁸ However, the economic and social integration of incoming family migrants (mostly women) will require particular attention (and among them, funding for language training and professional insertion), as this group of migrants have traditionally experienced integration challenges in many EU Member States.¹⁹

The number of rejected asylum seekers in the EU may surpass 1 million by 2020 (OECD, 2018). With the exception of a few nationalities (only nationals of Syria, Eritrea, and Yemen had a recognition rate of at least 70% from 2014 to 2017), asylum-seekers from the recent inflow have faced high rejection rates in the EU Member States. Moreover, as Figure 13 illustrates, the number of rejected applications significantly surpassed that of effective returns, in particular for those coming from African countries. Such a situation poses several problems. First, it creates a wrong incentive for non-refugees to set out on an irregular journey as reaching Europe *de facto* means almost certain prospects of staying. Second, rejected asylum-seekers have high chances of becoming involved in the underground economy and irregular activities, which again spurs negative attitudes among the native population towards immigrants. Third, forced return operations are difficult to implement, and these episodes are often covered by the media, making the issue salient for the general public. For policy measures, it is important to distinguish between existing and future asylum seekers. One of the options to curb *future* irregular inflows is to ensure effective readmission agreements with the main countries of origin of irregular migrants and provide options for legal migration. This requires joint EU efforts (MEDAM, 2018). Regarding rejected asylum seekers already in the EU, the emphasis could be put on incentivising voluntary return, provided their rights, freedom, and security in the countries of origin could be ensured. Legalisation programmes targeting asylum seekers already in the EU might be needed, however, and these programmes should be coupled with the above measures to prevent future inflows.

Political consequences of the 2014-16 refugee wave might be severe

Although the actual economic and social effects of the 2014-16 refugee wave are likely to be marginal, this immigration shock could still have strong political implications by contributing to the rise of populist parties and creating tensions between EU Member States. Yet such effects are not unique to the recent refugee wave.

A number of studies conducted with data from different countries, over longer time periods, finds a robust positive association between an increase in the share of immigrants in the population and the vote for extreme right parties.²⁰ The main concerns relate to the fear of labour market

¹⁸ See for instance the [following report](#) by Mixed Migration Platform.

¹⁹ See, for instance, Barslund and Laurentsyeva, (2018)

²⁰ See for Denmark – Dustmann et al., 2016; Austria – Halla et al., 2017; Germany – Steinhardt and Otto, 2014; France – Edo et al., 2018; Italy – Barone et al., 2016. Several studies (e.g. Steinmayr, 2018), albeit a smaller

competition, deterioration of public amenities, and cultural clashes. However, the effects are usually the strongest among low-educated individuals and in more disadvantaged areas, i.e. already experiencing relatively higher unemployment rates or crime.

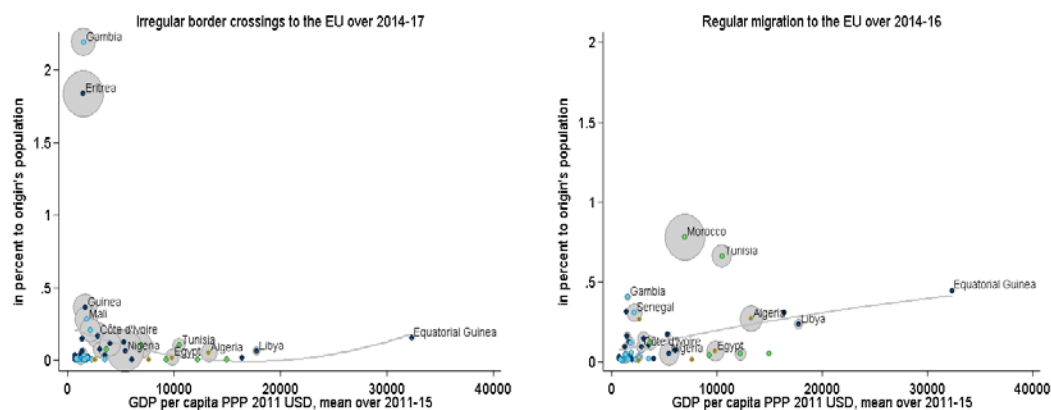
Immigration projections up to 2035

Regular migration: Labour migration will remain mainly driven by demand in EU Member States, as the existing migration system is tied to employers. Whether the EU will become more attractive, in particular for highly-skilled immigrants, depends on whether the returns to skills in the EU can become more competitive relative to the USA, UK, and China. This is directly related to the development and regulation of innovative industries (see the Chapter 4). As outlined above, one can expect a rise in family migration in the coming years proportional to the number of asylum-seekers recognised from 2014 to 2017.

Irregular migration: African countries are often considered the main source of future irregular migration to the EU. Although the peak population growth rate in the continent occurred in the mid-1980s, Africa will keep experiencing steady population growth until 2100. The majority of population growth will be concentrated in Sub-Saharan Africa, where the low quality of institutions makes it challenging to ‘convert’ population growth into economic growth. This raises concerns about future migratory pressure on the EU.

Such pressure, however, will be limited in the coming years. First, a lack of financial resources will continue to constrain migration from the poorest African countries.

Figure 17. Irregular and regular migration from Africa to the EU



Note: the grey circles are proportional to the absolute number of irregular/regular migrants coming over from a given country of origin. Population is taken as of 2014. Colours of the circles correspond to clusters of African countries presented in Figure 19 below. Regular migration includes residence permits issued by EU Member States for family reasons, work, or education.

Source: Frontex (irregular migration), Eurostat (regular migration), World Bank (GDP and population).

As Figure 17 shows, the data points for the poorest African countries are concentrated in the left-most corner of the graphs for both regular and irregular migration (i.e. meaning very low migration

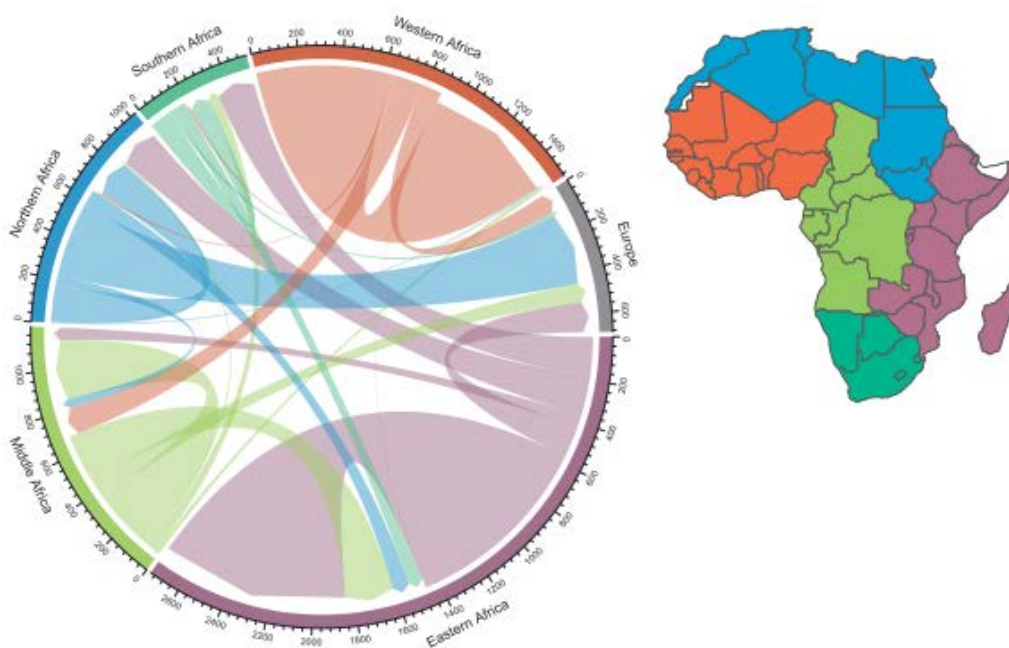
number, on the contrary, find evidence for the contact hypothesis, i.e. exposure to more immigrants decreases the support for extreme-right parties. These opposing effects can be explained by different contexts used in the analysis. Better-off areas (i.e. the largest cities) are in general less prone to developing populist attitudes.

rates to the EU and low GDP per capita). The apparent U-shape form for the relationship between economic development and irregular migration is driven by a few relatively small Sub-Saharan African countries with relatively well-established diaspora in the EU. Regular migration is possible either through family reunification or for highly-skilled individuals.

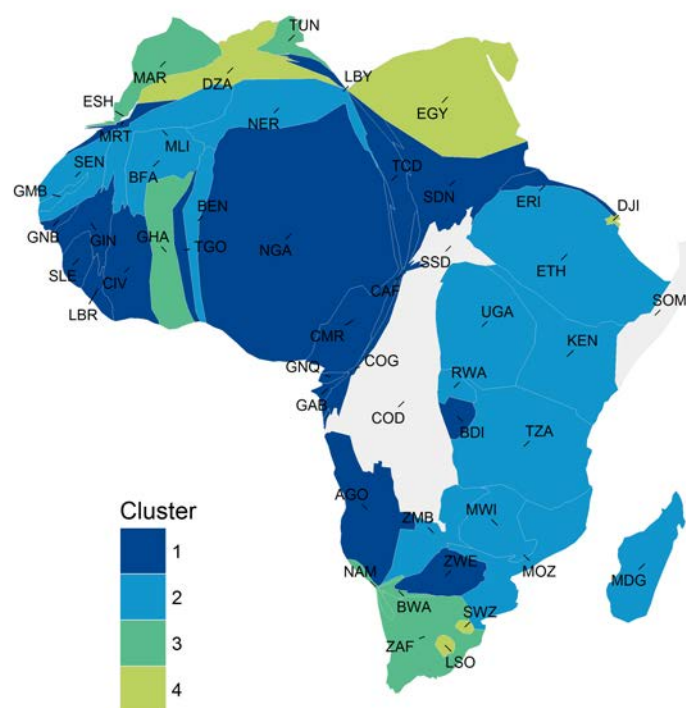
Second, past migration patterns will strongly influence future migration flows, and the EU has not been the major destination for African emigrants (apart from several countries with strong colonial links). The most important migration flows are intra-regional (see Figure 18). Most of the pressure due to population growth in Sub-Saharan Africa will fall on relatively more developed countries in the region.

Third, as **Figure 19** illustrates, African countries differ in their potential to convert future population growth into economic growth, mainly due to existing differences in the quality of institutions. Thus, economic inequality between African countries is likely to increase in the years to come, which will further stimulate internal migration. An open question remains whether future economic growth in better-off countries will be able to absorb growing populations or whether some countries, like Nigeria, will instead pull the continent down.

Figure 18. Migration flows within Africa and from Africa to the EU (in 1000), 2013



Source: MEDAM (2018).

Figure 19. Within-Africa heterogeneity and future population projections

Note: Countries' areas are proportional to predicted population (zero migration scenario) as of 2050, based on United Nations, Department of Economic and Social Affairs, Population Division (2017).

The four clusters of countries are identified based on several institutional indicators: ease of doing business, labour market integration of young adults (using the employment rate of 15-24-year-olds as proxy), voice and accountability, rule of law, control of corruption, political stability, government effectiveness, government expenditures on education and health, availability of improved water sources. Countries in different clusters are expected to differ in economic performance over the following years.

Cluster 1 – the most problematic group on all considered institutional dimensions. Over the past ten years, countries within this cluster had an average growth in GDP per capita of about 1%. It is unlikely that population growth will lead to substantial economic growth.

Cluster 2 – the group features a favourable business climate, good integration of young adults in the labour market, and while experiencing problems with government effectiveness, shows signs of positive institutional developments. Over the past ten years, this cluster had an average growth in GDP per capita of about 2.6 percent. If positive developments continue, the cluster has the potential to benefit positively from population growth and to partly absorb population growth from 'Cluster 1' countries.

Cluster 3 – the strongest group in terms of institutional development: favourable business climate and strong institutions. Over the past ten years, this cluster had an average growth in GDP per capita of about 2.8 percent. Economic growth is expected in the coming years. Potential threats could come from instability in neighbouring countries.

Cluster 4 – business climate and infrastructure investments are similar to Cluster 2, but high youth unemployment and problems with institutions still persist, which may substantially lower growth potential in the coming years. Over the past ten years, the cluster had an average growth in GDP per capita of about 2.3 percent.

Source: MEDAM (2008). The figure was kindly provided by David Bencek (Kiel Institute for the World Economy and MEDAM).

3 Vulnerable globalisation and an 'economic G3'

Recent events have unfortunately confirmed that globalisation is 'vulnerable'. For several years, trade volumes have declined and, more importantly, the US President is challenging, almost single-handedly, the multilateral trading system. Trumpian protectionism is not based on classic domestic political economy pressures.

The relative stagnation of trade volumes should not be a concern. CEPS (2013) showed that one should expect that 'globalisation' has naturally reached a plateau (in terms of trade to GDP ratios) as traditional export-led growth emerging economies (mainly China today) are turning towards domestic activities.

The concept of 'globalisation' needs to be extended to the exchange of technology and ideas. According to Baldwin (2017), this new form of globalisation risks cutting up value chains in an unpredictable way, thus introducing a fear of job losses even if few are actually lost.

Expansion of trade is driven by 'South-South', (where China is counted as 'South') trade, i.e. trade between emerging economies, as they are growing much more strongly than the developed economies.

3.1 The global trading system

It is difficult to discuss the likely long-term evolution of the global trading system when the still pre-eminent economic power of today is actively stoking trade tensions with the other two members of (today's) G3, namely China and the EU.

However, there is little reason to assume that the current transatlantic trade tensions will become so engrained that they persist until 2035. The EU and the US are fairly similar in terms of level of technology, wages and the way markets determine investment and production decisions. It is therefore difficult to see strong vested interests pushing for protectionist measures against the other. Moreover, the very high level of transatlantic ownership of large parts of industry means that transatlantic trade is dominated by intra-firm trade flows. The insight that profits generated from production and exports stem from partially foreign subsidiaries should contain demand for protection.

The political economy of reciprocal FDI thus favours open trading systems, and this force should continue to operate given that the stocks of FDI are huge and FDI flows continue.

Against this benign view, one has to set the fact that the term 'globalisation' has become increasingly contentious, at least in advanced economies. However, the nature of the opposition to globalisation seems to have changed. It is no longer specific to some well-identified sectors (like textiles in the past) or occupations (like steel workers).

Baldwin (2016) argues that the 'new' globalisation, based on offshoring of specific tasks of the value added chain, would indeed produce a generalised sentiment of insecurity, rather than the organised pressure from specific sectors for protection against imports.

Box 5. The New Globalisation's Very Different Economic Impact

Baldwin (2017) that 'this time is different'.

His main thesis is that it was flows of knowledge that changed globalisation and ICT that allowed the knowledge to flow. The new know-how flows explain the very different impact of the new globalisation. There are four differences between the old and new globalisation that stand out.

Globalisation's impact has become more individual, more sudden, more uncontrollable, and more unpredictable. It is more individual since it does not just happen at the level of sectors and skill groups. Globalisation during the Great Transformation was felt at the level of sectors – say, semiconductors, or earthmoving equipment, since foreign competition showed up in the form of products that were made in particular sectors. Moreover, since some types of labour – say, unskilled labour – were more important in some sectors than others, globalisation's impact tended to fall unevenly on skill groups. In the post-war period, for example, globalisation tended to help skilled workers and hurt unskilled workers.

With the new globalisation, extra competition and opportunities can hurt workers in one stage of production, while helping workers in other stages in the same firm. To put it differently, the new globalisation operates with a finer degree of resolution. It creates winners and losers as before, but they are not as clearly lined up with winning and losing sectors, or winning and losing skill groups. The new opportunities and competition are more individual. Added to this is the increasing speed of this process.

Before the ICT revolution, globalisation only transformed societies slowly. The "change-clock" ticked decade by decade. Since the ICT revolution, the change-clock ticked year by year. Industrialisation took a century to build up in the advanced economies. Deindustrialisation and the shift of manufacturing to emerging nations took only two decades. The reason for the unprecedented speed was the unprecedented nature of globalisation. The emerging markets were not industrialising the way the G7 nations had in the twentieth century. Much of the emerging-market manufacturing take-off, especially in the beginning, was coordinated by G7 firms.

Another defining feature of this new globalisation was that it was less controllable. Governments had lots of tools for monitoring the passage of goods and people across borders but very few tools for controlling firms' knowledge crossing them. And since it was the advance of ICT that drove this new globalisation, governments had few practicable tools for controlling the pace.

Lastly, new globalisation was more unpredictable. Since the 1990s, it has been hard to know which stages of a manufacturing process will be offshored next. This changed nature of globalisation created a generalised sense of vulnerability in advanced economies. No one in the manufacturing sector could really be sure that their job would not be next.

Finally, there is reason to fear that the present 'economic G3' will not be 'leading' because none of these three actors will be large enough to become a 'benevolent hegemon', and a generalised adoption of 'me first' policies would be prevalent.

This combination of a diffuse anti-globalisation sentiment with the absence of strong vested interests in keeping the multi-lateral system in place might foster a string of unilateral actions taken by the major trading powers. The protectionist turn in US policy under Trump might therefore not be a fluke, but the harbinger of a trend.

Tariffs had become largely obsolete, until recently. The question is whether they could experience a durable comeback. According to the 'new globalisation' paradigm, tariffs are anyway no longer a useful instrument to protect workers from globalisation. Tariffs (and quotas) had been useful to delay the adjustment, for example in the clothing sector, because they made imported goods more expensive. However, tariffs on intermediate products would do little to encourage domestic production when a large part of the components of the value chain are imported. In this case, tariffs mainly increase the domestic costs of production and might actually drive even more production offshore.

Tariffs on imported intermediate goods, such as steel, would thus do little to address the offshoring problem. Tariffs on final goods might lead to some relocation of production to the home country, especially if the domestic market is large.²¹ But this comes at the expense of higher prices for consumers. However, it remains to be seen whether the 'new protectionism' is driven by rational economic calculus, or whether it represents mainly a '*cri de coeur*' against anonymous market forces.

3.2 Intellectual property, the new battleground for trade wars?

Over time, data flows and market access for services (internet-based services) might become the key battleground. Even today they constitute an important point of attrition.

The key accusation levelled at China is that it forces major foreign high-tech enterprises to reveal their intellectual property if they want to be present in the country. Why is this a key issue for the US?

Consider the case of a dominant player in social networks or in search engines. The cost of entering a new market is essentially zero as the existing software can easily serve many more millions of users (this theme is taken up further in chapter 4). All that needs to be done is to translate the interface into yet another language. This means that entering new markets means mostly more profits for the 'winners'. Requiring them to reveal their software would destroy their business model.

In a competitive industry, by contrast, the cost of producing and selling more abroad is close to the price, so that there are few excess profits that could be taken away. This means that the gains of opening new markets are relatively limited in competitive industries. The lobbying by potential exporters to have better access to countries with high tariffs has usually been muted. This is why India's protectionism has never encountered much attention. However, the owner of a 'winning' intellectual property foregoes very large profits if a big market, like China, remains effectively closed.

²¹ During the early summer of 2018, the business press reported that the maker of the iconic US motor cycles Harley Davidson announced that it would re-locate production outside the US in response to EU countervailing measures to US steel import tariffs. Costs for the company had increased due to the steel tariffs imposed by the US, and market access to the EU had been endangered at the same time due to EU countermeasures. This provides an example of the unintended consequences of protectionism in an interconnected world. It remains to be seen whether the announcement will actually be implemented. The subsequent standstill agreement between the US and the EU of July 2018 should have reduced the fear of a loss of market access in Europe.

This difference in profit opportunities explains why trade conflicts become more acute in a 'winner takes all' economy. In such an economy, trade policy is about re-distributing rents; jobs and the interests of consumers come second. By contrast, under competitive conditions the overall productivity-enhancing aspect of trade can outweigh the distribution of rents across countries.²²

In China, the attempt to grab the rents of foreign multinationals has motivated the requirement that they reveal their intellectual property if they want to enter the domestic market.

However, why has there been so little pressure in Europe on the same US internet giants to reveal their intellectual property? This is not only due to a stronger respect of property rights, but also different incentives. In China, the benefits from either shutting out or accessing the intellectual property of high-tech foreign firms accrue to national champions, which are large enough themselves to make the most out of this knowledge. In Europe, by contrast, there are no 'European' champions, making it less attractive for EU authorities to follow the Chinese example.

A priori, the EU and the US (and all OECD countries) have a joint interest in protecting the intellectual property of their multinational firms operating in China. However, the degree of interest is very different. European exporters and investors operate mainly in the manufacturing sector, where profit margins are low. Even 'high-tech' German car companies have profit margins in the single digits. By contrast, the margins for the biggest US high tech firms, like Google or Amazon are in the range of 50-80%. This explains why European complaints have been much more muted.

This is also the reason why a 'trade war' promises to be asymmetric so long as the US remains home to the dominant tech firms with the fattest profit margins. The US will struggle to find allies against China, given that European and Japanese intellectual property is mostly in more competitive industries.

Trade wars in the old economy might be easy to win for a country with a large trade deficit, but a war designed to force the rest of the world to open up, so that one's own dominant firms can earn higher rents will be a different proposition.

In a medium-term perspective, this might change. Given their large domestic market, Chinese providers of network services should sooner or later become competitive even in Europe or the US. In that case, it remains to be seen whether the authorities on both sides of the Atlantic will entrust Chinese service providers with the data of their consumers.

²² Of course, the 'winner', emerges out of a fiercely competitive process. Venture capitalists know that for every winner that pays back handsomely, they are likely to have lost money on dozens of 'losers', i.e. new ventures that looked promising, but did not come out on top. If venture capitalists know that a winner will be heavily taxed, they will invest less in innovation. This is why it has long been known in economics that it is difficult to establish the optimal degree of protection of intellectual property, and of the taxation of monopoly profits, as one has to weigh the advantage of making intellectual property widely available today against the incentive to invest in tomorrow's knowledge.

But these intellectual arguments are lost when there are a few well established global players which dominate an entire industry and enjoy (near-)monopoly rents.

3.3 Key role of China ... and potentially India in the long run

Forcing technological transfer should no longer be an issue by 2035 as China will by then have become a major producer of innovation itself. This seems rather likely given the massive expansion of tertiary education and rapidly increasing spending on R&D, which is already higher now as a proportion of GDP than for the EU-27.

However, if the control of the Communist Party over the economy is maintained, it might be difficult for the OECD countries to accept maintaining an open trading regime when one of the largest economies follows different rules. State-owned enterprises (SOEs) constitute the most visible part of the problem of state interference or control over the economy. A key additional element is a recent regulation that a representative of the Communist Party of China must sit on all boards of large enterprises. This could potentially furnish the Party with a way to exert its influence everywhere. Investment might be directed towards certain sectors judged a priority by the Party, prices might be set to maximise exports rather than on the basis of costs and Chinese enterprises, even if private, might be instructed to buy foreign key companies. Security considerations will also make it difficult to accept that the data on millions of US or EU consumers are handled by firms in which the Chinese government has an ill-defined role.

Moreover, the weight of India, which has traditionally been rather protectionist, will also increase considerably.

The increasing weight of the two largest emerging markets might thus put the present system under considerable strain.

One might argue that neither China, nor India, will be able to escape the 'middle income trap' unless they open up further and liberalise their economies. This dilemma might become more apparent around 2035. But, as shown above, both of these two 'elephants' have enough room to grow with their current imperfect regime to become so large that their influence on the global economy cannot be ignored. India would need only to reach one fourth of the EU's GDP per capita and it would still be as large as the (shrinking) EU in 2035.

3.4 What future for the Global Multilateral Trading System?

Even in a 2035 perspective, it is likely that trade in goods will remain a key element of the global trading system. The present system, with its low tariffs, the MFN principle (most favoured nation) and the dispute settlement provided by the WTO seems the natural set-up.

It was not always like this. 60 years ago, when the present rules-based global trading system was conceived, the world trading system looked very different. Tariffs were high and many quotas limited trade even further.

At that time, the US was the economic 'hyperpower'. Its economy was by far the largest and it exported more than the next two 'followers' combined, which were in any case two countries over which the US had considerable political clout (Germany and the UK). Japan was at the time even less important than it is today (global trade share of 3%). Moreover, the US enjoyed an unquestioned dominance in the advanced manufacturing of the day; and its large firms bought up large chunks of European industry, which had been starved of capital and investment by the war and financial repression.

It was from this position of undisputed political and economic dominance that the US decided to push for trade liberalisation, accepting, somewhat grudgingly, that it would also accept to be bound by global rules. At the time, most European policy makers were fearful of US industrial dominance and reluctant to open their economies. Nevertheless, the political and economic pressure from the US was so strong that this was done anyway.

With the recovery of the European economies, and their coming together in a 'Common Market', US dominance in trade issues became less than absolute. The growing number of countries joining the European Community (as it was called then) created a block, which would slowly rival the US in terms of trade flows (and overall economic size). Moreover, Europeans had made the experience that liberalisation went together with economic success. From the 1960s and 70s, the US and the EU thus dominated the world's trade agenda in pushing for further liberalisation. They maintained, in general, a cooperative stance because the two sides had so many other links and common interests that the overall Trans-Atlantic partnership kept trade frictions between them under control. This relative benign duopoly was first disturbed by the rapid emergence of Japan and its Asian neighbours as major competitors. Moreover, trade had grown, affecting a larger part of the US economy, which had at the same time began to run large external deficits. As a result, US trade policy became more defensive, resulting in increasing frictions with many of its partners.

Fortunately, US leaders at that time recognised the value of a liberal multilateral trading system and supported a step forward, namely the establishment, in 1995, of the World Trade Organization (WTO). The WTO represents a step forward because it deals not only with tariffs, but also with other barriers to trade, including those arising from domestic regulations, which might have only an indirect impact on trade. However, judging how domestic regulations impinge on trade is much more difficult to assess than whether a tariff has been correctly applied. This is why the WTO agreement also included a system of binding arbitration of trade disputes.

However, the WTO system of arbitration can only work if its major members recognise the value of powerful independent panels, which sometimes deliver very politically inconvenient judgements. This is increasingly in doubt.

A first reason is that one has to ask what type of country would support a rules-based system. After World War II, the US had such a dominant position that it could, and did, perform the role of a 'benevolent hegemon'. It had the power to impose the system, and it could count on receiving the largest share of the benefits in terms of economic growth. Another constellation that would support an open rules-based system is one in which there are only many small countries, none of which could hope to gain dominance by relying on their economic power. Support for a global, multilateral system with rules might thus be strongest at the two extremes: One (benevolent) hegemon or many small open economies.

The more difficult case arises when there is a small number of large economies of similar size, larger than the many small ones, but not large enough to dominate the system. Paul Krugman (1989) assessed the incentives for a few large trading blocs and arrived at the conclusion that a world consisting of three trading blocs might be the worst of all constellations if each of these blocs were to behave uncooperatively, leading to increasing trade barriers. Unfortunately, this is exactly the point at which the global economy finds itself today. There are three dominant economies or trading blocs, i.e. the EU, the US and China and each of them has a very similar trading volume, around 4 thousand trillion USD (Japan, which used to be a strong contender 25 years ago, is now relatively much smaller). Together these 'G-3' account for 40% of global trade and 45% of global GDP. Economic power is thus, by chance, distributed in such a way that a lack of explicit cooperation among the major powers endangers the present liberal and rules-based system.

A second reason why, even with a different President, the US would be less interested in supporting the global trading system is that it exports much less of the manufactured goods which were the focal point of trade policy for a long time. Trade in raw materials has always been relatively free; and trade in agricultural goods has usually been considered as special, not subject to the usual rules, such as the 'most favoured nation' (MFN) principle, which apply to manufactures. In terms of exports of manufacturing goods, the US has actually fallen behind both the EU and China. It exports annually about 1 thousand billion USD worth of these goods, against almost 1.8 thousand billion USD for the EU and about 2 thousand billion USD for China.

What should one then expect for the global trading system? It is difficult to see beyond the upheaval caused by President Trump.

The outlook in the short-term might thus be for a US which becomes a 'black hole' inside the system, having bilateral spats with most of its partners, but the rest of the world continuing under present rules. The longer-term outlook could be very different. China's leaders today proclaim their support for a multilateral rules-based trading system. However, so far no one has seen concrete action in this direction. This is not surprising. China's leaders can confidently assume that within the current generation, their country will dominate the global economy. At that point, they might no longer want to be bound by rules. Moreover, the leadership role of the Communist Party has recently been enshrined throughout the economy, with all major firms having to accept a representative of the Party on their board. It is difficult to see how a dominant economic power governed by a single

party, which aspires to dominate economic life, can accept the primacy of international rules and procedures over domestic considerations.

An erosion of the WTO system, especially its conflict resolution mechanisms, seems therefore difficult to avoid, even without the antics of Donald Trump.

China's choices regarding the domestic governance of its economy represent thus another danger for the global, rules-based system. Pervasive, but informal state control even at the individual enterprise or sectoral level will be resented by a major competitor as creating unfair competition whenever the Party (or the state) favours specific sectors in which other countries also have a strong interest.

This type of 'informal' control is different from outright control by the state in the case of State Owned Enterprises (SOE). There already exist some rules, which deal with SOEs, and provide some discipline. The TPP (Trans Pacific Partnership) agreement provides one clear example. However, informal influence through Party presence in boards and moral suasion cannot be dealt with by formal rules.

Box 6. TPP-11 as a template for the new global trading system?

The Trans-Pacific Partnership (TPP) was supposed bring substantial benefits by opening a market worth about 4/10th of the global economy. But the unspoken aim was also to create a grouping of like-minded nations that all have a market economy and some key values, notably environmental and labour standards. One additional key ingredient of the TPP is its regime for state owned enterprises, subjecting them to market discipline.

The TPP proved highly unpopular in the last US elections, with most major candidates opposing it. President Trump withdrew from the TPP as one of his first acts in office. However, under the leadership of Japan, the other 11 partners went ahead and agreed on a Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), which incorporates most of the key elements of the TPP. Most of the content of the TPP (including the SOE chapter) is thus now in force among 11 of the original participants in the negotiations. The only elements left out were essentially extended protection for intellectual property rights and patents for the pharmaceutical sector. These provisions had been inserted at the behest of the US in the original TPP. However, their economic justification had been strongly contested by many economists.

The slimmed-down 'TPP-11' is open to other countries (without a geographic limitation), but the signatories would like to keep their 'acquis' intact in case the US changes its mind. A number of countries in Asia have already indicated their interest in joining the CPTPP.

The TPP-11 constitutes a group whose combined GDP is close to that of the EU (13.5 trillion USD for TPP-11 versus about the same figure in euros for the EU-27). A CPTPPEU would cover almost 40% of global GDP, constituting an attractive market for many other countries, much like the original TPP with the US was intended to become.

For the EU, the direct economic benefits from joining TPP-11 might be limited since it has already free trade agreements with a number of TPP-11 members. These are of varying depths (Mexico, South Korea, Japan and Canada) and at varying stages of negotiation/implementation, the most comprehensive agreement being with Canada. Negotiations with Australia are scheduled to start soon.

The real motivation would be strategic. There are at present two threats to the rules-based trading system: Trump's trade actions (they do not amount to a coherent policy) and Chinese state intervention in the economy. By joining TPP-11, the EU could help create a global network of market-based countries that accept multilateralism and can keep their economies open whatever happens in the US or at the WTO. A future US administration might well be tempted to join such a large grouping, especially if in the meantime it attracts the adhesion of a number of medium sized economies. Not joining this 'global' TPP-xx+EU would be a significant disadvantage for US exporters. For China, the choice would also be clear: if it were to accept subjecting its SOEs to market discipline, it could also benefit from enhanced access to this large market.

This creates the possibility that in the long-run more and more countries may take action against what they perceive as unfair competition from China. The end result might then be a global system with China as the black hole at the centre. However, such an outcome is difficult to imagine given the sheer size of the Chinese economy and its domestic market.

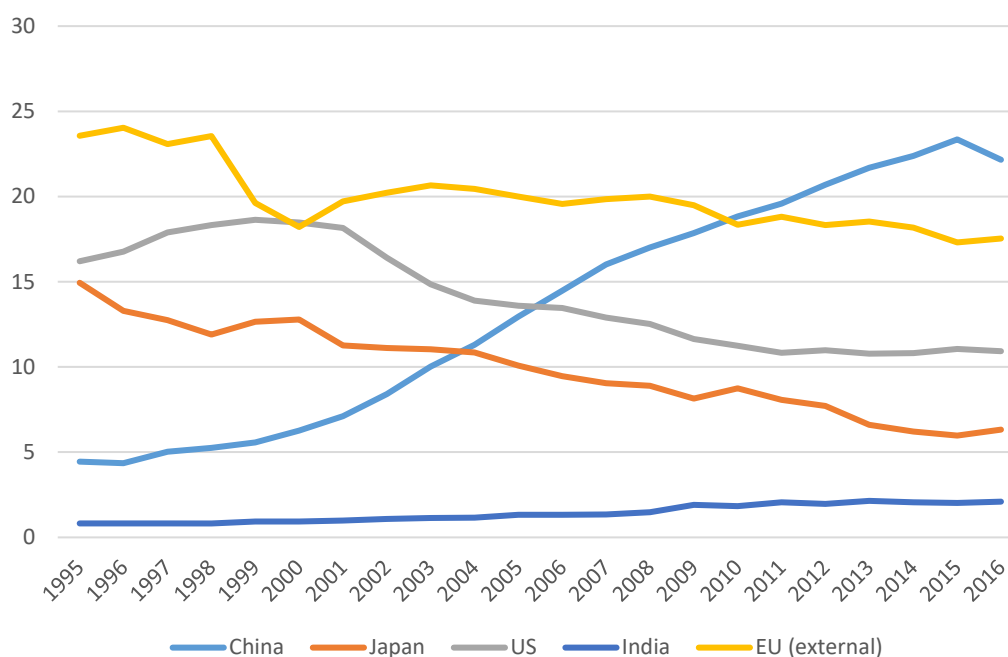
The one area where the reaction to the perception of continuing Party/state interference is likely to remain strongest is that of foreign direct investment (FDI). Most countries welcome FDI because it brings capital and is a way to import technology and know-how.

With informal Party control, it becomes difficult to accept a controlling stake by any Chinese company, because of the implicit potential that this might translate in the end into control by the Chinese government. In many cases, this might not be what is intended, but given the opaque nature of Party influence, it can never be excluded.

The challenges posed by SOEs and informal government influence in the economy are of course not totally unprecedented. During the heydays of Japanese growth in the 1980s, it was widely assumed that the Ministry for Trade was conducting an informal, but very effective industrial policy, spearheading Japanese companies into conquering new markets and sectors. This led to trade tensions, since specific sectors were perceived to receive implicit or explicit state aid (notably cheap credit), and generated a strong protectionist reaction abroad, notably by Europe and the US. Japan was forced to accept several 'Voluntary Export Restraint' agreements under which the country undertook to limit its exports of certain goods (notably cars). However, the tensions abated along with the gradual maturing of Japanese industry.

The problems posed by China today (and likely into the future) for established industrial countries are thus similar to those posed by Japan and the so-called NIC (newly industrialising countries) of East Asia during the 1980s and 1990s. What is different in the case of China is the scale and the speed of the change. In the mid-1990s Japan had about 15% of global exports in manufacturing, close to that of the US. Today, Japan's share is about one third of its initial share and in continuing decline. China is ten times as large as Japan in pure population terms and is already far above the maximum share reached by Japan. Given its large remaining potential for growth, tensions are more likely to increase than to fall.

Figure 20. Shares in global manufacturing exports



Source: Authors' elaboration based on UNCTAD.

Another factor that is likely to influence the shape of the global trading system by 2035 is the potential rise of India as a major economy and trading partner. As mentioned above, this potential of India (as compared to China) is likely to be limited by its much lower investment rates, both for human and physical capital. But as the working age population is expanding and becoming gradually equipped with at least widespread secondary education, the country seems poised for a

rapid expansion of industry and thus of manufacturing exports. CEPS (2013) had expressed the hope that India would gradually follow, with a lag of about 20 years, the path of China (and other emerging economies) which would imply a gradual opening of the economy.

However, this has only happened so far to a limited extent. Over the last few years, India's exports have stagnated. It is too early to judge whether this is a temporary, cyclical slowdown or whether the country's structural problems are already constraining the development of industry.

It thus remains to be seen whether India can also become one of the major trading economies by 2035. The protectionist tradition of its political system has so far only allowed partial liberalisation of trade and the exports-to-GDP ratio remains at less than 15%, rather small for an economy of its size and stage of development.

India has never been an active proponent of global trade liberalisation, but its type of formal state intervention poses less of a problem to the existing rules-based system because state intervention is visible and direct, whereas in China it tends to be opaque and indirect. The overt protectionism of India might thus remain less of a problem than the informal but pervasive Party influence over the economy in China.

3.5 Changing weights in the global monetary system

There are few apparent problems in the global monetary system. Financial markets have remained calm and the US dollar remains the dominant global currency. The role of the euro as a reserve currency has been stable (though it might have declined slightly more recently). But the real news might be what has not happened, namely the emergence of the Renminbi as a major reserve currency.

However, looking into the future, this is another key role that China will play. If the country keeps its capital account under control, the Renminbi cannot become a global reserve currency.

At first sight, capital account opening in China seems only a question of time. It is difficult to conceive of a very large and highly competitive economy continuing to need capital controls. Chinese authorities have several times announced that capital account opening was around the corner. But each time capital flows threatened to impair the impact of monetary policy the controls were tightened. So far, the Chinese authorities have preferred domestic stability to full capital account convertibility.

However, this could change. A real danger of instability might emerge during the 2030s if the Renminbi becomes attractive as a reserve currency. By that time, China's economic size might be much larger than that of the US and its domestic capital market should have evolved in terms of reliability and liquidity. Moreover, the US is likely to enter that decade with a huge foreign debt if its long-standing pattern of substantial current account deficits continues.

Recent research (Eichengreen et al., 2017, foreshadowed in Eichengreen, 2005) has discredited the idea that there can be only one dominant reserve currency. The emergence of a credible alternative to the US dollar should not be viewed as a source of instability per se. But the experience of Great Britain after the war shows that a combination of a loss of reserve currency status and domestic weakness can lead to considerable difficulties. The US already has a public debt-to-GDP ratio of close to 100% and has run a current account deficit for more than two decades. The deficit is at present equivalent to 3% of GDP. If it were to stay at that level, and if the growth rate of nominal GDP were to remain at about 5%, the US would accumulate a foreign debt of about 60% of GDP. This is slightly more than the upper threshold that Eichengreen et al. (2017) considers acceptable for a solid reserve currency.

These economic considerations thus point to a potential weakness of the US dollar over time. The erratic economic policies of Donald Trump add a political element. His election might have been a one-off, but it points to a weakness of the political system of the United States, which few had expected until recently.

The instability of today's dominant reserve currency is by far not the only, or even the most relevant feature of the global monetary system. But two existing trends point in this direction: the continuation of the US 'twin' deficits (current account and government finances) and the growing weight of China. Moreover, China is developing sophisticated financial markets. For the time being, they are separated from global markets by capital controls. However, when the controls are lifted, the domestic infrastructure needed for a reserve currency might become quickly available.

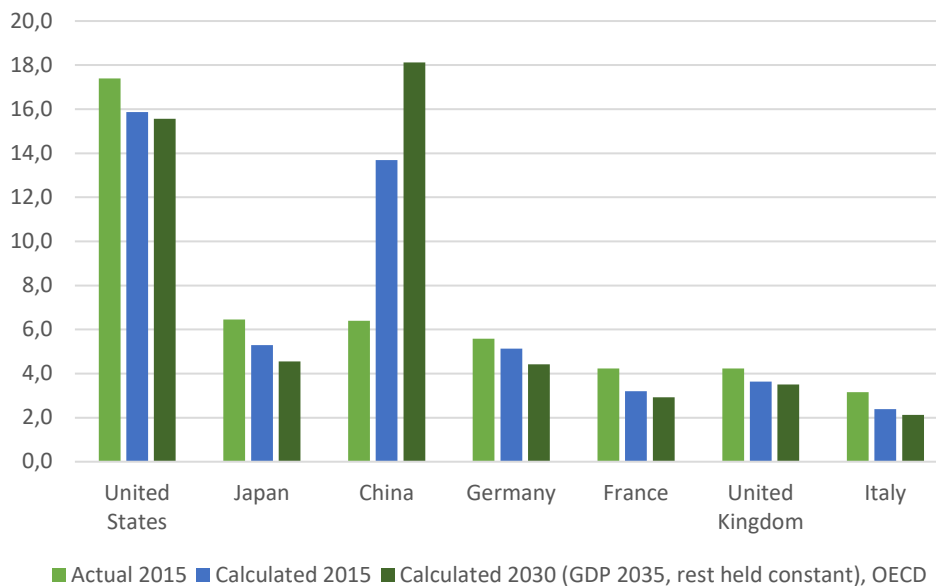
The euro might of course also benefit from any dollar weakness. However, the existence of the euro as a minor 'adjunct' reserve currency is unlikely to have a significant effect on the global monetary system and increased reserve holdings are unlikely to have a major impact on the European economy.

3.6 Shifting weights in the global financial institutions: the case of the IMF

The governance of the global financial institutions accords a disproportionately large weight to Europe, or rather the Member States of the EU. This is mostly a legacy of the past, when even individual European economies could have a significant impact at the global level. Today that is less and less the case.

The most visible way in which the governance of the global monetary system no longer reflects the actual weights in the global economy is the distribution of the quotas or shares in the International Monetary Fund (IMF). Figure 21 below provides an overview of the actual quotas (as of 2015), the theoretical quotas these countries should have if the IMF's own formula had been applied and, finally, the theoretical quota that would result if shares in the global economy were to change in the direction predicted by the OECD.

Figure 21. IMF quotas, actual and projected – selected countries



Source: own calculations based on IMF data.

The upshot is that China would naturally have the largest quota, simply because it will have become the largest economy.

The statutes of the IMF prescribe that its seat should be in the country with the largest quota. This would imply that, eventually, the IMF would have to move its headquarters to China.

Box 7. The future of the World Bank

The World Bank and the IMF are often called the Bretton Woods 'twins' because they were designed together and have parallel governance structures. The influence of Europe in the World Bank is thus also destined to wane.

However, more importantly, the future role of the World Bank itself seems destined to change. If the growth projections discussed above materialise, more and more countries might no longer need World Bank loans. China already clearly no longer needs them, but World Bank lending to that country is being wound down only very gradually. Something similar might happen with India by 2035, reducing the role of the World Bank, de facto, to an African and perhaps Latin American Development Bank.

3.7 Geo-strategy and the global economic order

This study concentrates on the economic trends. Hence, we have also concentrated on the economic aspects of globalisation and trade policy. However, it appears that trade policy is not only driven by economic considerations, but also more political ones, especially geo-strategic issues.

The key problem here is that China is threatening US pre-eminence, prompting a hostile reaction from the US. This is often called the 'Thucydides Trap'. The subtitle to Allison (2017) encapsulates the issue well:

"When one great power threatens to displace another, war is almost always the result -- but it doesn't have to be"

The 2017 US National Security Strategy also brings out this geostrategic rivalry:

"For decades, U.S. policy was rooted in the belief that support for China's rise and for its integration into the post-war international order would liberalize China. Contrary to our hopes, China expanded its power at the expense of the sovereignty of others....."

It thus cannot be excluded that for some time US trade policy might be determined more by a feeling of geostrategic rivalry, rather than standard protectionist logic. US

One scenario that cannot be excluded would be one in which trade is constrained between China and the US, but remains free and subject to existing multilateral rules otherwise. Since bilateral China-US trade constitutes only a fraction of global trade such a separated system might work. However, reforming the multilateral institutions, such as the WTO would become impossible, which would weaken the multilateral rules unless China and the US agree to disagree and the WTO is explicitly taken out of the bilateral rivalry.

It is highly unlikely that disruptions to bilateral US-China trade will have a large impact on overall Chinese growth rates. Growth in China is now driven mainly by domestic factors and the US accounts only for about one fifth of Chinese foreign trade. Constraints on Chinese direct investment in the US are anyway irrelevant for the Chinese economy itself. Less US investment in China might lead to a slower rate of transfer of technology and know-how. But European firms often have similar technologies, except in certain ICT fields and, as documented above, China is developing very rapidly massive resources for indigenous innovation and R&D.

It is of course not certain that China's growth rates will continue along the slowly declining path assumed here. A more sudden and permanent slow-down cannot be excluded, but trade frictions per se are unlikely to lead to this outcome.

We showed above that already today China exports about twice as much in manufacturing goods as the US (and 50 % more than the EU). Moreover, by 2035 the GDP of China might well be twice that of the US. By that time, it should have become apparent that the (unilateral) American attempt to contain the rise of the Chinese economy has been futile. It thus does not seem to be in the interest of the US to continue this 'trade war' for too long.

4 Industrial and technological transformation

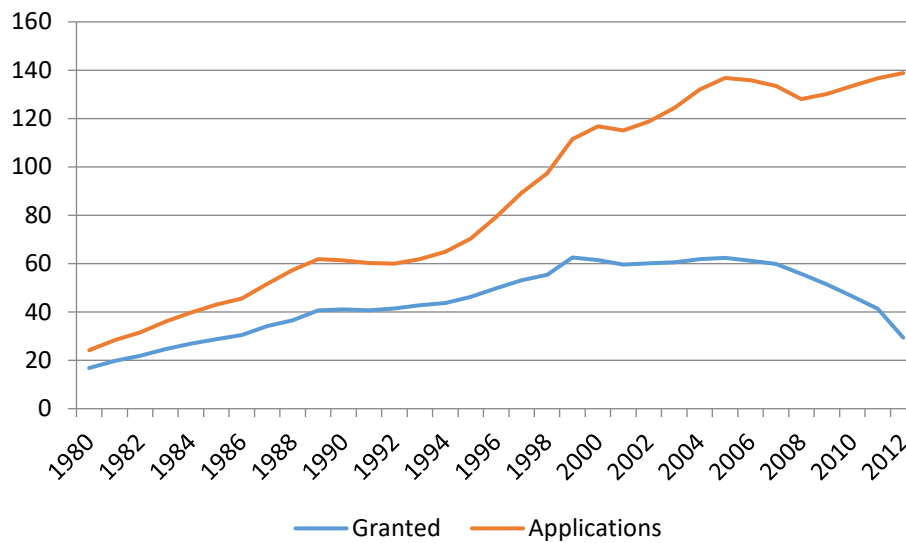
Technological progress seems to be accelerating and its nature appears to have changed. Recent advances have been mainly in software and artificial intelligence (AI). However, measurable productivity growth has still not picked up. One question is whether this could change soon. Is it possible that TFP growth will accelerate? One development over the last few years concerns the ability of software to mimic human brains. There might be hype around the deployment of AI, but some economically important tasks, such as driving a car or a truck, seem certain to be taken over by machines by 2035. Related to the emergence of AI in practical applications is the importance of data, i.e. the availability of vast amounts of data for deep learning and the commercial importance of information on potential consumers in general. A connected potential trend is the dominance of large first movers, whose position might become impossible to attack given that they already have most of the data.

Has technological progress accelerated? This question is surprisingly difficult to answer. One way to address this question is to look at **patents**.

The length and value of patent protection varies from country to country. There are thus very different national patterns in terms of how readily firms will apply for patent protection, which implies that in most cases the know-how can no longer be kept secret. Filing in just one country carries the risk that imitators elsewhere will be able to use the invention, so many patent applications concern inventions that are only of local importance. However, a patent application which grants protection globally should indicate something more important. This is why one cannot directly compare data from national patent offices; one should look instead at those that seek global protection. This can be achieved through filing under the IPC, the Patent Cooperation Treaty, which is an international patent law treaty (concluded in 1970). It provides a unified procedure for filing patent applications to protect inventions in each of its over 150 contracting states.

Filings under the IPC have grown continuously, rising from about 90,000 in 1999 to about 200,000 in 2013, more than doubling over this 14-year period. In this sense, technological progress has accelerated. If this growth rate were to continue, one would expect that patents should double again by 2035. Patent data (and the outlook for further increases) thus suggest that the supply of innovations is increasing all the time.

A very different picture emerges, however, if one looks at the number of patents actually granted. This number has in fact diminished in the US and Europe. Figure 22 below shows the longer-term trend for the European Patent Office. Until about the turn of the century, the number of applications and the number of patents granted (by all applicants) increased in parallel. Since about 2000 the number of patents granted peaked, first stagnated, and more recently has actually declined, whereas the number of applications has continued to increase throughout (with only a short interruption during the financial crisis).

Figure 22. European Patent Office (thousands of patents)

Source: OECD.

Data for the USPTO show a similar trend, so for the two major patent offices for which this data is available, the ratio of filings to granted patents has deteriorated continuously.

The reasons for the increased rate of rejection are not clear. It could be a change in policy, but it is also possible that fewer and fewer of the ideas presented deserve protection. This would suggest that there are diminishing returns to investing in innovation as more and more filings, or applications for protection are rejected. The conceptual problem was already discussed carefully in Griliches (1989), who, however, does not come to a clear conclusion.

Box 8. Beware of patent data

Data on patents has to be viewed with caution. Different sources often show very different numbers because they refer to slightly different concepts. Residency versus nationality of the inventor, place and date of first filing, when protection was granted, etc.

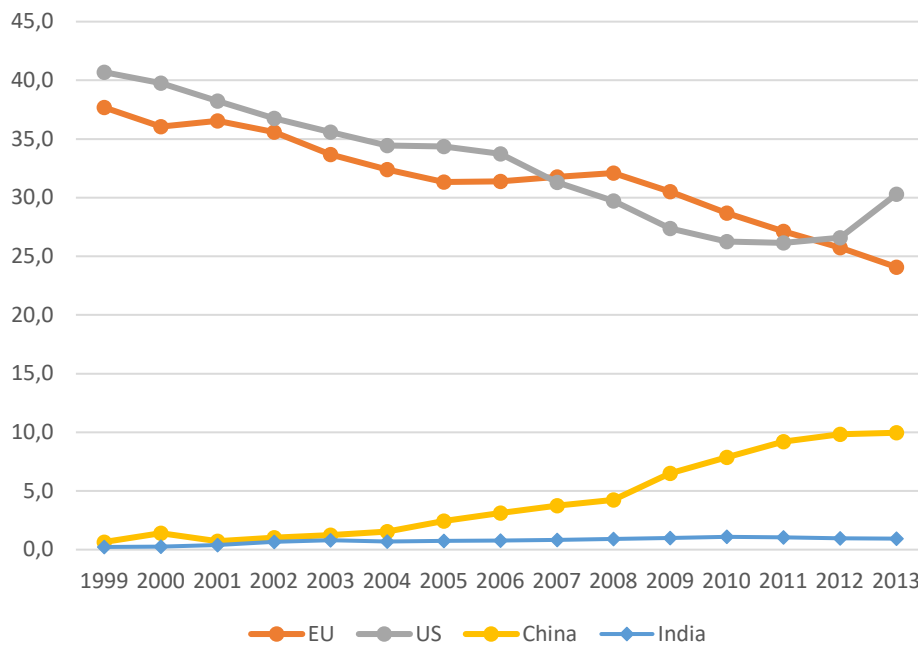
For example, the term ‘Triadic patent families’ was widely used until recently as a measure of economically relevant patents. The very term ‘Triadic’ patent betrays a view of technological dominance, which seems already outdated since triadic patents are those filed simultaneously, for the same invention, by the same applicant or inventor, in the EU, the US and Japan (i.e. at the European Patent Office (EPO), the United States Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO)). If one uses this measure, the total number of patents has been constant over the last decade and, not surprisingly, the US, the EU and Japan each account for about one quarter of the global total. (Most of the remaining quarter comes from other OECD countries.)

Moreover, data on patents is unfortunately only available with a long lag. The latest available year in the OECD database, the most reliable source, is 2013. But even from this source the data is sometimes inconsistent. For example, for the years 1999 and 2000, filings at the USPTO are reported as being lower than the number of patents granted. Griliches (1989) provides an in-depth discussion of the problems in measuring innovation activity.

For a recent illustration of the potential pitfalls in using patent data in social science research see Lerner, Josh and Amit Seru (2015).

What is clear, however, is that the origin of patent applications is shifting. The trends, shown in Figure 23 below are clear: the share of the established sources of patents, i.e. mainly the US and the EU, are declining, whereas that of China has risen. This figure also shows (again) that China is different: it has already become an important contributor to innovation at the global level. No other EME has achieved this status. The share of India, for example, has remained very small, although it is not that far from a medium-sized EU Member State such as Spain and nearing the value of G-7 member like Italy.

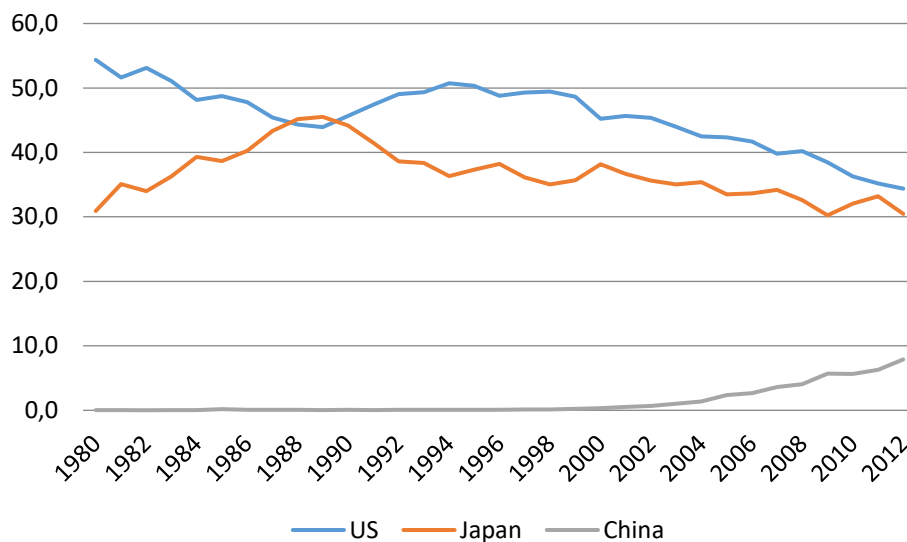
Figure 23. Global (PCT) Patents (shares of global total)



Source: OECD.

The data on patents actually granted show a similar trend, but with less change so far. At the EPO, the majority of patents are granted to EU inventors. Their share has remained around 55% of the total granted. However, the shares among third country inventors (i.e. non-residents of the EU) have changed over time as the figure below shows. In the 1980s, the US used to account for over half of the rest of the world; today only one third. The share of Japan equalled that of the US at one point (1990, the peak of the Japanese bubble). It is now somewhat lower, at around 30%. The rise of China is again clearly visible, but it has made much less progress on this metric.

Figure 24. Shares in patents granted by the EPO to third country inventors



Source: OECD.

4.1 Technological transformation

Predicting where digital technologies will have led us by 2035 is a daunting task. Eighteen years ago, in 2000, most connections were still narrowband, with upload and download speeds that were only a tiny fraction of what they are today. The iPhone would be announced only seven years later. Artificial intelligence and blockchain were very far from the public debate, and advances in cryptography were still a toy in the hands of a few techies. Those years were mostly characterised by emphasis on the deployment of digital infrastructure, or what the Clinton administration used to call the “Information Superhighway”. Even the network neutrality debate sparked only in 2002.

Since then, the pace of technological progress has accelerated, and several sectors have gone digital, often with disruption of existing business models replaced by data-driven multi-sided platforms. The ‘platformization’ of the Internet has been one of the mega trends of the past decade, with the emergence of large tech giants that now act as gatekeepers of the Internet (Clarke and Claffy, 2015; Renda, 2017). But this is not necessarily going to remain the key feature of the Internet ecosystem going forward: the ‘platformized’ Internet may exhaust its potential, leading towards more decentralised architectures.

The current decade has witnessed very important trends. These are a starting point for imagining the world in 2035.

4.2 Hardware: the end of Moore’s law, the rise of quantum computers and bio-computers

In hardware, current trends include virtualisation of functions, massive cost reductions, and the transition from central processing units (CPUs) to more efficient and powerful graphics processing units (GPUs) and ultimately tensor processing units (TPUs), designed as AI accelerators. However, the real discontinuity arrives in a few years, with quantum computing taking the stage and becoming commercially viable. This means an impressive acceleration in the ability of computers to solve complex problems, from logistical and optimisation problems to weather and climate modelling, personalised medicine, space exploration, real time language translation and, most generally, encryption.

There is a lively ongoing debate on the possibility that Moore’s law will come to a halt, and that accordingly, technological progress will slow down in information technology. However, this appears to be a very narrow perspective on the ongoing development of IT hardware, for several reasons:

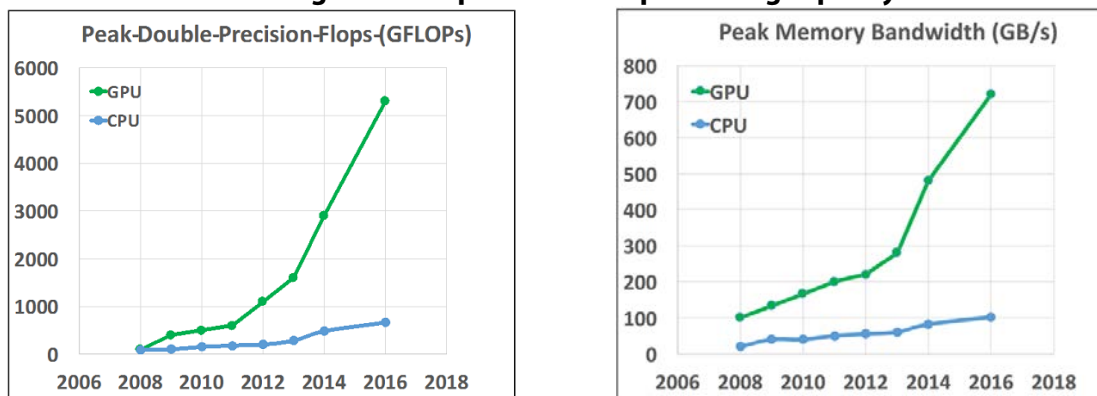
- First, simply counting the number of transistors in integrated circuits does not capture the architecture and performance of modern computer processors (e.g. GPU, TPU). Rather than focusing strictly on increasing transistor counts and clock speeds, companies now focus on performance, including power efficiency and component integration. The explosion of specialised processors for handling AI and deep learning workloads is partly a reaction to the fact that CPUs do not scale the way they used to.
- Second, the current trend in designing processors is to move from general-purpose machines to the tailoring of machines to specific applications, such as graphics and machine learning. Today, CPUs co-exist with GPUs (which improve performance by a factor of 10 over CPUs) and

TPUs (which improve by a factor of 10 over GPUs). CPUs perform the main tasks, GPUs do the graphics, TPUs the AI.

- Third, and relatedly, the emerging trend in IT is 'parallel computing', which achieves exponential growth in throughput by using a multitude of processors at the same time, regardless of the fact that the growth of transistors in integrated circuits is slowing down.

Looking at emerging new processors, the transition from CPU to GPU also implies a transition from incumbent chip manufacturers Intel and Advanced RISC Machine (ARM) towards players like Nvidia. And the rise of TPUs sees Google in the lead. While CPU performance improvements have been slow over the past few years, GPUs are progressing faster than Moore's law. GPUs are also more appropriate for parallel computing; they are eventually expected to replace CPUs entirely. Currently, CPUs and GPUs interact and co-exist, and some available processors are hybrid solutions (e.g. Intel's *Knights Landing*). It is eventually possible that the AI and deep learning processors deployed in data centres will be different from those deployed at the edge, in smartphones, wearables, PCs. When compared on a chip-to-chip basis against CPUs, GPUs have significantly better capability on both speed of calculation (FLOPS) and speed of data movement (bandwidth) (GB/s) (Figure 25).

Figure 25. Improvement in processing capacity



Source: HPC 2016.

The race for improving computational capacity and performance is thus much more vibrant than a simple, one-dimensional observation such as Moore's law can describe. Intel, for example, after seeing its CPU threatened by GPUs, started to compete head-to-head with NVIDIA and AMD with x86-capable 'manycore' chips. Google, with its TPUs, mostly aims at developing superfast computers for machine learning applications.

The state of the art today implies the application of distributed deep learning (DDL) algorithms to GPUs for high-speed data movement, to empower machines to ultimately understand images and sound. The DDL algorithms 'train' on visual and audio data, and more GPUs should mean faster learning. DDL has progressed at a rate of about 2.5 times per year since 2009, when GPUs went from video game graphics accelerators to deep learning model trainers. Next steps, according to tech companies like IBM, will entail the growing use of GPUs, the use of early quantum computers coupled with low precision and analogue devices (as they can tolerate imprecise data and information) to lower power and improve performance (so-called neuromorphic computing); and ultimately, after 2025, the fully-fledged quantum computing era.

There is still lots of uncertainty regarding the foreseen evolution of quantum computing. The Canadian company D-Wave Systems has already progressed from a computer with 128 qubits to an upcoming machine with 1,000. IBM has made a 20 qubits computer commercially available. A 50-qubit quantum computer already manages 300 TB of information, and potentially reaches 'quantum supremacy', i.e. a quantum device able to handle such a number of registers that no single classical device on Earth can keep up with it. A quantum computer with 50 qubits would be smaller, more powerful and more energy-friendly than the best existing classical computer on Earth. At 100 qubits, a quantum computer would surpass by far the number of options that can be stored in all the classical computers on Earth combined. Companies like D-Wave expect to be able to quadruple the number of qubits every two years, ultimately reaching a million qubits in 2035. However, the race is hectic, with incumbent players like Microsoft, Google, IBM and newcomers like D-Wave and Rigetti all pushing to be the first to develop a stable and sufficiently powerful quantum computer.

Future applications of quantum computing are widespread, ranging from the solution to complex cryptographic problems to the simulation of drug response to greater understanding of disease development through improved computational models, improved transportation logistics across the world, improved financial modelling to avoid economic downturns, and more. Not surprisingly, countries are racing to develop quantum computers, with the US and China competing neck and neck. The figure below shows however that recent years have seen Chinese patent applications skyrocket. This race has very important geo-political consequences: it is generally understood that global leadership and supremacy in the future will depend on the control of key IT such as quantum computing. China recently announced that it will create an 11 billion USD, four-million-square-foot national quantum laboratory in the city of Hefei. Russia is investing in quantum computing, spearheaded by the Russian Quantum Center (RQC). In the twenty-first century, supremacy will belong to the nation that controls the future of information technology, which is quantum. As we will see, it would be a mistake to assume that the United States is destined to be in this position. In the topsy-turvy, counterintuitive world of quantum mechanics and quantum computing, decades-long dominance in IT does not automatically translate into dominance in the coming era. However, strategy and commitment of resources, including funding, almost certainly will – and with it, the balance of the future.

Figure 26. Evolution of patent applications by country

Patent applications to 2015, in:

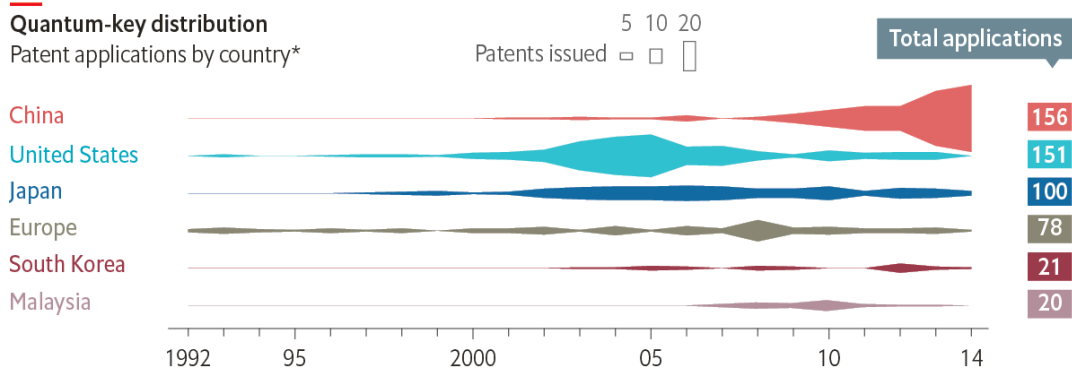
Quantum computing



Quantum cryptography



Quantum sensors



Sources: UK Intellectual Property Office; European Commission

*By location of corporate headquarters

Another likely development that may shake the world of computing is the rise of biological computers (or biocomputers), which typically perform operations using complex molecules such as DNA, could perform huge numbers of parallel calculations at once, and have been in development for decades. The EU funded a project (Bio4Comp) in this area with 6.1 million euros, in the belief that biocomputing could overcome the scale limits of quantum computing, as well as other experimental models such as DNA and microfluidics-based computation. Recently, Intel announced Loihi, a neuromorphic chip that can count on a total of 130,000 neurons and 130 million synapses (Reichert, 2017). Loihi is a 60-mm² chip fabricated in Intel's 14-nm process that advances the state-of-the-art modelling of spiking neural networks in silicon. It integrates a wide range of novel features for the field, such as hierarchical connectivity, dendritic compartments, synaptic delays, and, most importantly, programmable synaptic learning rules. Running a spiking convolutional form of the Locally Competitive Algorithm, Loihi can solve LASSO optimisation problems with over three orders of magnitude superior energy-delay-product compared to conventional solvers running on a CPU iso-process/voltage/area. This provides an unambiguous example of spike-based computation, outperforming all known conventional solutions.

The bottom line is: even if Moore's law slows down, computing will continue to progress at very fast pace, thanks to parallel computing, neural network structures, and quantum technologies. As Moore's law becomes obsolete, technologies will find new ways to support the growth of applications, content, and other hardware.

4.3 The ‘blockchain/AI/IoT stack’

On top of the hardware layer, a whole new stack is emerging, based on the combination of blockchain, artificial intelligence and the Internet of Things²³. In its essence, blockchain technology consists in the creation of an immutable, incorruptible digital ledger in which transactions are recorded chronologically and publicly; the ledger runs on a peer-to-peer network and is constantly synchronized, which means that all the nodes of the blockchain retain a full copy of the whole ledger²⁴. Blockchain is expected to gradually replace current infrastructures in a number of domains: By 2035, tax reporting, e-identity databases, voting schemes, may run on blockchain or another form of Distributed Ledger Technology. Blockchains provide two characteristics that make them attractive as a transaction recording solution: (i) Cryptographic immutability and verifiability, which makes it quite impossible to modify transaction records once committed, thus ensuring secure transactions; and (ii) distributed consensus allowing anonymous individuals across a peer-to-peer network to come to agreement on the state of the network, thus removing the need of a centralised agreement mediator/ organisation. This is specifically the case for the “purest” form of blockchain, i.e. the totally distributed, permissionless ledger; whereas future applications will most likely take a more hybrid, or permissioned, form²⁵. All in all, most business models in blockchain will not be entirely permissionless. Another important problem that will critically affect blockchain’s potential to scale and permeate many markets is energy consumption (see box below).

Box 9. Bitcoin’s energy needs

Bitcoin is the first and most famous application running on blockchain. It uses a specific mechanism to reach consensus among the nodes to validate transactions: so-called “bitcoin mining”, i.e. the process of adding transaction records to Bitcoin's public ledger of past transactions. It is well known that the ‘mining’ of bitcoins and other ‘cryptocurrencies’ involves massive and ever increasing computing power. The computers on which the mining is being performed require constant cooling. This means that bitcoin mining is very energy intensive (even if performed in cool climates like Iceland). For Bitcoin alone the annual electricity consumption is estimated for 2018 at 70.1 TWh (higher than the yearly electricity consumption of Austria), while for Ethereum the estimate is somewhat lower, at 20 TWh²⁶. These estimates are of course no more than informed “guesstimates”, since there is no central register with all active machines used by miners, their exact power consumption, etc. Looking at electricity consumed per transaction the numbers are even more impressive: each Bitcoin transaction is estimated to consume over one thousand KWh. This is similar to the yearly electricity consumption per capita in countries like Jamaica or El Salvador and would

²³ For a good non-technical introduction to blockchain, see De Filippi, Primavera and Aaron Wright, *Blockchain and the Law*, Harvard University Press, 2018, Chapter I. On Artificial Intelligence, a good introduction is found in Russell, S. and P. Norvig (2018), *Artificial Intelligence: A Modern Approach*, Prentice Hall, Third Edition, Chapter 1.

²⁴ Satoshi Nakamoto. 2008. *Bitcoin: A peer-to-peer electronic cash system*. (2008). And Don & Alex Tapscott, *Blockchain Revolution* (2016).

²⁵ Public blockchains are fully open to everyone; anyone may inspect and participate in the network, viewing transactions, creating transactions and mining blocks. The original blockchain concept was a public blockchain, and this was important to provide the transparency and immutability required for trustless, intermediary-free, decentralised transactions to take place. Compared to public blockchains, consortium blockchains add a layer of permissioning, such that only selected organisations can validate transactions. Private blockchains are the most restrictive, and reserve validation task to a single organisation.

²⁶ This is based on the “Digiconomist” website that estimates the energy consumption index for both Bitcoin <https://digiconomist.net/bitcoin-energy-consumption#assumptions> and Ethereum <https://digiconomist.net/ethereum-energy-consumption>.

imply a cost of 250 euro at European retail prices for electric power. For Ethereum, it seems that the cost of each transaction is much lower, but at 67 KWh, still equivalent to over 15 euros (more than a bank transfer within the euro area). The key reason for the difference is the time required for each block to be mined. In early 2018, a Bitcoin block could be mined every 10 minutes (approximately), while for Ethereum it is only 15 seconds²⁷.

There has been no reliable comparison so far between Bitcoin's electricity consumption and other systems consumption per transaction. A short analysis by ING compared the cost per bitcoin transaction (at October 2017 when the report was written the consumption was at 200KWh) with the Ethereum (37KWh) and the Visa (0.01KWh)²⁸. The claims of all these studies are difficult to verify and one should take not to extrapolate their findings based on 2017/8 data, into the far future²⁹. But the low energy needs of fiat currency has additional advantages since it leaves governments in charge of 'seigniorage', without allowing the private sector to 'waste' the seigniorage in a competitive game of who finds first the remaining bitcoins. For fiat currency the government also enforces a unique choice of numeraire, with competing crypto currencies the network externalities of having a single unit of account might not be guaranteed.

In other words, Bitcoin is considered by some to be too energy-intensive and costly to run, a feature that will only increase over time if the currency becomes more widespread. However, there are many ways in which Bitcoin, and blockchains in general, can (and probably will) become more energy-efficient over time. This is due to three causes: possible changes in the internal rules, improvements in hardware, and the upgrade of the protocol.

First, Bitcoin works at present with the 'proof of work' approach, which requires approval by all participants: such approach is now often replaced by a 'proof of stake' (PoS) approach, which would not involve approval by all participants. In PoS, nodes with more cryptocurrency (larger stakes) have higher probabilities of being chosen to validate the next block. The stake may be destroyed if the node behaves maliciously, which thus discourages such behaviour³⁰. Adopting PoS makes blockchains less energy-hungry, but it carries also risks, as it is less hacker-proof, it reduces the shared and democratic participation of users in blockchain, and gives priority and advantage to those that already have greater stakes in the blockchain (the so-called 51% problem).

Second, miners are using gradually more efficient hardware. Currently they employ an application-specific integrated circuit (ASIC) specially designed for mining Bitcoin. ASIC performs two orders of magnitude better than GPUs. Due to advances in chip technology, reported mining efficiencies have roughly doubled every 12 months, from about 500 J/TH (joules per Terahash, equivalent to watts per trillion hashes per second) in late 2014, to 250 J/TH in late 2015, to 100 J/TH in mid-2016. The new ASIC hardware like Bitmain's Antminer S9 is 2.5 times more efficient in energy consumption than its predecessor, the S7. This can reduce the yearly energy consumption down to 500 Gigawatts a year, so dozens times more efficient. Newer models like the S9 are also much more efficient in terms of heat dissipation and also reduce the amount of servers needed, so also the cost of cooling would go down.

²⁷ <https://www.cryptocompare.com/coins/guides/why-is-ethereum-different-to-bitcoin/>

²⁸ <https://think.ing.com/opinions/why-bitcoin-transactions-are-more-expensive-than-you-think/>

²⁹ See e.g. M. Bevand, (2017, 1 February). "Serious faults in Digiconomist's Bitcoin Energy Consumption Index," [Online] <http://blog.zorinaq.com/serious-faults-in-beci/>

³⁰ Tschorsch, F., & Scheuermann, B. (2016). Bitcoin and Beyond: A Technical Survey on Decentralized Digital Currencies. *IEEE Communications Surveys & Tutorials*, 18(3), 2084–2123.

Third, the Bitcoin protocol is also being upgraded to improve efficiency. The SegWit activation and the Lightning Network effectively move micropayments off the blockchain. The Lightning Network will take Bitcoin transactions off-chain by setting up channels between users. Transactions between them will occur and only be recorded on the blockchain when the channel is closed. This will reduce the number of transactions on the Bitcoin blockchain but there won't be a significant reduction in energy use because nodes use very little energy to record transactions. The majority of electricity used is for Bitcoin mining where computers generate hashes that fulfil a set of criteria. Reducing the number of transactions on the blockchain is unlikely to affect how many miners there are. For example, Bitcoin transactions have halved since December 2017 but the mining difficulty has doubled, indicating there is twice as much mining equipment being used.

All in all, improvements in hardware appear to be the most solid bet for Bitcoin when it comes to reducing energy consumption.

Artificial Intelligence will make important inroads towards simulating and complementing human intelligence, and totally departing from it. While there is no evidence that singularity (i.e. machine intelligence overtaking humans) will occur in 2045, as Ray Kurzweil originally predicted, artificial intelligence will certainly be able to perform the vast majority of tasks that human beings perform today. Human augmentation is most likely the new 'platform' by then, with corporations competing to offer the best 'Human 3.0' software to be run directly by nanocomputers inside the human body. 2035 might see the beginning of a decade-long process that could be described as 'human softwarization', and which follows directly from the 'softwarization' trend that was described above. This includes a process called 'mind uploading': humans exist on the Web, and project bodies when they want or need (whether in virtual or real reality), living indefinitely so long as they maintain their 'mind file'. This is indeed what Neuralink (recently acquired by Elon Musk) aims to develop over time.

The Internet of Things is the most mature of the technologies composing the 'new stack', with close to 30 billion devices already expected to be connected to the Internet by 2020. To give a sense of the acceleration of the connection of devices of all sorts into one single, dense information space, it suffices to note that according to one recent forecast, there will be 125 billion devices connected in 2030 (IHS Markit); and ARM, a big semiconductor firm recently acquired by Softbank, predicted that there will be one trillion connected devices in 2035. The real hubs of these interconnected devices, according to predictions, will be the human body: this will transform the Internet of Things into what some authors have called the 'Internet of me'.

At the higher layers of the stack, running on top of the new architecture, are content and applications. The pervasiveness of AI will permeate all aspects of our human lives. Here are some examples.

- **We access news and information** in a way that is heavily mediated by algorithms: as the amount of data produced every year skyrockets, navigating through data becomes impossible for a human being. The dense digital data environment in which humans are immersed can be easily manipulated in the form of deep fakes. Our behaviour and decision-making are heavily mediated by the IT environment.
- **Traffic** reaches the sky, with flying passenger drones being normal, optimised by advanced quantum computing. Hyperloops are used to connect major cities or traffic hubs. Self-driving cars may be the most common mode of transportation in the increasingly urbanised spaces, although other technologies such as carpods may ultimately prove handier.

Ownership of cars is a niche, luxury segment of the market, otherwise dominated by access-based use of cars. Humans flow seamlessly across various modes of transportation when they want to travel. Just like science fiction's 'jumps into hyperspace', hyperloops will become launching pads for humans, cars, freight in need of being quickly moved to other parts of the globe.

- **AI develops multi-laterally.** There is no possibility for human beings to rely solely on the current brain and body to live in the future information-rich world. At the same time, there is no possibility for humans to rely on 'mass AI', developed by tech giants, as the manipulation of our brains would be impossible to stop and even detect. This leads to the expectation that humans will train their own AI, either implanted in the body and 'softwarized', or in a device or group of personal devices. This 'inner layer AI' is our slave, avatar and enhancer: it knows us and our preferences, dreams, ambitions, and helps us fulfil and achieve them. Of course, the more sophisticated the AI, the more likely the accomplishments: this may itself bring more inequality, unless governments consider personal AI-based enhancement as a fundamental right.
- **Healthcare will be revolutionised.** Trends include: (i) *precision medicine*, a new approach for treatment and prevention of diseases in which variability in genes, environment, and lifestyle of each patient is taken into consideration; (ii) *Cognitive Computing* simulates human thought processes in a computerised model through deep learning algorithms and NLP (natural language processing), as in the case of IBM Watson; (iii) *Wearables* such as fitness trackers, skin patches, sleep sensors, smart clothing, smart glasses, activity monitors will reach 130 million by 2018, and will be gradually replaced by in-body implantable sensors after 2030; (iv) Blockchain will revolutionise electronic health record-keeping, bringing benefits to patients and doctors; (v) *Healthcare bots* will replace humans in providing immediate health support from care providers during and even after stipulated working hours.

4.4 AI, productivity and growth

It is difficult to predict what impact technological development will have on productivity over the next 17 years. A lot depends on whether policies will be able to promote the diffusion of new technologies, as well as address job displacement and skills erosion with adequate supporting measures.

As a matter of fact, as noted by Brynjolfsson and Syverson (2017), the most impressive capabilities of AI, particularly those based on machine learning, have not yet spread widely. More importantly, like other general-purpose technologies, their full effects will not be realised until waves of complementary innovations are developed and implemented. The discussion around the recent patterns in aggregate productivity growth highlights a seeming contradiction. On the one hand, there are astonishing examples of potentially transformative new technologies that could greatly increase productivity and economic welfare (see Brynjolfsson and McAfee, 2014). There are some early concrete signs of the promise of these technologies, recent leaps in artificial intelligence (AI) performance being the most prominent example. However, at the same time, measured productivity growth over the past decade has slowed significantly. This deceleration is large, cutting productivity growth by half or more in the decade preceding the slowdown. It is also widespread, having occurred throughout the OECD and, more recently, among many large emerging economies

as well (Syverson, 2017). We thus appear to be facing a redux of the Solow (1987) Paradox: we see transformative new technologies everywhere but in the productivity statistics.

Recently, several papers have analysed the impact of automation in Europe, mostly finding a positive contribution of robots to productivity. Among others, Graetz and Michaels (2015, 2018) use the industrial robots' database and estimate that in the 17 countries of their sample, the increased use of robots per hour worked from 1993-2007 raised the annual growth of labour productivity by about 0.37 percentage points³¹. By considering an industry-country panel specification, they found that robots appear to reduce the share of hours worked by low-skilled workers relative to middle-skilled and high-skilled workers; they do not polarise the labour market, but appear to hurt the relative position of low-skilled workers rather than middle-skilled ones. Nevertheless, the use of robots per hour worked appears to boost total factor productivity and average wages. Chiacchio et al. (2018) find that the use of robots per hour worked appears to boost total factor productivity and average wages: however, they also find that the displacement effect (labour to capital) offsets the productivity effect, leading to job losses (see below, Section 4.6.1).

Recent reports by Accenture/Frontier Economics, McKinsey and PWC conclude that AI will be a game changer for total factor productivity and growth, by gradually rising as a third pillar of production, together with labour and capital. Table 3 (from PWC) compares the three reports. Among them, as shown in the table, two are based on rather heroic assumptions: that the labour displaced will re-join the workforce and will be as productive as in 2014 (McKinsey); and that employment levels will be constant (Accenture).

³¹ http://personal.lse.ac.uk/michaels/Graetz_Michaels_Robots.pdf. The authors use International Federation of Robotics (2012) and EUKLEMS (Timmer, van Moergastel, Stuivenwold, Ypma, O'Mahony, and Kangasniemi, 2007) data to estimate robot density (the stock of robots per million hours worked) in 14 industries in 17 countries from 1993-2007.

Table 3. Role of AI in enhancing TFP growth, a comparison

	PwC: Sizing the prize	McKinsey Global Institute: A future that works	Accenture: Why AI is the future of growth
Key messages	<ul style="list-style-type: none"> Global GDP will be 14% higher in 2030 as a result of AI. Our analysis focusses on the period to 2030 and we do not conclude that the long-run growth rate of the global economy will fundamentally shift. North America GDP will be 14.5% (\$3.7tn) higher in 2030. Productivity impact accounts for 6.7%. Consumption impact accounts for 7.9%. Direct labour productivity impacts of 4-57% depending on country (North America 57%). These are only the direct impact of AI and further impact could occur in the general equilibrium. Total GDP impact by channel of impact for North America (productivity only): replacement (5.7%) and augmentation (0.8%). 	<ul style="list-style-type: none"> In the not-so-distant future, without an acceleration in productivity growth, there will not be enough workers for countries to meet their aspirations for growth in GDP per capita. Automation could help serve as a new productivity engine for the global economy, bridging that economic growth gap. In the next 50 years, automation will increase economic growth by 0.8 to 1.4%. They do not make a claim as to whether this sits above or as part of the 1.8% productivity forecast based on historical productivity growth. 	<ul style="list-style-type: none"> AI will redefine 'the new normal' as a period of high and long-lasting economic growth. AI has the potential to be not just another driver of TFP, but an entirely new factor of production. Growth rates will be doubled by 2035. US growth rate will be 4.6% with AI, instead of 2.6%. US GDP will be \$8.3tn/35% higher in 2035. AI-induced productivity impact: 3.8% of US GDP Additional AI-induced growth impact: 31% of US GDP. Boosts in labour productivity of 11-37% in 2035 depending on country (US 35%). Total GDP impact by channel of impact for the US: TFP impact (3.8%) Intelligent automation (16.9%) Augmentation (14.1%).
Channels of impact	<ul style="list-style-type: none"> Productivity (replacement and augmentation). Consumption. 	<ul style="list-style-type: none"> Only labour substitution gains (other gains in the form of improved quality, fewer breakdowns etc. would come on top). 	<ul style="list-style-type: none"> Intelligent automation Labour and capital augmentation. Innovation diffusion.
Approach and assumptions	<ul style="list-style-type: none"> Computable general equilibrium model developed by Adam Blake. Initial, direct employment effects of AI will fall in line with PwC job automation predictions before general equilibrium effects affect job creation and net job effects. Realised rate of adoption and realisation of potential using Global Innovation Index. Labour productivity growth determined through econometric panel-data models per region of factors of production, AI technologies and human capital supply. 	<ul style="list-style-type: none"> Based country-level GDP projections on their Global Growth Model. Complete their own analysis of technical automation potential using World Bank and US BoLS O*Net database. Bass diffusion model to determine adoption. Assume that labour displaced would re-join the workforce and be as productive as in 2014. 	<ul style="list-style-type: none"> Modified growth model developed by Robin Hanson, George Mason University. Assume that employment will be constant in the long-term. AI substitution is assumed to achieve 50% of its technological potential. Determine county-by-country adoption using a measure of 'national absorptive capacity'.

Source: PwC Analysis, MGI⁹ and Accenture¹⁰ reports

4.5 Technology, jobs and inequality

4.5.1 Job creation and job destruction

The relationship between technology and employment is the object of a classical controversy having, on the one hand, the idea that labour-saving innovations create technological unemployment; on the other hand, the idea that product innovations and indirect (income and price) effects can counterbalance the direct effect of job destruction brought about by the process innovations. While this debate has gained a lot of attention, quantifying such effects is a very challenging exercise. Predicting the effects of pervasive technological changes on job creation and destruction is even more difficult.

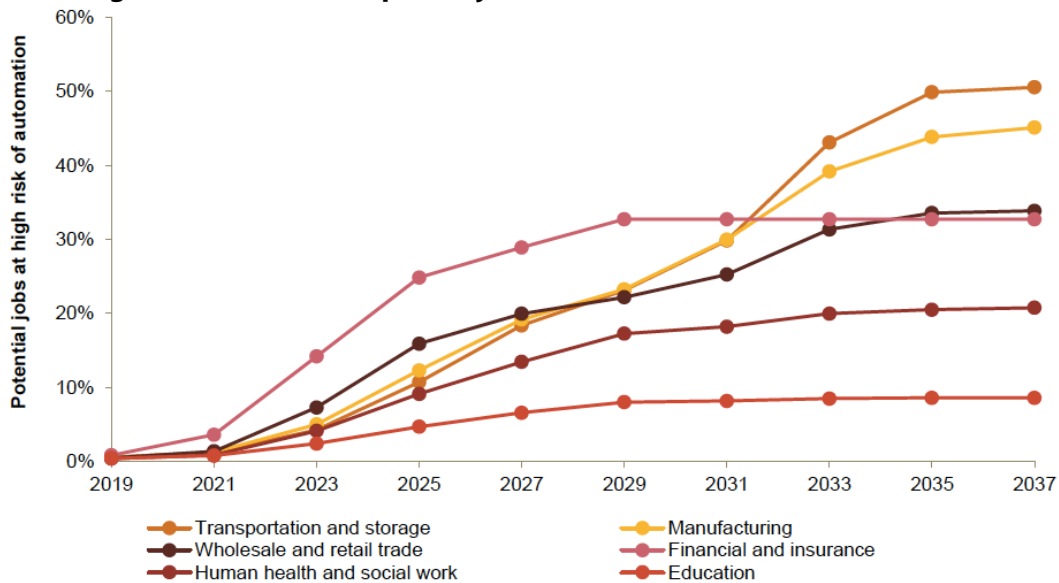
The MIT (Winick, 2018) collected and reviewed the most authoritative studies to date, showing how deeply diverging predictions are (see Table 4). Jobs may also fundamentally change in nature and mode of delivery: the Japanese government predicts that corporations will become more project-based, rather than hierarchical, and this will mean that workers may be selected on a project basis, or may want to apply for single projects. This means a Copernican revolution in the organisation of work: what happened outside of the human being, in a corporation-centric way, now happens in a human-centric way.

Table 4. Predicted Jobs automation will create and destroy (Winick, 2018)

When	Where	Jobs		Predictor
		Destroyed	Jobs Created	
2016	worldwide		900,000 to 1,500,000	Metra Martech
2018	US jobs	13,852,530	3,078,340	Forrester
2020	worldwide		1,000,000-2,000,000	Metra Martech
2020	worldwide	1,800,000	2,300,000	Gartner
2020	sampling of 15 countries	7,100,000	2,000,000	World Economic Forum (WEF)
2021	worldwide		1,900,000-3,500,000	The International Federation of Robotics
2021	US jobs	9,108,900		Forrester
2022	worldwide	1,000,000,000		Thomas Frey
2025	US jobs	24,186,240	13,604,760	Forrester
2025	US jobs	3,400,000		ScienceAlert
2027	US jobs	24,700,000	14,900,000	Forrester
2030	worldwide	2,000,000,000		Thomas Frey
2030	worldwide	400,000,000-800,000,000		McKinsey
2030	US jobs	58,164,320		PwC
2033	US jobs	67,876,460		Oxford University
2035	US jobs	80,000,000		Bank of England
2035	UK jobs	15,000,000		Bank of England
No Date	US jobs	13,594,320		OECD
No Date	UK jobs	13,700,000		IPPR

*Values that were given as percentages were converted to number of jobs based on the number of jobs in the US when the prediction was made according to the BLS

Figure 27, based on a PwC study (2018), shows what kinds of job are most exposed to substitution by automation. Manufacturing and transportation and storage are the sectors with the highest risk of job losses as well as those with a traditionally high share of employment, though this has already been on a declining trend for several years in most industrialised countries.

Figure 27. Potential impact of job automation over time, PwC (2018)

Source: PIAAC data, PwC analysis

Studies on Europe also show a significant impact of automation on employment. For example, Chiacchio et al. (2018) studied the impact of industrial robots on employment and wages in six EU countries (Finland, France, Germany, Italy, Spain and Sweden), which make up 85.5 percent of the EU industrial robots market. In theory, robots can directly displace workers from performing specific tasks (displacement effect). But they can also expand labour demand through the efficiencies they bring to industrial production (productivity effect). The authors find that the displacement effect dominates: one additional robot per thousand workers reduces the employment rate by 0.16-0.20 percentage points. The impact is even more evident for workers of middle education and for young cohorts.

McKinsey (2017) estimates that up to 30% of the hours worked globally could be automated by 2030, depending on the speed of adoption. Results differ significantly by country depending on the industrial structure, prevailing wage rates and demographics. In Europe, the countries with the highest impact appear to be Germany and Italy, where about 25% of hours worked could be cut out by automation. This rates are very similar to those of the US and Japan and just above those of Spain and France. The report emphasizes that while these shares are large, historically, they are on par with the scale of the great employment shifts of the past, such as out of agriculture or manufacturing

Finally, Van Roy et al. (2018) investigate the impact of innovation (patents), instead of automation, on employment in Europe. They find an overall labour-friendly impact on firms, however the sectoral estimates show that the positive effects are concentrated in new and emerging sectors characterized by technological opportunities.

Overall, there is no doubt that automation will continue to replace human work with negative impact on employment. This effect is concentrated in specific sectors, while others are likely to experience expansion and job creation. In the short and medium term the net effect is likely to be negative, but in the long run, similar to what happened during other industrial revolution job creation should prevail.

4.5.2 Jobs and income in the quantum age

Research consistently finds that jobs threatened by automation are highly concentrated among lower-paid and lower-skilled workers. This will place downward pressure on employer demand for this group of workers, deflating wages and increasing inequality. Deloitte has found that jobs paying less than £30,000 a year are nearly 5 times more likely to be replaced by automation than jobs paying over £100,000 and in London, such lower-paid jobs are more than 8 times more likely to be replaced. This is echoed by the Institute for Public Policy Research – whilst they dismiss the idea that AI-driven automation will lead to job losses and instead predict that workers will be reallocated into different roles, they insist that without ‘managed acceleration’, automation could exacerbate wealth inequality through the simultaneous erosion of the wages of poorer workers and increases in those of the highly-skilled.

There are three possibilities.

- Automation may lead to continuing skills-biased technological change – AI favours workers with more skills whilst substituting those with less skills.
- Automation may lead to capital-biased technological change, whereby the share of income that goes to capital increases as AI favours investment in technology.
- Automation may lead to ‘superstar-biased’ technological change, whereby the benefits of technology accrue to an even smaller portion of society than just highly-skilled workers.

In all three cases, the benefits of AI to productivity and economic growth could be hampered by rising inequality, as the Bank of England and the IMF have recognised.

In terms of the effect on labour relations, job-specific skills may become redundant, people may change jobs more frequently and the increasing precariousness of work may be exacerbated. Working in the ‘gig economy’ – characterised by a rise in self-employment, temporary positions and contract work (the ‘contingent workforce’) – may become the norm for an increasing number of people. This will fundamentally alter traditional employment relationships and may restrict the ability of workers to reap the rewards of potential increases in productivity and economic growth.

One possible reaction is finding new ways to remunerate user data as labour. In the future, Universal Basic Income will become a policy option in many countries, together with the possibility to remunerate so-called “Heteromation” (Ekbia and Nardi, 2017). Types of work that may end up being remunerated include communicative labour, cognitive labour, creative labour, emotional labour, crowdsourced labour.

More generally, this will lead to new trends in public policy, such as:

- The regulation of Internet giants as public utilities, which imposes more stringent conditions on their behaviour, and transparency obligations on their algorithms.
- The taxation of Internet giants based on their turnover and profits in places where they have ‘digital presence’.

4.6 Geopolitics and global competition

Key geo-political trends related to digital technology include the following:

- **The race for supercomputers** becomes political, especially in the age of quantum computing, which poses new challenges for cryptography. More generally, global competition for AI development and implementation will become hectic.
- **AI and data sovereignty** will become a major item in international relations. Countries will want to keep control of where their data are stored, as this represents a key safeguard against data theft, as well as appropriation of industrial knowledge. AI (or better, blockchain/AI/IoT) has, since 2025, been declared a critical infrastructure, as was the Internet by Obama in 2009. And while technology becomes global, data and their corresponding storage capacity are inherently local.
- **Cyberwarfare** will become almost the only form of warfare: while physical infrastructure may still be critical, no war or threat to the resilience of economic systems will be purely physical, as all objects (one trillion overall) are connected.

Against this background, without major new initiatives, Europe may end up losing competitiveness and relevance in the global landscape. However, this should not be taken as a given: there is a lot that Europe can do to reverse the trend, but this would need to be done now. We explore some possible actions below.

Europe as a global norm leader in AI

Europe should strive to set global standards on AI and blockchain. The experience with GDPR shows a fine example of how Europe can leverage its leadership in law-making and its relevance due to its solid legal traditions, its enduring focus on values, and an internal market of 500 million (relatively) rich consumers. The next step would be to set standards on AI and ethics – and impose them on all players that want to operate in Europe. This could be strengthened by procurement, another strong strategic option for the EU.

Can Europe achieve this goal? Due to its shrinking economy with respect to global GDP, the window of opportunity for Europe to remain relevant in the global AI debate is closing. This means that Europe should act quickly to develop world-class ethical guidelines on AI, backed by an ambitious industrial policy plan to raise EU's competitiveness in this field: as a matter of fact, simply setting rules without developing applications and services that comply with them would prove a futile exercise. This combination of competitiveness and high standards is difficult to achieve if one considers that the EU is lagging behind the US and China in terms of R&D, patents, market uptake and implementation in Artificial Intelligence³².

Achieving competitiveness and combining it with ethical developments in AI is the core mandate of the High-Level Expert Group on AI set up by the European Commission, which is also paving the way for an AI Alliance and an AI Observatory. These initiatives should lead to major recommendations in the first half of 2019. These recommendations will have an impact on EU policymaking only if they will be at once ambitious, rooted in EU's Agenda 2030 (i.e. on EU sustainable development goals), and concrete enough to show where Europe should concentrate

³² See the Digital Transformation Monitor, January 2018, at https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_AI%20USA-China-EU%20plans%20for%20AI%20v5.pdf.

its efforts in AI, rather than trying to play catch-up with US and China. They should also be comprehensive enough to avoid fragmentation of national AI policies, a trend that has emerged in the past two years, in particular after the presentation of the French AI strategy (so-called “Villani report”).

Future-proof competition policy

Another area in which Europe could take action to strengthen its competitiveness in technology-intensive markets is competition policy. There has been a lot of debate over the past decades on the difference in the US and EU approaches to competition law and policy, with scholars arguing that the US approach is more focused on guaranteeing dynamic efficiency and a cheap and abundant supply of goods, whereas the EU is more focused on preserving a pluralistic market structure and protecting smaller firms (Renda and Yoo 2016). As a result, even if the wording of Sections 1 and 2 of the Sherman Act and Articles 101 and 102 TFEU is broadly comparable, the overall approach to anticompetitive conduct, and specifically single-firm conduct has always been described as divergent in the literature. This is particularly the case for single-firm conduct (abuse of dominance in the EU jargon), due to the prevalence of the Chicago School of economics in the United States, and the influence of the more structuralist Ordoliberal school in Europe, starting from the early days of the debate on the Treaty of Rome.³³ The different antitrust economics applied in the two jurisdictions becomes even more relevant when it comes to high tech markets, and in particular on the Internet, due to the prevalence of network externalities and multi-sided platforms. Many of these settings, as a matter of fact, tend to be characterized by competition “for”, rather than “in”, the market, as firms compete in a high risk, high reward game that selects the one and only product that will spread to all or almost all consumers. Likewise, academic literature has also highlighted that in the United States, the protection of intellectual property prevails over the need to protect competitors when the two stances clash.

Without mimicking the US approach, which is based on completely different modes of enforcement and has proven to be excessively permissive in many cases, Europe should find a way to make its approach to antitrust more aligned with current and future market dynamics. This may require a refinement in market definition, the identification of dominance, the classification and finding of abuse, and a much more effective and reasonable set of remedies. Importantly, the EU approach to competition and the high-tech, platform economy should expand beyond standard abuse of dominance, to capture instances of B2B unfair commercial practices and unfair competition, as well as algorithmic discrimination and collusion when relevant. This would be another opportunity for Europe to build leadership in the crafting of comprehensive, clear, proportionate policies on competition and consumer protection in the digital economy.

A “Mission AI” in Europe

Europe could launch a mission-oriented initiative to develop European quantum computing and AI solutions in a coordinated way. This does not necessarily imply protectionism, but a coordinated development of AI solutions tailored to European needs, under European conditions. Neuromorphic computing could be coupled with a ‘mission Brain’, to exploit synergies between these two fields of research and enable a constructive debate on human-machine complementarity.

³³ See i.a. Gerber, David (1994), “Constitutionalizing the Economy: German Neo-liberalism, Competition Law and the ‘New’ Europe”, *American Journal of Comparative Law*, Vol. 42, pp. 25-84.; and Akman, Pinar, (2009), “Searching for the Long-Lost Soul of Article 82”, *Oxford Journal of Legal Studies*, Vol. 29, No. 2, pp. 267-303.

In this respect, Europe could invest in replacing the platform-based model of the current internet with an alternative model, at least for the delivery of public services. This model could, in several instances, be based on new architectures such as permissioned blockchains, with public authorities in Member States serving as nodes. It could also invest in less data-hungry AI developments, which would prove more compatible with EU's data protection rules (e.g. hashing algorithms, knowledge-based proofs, etc.).³⁴

³⁴ Hashing algorithms are cryptographic techniques that reduce any amount of data to a small digital signature (typically on 32 bytes). Zero-knowledge proofs are extremely sophisticated mathematical methods that allows one party (the prover) to prove to another party (the verifier) that the prover knows a value, but do it in such a way that does not reveal any information about that value. Homomorphic encryption is a technique that makes it possible to encrypt data in such a way that it can be analysed and processed without decrypting it. In secure multiparty computation a group of actors jointly carry out the computation needed for a transaction in such a way that each party only has part of the underlying data, and no party can deduce from their particular part what the full data set was.

5 Climate change and resource competition

Technological progress has continued uninterrupted in recent decades, resulting in lower marginal costs of extraction, and lower maritime transportation costs (LNG), which open natural gas up to a global market. There is little reason to fear 'peak oil' in supply. In this way, most available projections imply that global energy demand will still be satisfied to a very large extent by fossil fuels in 2035. Carbon markets have been developed and implemented in different regions of the world. Emissions reductions attributable to carbon pricing have been limited, but regulation (e.g. energy efficiency in buildings, product standards) or technology mandates (e.g. biofuels and renewable energy in general) have been more significant. It remains to be seen what the impact of Paris Agreement will be: the outcome in terms of emissions reductions is not binding. However, even if it is too early to tell whether the process will succeed or not, the Paris Agreement established a binding process for 195 signatories to move to steeper reductions.

However, the most visible development up to 2035 might be the rapid development of renewables in power generation, especially in OECD countries and China.

5.1 Trends in low carbon supply

Climate mitigation policies will require profound changes in the structure of energy supply and uses. So far, the power generation sector has seen the most important disruption. In many regions of the globe (e.g. Europe, Latin America, Gulf, US), power markets are being disrupted by the falling costs of renewable energy (essentially solar and wind) and, in many cases, decentralised generation. Renewable energy is now often cost-competitive. Therefore, we can expect market-driven uptake of renewables, provided that the flexibility issue³⁵ is addressed. Regulators are struggling to adjust to this evolving situation. However, the regulatory structure or market design, under which supply and demand could be brought into balance with a supply dominated by variable renewables is gradually being established.

The trend towards a cheaper renewables supply can be expected to be maintained up to 2035. However, it appears impossible to predict at what point the falling cost curves will become flatter. Consumption of variable renewables globally stands at a bit over 3%,³⁶ so growth starts from a low base.

As the (wholesale) price of power and overall energy has fallen rather than increased over recent years, it is not surprising that energy efficiency solutions in the wider economy have not made much progress.

5.2 Riding the downwards cost curve: three different cases

The production costs of so-called 'new renewables' (notably wind and solar) have come down to such an extent that in many cases they constitute the most competitive electricity generation source. Other sources, especially nuclear, and now coal in the US need subsidies to be able to compete. However, the cost of both solar and wind remains location specific.

³⁵ Variable sources such as wind and solar need to be matched by flexibility in the electricity system, which can be provided by fossil back-up capacity, storage, grid reinforcement and better solutions for use on demand.

³⁶ Together with dispatchable hydro, total global renewables consumption is at some 10%.

A similar development is taking place for batteries, where cost reductions have been more recent (and very large) and are expected to continue. This is likely to lead to a revolution in mobility, notably passenger cars, vans or urban buses, which are responsible for about 75% of road transport emissions (in the EU). The implications for heavy duty vehicles are less clear. Batteries, both deployed in cars and for domestic storage, will add additional flexibility to stabilise the grid.

Many estimates (see for example - Irena (2017), Nykvist and Nilsson (2015), Department of Energy (2015), Soulopolos, (2017) and Lazard (2017)) assume that by around the mid-2020s, light duty electric vehicles (i.e. passenger cars, vans and urban buses) will be cost competitive with traditional internal combustion engines (ICE). This implies that by 2035, most additions to the fleet will be electric vehicles. However, modern cars have a life span of more than 10 years.³⁷ Even from the point at which new ICE passenger vehicles can no longer be sold, it will thus be a decade before electrical vehicles (EV) dominate the car fleet.

These three key elements, solar, wind and batteries present different challenges in terms of forecasting their cost and thus likely adoption in a medium term vision.

Solar

The cost of solar panels has continued to decline, arriving at a fraction of its value only five years ago. However, the total cost of a photovoltaic (PV) system also has many other components, in which there has been little or no progress. This implies that the cost of producing power with a photovoltaic system would not go to zero even if the cost of the solar panels themselves went to zero. A recent estimate of the total cost of PV systems shows that the so-called 'soft costs' (project design, permit, installation, etc.) now dominate total costs (i.e. the sum of the cost of the panel and the soft costs) for small installations. The figure below shows estimates from the National Renewable Energy Laboratory (NREL) of the proportion of soft costs for three types of installations: i) residential (typically rooftop), ii) commercial (also often rooftop, but somewhat larger) and, iii) utility scale.

The chart shows that, over time, the proportion of soft costs has risen from one-half to over two-thirds of total costs. This implies that the cost of the panel constitutes only one third of total costs. For commercial installations, the cost of the panels has likewise fallen from two thirds in 2010 to 41% today. It is only for large, utility scale, installations that the cost of the panels remains decisive (accounting for 59% of the total).

This implies that if, as expected, the price of the panels continues to fall, the impact on the overall cost of PV will be smaller. Utility-scale installations should reap most of the gains. This has already led to very low bid prices at auctions in sun rich locations (such as Mexico or Saudi Arabia). With the anticipated further price reductions for panels, utility-scale PV should become competitive with fossil fuels (in terms of power generation costs) before 2035 in many parts of Europe.

Another implication of the high share of 'soft costs' for residential and commercial installations is that further reductions in the total cost of solar installation at the retail level will depend less on

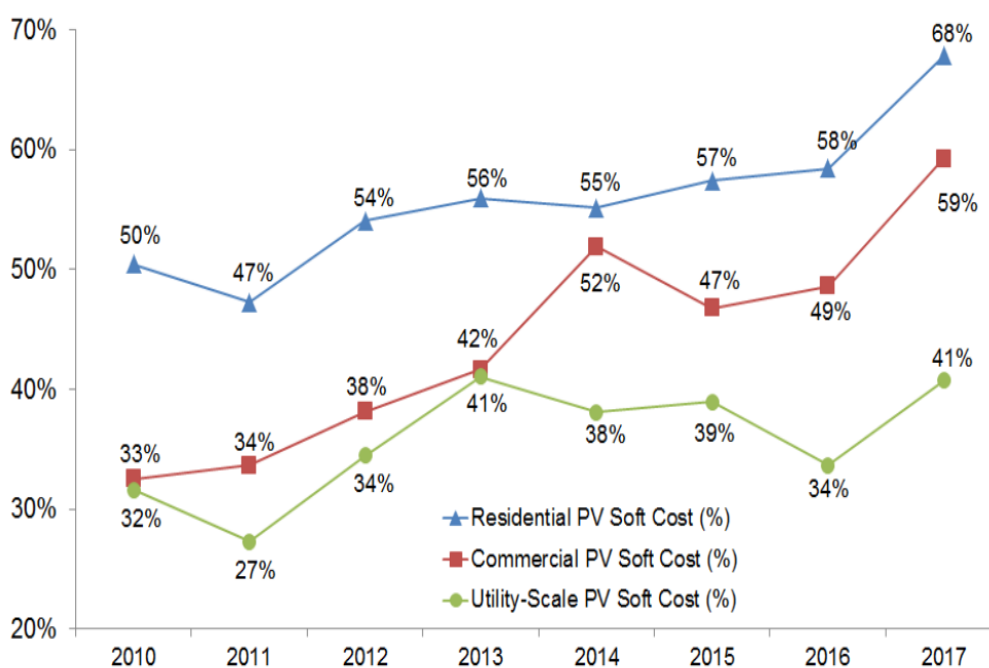
³⁷ There are over 250 million vehicles in circulation in the EU-28. New registrations run at about 15 million per annum.

further panel price reductions and more on 'soft factors', such as the availability of skilled technicians to keep installation costs low, clear regulations and easy permit procedures, etc.

At present, household PV is attractive because of very high retail prices – for example in Germany and Denmark (30 cts/Mwh). However, 80% or even more, of this price is taxes and charges. The fuel and pure generation components (i.e. the wholesale price) amount to less than 20%. This implies that currently, households with self-generation do not pay for the 80% taxes and grid charges. However, as the practice spreads, the burden on the remaining households will increase even further. It is thus likely that over time this regulatory distortion will be abolished. For example, households might have to pay a flat fee for being connected to the grid and then be charged only a rather low price per KWh effectively consumed. This is why the vision of a decentralised system with millions of semi-independent households is unlikely to materialise and centralised wind and solar solutions are more likely in the long-run.

'Soft factors' are also likely to limit the widespread penetration of solar in EMEs, where the greatest growth in energy demand is foreseen. The cost of capital is much higher in EMEs, especially for smaller borrowers, making it uneconomic for households and small- and medium-sized enterprises to make the capital-intensive investment in solar panels. Political and regulatory uncertainty further diminishes the appeal of projects with long payback periods. However, this might be an area where multi-national development banks can help to reduce both the cost of capital as well as limiting regulatory uncertainty. One key limiting factor for solar is, of course, the fact that it is available only when the sun shines. For a system that can ensure continuous availability of power, one would thus have to add the price of a battery system. This issue will be discussed below.

Figure 28. Modelled trend of soft cost as a proportion of total cost by sector, 2010-2017



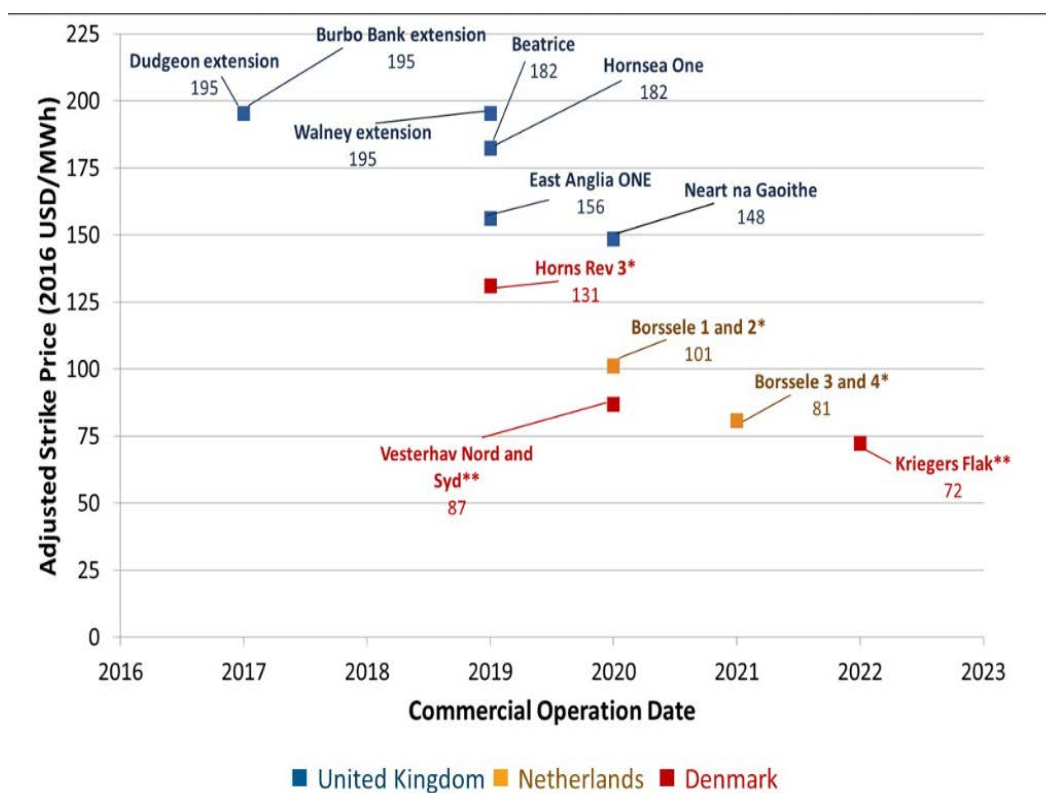
Source: Fu et al. (2017).

Offshore Wind

Offshore wind has become the new frontier of renewables. The key reason for this is that wind is much more reliable at sea than onshore. Offshore locations can often count on double the energy production of an equivalent onshore installation. In principle, one would not have expected an important potential for cost reductions in wind generation, since turbines and the production of towers are 'old' technologies. However, this has not been the case. The figure below shows the strike prices for offshore auctions in three EU countries by the time commercial operations are scheduled to begin. These values are not theoretical costs, but the strike prices bid by utilities in actual auctions. The key message of this figure is that prices have halved in the space of a few years. It would be tempting to project this reduction into future, but this would not be appropriate because the costs of wind are very location specific, depending on the depth of the water and the nature of the distribution of wind speeds to be expected.

However, the fact that cost reductions are continuing is confirmed by the results of two recent auctions at which no fixed support price was demanded by the winning bid. This suggests that, at least at some locations, offshore wind generation is already now competitive (even at a rather low permit price for carbon through the Emissions Trading System). This implies that in a longer-term perspective, offshore wind should be able to provide a growing share of renewable supplies as cost savings offset the move towards less favourable locations (deeper water and/or less wind). However, it seems impossible to predict the mix between solar and wind for the EU as a whole.

Figure 29. Strike prices of recent European offshore wind winning tenders



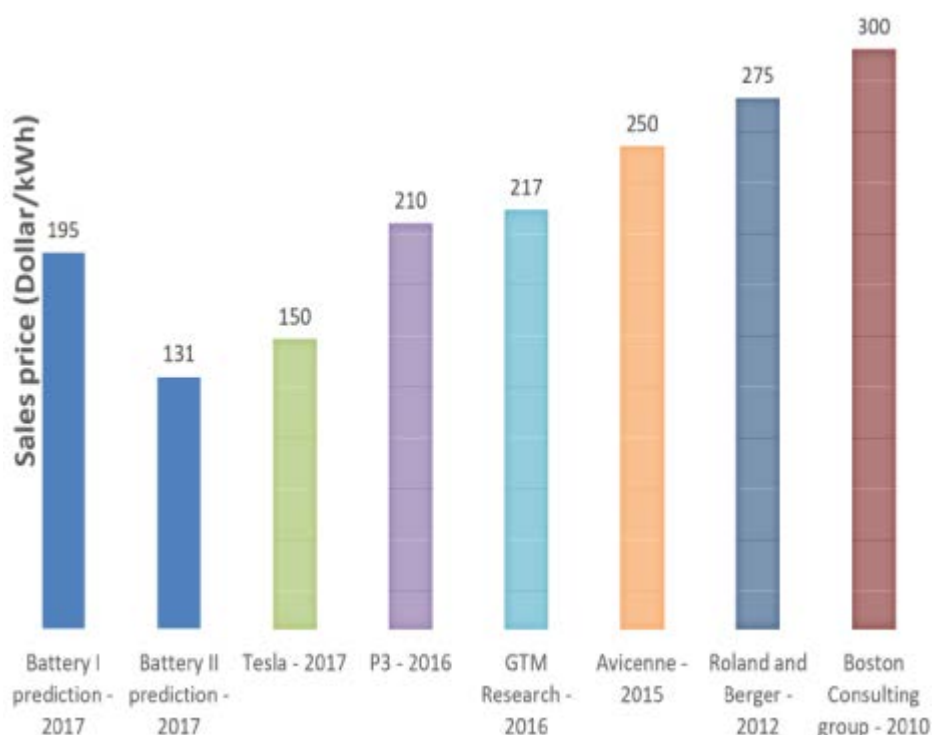
Source: Beiter et al. (2017).

Batteries (storage)

In this area as well, there have been significant price reductions recently. However, it is unclear whether this is due to temporary factors, such as excess capacity and/or pricing strategies, or whether costs have really come down and can continue to fall.

The unanticipated nature of the fall in sale prices is documented in the figure below, which shows the battery (lithium-ion type) prices for the year 2020 foreseen in the past. A respectable consulting group predicted in 2010 a price of 300 USD/KWh for 2020. By 2016, this had already been reduced to 210 USD/KWh.

Figure 30. Sales price prediction of lithium-ion batteries in 2020



Source: Berckmans et al. (2017).

This study also provides estimates of further cost reductions, which might be expected up to 2030, at which point it expects prices to have dropped well below 100 USD/KWh. Moreover, one has to take into account that battery packs must be designed specifically for the application for which they will be needed. The battery for a car might have a different cost per KWh than one for use at home to offset variations in the power supply from a rooftop solar installation. A price of 100 US dollars (or euros) per KWh is widely considered as vital for battery use to spread. A price of around 100 euros per KWh would mean a car battery costing about 4,000 euros (40 KWh of storage is typically needed).

For so-called 'balancing' applications, the cost of a battery of around 100 euros per KWh would imply a storage cost of approximately of 10 cents per KWh since one can expect a little over 1,000 charging cycles (if the battery is not always fully discharged).³⁸

³⁸ Manufacturers recommend not to discharge batteries by more than 80%. This implies that generally only about 80% of battery capacity can be used. The true cost per KWh available is thus about 25 % higher than the

The cost of a solar installation equipped with a battery so as to be available almost 100% of the time comprises not only the cost of the photovoltaic installation, but also the storage cost. Solar (and wind) will therefore only become fully competitive with fossil fuels when the sum of those costs drops below the cost of coal- or gas-fired power plants. This will remain challenging in most locations since the cost of coal- or gas-fired power plants is usually estimated at just below 10 cents per kWh produced. This implies that considerable advances in battery cost and technology will be needed to make the cost of storage of intermittent renewables low enough to make them profitable.

The expected cost savings on batteries are thus key for the wider adoption of renewables, but also for the most visible impact on daily lives, namely the advent of EVs.

Box 10. Should the EU subsidise battery production in Europe?

EBA (European Battery Association) is an industrial initiative representing the battery value chain. This sector of the economy comprises four initial main stages of manufacturing – component, cell and module production – and one assembly stage: the assembly into a battery pack. It also incorporates research centres and recycling activities (JRC, 2017).

A key feature of battery manufacturing is that it is capital intensive and that there are large economies of scale; hence the tendency to speak of ‘giga-factories’, i.e. plants which are supposed to churn out gigawatts of battery capacity every year.

At present there is no ‘giga-factory’ in operation or planned in Europe. The purpose of the EBA is to lobby for subsidies for a European giga-factory.

One argument is of course, that this would create jobs. However, battery manufacture requires little labour input. Estimates of the number of potential jobs vary as they are dependent on a host of factors, such as the location of the plant and its connection to a network of existing suppliers and academic centres.

A ratio of 90 direct employed positions or jobs per GWh of output appears to be the average value for Europe. At this value, EBA’s stated plan of 80 GWh of production in the EU would only lead to 7,200 direct additional jobs. However, as the output of a 80 GWh giga-factory is only enough for about 2 million EV batteries and total production of passenger cars in the EU-28 runs at about 16 million units per annum (and this should change little given a stagnant population), by 2035, at least eight such giga-factories would be needed to supply the batteries for EVs, if by then, as expected, all new vehicles have to be electric.

The surge in electrification, which can thus be expected in OECD countries by 2035, could lead to a surge of some minerals and raw materials (especially for batteries). This has led to a fear of a struggle for these scarce resources. CEPS (2013) already treated this issue. Even if the precise range of minerals that might be in short supply has changed since then, the principle remains the same: all the evidence shows that if a shortage actually materialises, new supplies or replacement materials are usually found quite quickly.

cost per nominal storage capacity. However, a well-maintained battery can support around 1,500 recharging cycles, thus lowering the cost per kWh.

5.3 Impact on fossil fuel demand

The cost reduction potential described above is likely to lead to a disruption of both the electricity (and energy) and urban transport sectors, especially in OECD countries. However, the impact on global fossil fuel demand should remain very limited in a 2035 perspective. The contribution of 'new' renewables is still only marginal. Globally, 3.2% of global energy demand is covered by new renewables with another 6.8% by 'old' renewables, i.e. hydro (2016 figures). Even at a growth rate of 10% per annum, it will take a long time until new renewables obtain a major share in global energy (as opposed to power generation). The same applies to electrification of transport. Currently, the share of electrical vehicles in the EU is 1.4% of new registrations. In the US, the figure is similar. The impact of electrification on transport will have limited effect on both oil demand and greenhouse gas emissions in a 2035 perspective. Even if by 2035 all new cars sold in the EU were EVs, the impact on oil demand would only be about 4 million out of a total 100 million barrels per day by 2035, a reduction of around 4%.

5.4 The outlook for emissions and climate change

Even a full implementation of the Paris Agreement would only start seriously impacting the pathway of global emissions and industrial value chains after 2035. The Paris agreement does not have any legally binding mechanism to keep emissions at or below the desired level. It only asks signatory states to notify their own plans in the form of so-called Nationally Determined Contributions (NDC).

However, it might be wrong to look at the Paris Agreement as a binding limit on emissions, which has never existed anyway. It should be viewed more as a process, which pushes its signatories in the right direction. In this sense one should not look at the precise numbers, but whether it provides a framework and focal point for global negotiations.

One remaining criticism of the Agreement is that, as the figure below shows, the sum of the national 'contributions' is not compatible with the aim of keeping the temperature increase within the 2°, much less the 1.5° range. However, one could also argue that the level of ambition achieved through the NDCs is at least much better than a 3.5-4° degree trajectory, which might have been the alternative.

Box 11. The Paris Agreement

Ten years ago, the UNFCCC agreed on 2°C global warming as the threshold of dangerous climate change compared to pre-industrial ages. It acknowledged this danger as being largely caused by the use of fossil fuels in economies and societies.

As successor to the Kyoto Protocol (1997), the Paris Agreement was signed in December 2015. It represents the first truly global Agreement on climate change, covering virtually all greenhouse gas emissions in the world.

It entered into force on 4 November 2016 after having reached the necessary thresholds of being ratified by at least 55 Parties, accounting for at least 55% of global greenhouse gas emissions. Its primary objective is:

Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change.

In terms of governance, the Paris Agreement is binding in its processes, but not binding in outcomes. By now, the Agreement has been signed by every country, including major oil producing countries. It is a universal agreement, whereby parties collectively agree to submit national pledges, the Nationally Determined Contributions (NDC), and increase their level of ambition in subsequent NDCs. It remains at the discretion of the Parties to the Agreement to formulate their own national pledges through these NDCs. Every five years, the Parties to the Paris Agreement come together in so-called 'global stocktakes' to discuss the adequacy of the collective commitments. The first global stocktake is in 2023, which means that by 2035 three stocktakes will have been completed. The system of collectively reviewing and updating commitments is sometimes referred to as the 'ratchet mechanism' as it should lead to increased global ambition over time. Nevertheless, the contents of NDCs are not formally part of the Paris Agreement, and there is no strict legal obligation to implement them.

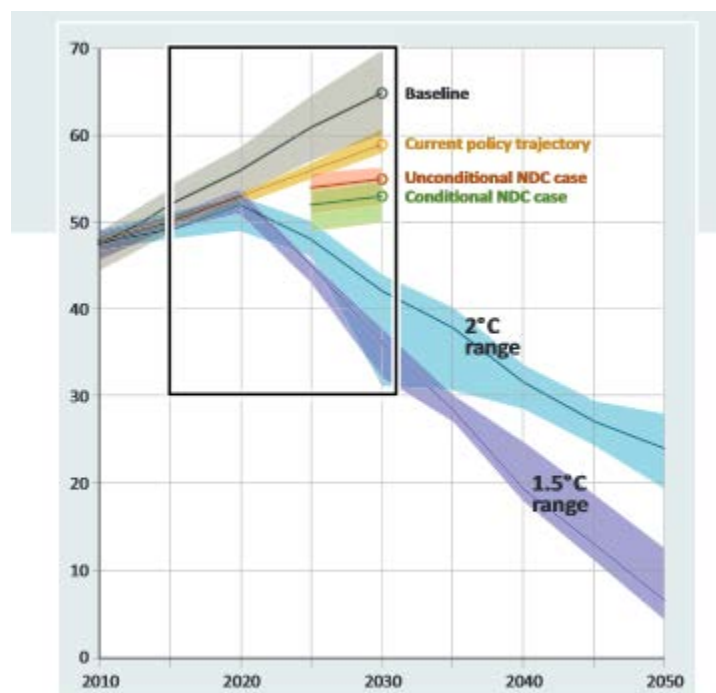
If the Paris Agreement is a clear catalyst for domestic measures to take place, it also provides more clarity on the role and responsibility of two large sectors of the global economy – the industrial and financial sectors. To this extent, the Paris Agreement underpins the definition of the roles of the different actors in the fight against global warming and climate change.

By some observers, the Paris Agreement is seen as a dedicated proof of 'soft power', reflecting a consensus between the scientific community and policy makers on the 'necessity' to act through climate mitigation and adaptation policies. Being forged in a "soft power mould", the Paris Agreement empowers low carbon technologies (wind, solar, electric vehicles), as climate mitigation tools. However, these would require to be complemented with major infrastructures, such as carbon capture and sequestration. In recent models underpinning the 1.5 °C global warming pathway, carbon capture technologies ramp up after 2020 and could be 20 GtCO₂ by the end of the century, which is around half of global CO₂ emissions in 2018. Under this approach, the intention of the United States to withdraw from the Paris Agreement could be interpreted as the consequence of the weak nature of this international climate agreement, and the economic and social costs attached to the transition.

On the other side, the Paris Agreement can be seen as setting the scene for a new model of global governance, including relations between countries in the northern and southern hemispheres. In this vision, a new trade and aid development relationship model is being shaped, via the transfer of climate finance and low carbon technologies. Developed countries have committed to providing 100 billion US dollars annually in climate finance.

New alliances have been consolidated, such as the G77. However, in order to be considered as a new model of global governance, the Paris Agreement would require additional policy building blocks – implementing rules – to ensure effective policy implementation, and possible integration into comprehensive trade agreements.

The difference to the most likely trajectory under current policies (but without Paris agreement NDCs) is only minor.

Figure 31. Emissions gap


Note: NDC refers to Nationally Determined Contributions.
 Source: United Nations (2017).

A difficult to avoid conclusion is that it is unlikely that a 2° increase in mean temperature can be averted. The figure above shows that emissions growth would have to change dramatically, already going negative around 2020, if even the 2° goal is to be achieved. However, there is little indication of this happening, as the NDCs show. For the time being, a continuation of the present pattern of continuous diplomatic activity, but little action appears likely. Countless studies and high-level groups (the latest example is the Stiglitz Commission Report of 2017) have indicated that a carbon price of at least 50 and maybe up to 100 US dollars (per ton of CO₂) would be needed to achieve these goals. This kind of price appears unacceptable in the political reality of even relatively rich regions (like Europe) that officially fully support the goal of reaching the 2° goal. The carbon price in the European emissions trading system (ETC) has hovered for years below 10 euros per ton. Future prices are now somewhat higher, but remain a fraction of what would be necessary to provide an incentive for significant changes. Moreover, action by the EU has become marginal as Europe is now responsible for only about a tenth of global emissions. European emissions are stagnating in any case as the effect of slow economic growth is offset by gradual increases in efficiency and the growing supply of renewables.

New emissions growth now comes naturally from the more dynamic EME (and the US) and it is difficult to see these regions accepting the required high carbon prices. The most likely scenario by 2035 might therefore be that emissions have increased further (instead of turning around in the 2020s).

5.4.1 The cost of no action

If something like the current policy trajectory materialises (which we regard as the most likely scenario), it follows that climate change itself (and efforts to adapt to it) might have a bigger impact on the economy than mitigation (i.e. subsidies to renewables, carbon pricing, etc.).

By 2035, it might have become clear that the earth is maybe heading for a 3° plus scenario, but actual temperatures will only have increased a little by then, perhaps less than half a degree. The fact that the impact of (cumulative) emissions arrives with a lag is of course one key factor why it is difficult to mobilise effective action today.

However, some regions might already be affected by 2035. In a strong economy with a well-functioning infrastructure, adaptation to the approximately 0.5° increase in mean temperatures should be manageable. However, unfortunately all simulations suggest that the economically and politically weakest regions, like Sub-Saharan Africa, might also experience the strongest increases in temperatures and other climate change effects like changing rainfall patterns.

Even within Europe, vulnerable regions like the Mediterranean (north and south) might be seen as too risky to invest in, as opposed to regions where climate change impacts are lower, or even beneficial. These trends would be driven by the private sector (e.g. financial markets) and might be largely impervious to government policy.

5.4.2 Too little too late?

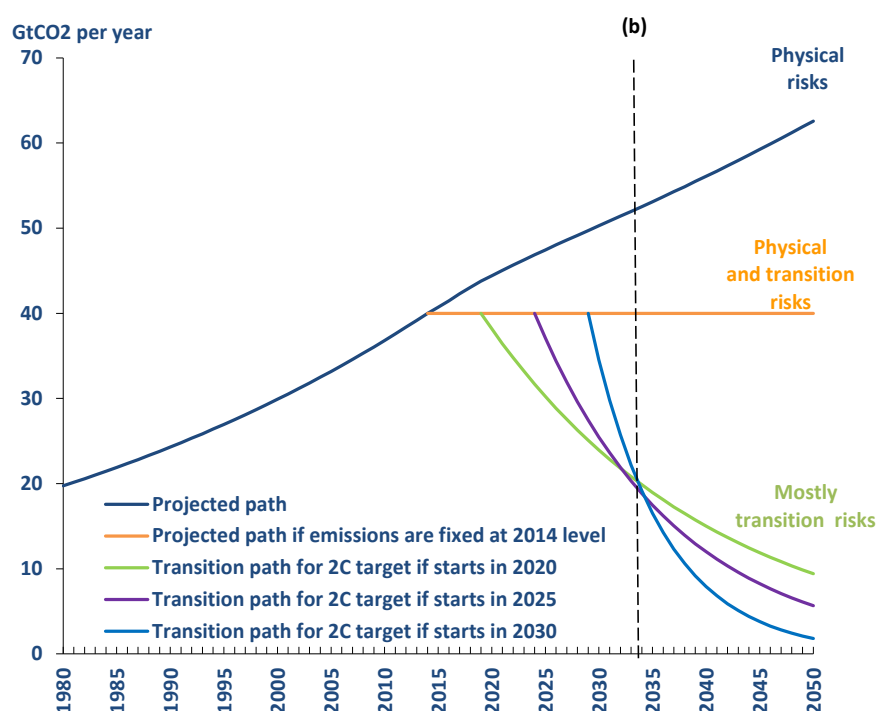
Under a scenario when the world suddenly wakes up to the danger of catastrophic climate change, drastic action might have to be taken.

Figure 32 below shows the steep declines in emissions that would be necessary if action were to be delayed to 2030. The sudden introduction of high carbon prices and maybe even quantitative restrictions on emissions might have an impact on financial stability.

This 'adverse' scenario is described in the ASC report, which shows that in this case, systemic risk could arise via two channels:

1. Macro-economic effect due to reduction in energy supply and/or increase in energy costs as external effects are suddenly priced in.
2. Sudden devaluation of carbon-intensive assets, (i.e. real and financial assets whose value depends on the extraction and/or usage of fossil fuels and other high carbon resources).

These two channels could interact with other financial frictions and stimulate negative feedback loops. They might further interact with a third channel: the impact of physical shocks (e.g. natural catastrophes) associated with climate change, which are likely to increase along with temperatures.

Figure 32. Emission projection

Source: ASC (2016).

5.5 Climate change and its impacts

The objectives of global climate change policy are expressed in the desire to limit global warming to a given temperature increase: “well below 2C and pursuing efforts to limit the temperature increase to 1.5C” being the goals of the Paris Agreement. Currently, the global temperature increase relative to the 1951-1980 average is about 1C.³⁹ Additionally, 17 of the warmest 18 years on record have occurred during the 21st century.⁴⁰

Global average temperature increases are linked with the rising concentration of CO₂ in the atmosphere, measured in parts per million (ppm). This stock of CO₂ fluctuates throughout the year, but has peaked at 412 ppm in 2018 so far; as measured at the benchmark Mauna Loa observatory.⁴¹ The IPCC’s benchmark value for limiting global warming to 2C is generally considered to be 450 ppm.⁴² By contrast, the ppm of CO₂ in the atmosphere stood at about 355 in 1992, the year the United Nations Framework Convention on Climate Change (UNFCCC) was conceived.

³⁹ <https://climate.nasa.gov/vital-signs/global-temperature/>

⁴⁰ <https://public.wmo.int/en/media/press-release/wmo-confirms-2017-among-three-warmest-years-record>

⁴¹ <https://www.esrl.noaa.gov/gmd/ccgg/trends/weekly.html>

⁴² https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf p.10

A major update with regard to the state of the art of climate science is expected with the release of the IPCC's "Special Report Global Warming of 1.5C". The 'Summary for Policy Makers' is set for release on October 8,⁴³ following an IPCC conference in South Korea. This will be the first IPCC report that explicitly considers the aspirational temperature goal of the Paris Agreement. It will cover expected impacts of 1.5C warming as well as mitigation pathways compatible with this temperature goal.⁴⁴

While the growth in global greenhouse gas emissions in 2016 (the latest year available due to lags in reporting) has slowed down to the lowest levels since the economic crisis years of 2008-09, they have nevertheless reached all-time high levels with 49.3 giga-tonnes of CO₂ equivalent GHG emissions.⁴⁵ The G20 countries collectively contribute about 4/5th of total GHG emissions, while the EU contributes slightly under a tenth.

Some effects of climate change are already visible today, and are expected to be (much) stronger in the future. These effects include shrinking glaciers, shifts in plant and animal ranges, loss of sea ice, accelerated sea level rise, and more intense heat waves and extreme weather events.⁴⁶ Specific climate anomalies observed over 2017 include the arctic sea ice extent being 8.5% lower than during the 1981-2010 average, and a number of hurricanes in the Atlantic Ocean resulting in precipitation records.⁴⁷

An important element of climate change impacts is the variance across different regions, sectors and across different timescales. Even if aggregate macroeconomic impacts may be more limited for shorter time horizons, individual sectors and countries could face more significant impacts already. According to the World Bank,⁴⁸ by 2030, over 100 million people globally could be forced back into extreme poverty, while in Europe impacts for these time horizons are more focused on the agricultural sector. These impacts on agriculture may not even be negative everywhere: in cooler climates higher temperatures will lead to rising yields. Globally, however, the impacts on agriculture are unequivocally negative, with wheat and rice yields expected to decrease by 6% and 10% respectively for every 1C of global warming.⁴⁹ Beyond impacts on water and food security, climate change may also have direct impacts on public health due to an increase in the distribution of vector-borne diseases that accompanies temperature increases.

Migration is another area where climate impacts may be significant. By 2050, 143 million people living in vulnerable developing countries in sub-Saharan Africa, South Asia, and Latin America are expected to be forced to move within their own countries due to climate impacts.⁵⁰ Such displacement may reinforce or create migration flows which can have effects well beyond the borders of initial impact.

⁴³ http://www.ipcc.ch/news_and_events/ma-p48.shtml

⁴⁴ <https://unfccc.int/topics/science/workstreams/cooperation-with-the-ipcc/ipcc-special-report-on-global-warming-of-1-5-degc#eq-4>

⁴⁵ http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2017-trends-in-global-co2-and-total-greenhouse-gas-emissions-2017-report_2674.pdf

⁴⁶ <https://climate.nasa.gov/effects/>

⁴⁷ <https://www.ncei.noaa.gov/sites/default/files/sites/default/files/2017-global-significant-events-map.png>

⁴⁸ <http://www.worldbank.org/en/topic/climatechangeandhealth#1>

⁴⁹ http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap11_FINAL.pdf

⁵⁰ <https://openknowledge.worldbank.org/handle/10986/29461>

Finally, while there is broad consensus on the general drivers and long-term trends of climate change, there is more uncertainty in general about impacts that may trigger so-called tipping points, where climatic feedback loops rapidly exacerbate climate change impacts beyond those already discussed.⁵¹ Such tipping points can include the collapse of the Greenland ice-sheet or the melting of permafrost, releasing vast amounts of methane, a greenhouse gas 25 times more powerful than CO₂, into the atmosphere.

5.6 Resource competition

Resource competition is a frequently cited source for future conflicts. However, there is little indication that important resources will become so scarce that their price makes them unaffordable to some. On the contrary, especially in the area of fossil fuels the long-term outlook has changed radically. About a decade ago, the term 'peak oil' referred to the idea that the production of oil might soon be limited by the availability of affordable reserves. The change in outlook is illustrated by the fact that today the same term refers to the expectation that the demand for oil might soon peak because unlimited consumption of fossil fuels would have catastrophic consequences for the climate.

As already mentioned in CEPS (2013) and many others, the atmosphere of the earth can only absorb a limited amount of further CO₂ (and other so-called greenhouse gases) emissions. This CO₂ 'budget' is close to being exhausted. In order to reach the official Paris goals, emissions should already start to decline in a few years. This would naturally imply a reduction in the use of oil (and gas).

As explained above, it is unlikely that the 2° path will be adhered to. Actual emissions might thus continue to increase for some time. However, a large part of oil consumption is used in the transport sector, which is likely to be the first sector to switch to electricity (hopefully produced by renewables). If this happens, the demand for oil might actually start to decline.

A number of major oil producers have already tried to calculate what the electrification of transport would mean for their main product and have published corresponding scenarios. The predictions vary considerably, with one scenario of peak oil demand occurring already in the mid-2020s. For others, this point will arrive only a decade later (around 2035). There is thus considerable uncertainty today about the future path of oil demand. By 2035, the situation should be very different. At that point, EVs should be dominant and only the speed of adoption in different parts of the world should still be open to discussion.

The search of new oil fields is very time consuming and capital intensive. Anticipation of 'peak oil' should thus already lead to lower investment and prices well before it materialises. In this sense, the scenarios prepared by major producers are important, independently of whether they actually materialise.

A new element that is likely to limit price fluctuations over the medium term is the so-called shale oil. The production technologies to bring 'tight oil' to the surface have relatively high marginal costs

⁵¹ <https://www.oecd.org/env/cc/Adapting-to-the-impacts-of-climate-change-2015-Policy-Perspectives-27.10.15%20WEB.pdf>

as a complex mix of chemicals has to be pumped at high pressure underground. This type of field is thus different from conventional oil where the marginal cost of producing an additional barrel is close to zero once the field has been developed. Shale oil (and gas) production is thus rather price sensitive. It can increase rapidly when prices are high and, in contrast to conventional sources, will stop when prices fall below marginal cost.

The exploration of shale oil and gas has so far been limited to the US where local environmental concerns have been offset by the fact that local real estate owners also profit from selling drilling and production rights (CEPS, 2013).

Geological studies suggest that in many other parts of the world, including in Europe, there should also be considerable potential hydrocarbon resources in shale formations. So far, this potential has not been developed, but this could change should prices increase and remain high. Moreover, this technology is likely to mature over time, leading to lower production and environmental costs. A 'latent' supply of shale oil could thus remain an important factor in the global oil market even if actual production remains centred on North America.

6 Inequality

This Chapter attempts to shed light on income and wealth inequality in Europe, comparing it with that in the US, on which most research has focussed until now. To better understand future developments, we also investigate long-term patterns in the labour share of income as well in real wages in relation to productivity.

6.1 The falling share of labour

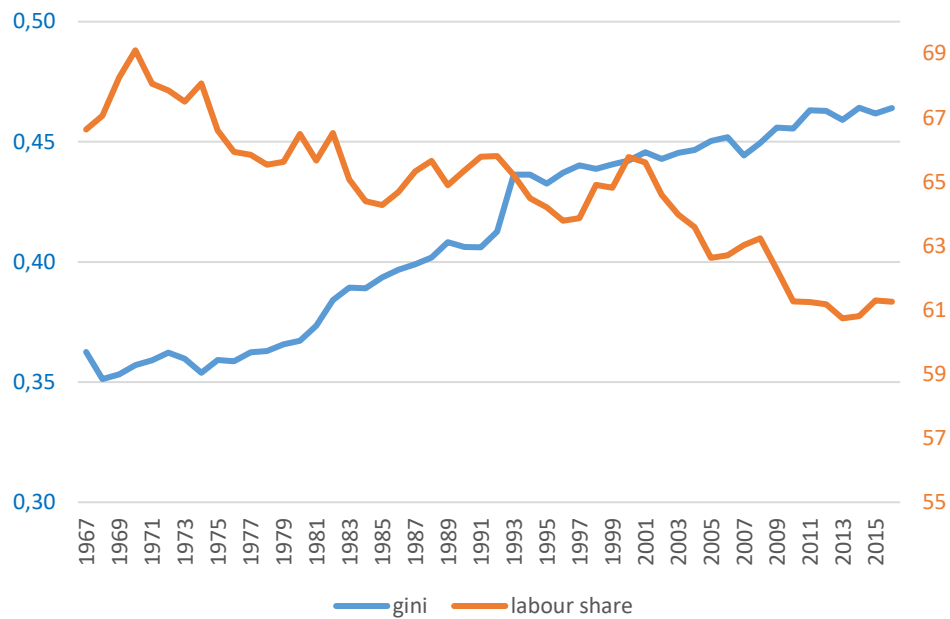
In recent years, the evolution of the labour share of income has gained the renewed attention of policy-makers and academics. Driven by the evidence that, in the US, the labour share has been on a continuous declining trend for several decades, the debate has been animated by the widespread perception that globalisation and technology are responsible through having tilted the distribution of income in favour of capital.

A falling labour share of income not only challenges one of the key foundations underlying most macroeconomic models – constancy of labour-share of income – but it may be signalling rising income inequality. The latter is increasingly perceived as a macroeconomic issue, i.e. potentially having an effect on long term growth, as well as a crucial political issue possibly leading to political instability and the rise of populist and extremist parties.

Though there has also been a slight downwards trend in the group of emerging and developing economies since the 1990s (see EPRS 2018), a falling labour share has been a particular feature of advanced economies over the last 50 years, driven largely by the US, where the downward trend has been fairly constant over time, with an acceleration of the fall since 2000.

In the US, the labour share declined from 69% of total income in the early 1970s to just above 60% in 2016. As illustrated in Figure 33, this has been accompanied by a sharp increase in income inequality, as measured by the Gini coefficient.⁵²

⁵² The Gini coefficient is a measure of concentration of income, comprised between 0 and 1; an increase in the indicator means higher concentration of income and hence higher inequality.

Figure 33. US: Falling labour share and rising inequality (Gini coefficient)

Source: Ameco and United States Census Bureau.

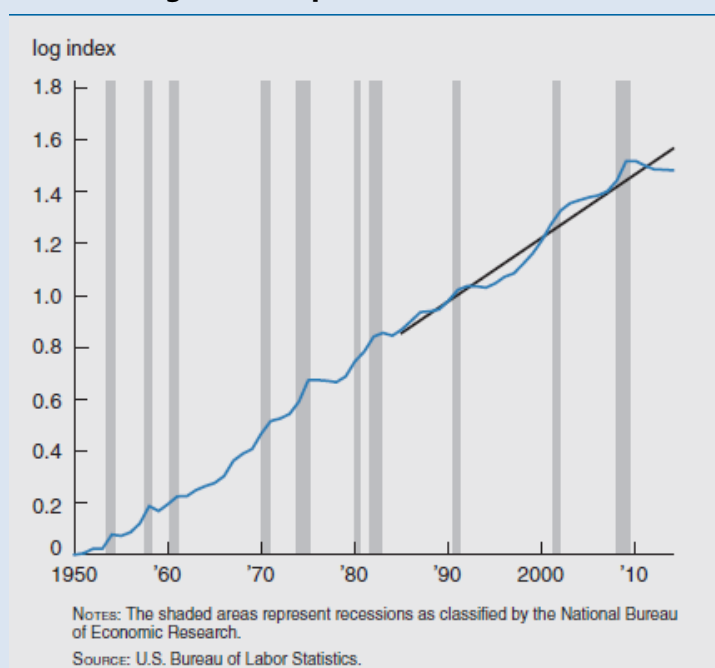
Many explanations for these two facts have focused on technology and globalisation, but it is difficult to disentangle one from the other. Box 12 attempts to provide a non-exhaustive overview of the large economic literature investigating such issues.

Box 12. Why is the labour share falling in the US?

The fall of labour's share of GDP in the United States in recent decades is well documented, but its causes remain uncertain. Existing empirical assessments have relied on industry or macro data and a consensus is far from being reached.

Based on a macro approach, the natural starting point for explaining the behaviour of factor income shares is the theory of the distribution of income based on the production function, where the combination of labour, capital and total factor productivity explains GDP.

The theory essentially relies on the assumption about the ease with which capital and labour can be substituted. Under the assumption that the degree of substitutability among factors is high, several authors have claimed that a rise in the quantity of capital relative to the quantity of labour (capital deepening) is responsible for the decline in labour's share in US income. This hypothesis dates back to Hicks (1932) and has recently been revived by Karabarbounis and Neiman (2013). However, two corollaries of this account are not supported by US data. First, the acceleration of the decline in the labour share in the 2000s was not accompanied by an increase in the rate of capital deepening.

Figure 34. Capital-Labour Ratio, US

Source: Chicago Fed Letter, 2015- N344.

Second, contrary to the predictions of the theory, growth in real wages and output per hour slowed down rather than accelerated during the 2000s.

Among other studies such as Chirinko (2008) and Rognlie (2014), Lawrence (2015) challenges the hypothesis that the substitutability between capital and labour is high and offers evidence that the elasticity of substitution between capital and labour is less than one and adds that a falling labour share is driven by the fact that technical change makes labour more productive (Antras, 2004, Wei, 2014 and Young, 2010). This implies that even if the ratio of labour to capital might have fallen, once technical change is taken into account, the 'effective' supply of labour relative to capital might in fact not have changed.

Elby et al. (2013) go beyond an aggregate production function representation and investigate the sources of within-industry changes in payroll shares by exploiting cross-industry data. The analysis identifies offshoring of the labour-intensive part of the US supply chain as a leading potential explanation for the decline in the labour share. They find that increases in the import exposure of US businesses can explain more than 75% of the decline in the US payroll share over the past quarter century.

Autor et al. (2017) document empirical patterns of US firms' data to assess whether the fall in the labour share can be explained by the rise of 'superstar firms'. Their hypothesis is that if globalisation or technological changes advantage the most productive firms in each industry, product market concentration will rise as industries become increasingly dominated by superstar firms with high profits and a low share of labour in the firm's value added and sales. As the significance of superstar firms increases, the aggregate labour-share will tend to fall. Such a hypothesis leads to predictions in industry concentration and between-firm factor allocation, which are all confirmed by data.

Koh et al. (2016) argue that the decline in the labour share is entirely due to investment in intangible capital. Similar to Lawrence, they reject the hypothesis of constant elasticity of

substitution between labour and capital, and argue that intangible investment increases the demand for skilled labour. This implies that technology can have an amplifying effect on labour, making it less necessary in terms of quantity but requiring qualified labour.

This explanation offers a direct account of how increases in intangible investments could lead to increased inequality and polarisation in the labour market associated with the heterogeneous distribution of skills and abilities (Haskel & Westlake, 2017).

The winners of an intangible economy are those with the skills to master the new economy, whereas the losers are supposedly less-educated and less-trained people. In turn, this pattern accelerates polarisation and can undermine social cohesion.

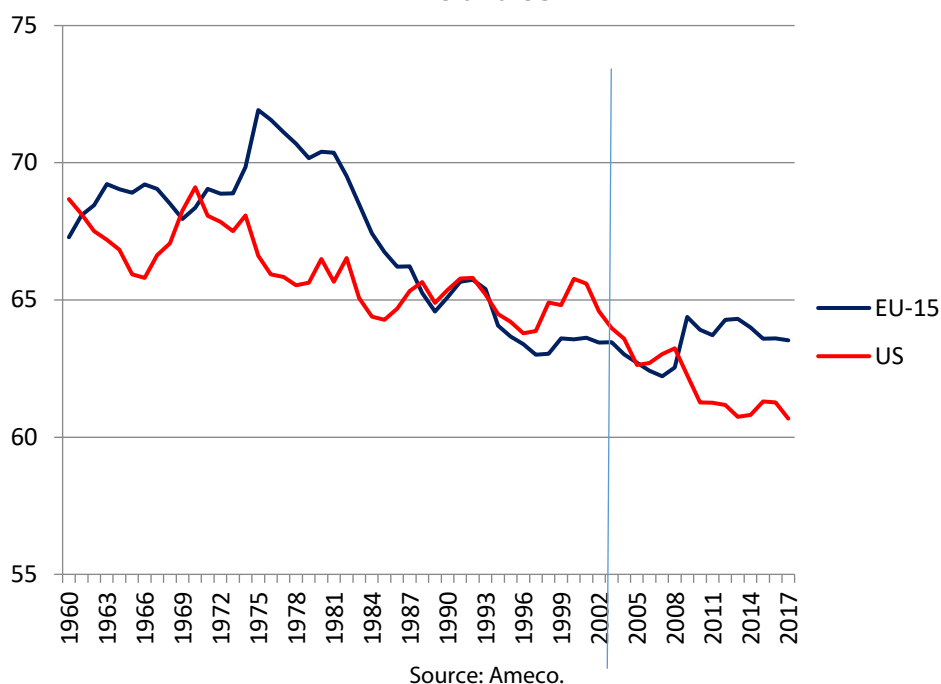
The explanations illustrated above are not exhaustive, but offer a variety of arguments illustrating recent changes in the US economy as largely linked to globalisation and above all to technological change. It seems difficult to see how any of the factors explained above, especially those linked to technology, are likely to change in the future, making it unlikely that the falling trend in the labour-share could be halted, let alone reversed.

The debate on a falling labour-share has also been echoed in Europe, where references to increased income and wealth inequality have multiplied in recent times, not least as an explanation for political changes in several countries.

The first important point to clarify is whether a falling labour share and/or increasing income inequality are also features of the EU economy. The answer to both questions is much less clear than for the US.

Figure 35, which compares US and EU labour-shares, shows two interesting points. The first is that the difference from peak to trough is just below 10 percentage points both in the EU and in the US. This makes the fall comparable in size, though the peaks and troughs do not coincide for the two regions. The second is that while for the US the downward trend has been relatively consistent since the mid-1960s, even if it has become steeper in recent years, for the EU the last 20 years have been marked more by stability than a fall. In making this judgment, we should avoid putting too much emphasis either on the trough of 2007 or the local peak of 2009, which may have been driven by financial crisis effects, negative and positive, on GDP and are likely to be exceptional.

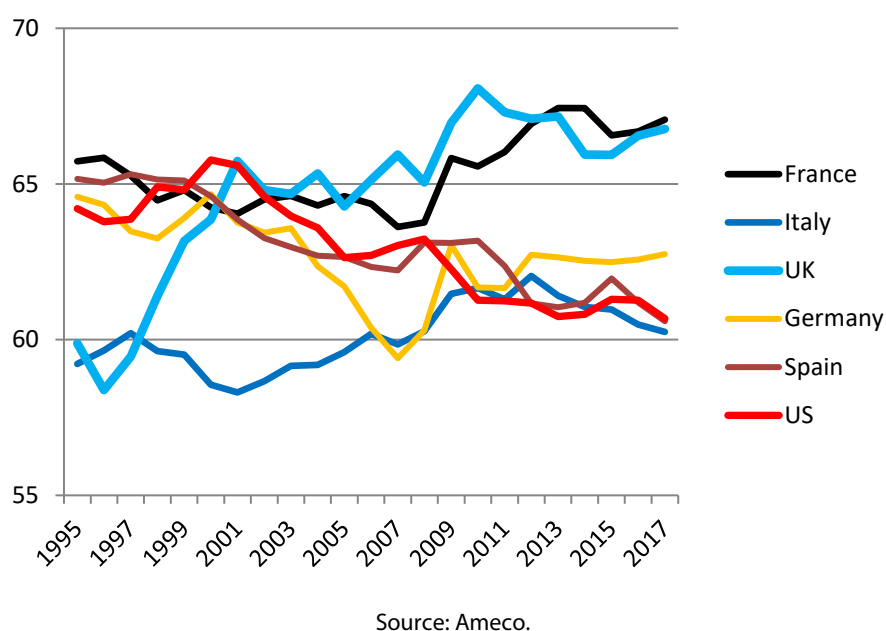
Figure 35. Adjusted wage share as % of GDP (at factor price), 1960-2017, EU and US



Note: EU-15 data are combination of two Ameco series, EU15 (including D_W West-Germany) until 1991 and EU15 afterwards.

To better illustrate the dynamics of recent years, Figure 36 displays the labour share in the largest EU countries and the US focussing on the period after 1995. The figure suggests the labour share has remained fairly constant in most countries and even resumed quite spectacularly in the UK. This seems to indicate a different trend than in the US, where the downward trend accelerated after 2000. Among the countries considered, it is only in Italy that today's labour share is lower than in the US.

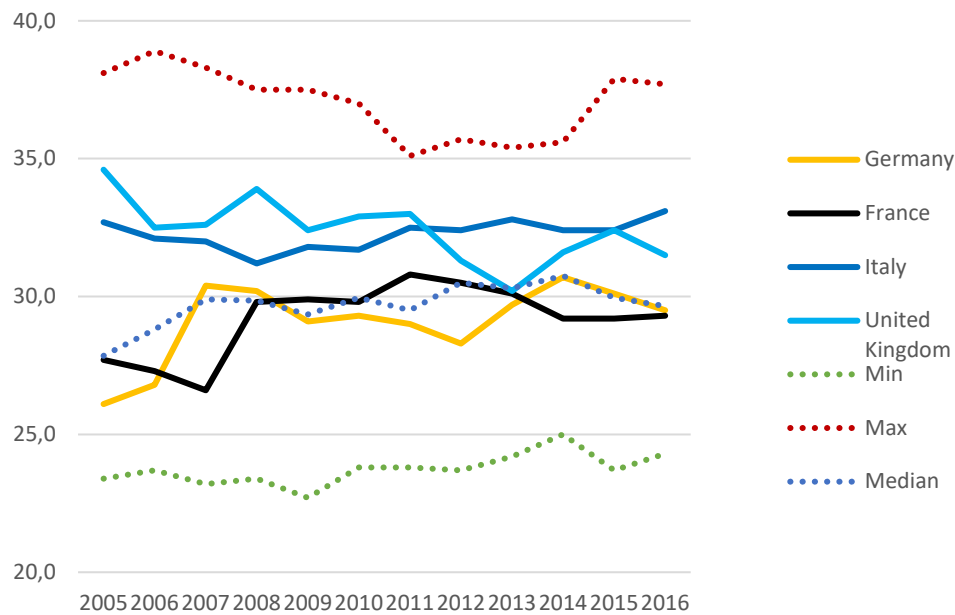
Figure 36. Adjusted wage share as % of GDP (at factor price), 1995-2017, EU selected countries, and US



This picture of the EU, in comparison with the US, makes it difficult to point to globalisation as the major culprit for current EU problems. This remark is even more relevant if one takes into account the degree of openness, one proxy for trade globalisation, which is higher in the EU than the US.

The argument that the US is different is, to a certain extent, reinforced by the fact that a clear-cut indication of a trend of increasing inequality is difficult to find in the EU data. Based on available data, which are admittedly limited, the Gini coefficient displays narrow changes over the last two decades and no clear pattern across countries can be identified (see Figure 37).

Figure 37. Inequality in the EU: Gini coefficient, selected EU countries (2005-16)



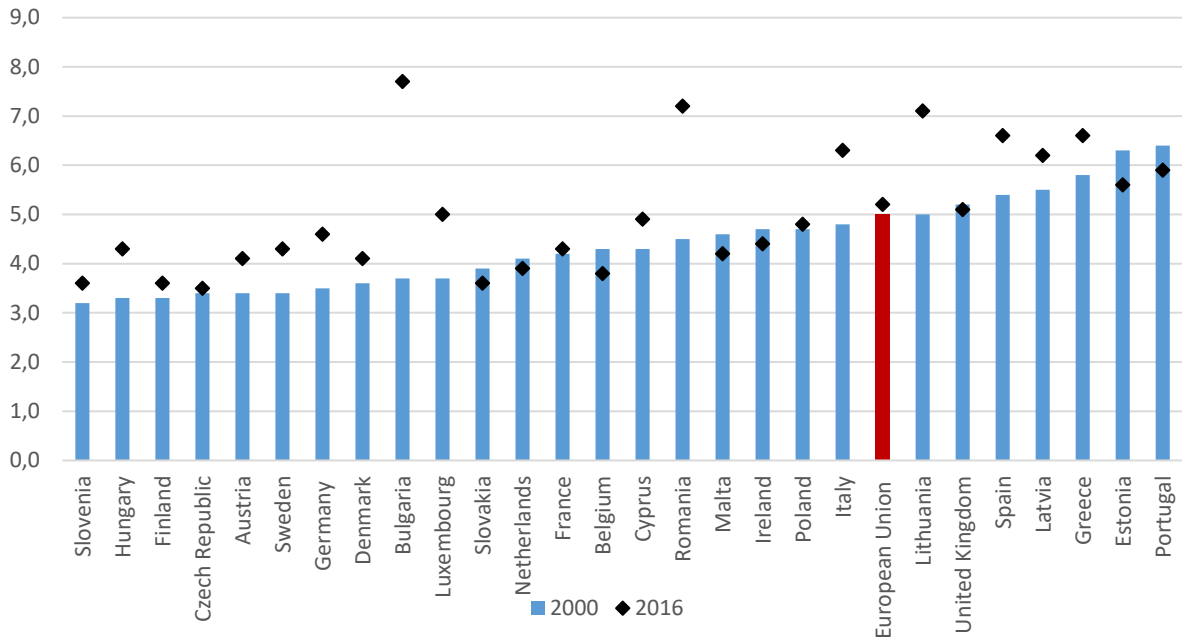
Source: Eurostat, June 2018.

Since the Gini coefficient is only one of the possible indicators to measure a complex phenomenon like inequality, we complement it with the income quintile share ratio, which focuses on the tails of the income distribution. This indicator is given by the ratio of the total income received by the 20% of the population with the highest income (top quintile) and that received by the 20% of the population with the lowest income (the bottom quintile).

Figure 38, which compares the ratio in 2016 to the one in 2000,⁵³ suggests overall conclusions similar to the Gini coefficient. While in some countries, inequality has increased, most markedly in Romania, Bulgaria and Lithuania, in roughly half of the countries considered there is very limited change, either positive or negative.

⁵³ For some countries 2000 is not available, hence we use 2001 for Czech Republic and Sweden, 2003 for Denmark and 2005 for Slovakia, Cyprus and the EU.

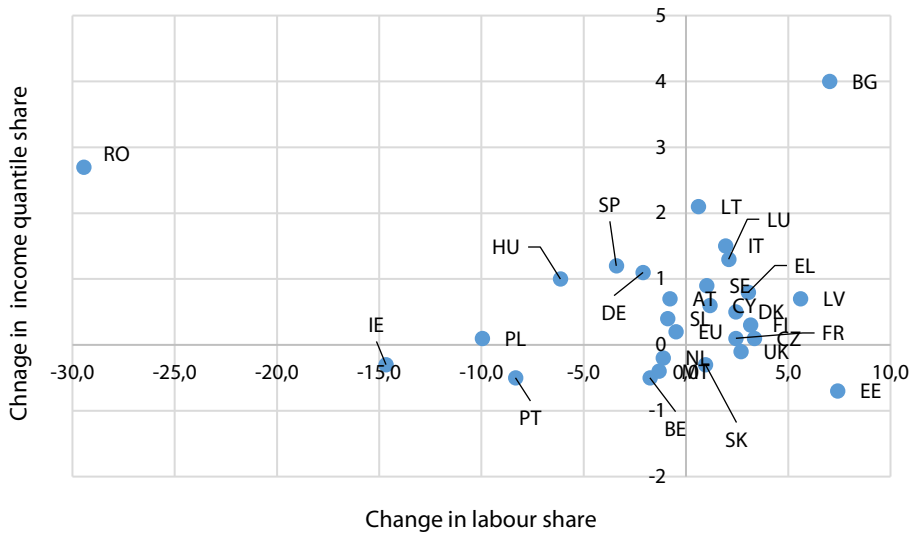
Figure 38. Income quintile share ratio, 2000 and 2016



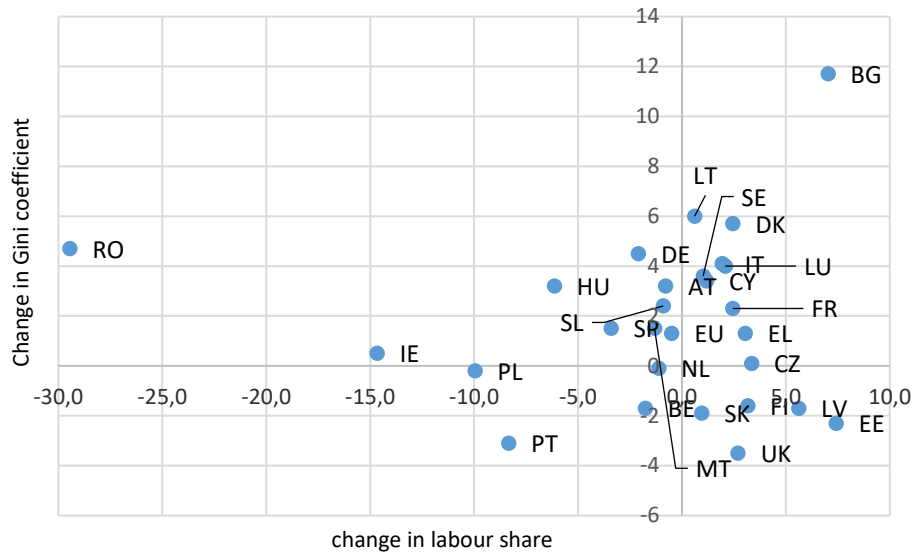
Source: Eurostat, August 2018.

The same result is found in the two scatterplots below (Figure 39 and Figure 40), which attempt to capture a possible relation between trends in labour-share of income and the two measures of inequality. No pattern emerges in any of them.

Figure 39. Change in labour share and in inequality, EU countries, 2000-16



Source: Own elaboration based on Eurostat and Ameco, August 2018.

Figure 40. Change in labour share and in Gini, EU countries, 2000-16

Source: Own elaboration based on Eurostat and Ameco, August 2018.

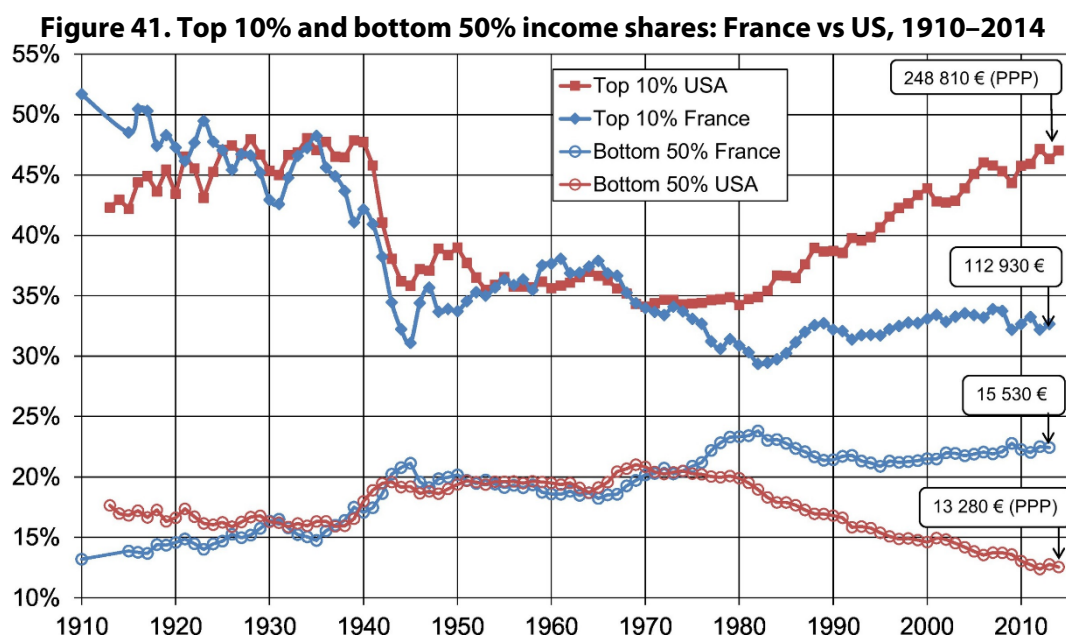
Although the period covered is much shorter than for the US, the key message from the EU data is that the EU is different from the US. While it is indisputable that the EU labour share has declined substantially since the 1970s, the process has slowed since the mid-1990s. However, it has accelerated since then in the US. Therefore, the statement that a falling labour share has been combined with increasing inequality only really applies to the US phenomenon, at least for the time being.

To better illustrate the point that the US case is not necessarily representative of EU inequality patterns, it is instructive to look at the work of Garbiniti et al. (2018), who investigate income inequality patterns in France, for which long data coverage is available, in comparison with the US (see Figure 41). By considering over a century of data, they find that France today, and for the last 40 years, has been substantially more equal than the US. Using historical data, they show how France, which used to be more unequal than the US until the 1930s, then experienced a level of inequality roughly comparable to the US for almost 40 years, up until the 1960s-1970s. It is only subsequently that the two countries experienced different patterns.

The data illustrated in Figure 41 lead to two important considerations. First, the often-heard statement that inequality has increased in Europe is more likely to be driven by the end of a process of reduction in inequality, which lasted about five decades, rather than a visible increase in inequality. When inequality is on a declining trend for decades, every new generation in the bottom income share (50% in Figure 41) will, on average, experience improvements in its income status. A stagnation in this process implies a reset in the expectations of many households, even if inequality has not changed much in the last 30 years. Accepting the idea that future generations will not necessarily be better off, is likely to lead to lower social mobility and a higher risk of future inequality. This may be one of the sources of discontent of lower and middle classes.

The second point is that country differences in inequality are not permanent and deterministic, and can vary a lot over time, depending on country-specific histories, institutions and policy regimes. As

argued in Garbinti et al. (2018), the rise of US inequality occurred mostly since 1980, and certainly involves a complex combination of factors, including changing labour market rules, a highly unequal education system, changing governance and incentives for top executive pay-setting. Technology is also often included among these factors.



Source: Garbinti et al. (2018), Figure 11.

In a forward-looking perspective, one could argue that if faster and more pervasive technological change bears the greatest responsibility for displacing labour and reducing its share of income,⁵⁴ the EU delay in the adoption of new technology, lower investment in intangible capital (and less superstar firms) may be preserving higher labour income. An EU catch-up process in technology adoption could increase productivity and GDP growth, but it could also result in a fall of the labour share of income and more inequality in the future.

6.2 Real wages and productivity

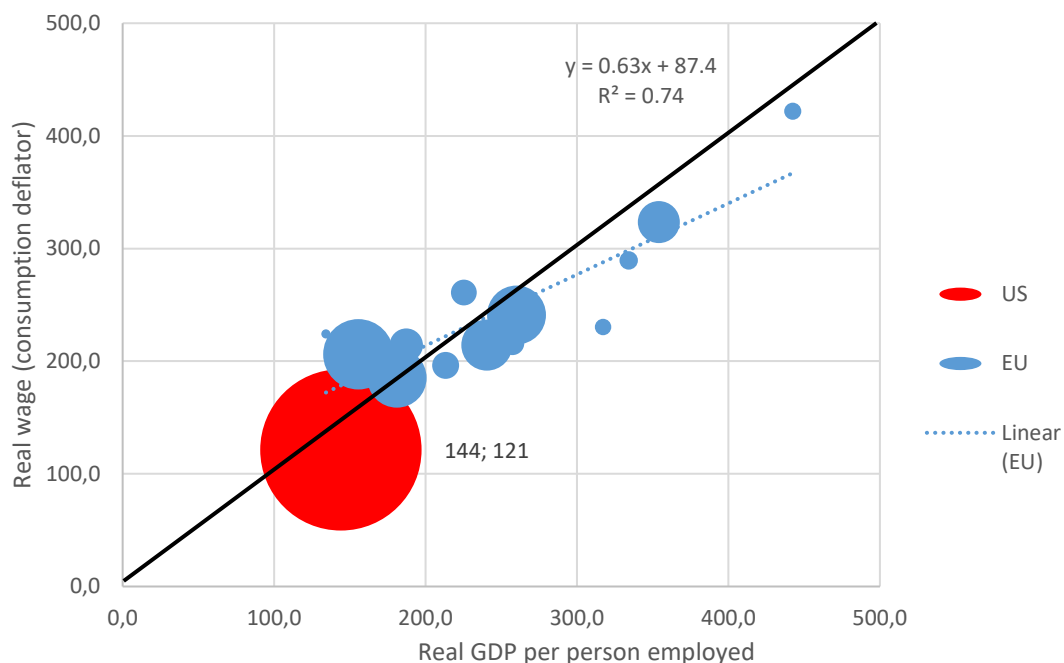
One important factor in the dynamics leading to changes in the labour share is the linkage between wages and labour productivity. Basic macroeconomics suggests that over the long run, compensation per worker should grow in line with GDP per worker, i.e. labour productivity. According to Stansbury and Summers (2018), between 1973 and 2016, US hourly productivity grew by 75% in real terms, while median hourly compensation, using production/non-supervisory compensation as a proxy, only grew by 11%. Such a large gap seems to suggest a dramatic decoupling between productivity and wages. While other authors also point to diverging trends, the spectacularly poor performance of US wages claimed by Stansbury and Summers is specific to the measure of compensation they use, the median wage, which accounts for the distribution of wages across occupations. Average measures of wages suggest a smaller gap, though US productivity growth also outperformed wages on average. A specific feature of the US labour market in recent decades has been the increased inequality in wages. Increasing automation of economic

⁵⁴ See for instance Rogoff (2018).

activity and of work activities had led to a decline for medium-skill tasks, a proliferation of low-skill/low-wage personal services contrasting with a concentration of high-skill, high-paid jobs. Such dynamics tend to be hidden by the average wage.

In Figure 42, we try to compare real wage⁵⁵ and labour productivity in the US and EU member states. Because of data availability in the EU, and with the caveats above in mind, we set average wages against labour productivity. Consistent with the findings of the literature, as illustrated in Figure 10, over the period 1960-2017, US real wages (average) grew by 21%, while productivity increased by 44%.⁵⁶ A higher increase in labour productivity has also been a feature, on average, of EU member states (old member states) as shown by a coefficient of regression of less than 1. However, the gap looks relatively small, and the regression coefficient comes very close to 1 if we impose that zero productivity should be associated with zero wage.

Figure 42. EU-14 Real wages and productivity changes: long term trend – 1960-2017, size of the bubble GDP



Source: Ameco.

Note: Due to data availability, only 14 EU Member States are included.

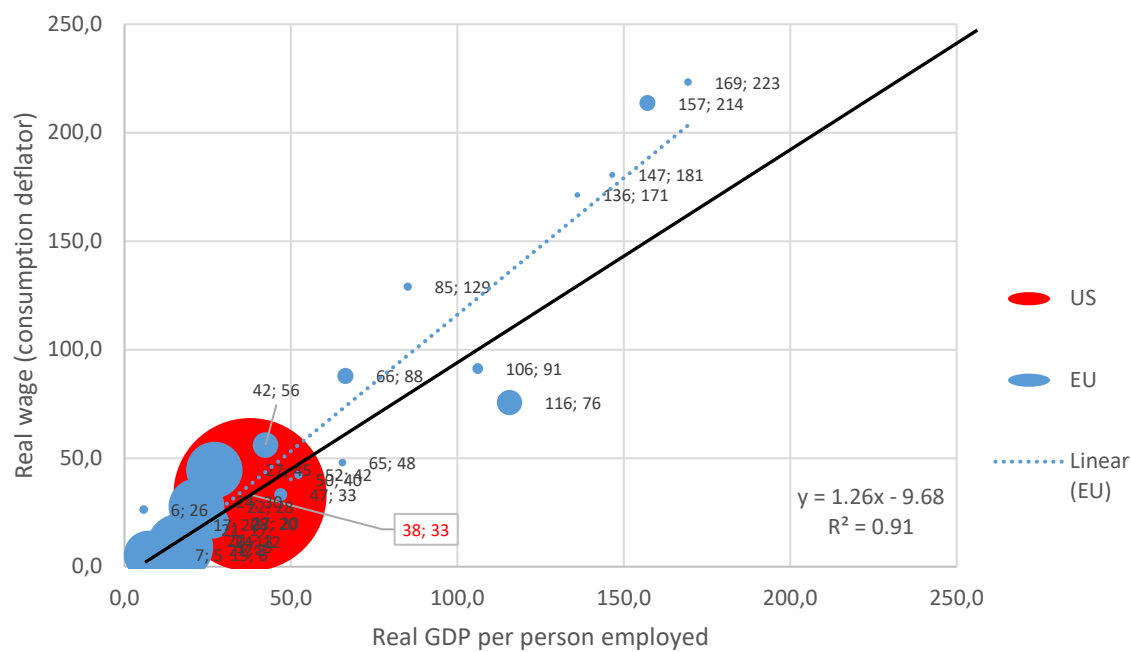
When repeating the same exercise over a shorter period of time, both to capture the potential effect of globalisation on wages and also to extend the sample to include all EU countries, we find that the slope of the regression line becomes greater than one, suggesting real wages grew more than

⁵⁵ Here we use real wages computed as a ratio between nominal compensation and the consumption deflator. Interestingly, the use of the GDP deflator, instead of the consumption deflator may give somewhat different results as in some EU countries the gap between the two deflators is not negligible. Similar considerations also hold in the US, as highlighted by Stansbury and Summers (2018), where, using the PCE consumer price deflator instead of the CPI-U-RS consumer price deflator, the median compensation has risen by about 26% over the period 1973-2016 rather than 12%. The use of the consumption deflator is driven by the idea that it leads to a better indicator of purchasing power.

⁵⁶ See for instance Stansbury and Summers 2017.

labour productivity (see Figure 43). Such a result is completely driven by dynamics in the new EU member states. In old member states (same sample considered for the period 1960-2017), the slope of the line is exactly one, suggesting that on average, wages and productivity moved hand in hand, even though productivity explains a smaller part of the wage change.

Figure 43. EU-27 Real wages and productivity changes: 1995 – 2017



Source: Ameco.

Note: EU-27, excluding Ireland.

With the caveat highlighted by Stansbury and Summers, and as emphasised by Pasimeni (2018), the use of the average wage could lead to an underestimation of the wage-productivity gap, if the distribution of wages within countries is very skewed. However, if the difference in median and average income is of any guidance on this, EU-SILC data suggest that it is in some new EU member states, in particular Romania, Bulgaria and Poland, and a few old member states like Ireland, that a large difference or an increasing gap between the two measures of wages exists. Overall, based on the data available, and with all caveats mentioned above in mind, while a wage-productivity gap exists in the EU, fact-based evidence of a dramatic decoupling, as the one documented for the US, cannot be found.

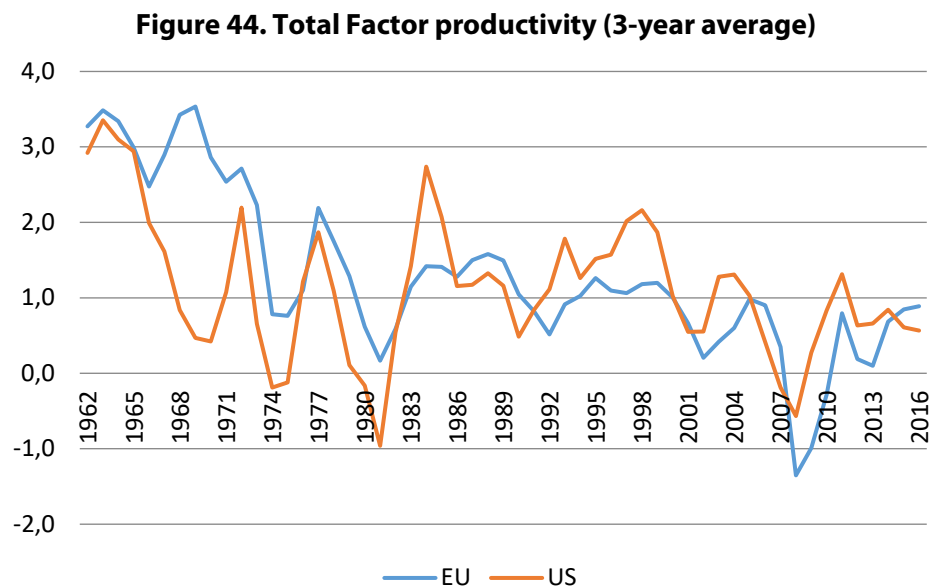
6.2.1 The slowdown in total factor productivity

While labour productivity is an important indicator, especially when it comes to distribution of income, it is an incomplete indicator for gauging the potential of the economy. Firms can boost output per man-hour by investing more and equipping workers with better machinery. But once the extra capital spending is taken into account there may be little or no gain in overall economic efficiency.

Instead total factor productivity (TFP), which tries to capture the efficiency with which inputs of capital as well as labour are used, is a better indicator. TFP growth is the main driver of long-run economic growth as it drives real incomes, inflation, interest rates, profits and stock prices.

Productivity growth has declined over the last decades both in the EU and in the US. Figure 44 below shows that it declined quite substantially until the 1980s; it then remained relatively stable at above 1%; finally, it has been mostly below 1% per annum since the turn of the century, much lower than during previous periods.

The reasons are multiple but seems to go again common sense. William D. Nordhaus already remarked in 1989: "After almost two decades of study of the slowdown in productivity growth, economists have made remarkably little progress in understanding its causes. Among the many potential villains are such economic factors as low saving or capital formation, energy scarcity, regulation, and errors of measurement. Some analysts suggest that the productivity growth slowdown may reflect technological factors, in particular a decline in fundamental invention."



Source: Own elaboration based on AMECO.

Just a few years earlier, Solow (1987) had claimed "you can see the computer age everywhere but in the productivity statistics". Such considerations were driven by the fact that productivity growth lagged in the 1970s and 1980s, despite the gathering strength of the computing revolution. This phenomenon, which became known as the Solow Paradox, appeared to be resolved in the US in the 1990s when a few sectors led an acceleration in US productivity growth. But never in Europe. In more recent years, with digitisation, it seems that we have been living through a second round of the Solow Paradox.

Cloud computing, e-commerce, the mobile internet, artificial intelligence and other new technologies are fundamentally transforming business models and blurring the borders of industries, but productivity gains are still missing from statistics.

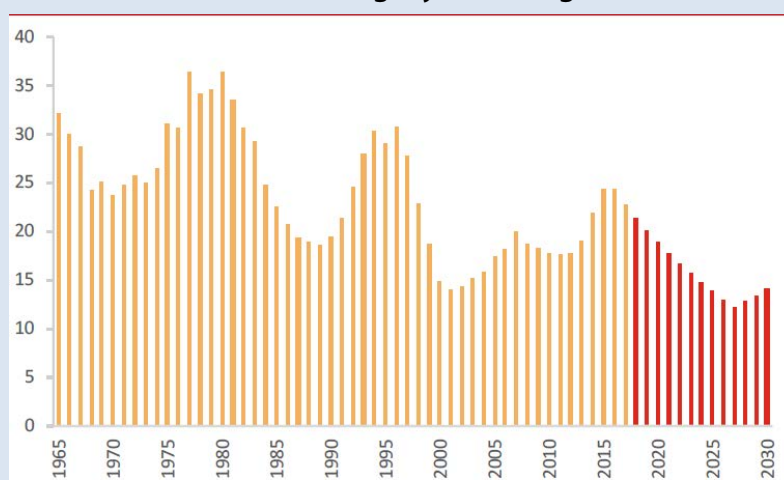
However, as argued in chapter 4, the near future may be different from the past. As the 'product-innovation', which has characterised recent years, combines with 'process-innovation', where

productivity gains will show up on the supply side of the economy, instead of in consumption, TFP is more likely to capture such effects.

Box 13. Falling life span of companies: higher innovation or higher profits?

Company longevity is often used as a proxy for the rate of innovation in the economy. Short corporate lives are usually associated with rapid innovation or what Schumpeter called “creative destruction”. A recent report (led by Richard Foster of Yale University) shows that the average lifespan of a company in the S&P 500 index has decreased from 33 years in 1958 to just 24 years in 2017. If such a fall is projected over the next 10 years, by 2027 more than three-quarters of the S&P 500 will be companies that do not exist today.

Figure 45. Average Company Lifespan on S&P 500 Index (Years, rolling 7-year average)



Data: Innosight analysis based on public S&P 500 data sources. See endnote on methodology. www.innosight.com

Source: Corporate Longevity Forecast 2018: Creative Destruction is Accelerating.

The report argues that the shrinking lifespans of companies provide evidence for creative destruction. In general, exits and entries are claimed to be linked to market forces mostly associated with mass disruption in retail, the rising dominance of digital technology platforms and the downward pressure on energy prices. On the one hand, the inability of companies to adapt their business model to changes or the failure to adequately predict and invest in new growth areas drove the exits from the index. Entries, on the other hand, were achieved by companies that managed to create new products, business models, and serve new customers. A study by Credit Suisse (2017) takes a very close look at the same data and tries to disentangle, through empirical analysis, the main causes for exits from the S&P500. The study finds that, while failures, which in most cases are driven by declines in capitalisation rather than bankruptcy, explain about one third of the exits, more than half of removals from the index was the result of mergers and acquisitions (M&A). This reveals the limitations of associating turnover with creative destruction. That innovation is also linked to M&A and not only to failures still holds true, but several other factors, including capital availability and stock prices, influence M&A waves.

A corollary of this finding is that rising profitability, emerging from market concentration and thereby increased market power, may be as important as creative destruction in explaining current trends in the longevity of companies.

The dominant role of M&A emerging from this analysis may be interpreted as supporting the industry concentration evidence mentioned in Box 12, which according to some authors is at the heart of falling labour share and rising inequality.

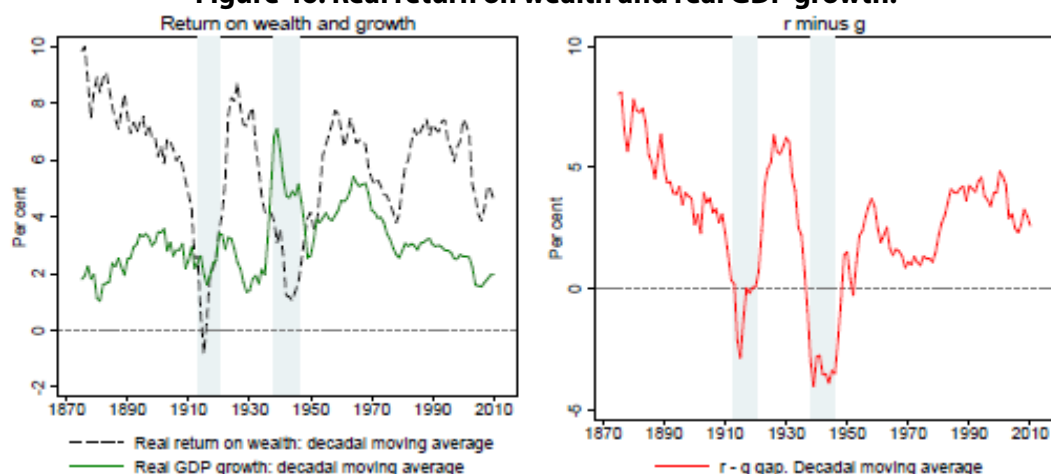
A better understanding of these issues is required, as policy implications should move from innovation to competition policies.

6.3 Wealth inequality: growth rates and interest rates

The debate on inequality has not only focussed on income. The work of Piketty in 1997 and in 2013 on wealth inequality has inspired a lot of debate on wealth distribution. The income rich are not necessarily the wealth rich. So wealth should also be considered in order to gain full overview of inequality. In practice, an assessment of wealth distribution is a particularly difficult exercise because of the limit to accessing data on personal wealth, defining wealth (e.g. whether only financial assets should be included or other assets should be counted) and pricing financial assets over time. Piketty's work is one of the first comprehensive attempts to fill a long standing gap in the literature, based on tax data. See Box 2, on the case of France.

The main finding of his analysis of capitalism in the 20th century is that, under no policy change scenario, wealth inequality is deemed to increase further in the future and the concentration of wealth is the principal threat to democracy. Such a result is mostly driven by what he claims to be a major contradiction of the capitalist system: the average annual rate of return on capital is, in the long-run, greater than the growth of the economy (i.e., the annual increase in income or output). If the rate of return on capital remains significantly above the growth rate for an extended period of time, then the risk of divergence in the distribution of wealth is very high. One fundamental reason for this is that people with inherited wealth need to only save a portion of their income from capital to allow their capital to grow more quickly than the economy as a whole.

In this context, a better understanding of the composition of wealth is important. Jorda et al. (2015) draw on the work of Piketty and develop the comparison between return on capital and growth rates further. Piketty defines capital as a basket of financial and non-financial assets which can be traded on a market. Jorda et al. (2015) attempt to unbundle the basket and the return on different assets, considering equities, housing and government bonds over almost 150 years. Their analysis supports Piketty's findings that over the long run, the return on wealth tends to be higher (by several percentage points) than the growth rate of the economy. According to the picture below (Figure 46), it is only during the two world wars that the real return on wealth was lower than GDP growth.

Figure 46. Real return on wealth and real GDP growth.


Source: Jorda et al. (2017), Figure 15, p. 46.

In addition, they provide cross-country differences and changes over time. Table 5 suggests that both return on capital and growth rates varied, but the positive spread between the former and the latter is a very robust feature across countries and over time.

Table 5. Return on wealth, r , and GDP growth, g

	1870-2015		r-g	Post 1950		r-g	post 1980		r-g
	r	g		r	g		r	g	
Australia	5.91	3.58	2.3	7.4	3.85	3.6	7.55	3.41	4.1
Belgium	6.37	2.31	4.1	7.27	2.65	4.6	6.87	2.12	4.8
Denmark	7.5	2.78	4.7	7.24	2.59	4.7	6.68	1.76	4.9
Finland	9.7	3.58	6.1	11.84	3.29	8.6	11.66	2.4	9.3
France	5.01	2.61	2.4	8.24	3.37	4.9	6.96	2.07	4.9
Germany	6.95	2.84	4.1	5.25	2.86	2.4	4.7	2.49	2.2
Italy	5.05	3.81	1.2	5.04	3.29	1.8	4.95	1.35	3.6
Japan	5.58	4.15	1.4	6.33	4.17	2.2	4.21	2.04	2.2
Netherlands	5.27	3.16	2.1	6.68	3.2	3.5	6.73	2.28	4.5
Norway	6.91	3.06	3.9	7.62	3.45	4.2	9.25	2.79	6.5
Portugal	5.76	3.39	2.4	5.53	3.48	2.1	6.77	2.12	4.7
Spain	4.5	3.21	1.3	5.37	4.03	1.3	5.18	2.55	2.6
Sweden	7.4	2.88	4.5	8.66	2.86	5.8	9.82	2.35	7.5
Switzerland	5.67	2.33	3.3	6.06	2.68	3.4	7.2	1.94	5.3
UK	4.7	2.04	2.7	5.92	2.5	3.4	7.29	2.45	4.8
USA	5.91	3.38	2.5	5.77	3.32	2.5	6.37	2.8	3.6
Average, unweighted	6.28	2.87	3.4	6.89	3.25	3.6	6.97	2.3	4.7
Average, weighted	5.89	3.05	2.8	6.01	3.33	2.7	5.98	2.48	3.5

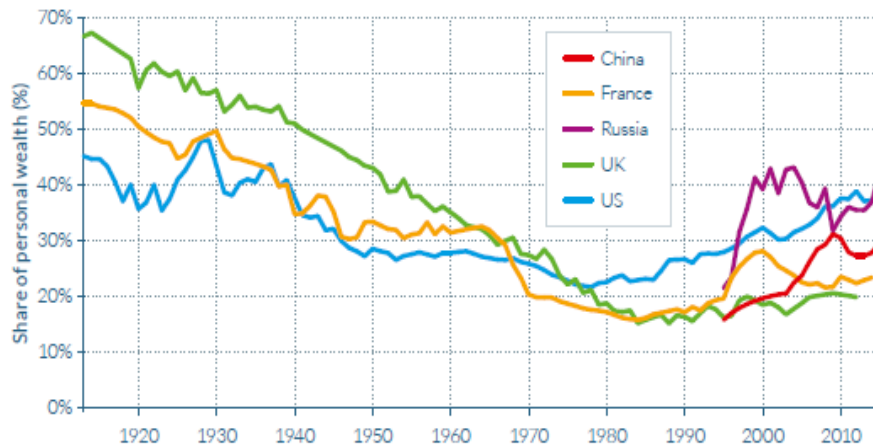
Source: Jorda et al. (2017), Table 12, p. 47 and own calculations.

Another element emerging from the table is that the US, which is the country where wealth inequality has increased most strongly in the last 4 decades (see for instance Figure 47 and

also on wealth inequality in France), it is not the country with the largest gap. In this respect, it is worth noting that the authors point to housing as a major driver of returns. In addition, the concentration of house ownership can significantly affect the concentration of overall wealth and this varies a lot across countries.

Figure 47. Top 1% wealth share

Top 1% wealth shares across the world, 1913–2015: the fall and rise of personal wealth inequality



Source: WID.world (2017). See wir2018.wid.world for data series and notes.
In 2015, the Top 1% wealth share was 43% in Russia against 22% in 1995.

Source: World inequality report (2018), p. 12

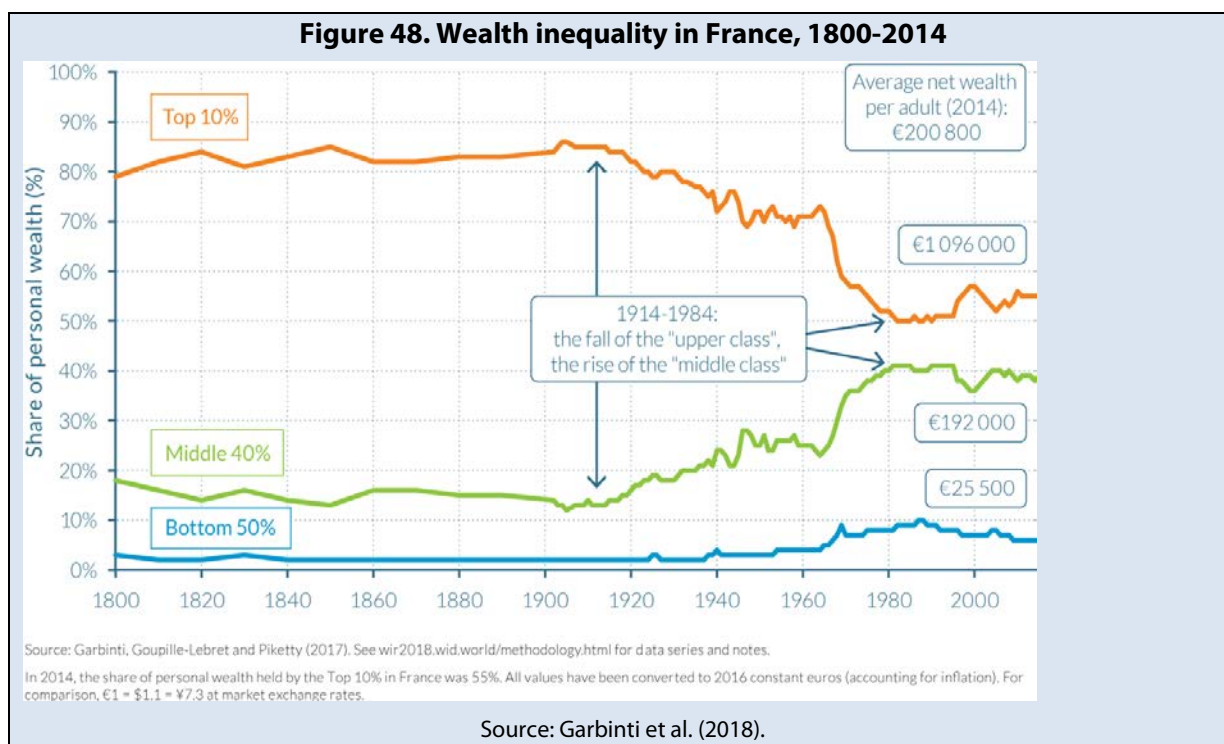
Box 14. Wealth inequality: the case of France

This Box focuses on the case of France, for which the analysis of wealth distribution is extended and covers a very long time span, as an example of changes in recent decades. In doing this we follow Garbinti et al. (2018).

As illustrated in the figure below, during the XIX century and until the early 1900s, most wealth was concentrated in the hands of the richest 10% of people and the middle class was inexistent. World War I seems to mark the end of a long period of stable and high inequality and the beginning of about 70 years of falling inequalities and an emerging middle class. Between 1910 and 1985, the wealth held by the richest 10% fell from 85% to 50%, while the wealth of the middle 40%, namely those whose wealth was between the richest 10% and the poorest 50% increased from 14 to 41%.

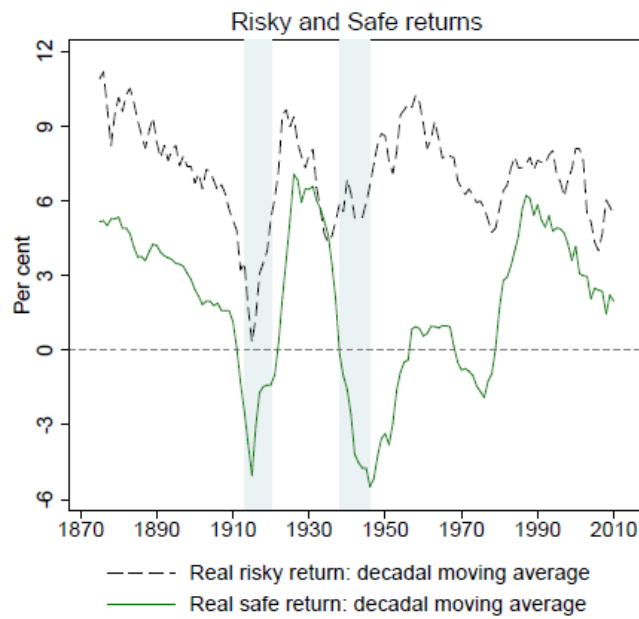
These patterns came to a drastic stop in 1980. The fall in the wealth of the richest ended and their share started to slowly increase; in a mirror behaviour, the increase in the middle 40% stopped and their share has remained fairly stable since.

Similarly to the argument regarding income distribution, while it is difficult to claim on the basis of the data that inequality is drastically increasing, the change in the trend and the inability of a large part of French people to increase their accumulation of assets for the last 30 years, in contrast to what happened over the previous 70 years, is likely to be perceived as increased inequality and generate fears of a downgrade of social and economic status for future generations within the same household.



6.4 Safe assets: the other side of wealth accumulation

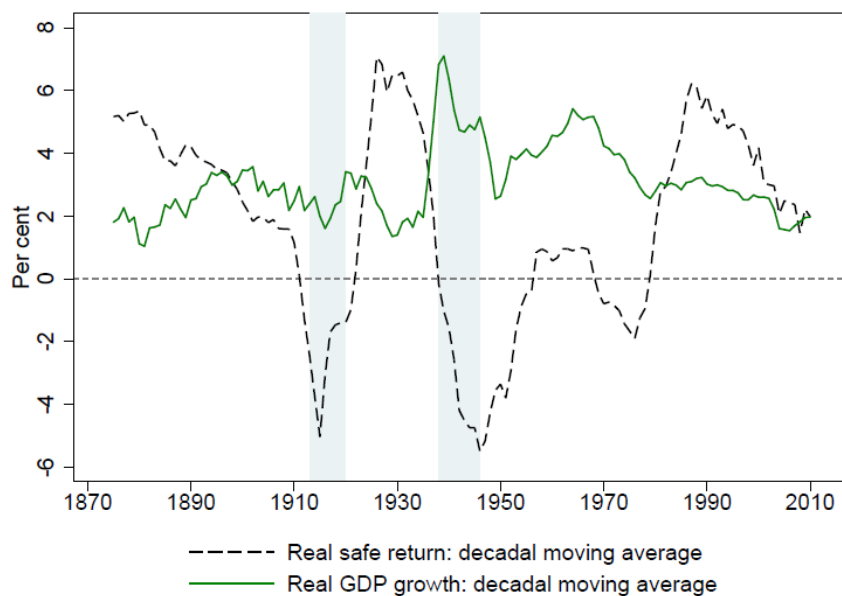
A last point is regarding return on safe assets. Based on Jorda et al. (2017), Figure 49 shows that while historically rates of return on both risky and safe assets were high during the 19th century, they had been gradually declining in the lead up to World War I, after which they increased sharply. From 1930 onwards, the 'risky rate' stayed high and relatively stable, whereas the 'safe rate' dropped sharply and remained low until the late 1970s, before increasing and falling back again during the past three decades. Unlike safe rates, risky rates show little sign of a secular decline. By contrast the safe rates exhibit higher volatility and a declining trend has appeared recently. In historical perspective, a slow and long lasting declining trend is not an exception, a similar pattern had emerged in the last decades of the XIX century and led to a period of negative real rates.

Figure 49. Global real risky vs. real safe return.

Source: Jorda et al (2018) Figure 13, page 42.

An additional interesting finding of Jorda et al. (2017) is that return on safe assets has been on average 'below, but close to' the growth rate of GDP, even though this average hides very large swings.

The comparison of the two rates is not only relevant for consideration of wealth accumulation, but also from the perspective of public finances, as the safe return measures the cost of raising and servicing government debt, and over the long run, a GDP growth rate larger than return on government debt securities is a condition for public debt sustainability.

Figure 50. GDP growth rate and interest rate

Source: Jorda et al. (2017) Figure 5, page 18.

After World War II, high growth and inflation contributed to creating a positive gap between the growth rate and the safe rate as large as 10 points, hence greatly helping to reduce the value of debt. More recently, the Great Moderation saw a reduction in inflation rates and a corresponding increase in the debt-financing burden. By contrast, the impact on $r-g$ in the aftermath of the financial crisis remains broadly neutral, with the two rates roughly equal.

Based on ongoing trends, it is likely that looking forward to the 2035 horizon, interest rates on safe government bonds will drop even further below the growth rate, thus making it easier to reduce still high debt levels, at least for those countries where country-risk remains low.

6.5 Summary conclusions on EU-US comparison

The evidence presented in this chapter and the comparison between US and EU of secular trends on labour share of income, income inequality and wealth inequality suggest two broad conclusions. First, the US is characterised by quite extreme patterns in labour share of income and inequality both in income and in wealth. On the EU side, data availability is more limited and literature scant, but existing information does not support viewing trends as similar to those in the US. Nevertheless, labour share of income fell substantially in the past and a number of indicators point to a clear halt in the process of declining inequality that was a feature of the seven decades up to the 1980s. The second conclusion is that, against a general perception, trade globalization seems not to have affected trends in labour share and in income inequality in Europe. None of the two indicators exhibit dramatic changes since the late 1990s in Europe, despite the greater opening of the EU relative to the US. If anything, changes started earlier. However, if it is the adoption of technology, instead of trade globalisation, that drives inequality, the future in Europe is likely to be different from the past.

6.6 Efficient and inefficient social models in the EU

This section focusses on the EU and link between one aspect of inequality, namely poverty, and redistribution policies.

There is wide agreement that the European social model (or models, according to many) is (or rather, are) in severe difficulty. The challenges have been debated at the highest political level for over a decade now, starting with the special European Council meeting on the European social model in 2005. Years later the Union adopted the “Europe 2020” strategy, which was supposed to deliver “smart, sustainable and inclusive” growth. Europe 2020 never had a chance to succeed because it was elaborated just when the euro crisis was about to start. An important element, which has survived, is the ambition to deliver inclusive growth. This implies a reduction in poverty and social exclusion.

The common diagnosis today is that the combination of lower growth resulting from the crisis, an ageing population and increasing competition from low-wage countries are straining the capacity of governments everywhere to deliver appropriate income redistribution and insurance against risks that electorates seem to expect, and populist promise to deliver instantaneously.

The discussion about the sustainability of social models often implicitly assumes that countries can somehow ‘choose’ what kind of model they want to adopt.

Since over the last decade the Nordic countries have had the best economic performance within the EU, it is often argued that other countries should copy this 'model'. Nevertheless, this line of advice is misleading.

We argue that it is not possible to just copy a different social model. Governments might be able to choose how much to spend on social security benefits, but they cannot guarantee the level of equality to which this will lead (assuming that the aim of social security benefits is to reduce inequality and poverty). Different institutions, governments and societies often exhibit different degrees of efficiency in alleviating poverty. Enhancing efficiency might be more important than increasing expenditure.

6.6.1 Efficient and inefficient social models in the EU

Welfare state 'models' in Europe can be categorised into 4 groups, which mix to a different degree employment and equity (or the acceptance of inequality).

These 'stereotypes' are usually represented in a matrix, with equity and efficiency as the two axes (Table 5).

Table 6. Standard classification of social models

		Efficiency (= employment?)	
		Low	High
Equity (=1- poverty)	Low	Mediterranean (usually EL, IT, ES and PT)	Anglo-Saxon (usually the UK and IE, only in the EU)
	High	Continental (usually the remainder, including FR, DE, BE and AT)	Nordic (usually Nordic countries plus NL)

Source: own elaboration based on Sapir (2005).

Sapir (2005) provides a useful restatement of this classification (based originally on work by Esping Andersen (1990)). This standard classification is nonetheless of little use in deriving policy conclusions.

Does it imply that the societies of the southern EU countries somehow prefer low employment (taken as synonymous with low efficiency by Sapir (2005))? A more useful explanation of the differences between social models should start from what one can observe directly about political choices. A key variable in this respect is the amount a society is willing to spend on equity.

There are wide variations in this respect, ranging from a low of spending on social security benefits of only 14% of GDP⁵⁷ in countries like Estonia to more than 30% of GDP in Scandinavia (with the EU-28 average slightly around 22% of GDP).

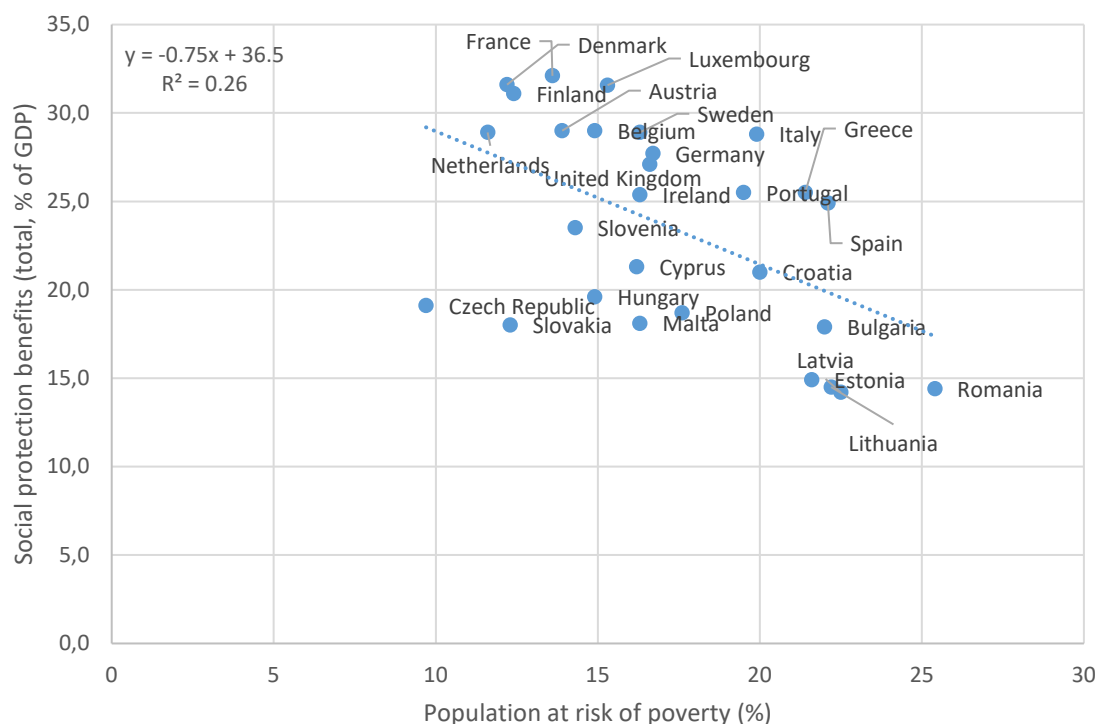
One of the main purposes of social security benefits should be to reduce poverty. Adopting the share of the population in poverty (which is usually defined as a household income below 60% of the median) as one measure of inequality, one should be able to identify different social models as assorted combinations of expenditure and social security benefits. Societies that value equity highly

⁵⁷ GNP should be used for Ireland and Luxembourg because for these countries the GDP numbers do not give a good indication of the tax and income base of the country.

should be characterised by a combination of high social security expenditure and low inequality or poverty.

However, the link between the amount spent on social security and the share of population at risk of poverty is surprisingly weak. Variations in social security expenditure can explain less than 30% of the variations in poverty rates among member countries, as can be seen from Figure 51. It is also interesting to note that there is a clear gap separating the new and the old Member States.

Figure 51. Poverty and social security expenditure (2015, EU-27)



Source: own elaboration on Eurostat data

Thus, if one looks at the observable effort countries make and the results in terms of poverty, a clear split emerges between the 'old' Member States and the 'new' ones. All of the new Member States are located below the regression line, which means that a given level of poverty the old Member States tend to spend much more on social security benefits.

The scatter plot also shows that there are large differences in terms of the result achieved even among the old Member States. Italy, Austria and Sweden show similar spending on social security, but quite different outcomes in terms of the poverty rate. Italy has a much higher rate of poverty than other countries.

A more direct explanation for the lack of a tight correlation between the amount a society spends on social security and the resulting poverty level might be the different degree of efficiency in which social security spending is targeted towards the needy. More efficient countries are likely to obtain a greater reduction of poverty for any given level of social security spending than less efficient ones.

The observation that some countries spend a lot on social security, but achieve little in terms of a reduction in inequality suggests that one should try to link poverty to two variables: how much is spent to alleviate it, and how efficiently a government might be expected to go about it. The efficiency of a government is difficult to measure objectively. Nevertheless, there are numerical indicators resulting from extensive survey work done by international institutions. The indicator used here comes from the World Bank and is called 'government effectiveness' (see Kaufmann et al. (2005) for more details).⁵⁸

To test this proposition a simple OLS equation was run on cross-country data (2015), in which the risk of poverty was explained by two variables:⁵⁹

- 1) social security benefits (as a percentage of GDP), and,
- 2) the above-mentioned indicator of government effectiveness.

The results are reported in Table 7 below. This equation explains almost 80% of the observed variability of poverty rates across the EU-15 (minus the special case of Luxembourg), indicating that there is a systematic relationship between the explanatory variables used here and the observed degree of poverty.

Table 7. Dependent variable Risk of poverty (after social security benefits)

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	27.95	1.50	18.61	0.00
Soc sec benefits	-0.22	0.07	-3.40	0.00
Government eff	-4.05	0.82	-4.93	0.00
Visegrad ⁶⁰ Dummy	-7.41	1.11	-6.68	0.00

Source: own elaboration on Eurostat data

This simple exercise suggests that income equality (here measured by the risk of poverty) can indeed be reduced by paying out more social security benefits. Each percentage point increase in expenditure on social security benefits reduces the risk of poverty by a little over 0.2 points.

At the same time, this is only half of the story. In this equation, the contribution of the differences in government efficiency explains slightly more of the variation in the risk of poverty than differences in the social security benefits (as measured by the t-statistic). To give a concrete example, an increase in government efficiency by 1 full point (which would be equivalent to the difference between Italy and some of the Nordic countries) would be associated with a reduction in poverty of 4 percentage points. The relationship evidenced by the equation thus suggests that Italy, which has a rather high degree poverty, could reduce this to close to Nordic levels if it could acquire a Nordic degree of

⁵⁸ This is how Kaufmann et al. (2005) define government effectiveness:

In "Government Effectiveness" we combine responses on the quality of public service provision, the quality of the bureaucracy, the competence of civil servants, the independence of the civil service from political pressures, and the credibility of the government's commitment to policies. The main focus of this index is on "inputs" required for the government to be able to produce and implement good policies and deliver public goods.

⁵⁹ Gros and Roth (2012) provide a similar exercise (concentrating on the old EU-15) and find similar results.

⁶⁰ Visegrad identifies four Central European states: Hungary, Poland, Slovakia and the Czech Republic.

government efficiency. A similar observation applies to the other Southern Europe members. Hence, it might be more appropriate to speak about inefficient governments, instead of a Mediterranean model.

These illustrative results suggest two conclusions. First of all, there is a gap between old and new Member States in terms of the combination of spending on social security and poverty. Second, more spending on social security is indeed associated with lower poverty. But, the efficiency of the government machinery matters as well. Some Member States have ended up with a combination of rather high expenditure on social security benefits and a high degree of poverty, not because they (their governments, their societies) like this combination. They have arrived at this point because their governments are inefficient. This is the case for some old and some new Member States. Only the Central European Member States stand out as having different systems, which lead to lower poverty rates than one would expect otherwise.

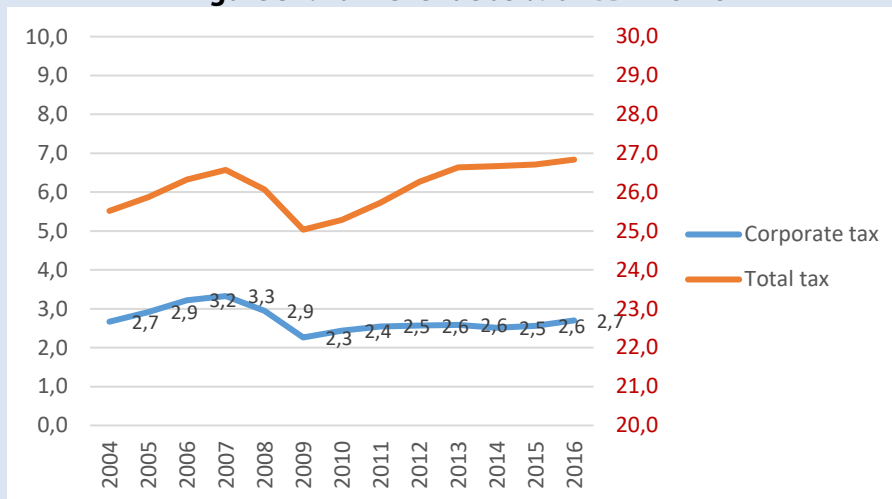
This also suggests that the argument that Maastricht fiscal rules and austerity causes social hardship might be correct in that a reduction in social security expenditure is usually associated with more inequality. But the payoff from making the government more efficient would be much higher.

The best way to achieve a sustainable improvement in poverty rates (one of the key aims of the Europe 2020 strategy) is thus to make the government more efficient. In a long term perspective this means that at least part of the widely perceived problem of increasing inequality should be addressed through reforms which improve the efficiency with which governments distribute social security benefits, rather than through new taxes.

Box 15. Corporate income tax: revenues and rates

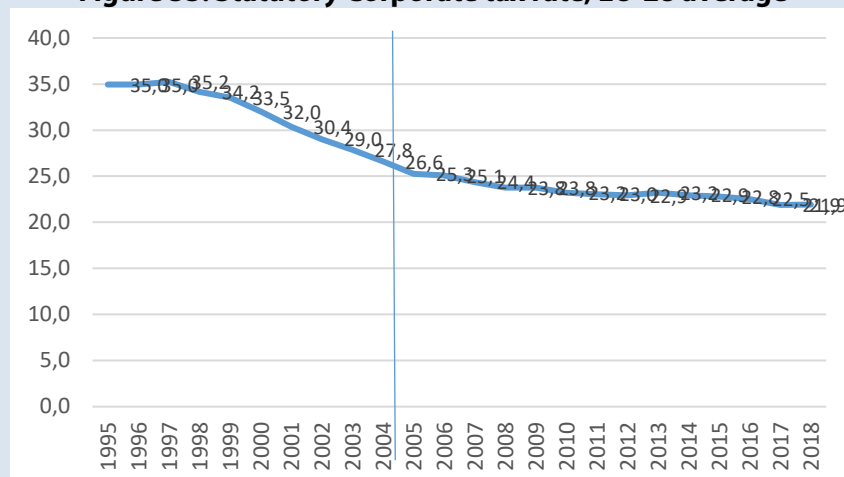
According to the European Commission Tax Report (2018) in 2016, EU-28 revenues from taxes on capital, which include taxes on the capital income of households and corporations and on capital stocks, represented 8.4 % of GDP. These revenues fell during the crisis but have gradually edged upwards since 2010 as a proportion of GDP.

Within this share, corporate income tax revenues rose to 2.7 % of GDP in 2016 compared with 2.6 % in 2015, continuing their gentle increase since the crisis. However, they have not yet recovered their pre-crisis levels. Overall, the tax revenue from corporate tax amounts to about one tenth of total tax revenue (excluding social contributions) in the EU, about 30% of GDP. This is small part of GDP and of total tax revenues. As shown in Figure 52 while total tax revenue increased since 2009 corporate tax revenue remained quite constant, at a lower level, compared to the peak of 2007. There is cyclical component in the indicator

Figure 52. Tax revenue as % of GDP EU-28

Source: DG Taxation and Customs Union, based on Eurostat data

The rather stable behaviour of corporate tax revenue in GDP contrasts with a very clear decline in the statutory rates. The decline is of the order of about 15 percentage points over the last 20 years (see Figure 53), and about 5 percentage points between 2004 and 2016 (the same period for which tax revenue data are available)

Figure 53. Statutory Corporate tax rate, EU-28 average

Source: DG Taxation and Customs Union, based on Eurostat data

It is interesting to note that it is mostly the new EU member states that adopted the most aggressive cuts. And this reflected also in the implicit tax rate on corporate income. Most new MS experience a substantial decline, up to 50% compared to 1995, in the case of Hungary, and 25% in Slovakia and Romania. By contrast, in the largest and old EU member states rates remained unchanged (Germany) or even grew (France).

Write and Zucman (2018) argue that the decline in corporate income tax rates is one of the most striking developments in tax policy throughout the world over the last few decades has been. According to their data, between 1985 and 2018, the global average statutory corporate tax rate fell by more than half, from 49% to 24%. An even sharper decline than the one shown for the EU after 1995 shown above.

One argument to explain this trend is that because of globalisation countries compete to attract for productive capital. Nevertheless, there are two factors at odds.

The data suggest that the fall in tax rates started well before globalization occurred. So it is likely to have been a clear policy choice.

Second, while governments may compete with each other, there is no doubt they cannot compete with tax havens. Here one strategy is that they may be willing to tolerate profit shift to tax havens and collect less tax revenue, but keep unchanged rates. This may have been the strategy followed by some large countries in recent years.

The estimates of Tørsløv et al. (2018) suggest that tax avoidance by multinationals reduces EU corporate tax revenue by around 20%. The authors estimates that adding back the profits shifted out of high-tax countries increases the corporate capital share significantly. In particular, the rise in the European corporate capital share since the early 1990s is twice as large as recorded in official national account data. This would have implications for the relation between capital and labour share of income.

In terms of implications for redistributive policies, two aspects should be considered: size and fairness.

On the one hand, in the EU, given the small sheer size of corporate income tax revenue in GDP (around 3%) the impact at macro level of better tax collection is likely to be limited. On the other hand, tax avoidance raises huge issues in terms of fairness. This becomes an even more marked issue in a context of higher concentration of income and wealth.

7 Identifying new trends: text analysis

This Chapter studies trends among a global community of experts, using text analysis of online resources. This serves two purposes: first, this exercise can support or challenge the results of the literature review and data analysis presented in previous chapters. Secondly, variations of trends over time can help to distinguish one-off or cyclical phenomena from structural, long-term changes. This should provide some protection against the cognitive trap of placing too much emphasis on recent high-profile events. The idea

7.1 Data

We obtained the main data for the analysis from the *Project Syndicate* website.⁶¹ The website delivers original, high-quality commentaries to a global audience. About 85 percent of commentaries relate to either 'Economics and Business' or 'Politics and World Affairs' topics. The website features exclusive contributions by prominent political leaders, policymakers, scholars, business leaders, and civic activists from around the world. Commentaries are available online and are later disseminated to newspapers and other media in both developed and developing countries. Moreover, the content is original and, therefore, in contrast to other possible resources (e.g. blogs or tweets), it is less exposed to the problem of cross-postings or herding around major events.

We complement the Project Syndicate data with the extraction of article information from the New York Times (NYT) Article Search API.⁶² The NYT articles are in particular helpful to identify trends and validate our analysis on industrial and technological transformation (Chapter 4), while the Project Syndicate articles focus primarily on economic and political developments. Both Project Syndicate and the NYT target general audiences, therefore the contributions are likely to reflect developments that, at least at the time of writing, have manifested or have the potential to manifest societal impacts. The main practical difference is that for the NYT the full texts of the article is not available.

We created a database of over 11,000 commentaries (in English) published on Project Syndicate from 1996 to May 2018. The database contains the original texts as well as the additional information: timestamp of the publication, author, topic section, and keywords. In addition, we retrieved the key information (headline, abstract, keywords) for over 20,000 NYT articles published from January 1990 to July 2018.

7.2 Methodology

Word count: As the most basic exercise, we check when and how Project Syndicate and NYT posts mention specific terms. For each year, we count unique occurrences of a given term in the Project Syndicate posts⁶³ and normalise the result to the total number of posts published this year. As a topical example one might take the words 'refugee' and inequality analysed in Figure 54 and Figure 55.

⁶¹ <https://www.project-syndicate.org/>

⁶² NYT provides an open access to its database of articles starting from 1851, see <https://developer.nytimes.com/>

⁶³ For example, if a word 'refugee' occurs two or more times in a post, it will still get a value of 1.

Figure 55 shows that almost 7 percent of posts published in 2015-16 mentioned the term 'refugee' (or its synonyms) at least once. While simple, word count can illustrate important developments over time, such as varying concerns about immigration (dashed line in Figure 55). For the NYT, not having the full text of articles, we count the occurrences of specific terms in the headline, the abstract, or keywords of an article to identify trends.

Context analysis: We also analyse the contexts in which given terms have been used (Figure 56 shows an example with posts mentioning 'China'). We first identify posts that include at least one mention of 'China' in their main text. As a second step, we select keywords that commonly appeared on posts with 'China' in a given year. As in the word count, we normalise all results to the total number of posts published in a given year. For example, Figure 56 shows that from January to May 2018, almost 30 percent of posts mentioned 'China' at least once. About half of these posts had 'Trump' as one of their keywords.

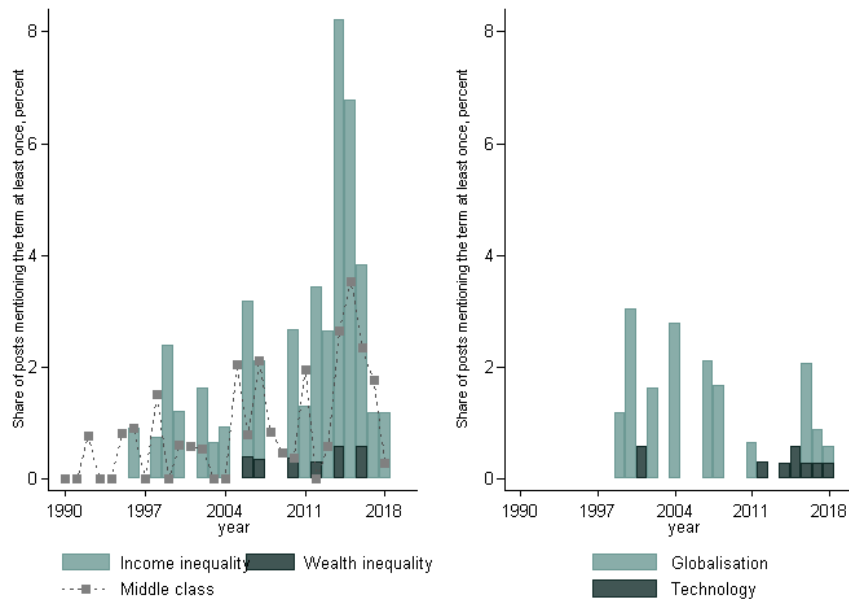
We present the results of this text analysis according to the Chapters in this report.

7.3 Demographics and growth

For this topic, we focus on analysing two social issues: inequality and concerns about immigration. In recent years, both seem to be on the rise. Text analysis verifies whether these are indeed new trends or rather cyclical phenomena.

Both the Project Syndicate and the NYT data show that mentions of income inequality rose sharply in 2014-16 (Figure 54).⁶⁴ The term 'middle class' showed similar dynamics, which is consistent with one of the report's conclusions that perceived rising inequality could relate to the decline of the middle class in advanced countries. Globalisation has been associated with inequality starting from the 2000s (China's accession to the WTO took place in December 2001), while technology has been evoked since 2012. In 2017-18, both mentions of 'income inequality' and 'middle class' dropped again; it is not clear, however, whether this drop is temporary and the rising trend will continue or whether, on the contrary, the rise in 2014-16 was a short-term phenomenon, for instance, related to the US presidential elections campaigns.

⁶⁴ Contributions on both sources refer mainly to 'within-country' inequality. We use NYT results for the illustration, as this resource has a better coverage of the term.

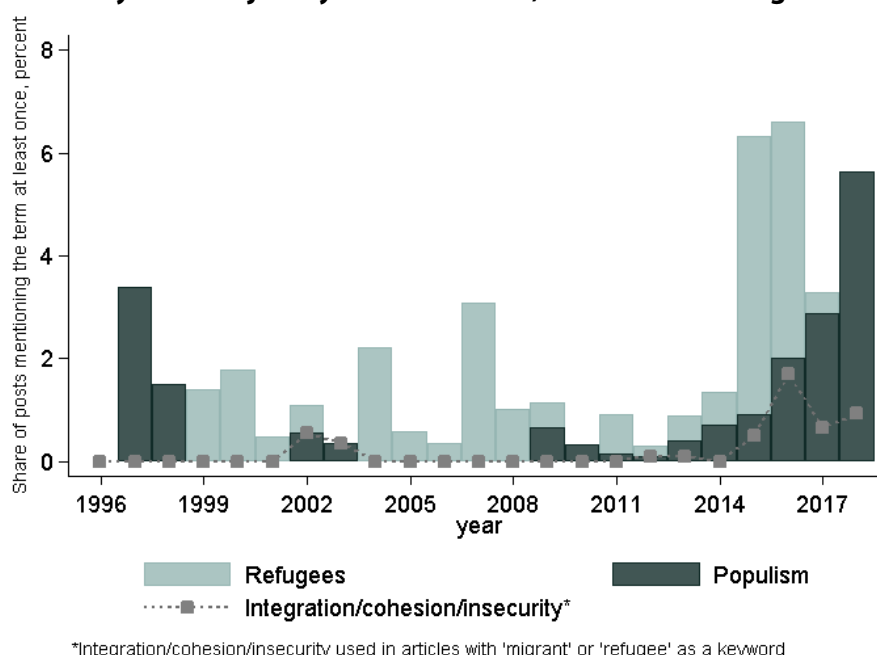
Figure 54 Text analysis of NYT articles, pre-selected based on the keyword ‘inequality’

Note: The analysis was conducted on 6,209 unique articles from the NYT database. The articles were pre-selected based on the keyword ‘inequality’.

Source: Authors’ calculations, 2018, using the NYT data (the Project Syndicate data shows similar dynamics, but has a poorer coverage of the term).

Figure 55 documents mentions of ‘refugees’, concerns about immigration, and populism. As expected, mentions of ‘refugees’ increase around significant inflows: the war in Kosovo in 1998-99, the Iraq war in 2003-11, and the most recent Syrian war. Mentions of populism reappeared on Project Syndicate in 2009 – in the aftermath of the financial crisis, while part of the most recent increase in 2015-18 indeed coincides with mentions of refugees/immigrants. Yet, as we argue above, the rise in concerns about immigration is not specific to the recent wave of refugees. Rather, the inflows of refugees, usually followed by broad media coverage, make the existing issues (such as the persistent challenge of immigrant integration in host societies and the general anxiety about ‘newcomers’) more salient for the general audience.

Figure 55. Text analysis of Project Syndicate articles, mentions of ‘refugees’ and ‘populism’



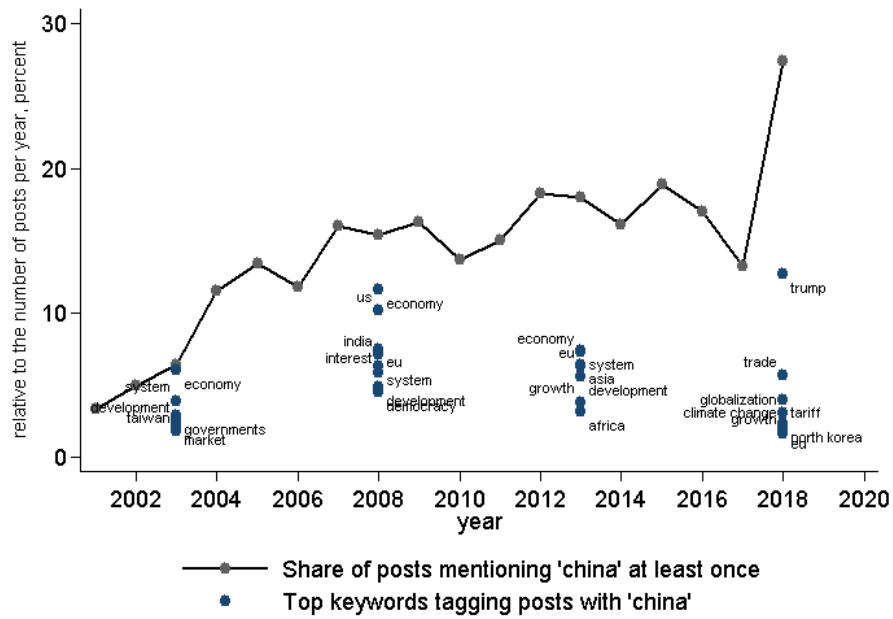
Note: The analysis was conducted on 11,000 unique articles covered by the Project Syndicate data.
 Source: Authors’ calculations, 2018, using the Project Syndicate data.

7.4 Vulnerable globalisation and an ‘economic G3’

Figure 56 illustrates the steady rise of China as a global player. While in 2002, less than 5% of Project Syndicate articles mentioned China, in 2018, almost 30% of the contributions evoked China. The keywords associated to China have also changed to reflect global (and not only economic) issues, e.g. globalisation, climate change, or North Korea.

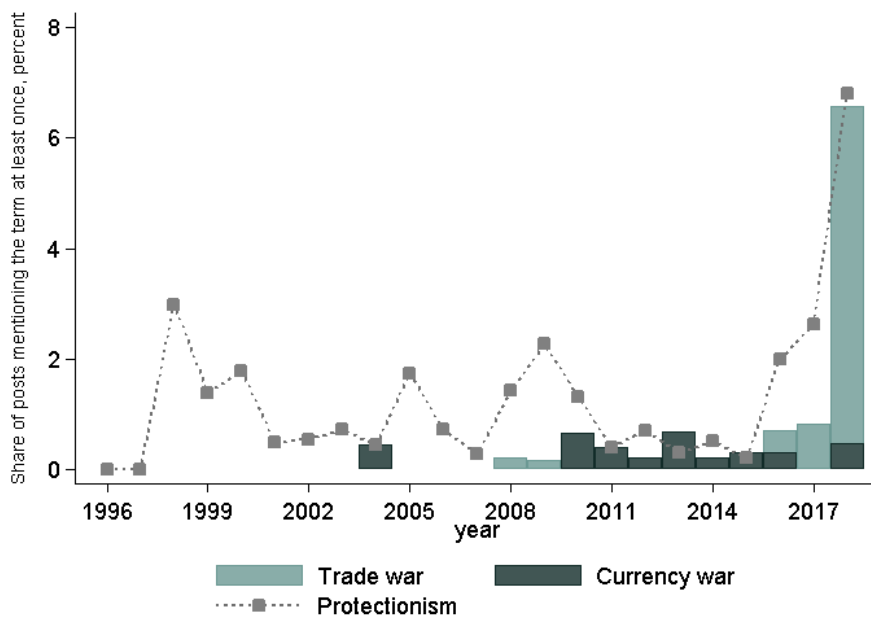
Figure 57 shows that ‘trade wars’ have overtaken ‘currency wars’ as major perceived threats to globalisation. However, the text analysis also reveals that the turn to protectionism is a fairly cyclical phenomenon: while it might affect international trade in the short-term, it is unlikely to disrupt globalisation permanently.

Figure 56. Text analysis of Project Syndicate articles, mentions of 'China'



Note: The analysis was conducted on 11,000 unique articles covered by the Project Syndicate data.
Source: Authors' calculations, 2018, using the Project Syndicate data.

Figure 57. Text analysis of Project Syndicate articles, mentions of 'trade wars', 'currency wars', and 'protectionism'



Note: The analysis was conducted on 11,000 unique articles covered by the Project Syndicate data.
Source: Authors' calculations, 2018, using the Project Syndicate data.

7.5 Industrial and technological transformation

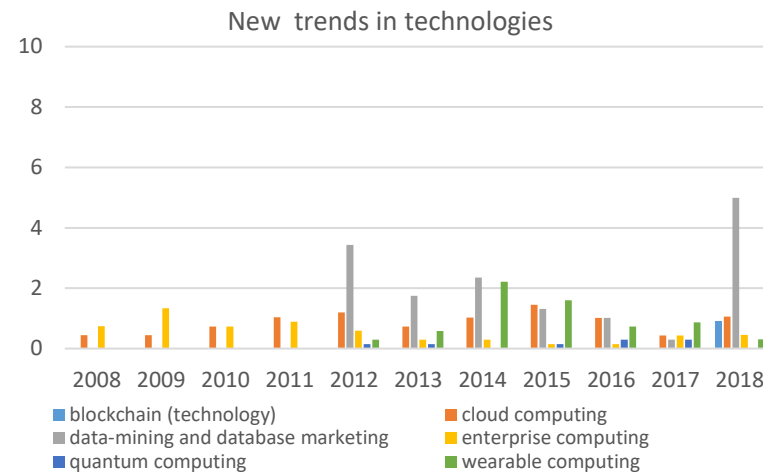
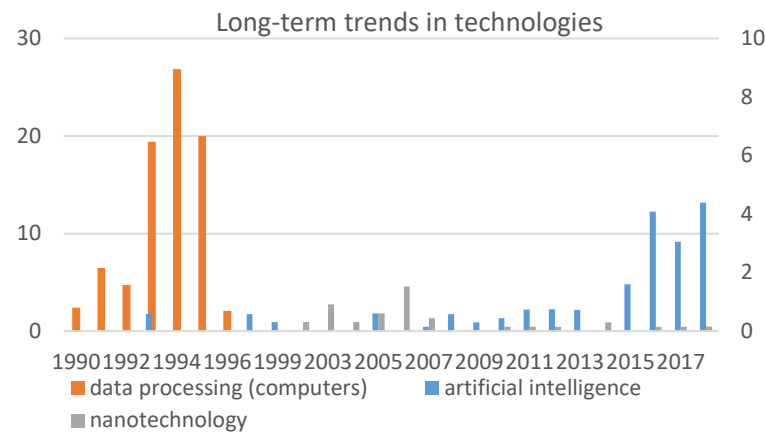
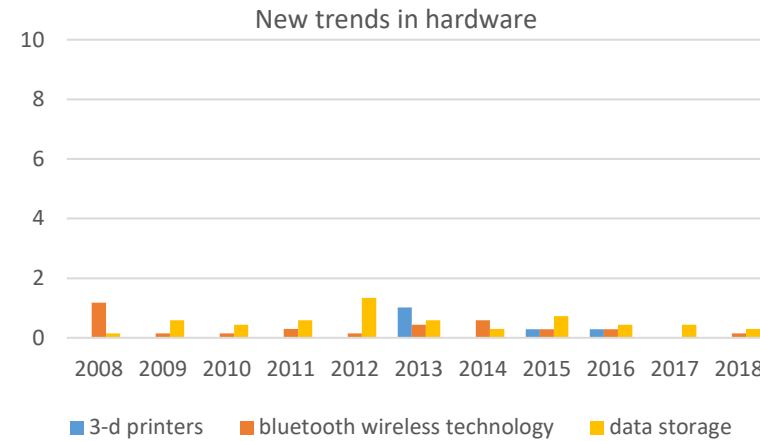
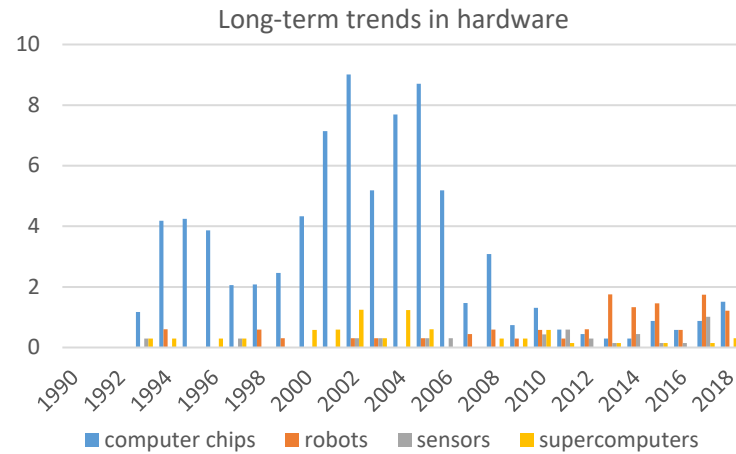
Panels of Figure 58 illustrate long-term and new trends related to technology. The text analysis confirms that changes in this area occur fast and are difficult to predict. For instance, the race for more sophisticated computer chips appears less relevant today, compared to robotics or advances in sensors (not the case before 2008). The falling relevance of 'Moore's law' for CPUs; already mentioned above, is confirmed by this analysis. The term 'artificial intelligence' has been evoked in articles since 1993; yet, its fast rise occurred only in 2015.

A number of technologies and their applications were not mentioned prior to 2008; among them, data storage, cloud computing, quantum computing, data-mining, blockchain, home automation, driverless cars, and social media. What societal impacts will they have? Will, for instance, quantum computing, which first appeared in the NYT (media for general public) in 2012, but as of now has only been mentioned marginally, eventually show similar dynamics to artificial intelligence?

When looking at issues related to technology, computer security and privacy appear to have a long history, with the relevance of the latter substantially increasing since 2012. Cyberattacks and cyberwarfare are relatively recent developments: they have appeared in the NYT only since 2011.

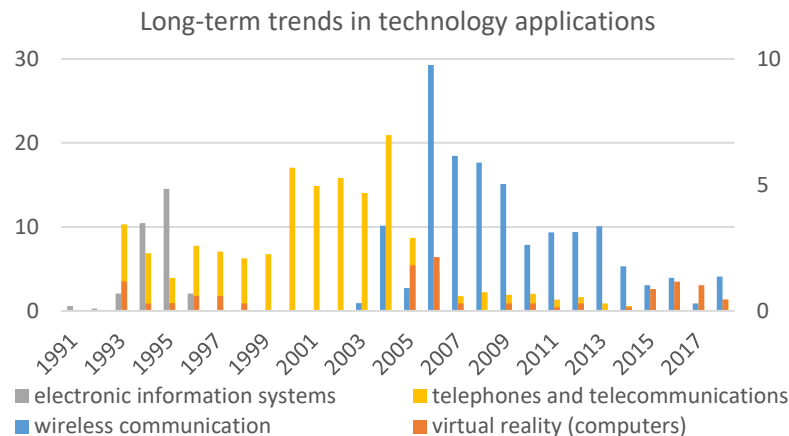
Figure 58. Text analysis of NYT articles, pre-selected based on the keyword 'technology'

Mentions in the New York Times, in % to technology-related contents

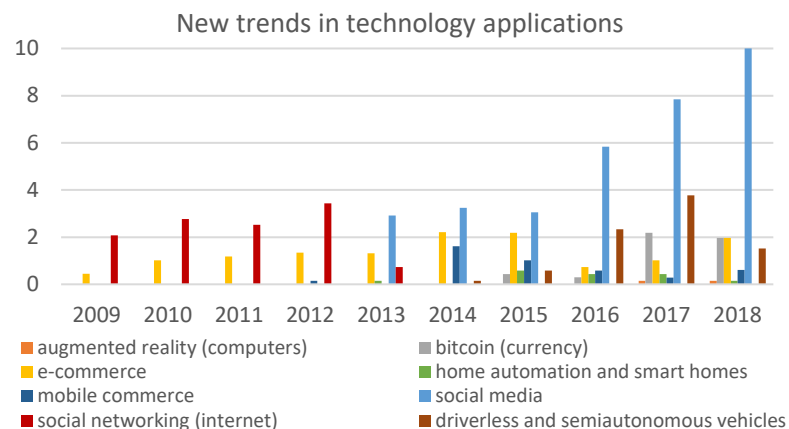
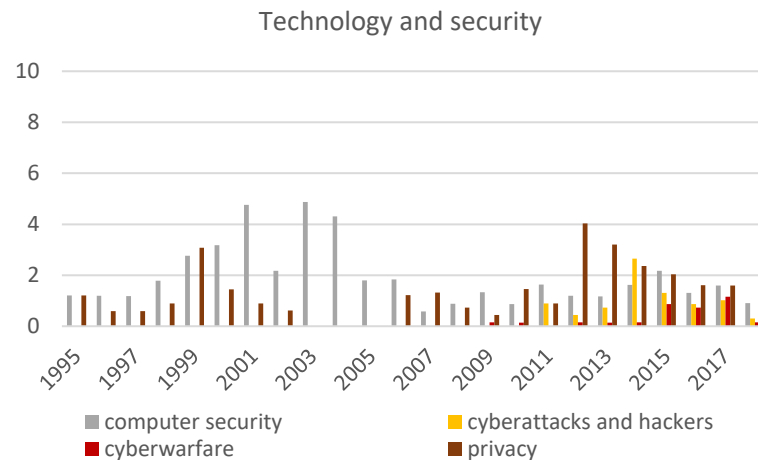


Note: The left-hand axis (0-30) is for data processing; the right-hand axis (0-10) is for artificial intelligence and nanotechnologies.

Mentions in the New York Times, in % to technology-related contents



Note: The left-hand axis (0-25) is for telephones and telecommunications and electronic information systems; the right-hand axis (0-10) is for wireless communication and virtual reality.

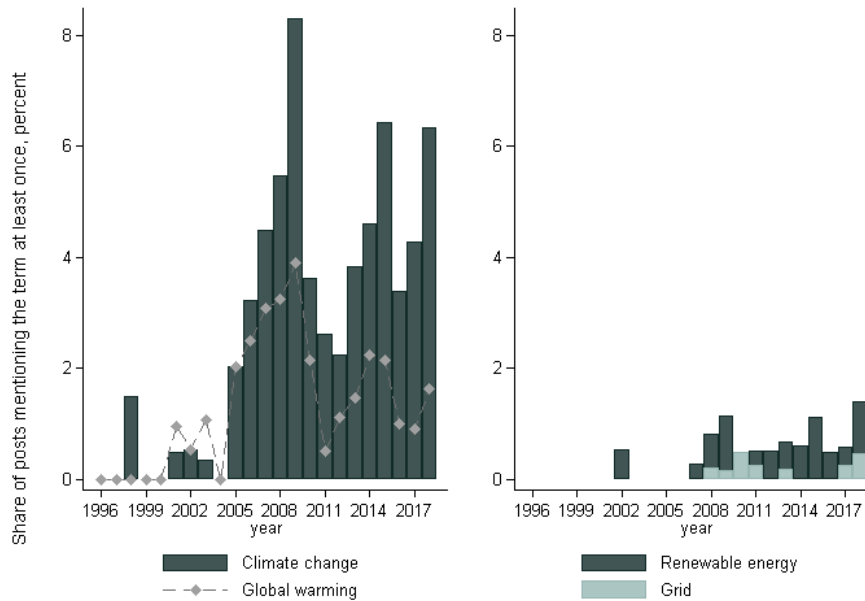


Note: The analysis was conducted on 13,831 unique articles from the NYT database. The articles were pre-selected based on the keyword 'technology'.

7.6 Climate change and resource competition

Figure 59, in line with the analysis in Chapter 5, illustrates the persistent awareness of the climate change problem and the advances in renewable energy sources. Both appear as long-term structural trends.

Figure 59. Text analysis of Project Syndicate articles, mentions of 'climate change', 'renewable energy'



Note: The analysis was conducted on 11,000 unique articles covered by the Project Syndicate data.

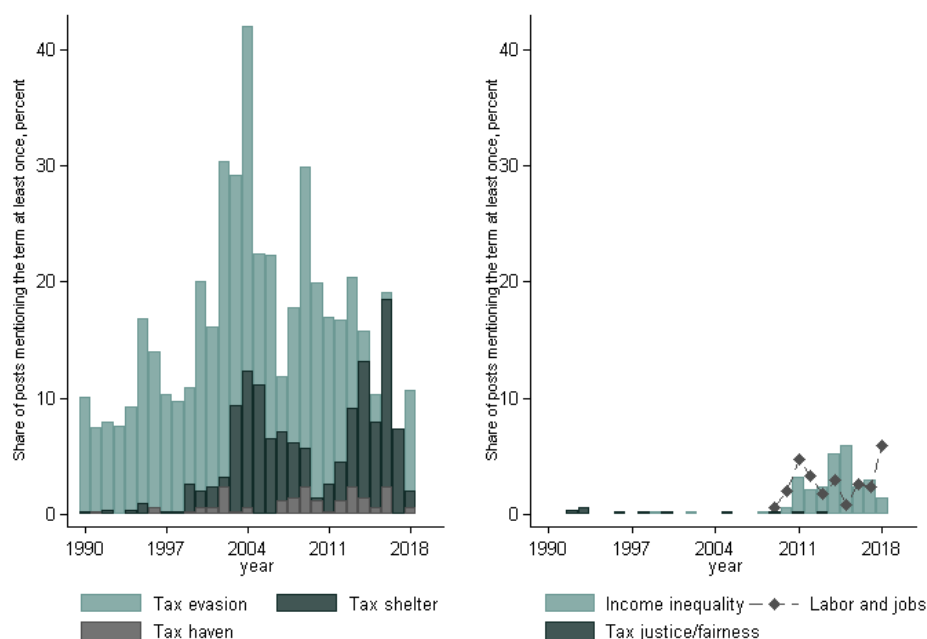
Source: Authors' calculations, 2018, using the Project Syndicate data.

7.7 Taxation

In order to complement the analysis in Chapter 7 and in section 8.2, this section looks at key words linked to taxation. The left-hand side panel of Figure 60 indicates a very high coverage and persistency of tax evasion. This holds for almost 0 years with a high with peak in the early 2000s. After 2008, this has gone down to leave room to two specific aspects of taxation: tax havens and, even more, tax shelters. The heights are associated with the Panama paper scandal of 2016 and then the coverage gradually declined.

The panel on the right-hand side seems to suggest that the coverage of issues related to jobs and labour, and income inequality have increased since the 2008 global financial crisis, with the former keeping momentum. By contrast, tax fairness does not appear to have received relatively high interest, despite the US debate about the tax reform.

Figure 60. Text analysis of the NYT articles, pre-selected based on the keywords 'tax', 'taxation'



Source: Authors' calculations, 2018, using the NYT data (the Project Syndicate data shows similar dynamics but has a poorer coverage of the term).

Note: the analysis was conducted on 9853 unique articles from the NYT database. The articles were pre-selected based on containing a keyword 'tax' or 'taxation'.

7.8 Conclusions

The main purpose of the text analysis has been to gather additional evidence to assess whether what appears today as an emerging trend could turn out to be just a temporary issue. This has been done by assessing the coverage of keywords associated with major events, changes and growing social concerns in the public opinion.

In the exercise, particular interest is placed on identifying long-term trends and understanding whether what was perceived as an emerging trend some years ago in practice has realised or whether it was just a blip.

We could thus classify all analysed trends in three groups: i) those that turned out to be temporary phenomena; ii) persistent trends that have been prevalent over prolonged periods; iii) emerging trends.

For instance, currency war and 3-D printing are two example of the wrong expectation: They were both considered to be a major challenge and major technological change, respectively, in the early 2010s. Not much happened in either respect. Consistent with the limited relevance of such phenomena, the text analysis shows that even in the short period around 2013 neither word got extensive coverage, at least compared to some other key words we have tested.

By contrast, the analysis shows that protectionism or concerns about refugees reoccur. Regarding technology, data processing and wireless communication have had large coverage over the analysed period of almost 30 years and indeed they turn out to be major trends.

In a forward-looking perspective, if one focuses on the period after 2005, five keywords exhibit both high coverage and high persistence. They are: the rise of China, Social media, AI, taxation evasion, and to a less extent, climate change.

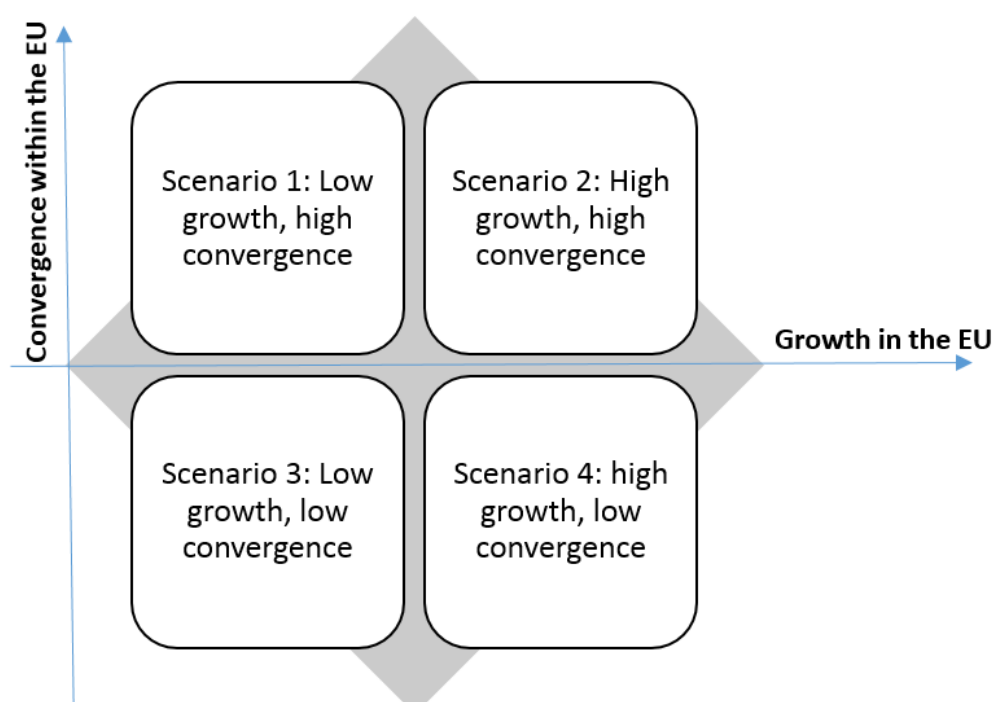
These results confirm two clear trends, namely the role of China and climate change, and one emerging trend, namely AI, we identified in the report. But they also point to two aspects which may have been underestimated. One new, the emergence of Social media, and another one, definitely not new, taxation.

8 The economic and social impact of trends in the EU under different scenarios

This chapter develops some stylised alternative scenarios for the EU. Our scenarios are constructed along two axes: low/high growth and convergence/divergence.

This leads to four basic scenarios (Figure 61).

Figure 61. Alternative future (basic example)



Source: authors' elaboration.

Before going into the description of the scenarios and how they might result from a combination of global trends and European policy response, it is useful to consider the recent track record of convergence in more general terms, including using the US as a comparator.

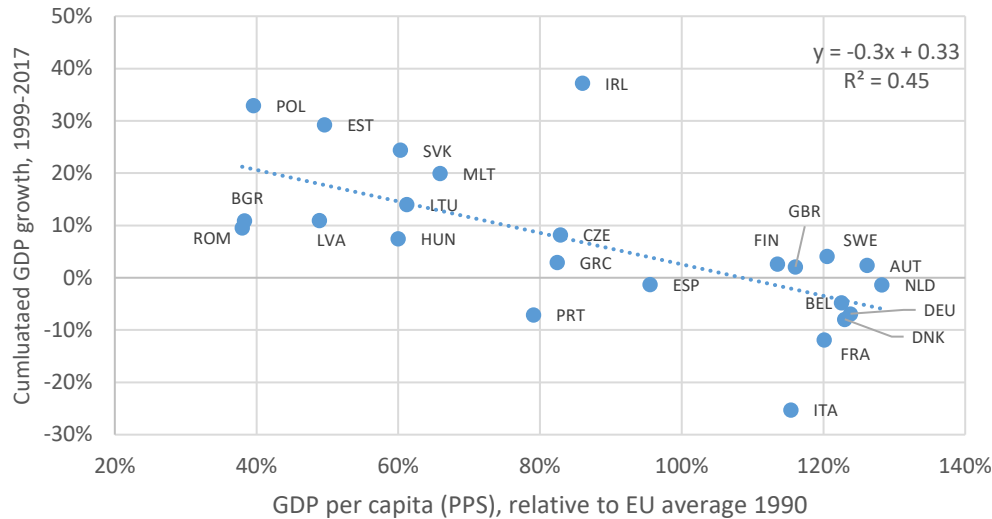
8.1 Convergence in the EU, recent developments and the outlook

Over the past three decades, convergence between the current EU member states has been quite strong, especially east-west. This can be seen in Figure 62 below, which shows a clear beta-convergence⁶⁵ of those member states with a lower starting point in terms of GDP per capita growing faster and thereby catching up to the leaders. This trend is particularly pronounced between eastern and western European member states and also holds within the group of new member states, with the poorest growing somewhat faster. However, within the group of old

⁶⁵ As mentioned also in Chapter 3, beta-convergence is based on the idea that poorer countries grow faster than rich countries. In the long term, this process should allow them to converge towards the average level. Technically, the beta coefficient of the regression measures the speed of convergence

member states, one finds little convergence over a very long time period (1990-2017) and even some divergence over a shorter period (e.g. since the start of the euro).

Figure 62. Beta-convergence of GDP per capita (PPS), 1990-2017



Source: Authors' elaboration AMECO data.

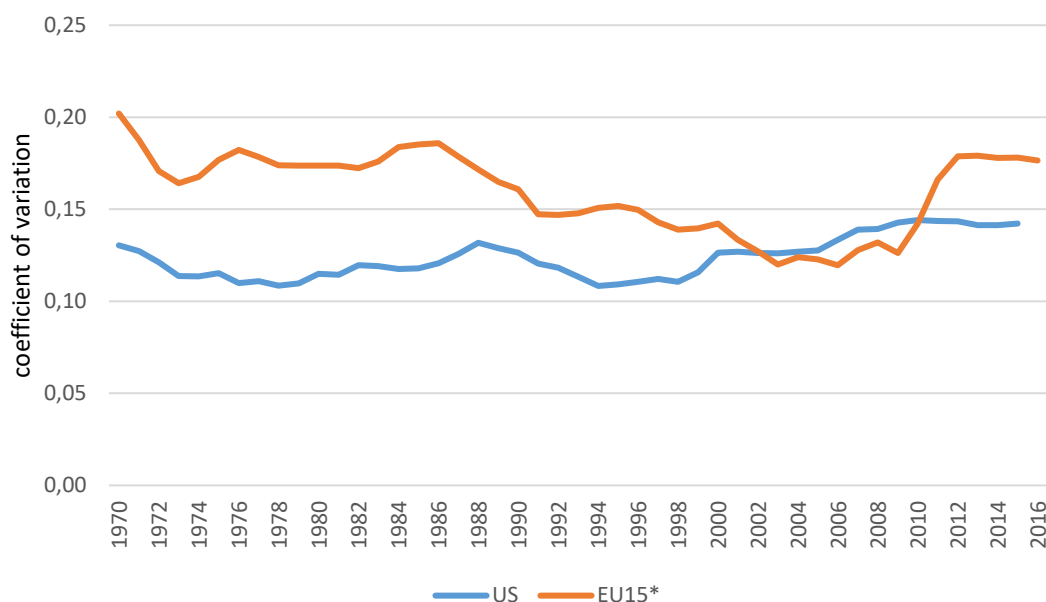
Another measure of convergence, the sigma-convergence, is based on the dispersion of income per capita across countries at each point in time. If the beta-convergence process mentioned above were to continue, the cross-state variability would also continue to fall over time. In this case sigma convergence is achieved.

In principle, this is what one should expect in the US states. Figure 63 below shows the variability (the coefficient of variation) of income per capita across EU Member States and US States, both since 1970.

The line for the US is relatively flat, suggesting that in the US convergence has not progressed over the last half century. The value of the indicator today is in fact somewhat higher than in the 1970s or early 1990s. Convergence appears to have stopped in the US, and even reversed, since the turn of this century.

For most of this period, the US exhibited a lower degree of cross-state income variability than Europe, which started out in the 1970s with much larger differences in income per capita. But for a few years (2002-06), a continuous convergence process brought the EU-15 to the point where income dispersion was even lower than in the US. However, much of this convergence was then undone in the EU (-15) by the financial crisis (which apparently did not have such a regionally differentiated impact in the US).

Figure 63. Comparison of income per capita convergence/divergence across the Atlantic, 1970-2016



Notes: EU15 excluding Ireland and Luxembourg. US data is based on FRED sample of 24 selected US states. The variables pictured are the (unweighted) standard deviations of the income per capita, across states relative to the average of the EU for both samples. If one were to weigh each country/state by its GDP, the picture would not change for the US, but the EU would show a markedly stronger increase in variability (mainly because of Italy).

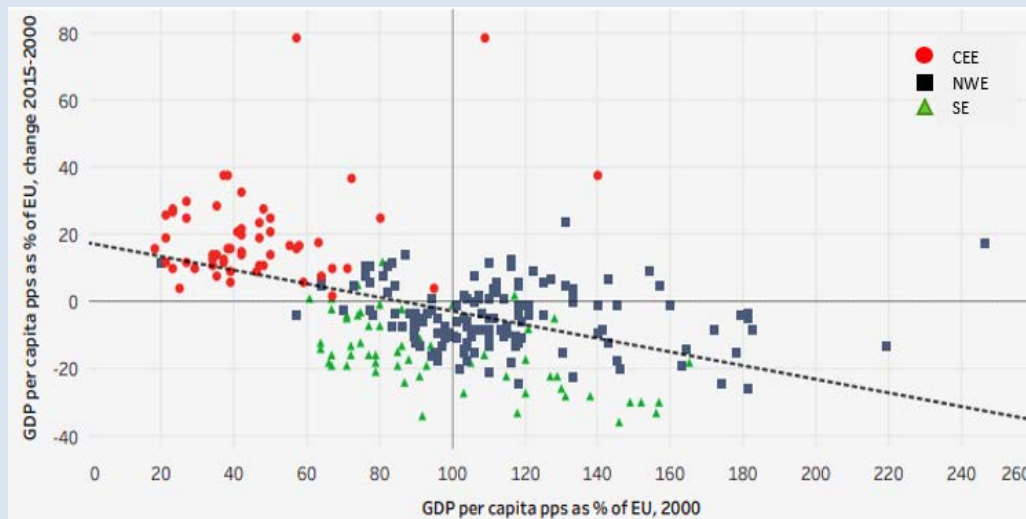
Source: AMECO (Annual Macro-economic database of the European Commission and FRED (Federal Reserve Economic Data)).

This comparison with the US shows that convergence has its limits even in an economic and monetary union that is generally regarded as being complete. Some cross-state differences in income seem physiological in any large and diverse economic area. If one were to take the US as the model for the EU or the euro area, one should not expect income differentials to fall forever. Expectations of full convergence might be misplaced. A recent IMF study (Franks et al. (2018)) concurs with this point of view. We will discuss this issue in more detail below.

Box 16. Regional Convergence in the EU

When focusing on the regional dimension, data show that convergence is still taking place in the EU but with higher dispersion than at country level. The distribution reflects the one observed at country level, with, on one hand, regions in Central Eastern Europe (CEE) registering the largest improvement between 2000 and 2015 and, on the other hand, southern regions underperforming compared to the EU average. In particular, a considerable share of southern regions was already below the EU average in 2000 and saw their position deteriorate further over the 15 years under analysis (bottom left quadrant).

Figure 64. Beta-Convergence in EU regions (NUTS2), by cluster of countries



Notes: Central and Eastern Europe (red circles): BG, CZ, EE, HR, HU, LT, LV, PL, RO, SI and SK. North Western Europe (black squares): AT, DK, DE, FI, FR, LU, NL, SE and UK. Southern Europe (green triangles): CY, EL, IT, MT, PT and ES.

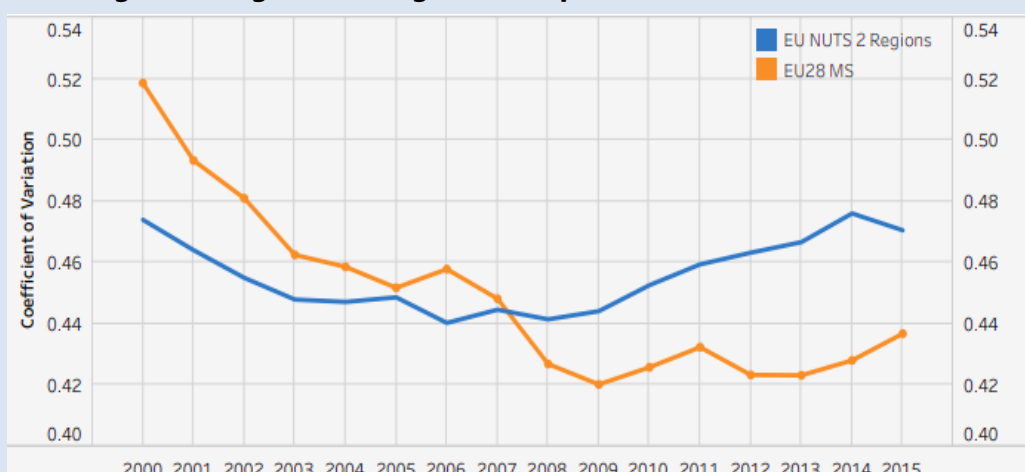
$\beta = -0.203$, R-squared = 0.232, p-value < 0.0001. Inner London West excluded (GDP p.c. pps 2000, % EU = 500). Irish regions excluded (latest data available is 2014). Belgian regions excluded (oldest data available is 2003).

Source: Authors' calculations based on Eurostat [nama_10r_2gdp] (PPS per inhabitant as percentage of the EU average).

In order to better understand differences between convergence at country and regional level, it is worth looking at sigma-convergence. As mentioned in Chapter 3, if this thesis is validated, the variability of real GDP per capita across economies should fall over time.

Until 2007, the coefficient of variation was falling both at country and regional level, meaning that differences in GDP per capita in PPS were shrinking and sigma-convergence was taking place. Yet, since 2008, the two trends started diverging, with variation at regional level increasing while flattening at country level. At the end of the period, dispersion at regional level has not changed compared to the level in 2000; by contrast, the coefficient of variation among countries dropped from 0.52 to 0.44.

Figure 65. Sigma-Convergence: comparison EU Member States and EU regions

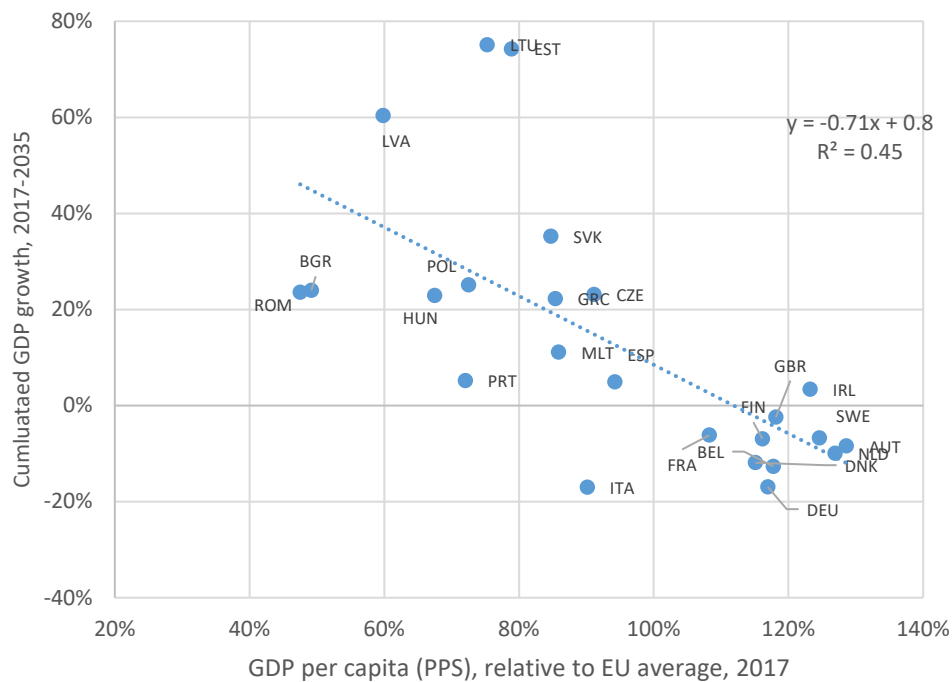


Note: The coefficient of variation is equal to the standard divided by the mean.

Source: Authors' calculations based on Eurostat [nama_10r_2gdp] (Purchasing power standard (PPS) per inhabitant).

Overall this suggests that CEE regions lead the convergence process, while southern regions have systematically underperformed relative to the EU average. However significant differences exist also within counties. This is particularly the case for CEE countries, where capitals are leading the convergence process with other regions lagging behind.

Current medium forecasts imply that the cross-country convergence trend should continue at least for a few years. The same applies to the, necessarily more speculative, longer term forecasts. Both the OECD and the other forecasts mentioned above which extend to 2035, imply that income inequality across Member States should diminish further. Figure 66 below shows the predictions of the MaGE model, the model used in CEPS (2013), for 2035 (see Fontaigne, 2017). There is still the beta-convergence tendency of the countries that are relatively poorer today to grow more quickly.

Figure 66. Predicted Beta-convergence of GDP per capita (PPS), 2017-2035

Source: Authors' elaboration on CEPS 2013 and AMECO data.

The expectation of an ever-lasting convergence process is consequence of a dominant economic growth model, which assumes that countries that share the same technology, have access to capital markets and similar levels of human capital should tend towards reaching similar income per capita levels.

However, the standard model on which these forecasts are based inherently relies on the assumption of constant returns to scale which without any role for more dynamic interactions between human capital and technological progress and its transfer mechanisms.⁶⁶ As already mentioned above, taking into account the non-rival nature ideas opens the way for self-reinforcing technological progress and agglomeration effects. Below, we will use one study that applies these concepts.

8.2 Lessons from longer-term US developments: the key role of knowledge

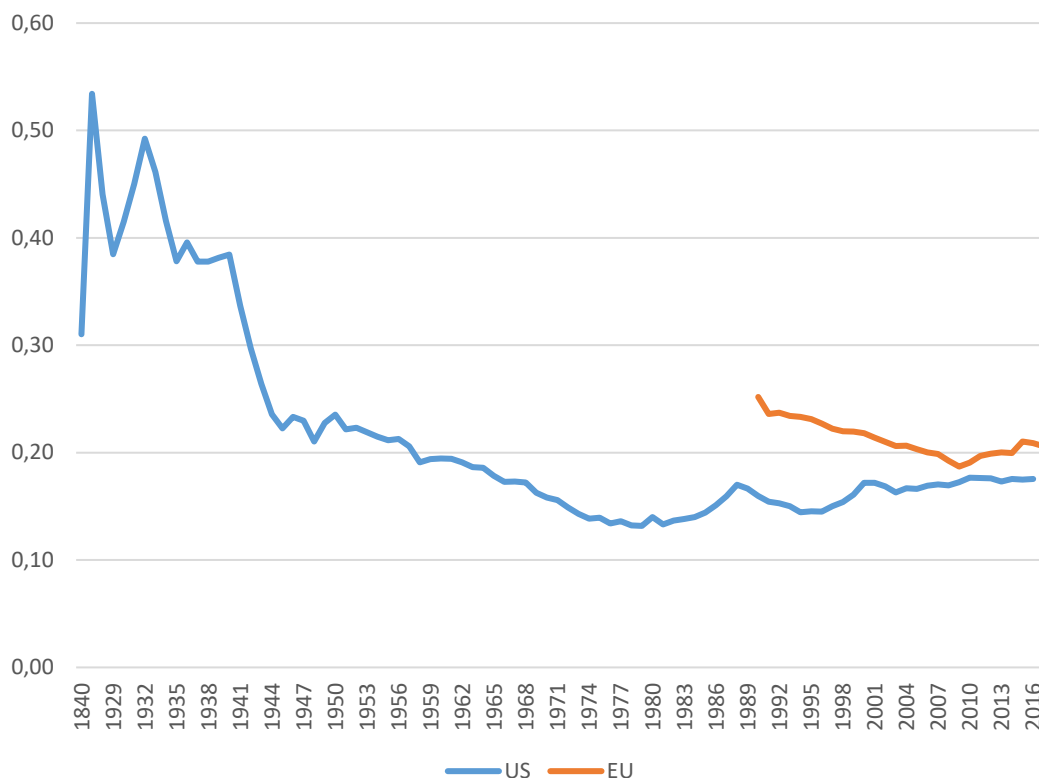
The US experience from earlier last century holds another lesson because it allows a very long-term perspective. Figure 67 below displays the degree of dispersion of personal income across US states since 1929. At that time, the dispersion indicator was more than two times higher than it is today, and much higher than it is in Europe today.⁶⁷ It is difficult to explain why, in 1929, roughly 150 years after the formation of the United States, there should have been such a large degree of dispersion

⁶⁶ Moreover, the past convergence trends had been interrupted by crises and country specific incidents. These cannot be incorporated for the future due to the unpredictability of these occurrences.

⁶⁷ See also a FRED Blog on this issue (<https://fredblog.stlouisfed.org/2016/11/the-convergence-of-income-across-u-s-states/>).

of income in an otherwise unified area. Labour mobility had been high in the US for a long time and the country had had a single currency at least since the end of the civil war, i.e. 60 years earlier.

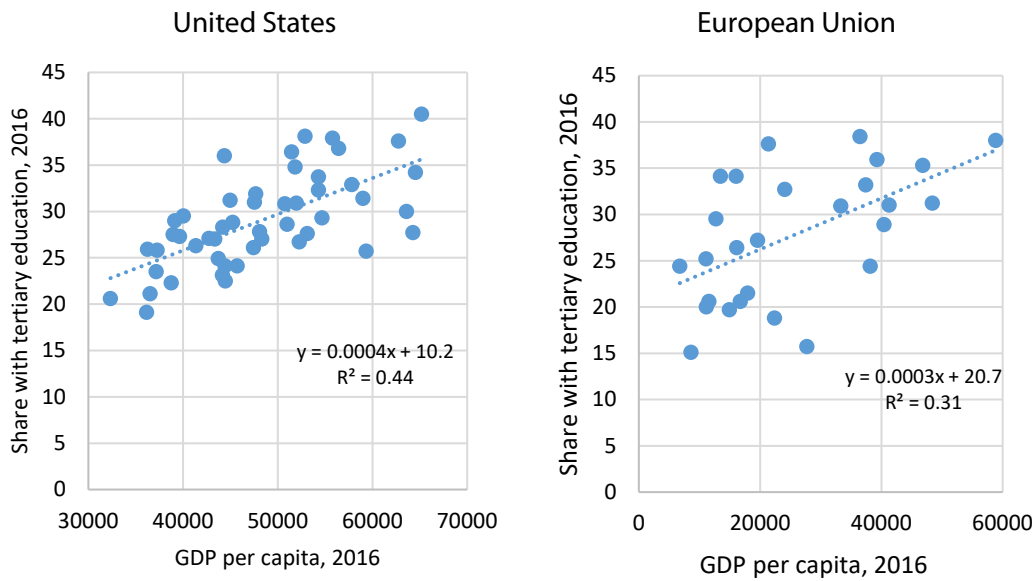
Figure 67. Coefficient of Variation of GDP per capita, US and EU



Source: Authors' elaboration on data from BEA, Eurostat and [Jenkins](#).

This end to convergence in the US could of course also be a harbinger of a similar development in the EU. If convergence no longer progresses in an area as integrated as the US, one would expect that it should also not progress in a somewhat less integrated area like the EU, where factor mobility is much lower. Bauer et al. (2006) provide an in-depth analysis of the convergence in the US since 1939. They find that there is tendency towards convergence, but it is offset by a lack of convergence in some fundamental growth factors, which all have to do with knowledge, namely education and patents. The level of education of the local population is not surprisingly a key variable. As already mentioned above, in the standard growth model, labour input is not measured just by bodies or hours work, but also by the quality of these hours, which depends on the human capital accumulated by the work force. Bauer et al. (2006) measure this human capital by high school and college graduation rates. Full convergence would thus require that the work force in different states have the same proportions of high school and college graduates. However, this is not the case. Even in the US, there exist surprisingly large differences across states in the percentage of the population that has either finished secondary (high school) or tertiary (college) schooling. For example, some of the poorer states (Arkansas or Mississippi) have college graduation rates, around 13%, which are only one half of those in more advanced states such as Massachusetts), of above 27%. There is a strong association between educational attainment and income per capita across States (Figure 68). Among EU Member States one finds a similar correlation, but it is less strong, maybe because some the New Member States are still in a catch-process.

Figure 68. GDP pc and educational attainment

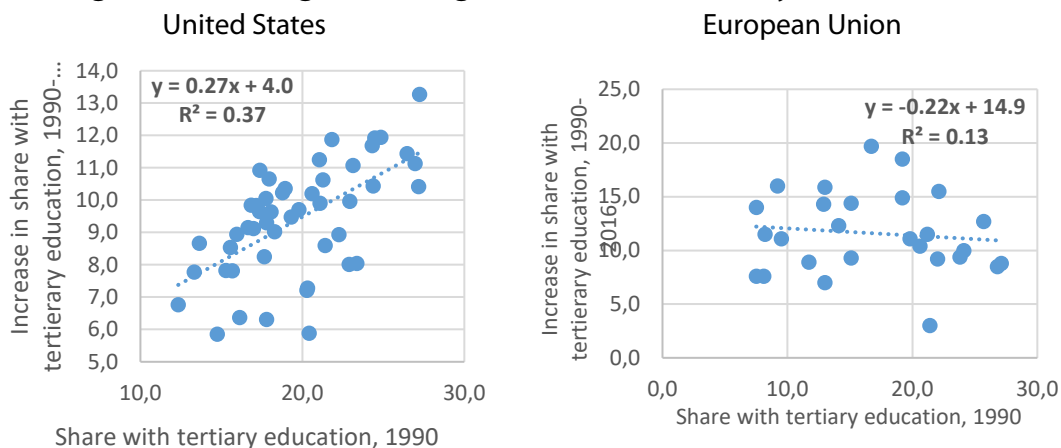


Source: U.S. Census Bureau.

Source: Eurostat and AMECO.

Moreover, these differences in education rates have not diminished over time. On the contrary, the standard deviation of college graduation rates has actually increased somewhat over the last few decades. Figure 69 below shows (left-hand panel) that one can observe a tendency of college graduation rates increasing more strongly in states that already had a high proportion of college graduates in their population in 1990.

Figure 69. Convergence/divergence of shares in tertiary education attainment



Note: For the US (48 contiguous States) share with tertiary educational attainment, of age group 25 years and above; for the EU share in population age 15 -64 with tertiary education, * EU data for 1992 or earliest available.

Source: Authors' elaboration on US Census data and Eurostat

The conclusion is thus that convergence has not progressed in recent decades in the US because of continuing large differences, in some cases even divergence, in education. Applied to the EU, this reasoning would imply that continuing convergence within Europe would require convergence in education levels. The right-hand panel of Figure 69 thus shows that the EU data indicate a very different pattern. There has been a slight tendency of graduation rates to increase more in those countries where they were low. If this trend continues, one could expect that convergence should continue in Europe. In this perspective, the EU's 2020 goal of achieving the same graduation rate, of 40%, in all Member States, could be seen as being key to fostering continuing convergence in the long run.

Convergence in education levels is, in a sense, easier in Europe than in the US because the starting points are different. A comparison of the horizontal axis of the right-hand and left-hand panels of Figure 69 shows that the starting level and differences in graduation levels are higher in Europe than in the US. Within Europe, the range goes from below 6% to over 25%, whereas for the US the range is between 12% and 27%. The standard deviation across Member States is today about 7 percentage points, versus about 5 for that across US States. There is thus much more room in Europe to achieve 'upwards convergence' in education levels.

The other key variable identified by Bauer et al. (2006) is the number of patents (per inhabitant). This is of course not a policy variable, but a good indicator of the capacity of the local economy to generate, and presumably also to absorb, productivity enhancing innovations. This is an area with extreme differences within the EU, especially east-west. For example, the number of patents (per million inhabitants) ranges from 3 in Croatia (and single digit values in many other CEECs) to over 240 for Germany and Holland. Moreover, these differences have not diminished in recent decades. On this account, one cannot expect a boost to convergence unless the numbers were to change radically very soon. However, there is no convergence on this measure in the US as well.

The conclusion is that education is certainly not the only variable that influences growth and convergence in a large set of advanced economies. But the analysis above and the evidence of the lack of increasing convergence in the US suggest that there is at least one area, which is under partial government influence, where convergence towards a higher level is likely in the EU.

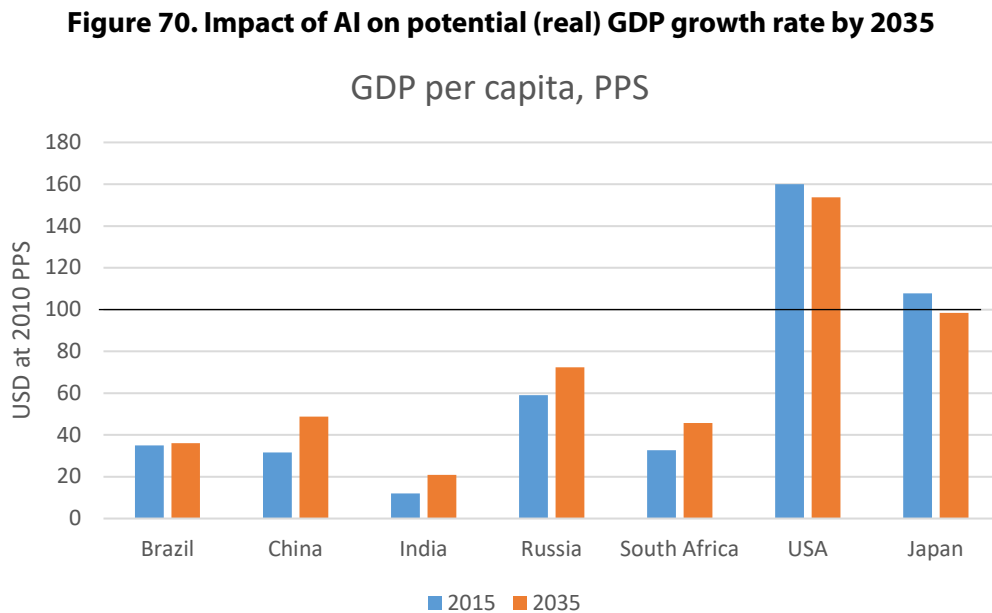
8.3 Technology and growth

One megatrend that will have a profound impact on the growth and convergence mix is naturally technological change. This is not new, as the US experience analysed above shows. However, there is great uncertainty about how present technology trends will impact growth and productivity even across studies based on models estimated or calibrated carefully on past data. For example, the growth rates predicted by the OECD and by the MaGE model used in the 2030 study (CEPS, 2013) arrive at rather different growth predictions for Germany (1.1% OECD versus 0.3% for MaGE) and even greater differences for Italy (1.7% for OECD, against 0.2% for MaGE). These differences result, *inter alia*, from different importance given to different types of human capital.

It is thus difficult to gauge how future technology development will impact growth if one uses past data. We therefore use a recent study of professional consultants, Accenture (2017), which can observe the impact of technology first hand. This study contains concrete predictions for growth up

to 2035 under two scenarios: 'business as usual' and another scenario under which AI helps to improve productivity.

Figure 70 shows the (annual) GDP growth rate for both scenarios. There are stark differences in growth rates across the EU.⁶⁸



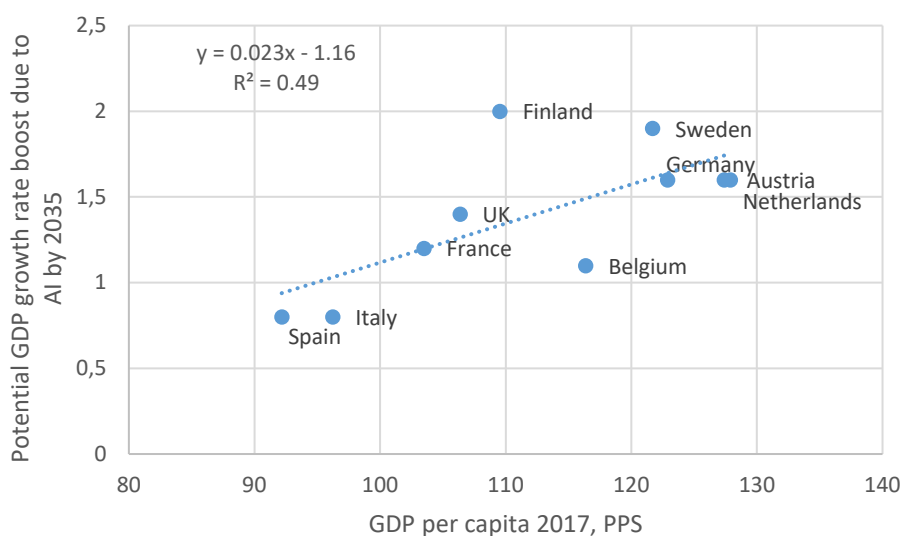
Source: Authors' elaboration on Purdy and Daugherty 2017 (Accenture) data.

The series denoted 'AI growth boost' shows the potential growth that could be achieved by 2035 if AI was fully absorbed. The 'AI boosted' growth rates are substantially higher, with some economies such as Japan tripling the growth rate via AI. All countries thus stand to gain from this process, though the opportunities are unevenly distributed.

Figure 71 shows that this study assumes that the countries that are better prepared to absorb the growth boosting potential of AI are also the ones that are better off today. The upwards slope in the figure shows that the member states with high GDP per capita today are also the ones that might experience the strongest boost to growth rates due to a better absorption of AI. In other words, the diffusion of AI might be so uneven that it leads to divergence, instead of convergence.

Looking closer at the country characteristics that should foster productivity boosts through AI one finds that the key variable seems to be expenditure on R&D (as a percentage of GDP). Given that R&D expenditure is closely related to patents, this suggests a similar result as that for the States in the US mentioned above: States (Member States of the EU) in which expenditure on R&D is high and/or many patents are being found, are those which are better placed to take advantage of new technology.

⁶⁸ The estimates are not available for Central and Eastern European member states.

Figure 71. AI impact on convergence

Source: Authors' elaboration on Accenture and AMECO data.

One simple conclusion of this study is thus that AI could push the EU from a low-growth scenario with moderate convergence to a high-growth scenario with increasing gaps in income across Member States.

8.4 Scenarios

The analysis presented so far leads naturally to the four scenarios mentioned above.

Scenario 1 (low growth, high convergence)

Such a scenario might be called 'business as usual' (BAU) because this combination also characterises the longer-term trends on EU growth and convergence described above. 'High convergence' might be an exaggeration, but a considerable trend towards convergence has characterised the EU, at least until the financial crisis – and is predicted to restart again now that the crisis has been mostly overcome.

This scenario then yields a base case for the EU 2035: GDP per capita would only be moderately (about one third) higher than today since, in the meantime, the average growth rate might have been only around 1.7%. Around this average, growth would likely be somewhat below this value in most of the 'old' EU-15 (resulting in an increase of per capita GDP of only around 30%; but somewhat above in most of the new Member States from Central and Eastern Europe (resulting in increases in GDP above 50%). As already mentioned above, intra-euro area differences would decline under this scenario, probably back to the level seen about 10 years ago (before the crisis) or similar to the ones observed in the US today.

The EU policy context would naturally be similar to the one established over recent years. Economic policy would remain primarily national with little effective coordination, even if lip service may be paid to established exercises as the European Semester, the Macroeconomic Imbalances and the

Excessive Deficit Procedures. Although the formal mechanism might not have much teeth, macroeconomic policies would still remain prudent on average, on account of the memory of the financial crisis and also because the 3% of GDP deficit figure presents a focal point for national political decisions.

Under BAU, little will be done to create a truly integrated market in ICT services and public investment in R&D is unlikely to increase given the demographic pressures on budgets (whose full force might, however, come on stream only around 2025, as argued above).

An important underlying trend is the continuing increase in education of the younger, but without any great acceleration. Since the employment rates of those with tertiary education are usually high, this would imply a trend increase in employment rates coupled with lower unemployment rates.

One might also call this scenario also the 'Japanisation' of the euro area. The working age population of the euro area is likely to decline at about the same rate as that of Japan over the last two decades. This demographic slow down leads to very low absolute growth rates, but GDP per capita could still continue to increase at a rate only slightly below that experienced before the crisis. Moreover, this ageing population is likely to produce excess savings. Investment might naturally be lower than before given that overall growth will diminish. This would result in continuing current account surpluses, which could well transform the euro area into the biggest global creditor economy (maybe ahead of China). This would tend to strengthen the euro area relative to the US, whose external deficits are likely to continue, which in turn could put the US dollar and the US economy in a difficult position in the (unlikely) case that the Chinese authorities open their capital market, allowing the Renminbi to become the new global reserve currency.

The main difference between a 'Japanese' euro area and Japan itself would be fiscal policy. The government of Japan has run a deficit above 5% of GDP for decades, resulting in a (net) debt-to-GDP ratio of close to 140%, and rising. By contrast, few European or euro area countries are likely to run deficits even above 2 or 3% of GDP over longer periods. The euro area is thus likely to arrive at 2035 with a substantially lower debt-to-GDP ratio than today and one that is very likely to be almost one half of that of Japan.

One important lesson from the case of Japan is that 'appearances matter'. The generally accepted image of Japan is that of a stagnating economy, which just experienced 'lost decades'. This impression is the result of the very low headline real growth rates. With its working-age population declining, the headline growth rate is likely to remain below 1% even if GDP per capita increases by more than 1.5% per annum. A similar combination is not unlikely for the euro area, which might result in a similarly negative impression of the dynamism of the EU, which in turn would render membership, at least superficially, less attractive. The mere impression of a slow growth EU could thus endanger internal cohesion.

Scenario 2 (high growth, high convergence)

This scenario represents of course the ideal and it would require a break in policies. 'High convergence' and 'high growth' seems possible only if all Member States prepare themselves to absorb productivity enhancing technologies, such as AI.

As discussed above, 'knowledge' would be one key ingredient for this. The natural conclusion is that such a scenario would be possible only if all MS reach the Europe 2020 goals in terms of R&D expenditure and tertiary education. This would require a substantial policy effort along several fronts in many countries. Extensive educational reforms might also be needed to improve the quality of education, given how the PISA and other studies have revealed a considerable heterogeneity of results across Member States. Investment in the future in many forms, like R&D, universities, schools, and maybe also the equivalent to broadband, etc. would have to be increased, which might require cuts in other expenditure items.

A key element enabling this ideal scenario would be the creation of a really integrated internal market in ICT services and an opening up of national spending on R&D to more European competition. More than 90% of all R&D spending is today spent at the national level, and often with little competition because few Member States are likely to have many world-class research institutes in any given area. A few large, targeted, mission-oriented projects at the EU level might further contribute to make this scenario more likely (Mazzucato, 2017).

If this 'convergence to the best' were achieved, all Member States should experience a substantial boost to growth, leading potentially even to overall growth of 3%, resulting in an income per capita by 2035 more than 50% higher than today, even for the EU-15.

Stronger growth prospects should strengthen investment, thus potentially lowering the external surpluses. Stronger growth should also make it easier to keep deficits under control, putting the Maastricht 'reference value' of a debt level of 60% of GDP within reach.

Under this scenario, the decline of the relative weight of the EU in the global economy might be somewhat slower than assumed so far. A more dynamic EU should also strengthen its soft power at the global level and should strengthen its internal cohesion. However, even under this best case, the growth of the EU would still remain considerably below that of emerging economies, making a decline in the relative weight inevitable.

Scenario 3 (low growth, low convergence)

This would be the worst case. It could result from a slowing down of the recovery in some countries as the result of populist distributive policies, which in turn, are adopted because of the dissatisfaction with lingering unemployment and low incomes. Italy in 2018 provides a real life example for this scenario.

One reason why some countries have fallen so much behind over the last years might simply be the nature of technological progress, which today requires even more knowledge and an efficient domestic governance system. Micro enterprises, which work in an informal economy based on personal contacts, might flourish in certain basic manufacturing sectors, but they are unlikely to be

able to compete with AI-enabled modern manufacturing processes. Moreover, as shown above, a high level of education is necessary to absorb technological change, not to speak of being able to participate in the development of new ideas. Countries that have failed to prepare for the future might then elect leaders who find external scapegoats rather than concentrating on implementing the reforms needed to make them competitive again. Investment in education, in R&D, as well as the quality of education are all unlikely to be improved under populist rule.

Needless to emphasise, under this 'populist stagnation' scenario, nothing will be done to create a truly integrated market in ICT services and EU spending on R&D might even be curtailed.

The EU policy framework might be little different from the past and the BAU scenario sketched out above. Economic policy would become even more national with even less effective coordination and less lip service to established exercises as the European Semester, the Macroeconomic Imbalances and the Excessive Deficit Procedures. There might be even greater differences than today. Populist politicians might use the procedures to portray themselves as the defender of (perceived) national interests and actively seek conflicts with EU instances. Actual policies will not necessarily turn anti-growth under populist governments, at least those which are based on identity politics.

So far it seems that 'left wing' populists, which would tend to favour redistribution over investment and growth-enhancing reforms have become influential only in part of the euro area periphery (Greece and Southern Italy).

Box 17. Populism with conservative economic policies

What would a scenario of a rise of ‘populism’ in Europe imply for economic policy? Populist parties are usually centred on one person who concentrates power, with the consent of a majority, typically by over-riding checks and balances, such as independent media and judiciary. Putin in Russia, Erdogan in Turkey and Orban in Hungary represent the three most visible variants of this phenomenon.

However, these regimes have so far followed remarkably ‘un-populist’ economic policies (Erdogan in 2018 represents a first deviation from this pattern). But at the same time these regimes retain popular support.

Control over the classic media, like television, radio and newspapers, are of course one reason why these regimes can maintain majorities in formal elections, especially if there is a strong premium for the relative majority. But manipulation, or even outright control, of the media cannot explain the enduring popular support of some populists (e.g. Orban, Erdogan, Kraswniewski, etc.) which can be measured by opinion polls and election results, which even if flawed, show still majority support.

One key reason for the enduring popular support is that the economy has done relatively well. And the reason that growth has remained strong is, somewhat ironically, that these regimes have followed prudent macroeconomic policies and kept markets open.

Russia under Putin should be the poster child for this macroeconomic prudence. The Russian government has run surpluses most of the time and has accumulated vast foreign exchange reserves. Hungary has also followed a quite prudent fiscal policy under the present Orban government; and Erdogan has done the same in Turkey since he came to power. Public debt in all three countries is thus either already very low or declining (Hungary). In two of these three cases, the previous ‘liberal’ democracies had lost credibility because they had led the country into a financial crisis.

Inside the EU, and even more inside the euro area, populists have little leeway to pursue excessively expansionary policies or engage in gross cronyism, unless of course they are looking for a direct confrontation with the EU authorities (and other Member States).

However, populists, especially those aiming to create a durable illiberal regime might choose to adhere to the macroeconomic framework of the euro area.

The basis of the ‘Maastricht’ approach is simply that prudent macroeconomic policies deliver better economic performance in the long-run. Today’s European strongmen have accepted this insight and usually delegated macroeconomic management to experts whom they have kept out of politics. They have typically resisted the temptation to use short-term fiscal or monetary stimulus to increase their popularity, relying instead of identity politics to dominate the political agenda. The longer run result of these prudent policies has been good growth, which in turn kept the majority happy.

For populists who can base their appeal on migration or other ‘identity’ issues, prudent policies might thus constitute an efficient long-term strategy for regime preservation. The strongmen realize that overspending leading to a financial crisis and the need to ask the ESM for assistance could mean their own demise.

However, those countries, in which populists do not dominate, might still welcome the peer review and the pressure for reforms embedded in the existing coordination mechanisms, and would probably be more likely to invest in education and R&D.

Macroeconomic policies might diverge that much between the (identity) populists and the happy few as explained in the box. However, when poverty based populism becomes dominant, or where the nationalistic element in identity politics questions membership in the euro, financial stability cannot be taken for granted. In extreme cases, this might lead to another fiscal crisis as markets anticipate even worse policies in the future, initiating the by now well-known vicious circle of higher risk premia and stronger fiscal pressures.

In the long term this scenario is likely to lead to average growth rates even lower than under the 'base case'. Conservative fiscal policies are a necessary condition for growth, but not sufficient. When the quality of governance deteriorates, as it usually does under populist/nationalist regimes, growth will also suffer. By 2035, GDP per capita might thus be only be a little above today's level in many Member States, though it might still have increased substantially in the 'happy few' that have continued to invest in the future.

The result would be an increasing divergence between the 'happy few', mainly in the north and north-west that maintain well-functioning institutions and are able to absorb new technologies. Cohesion would become even more difficult to maintain. Pressure for some fiscal re-distribution might increase and lead to conflicts between the populists and the happy few.

Scenario 4 (high growth, low convergence)

This could be seen essentially as the scenario described in the Accenture study presented above, or a variant of the previous scenario, but with largest Member States among the 'happy few'. Under this scenario, AI becomes a pervasive productivity enhancer, but mainly in countries that are prepared for it. The other countries (those with lower investment in human capital and R&D) would not experience a deterioration in their growth prospects, but they might feel 'left behind'.

In this scenario as well, the EU policy context would be similar to BAU. Economic policy would remain primarily national with little effective coordination although lip service may be paid to established exercises as the European Semester, the Macroeconomic Imbalances and the Excessive Deficit Procedures. Although the formal mechanism might in reality not have much teeth, macroeconomic policies would still remain prudent on average, on account of the memory of the financial crisis and also because the 3% of GDP deficit figure presents a focal point for national political decisions.

Under this 'AI is coming' scenario, something might be done to advance the internal market in ICT services since the potential productivity enhancing prospects would have become visible and would be available for a majority of Member States. The same demonstration effect should also foster private and public investment in R&D.

Under this scenario, the average growth rate for the EU should increase, probably into the 2-2.5% range, but with a high variance as some Member States would not benefit from the AI revolution. The increase in overall growth could be substantial because some of the major EU-15 economies seem well prepared to absorb new technologies (even if they might not participate much in pushing the frontier of research).

Cohesion would naturally suffer. The pressure for fiscal compensation for the laggards would be strong and might result in some redistribution mechanism being created because enough countries are doing well so that the burden on them remains bearable.

9 Conclusions and policy implications for the EU

In this final chapter, we examine the new challenges for the EU resulting from the likely, or simply just possible, changes that have appeared in recent years in the trends identified above. Our aim is to analyse how these challenges could change the socio-economic picture in the EU for 2035.

Some challenges for the EU are clear:

In the post-Brexit period, the European economy, and indeed the entire European 'economic space', needs to be reshaped, with the EU now centred on the euro area.

With growth in the rest of the world continuing to outpace that of Europe, it is likely that intra-EU trade will continue to lose importance relative to external trade. This implies that the importance of the internal market relative to the global market will diminish. This centrifugal force is likely to have political implications.

Trade policy in general might have to be reassessed if the global multilateral institutions and rules were to fray. The immediate danger today seems to be the erratic policy of the current US President and a looming Sino-US geo-strategic rivalry. However, transatlantic trade tensions are unlikely to become structural because there are no fundamental differences or conflicts of interests between the EU and the US.

The EU-27 will likely become a 'small open economy' whose relative weight in the global economy will, by around 2035, be similar to that of Japan at the start of the century. It is thus unlikely that, on its own, the EU will have enough influence to shape the global trading system. The EU will either have to accept more bilateralism itself (in which it might still remain a relatively large player) or try to forge a 'global alliance to save globalisation'.

It seems impossible to predict whether the current 'democracy recession' around the globe will continue. However, it seems very likely that the economic weight of many countries, that are today authoritarian, will increase over time. Even within Europe, it cannot be excluded that illiberal tendencies gain further ground. The existing elaborated framework of economic policy coordination might then lose most of its relevance. However, this does not mean necessarily a return to excessive spending and financial crisis. Populist strongman can retain their power by appealing to identity politics while maintaining prudent financial policies, which should deliver an acceptable economic performance in the long run.

Overall, while it has been already widely accepted that Europe needs to move toward a society of change and innovation, there are many uncertainties remaining. Today big data and AI appear to be the developments that shape our future. However, this might change over time. The only certainty seems further change.

Finally, one key challenge for Europe will be how to deal with inequalities, possibly more inequalities in opportunities and perceived social status, rather than inequalities in income. This might need a re-think of social policy and perhaps the indicators to be used to measure success.

Restoring a healthy economy that is also perceived as delivering security for everybody would be a key ingredient for restoring trust in democracy and the EU institutions. The EU economy is currently enjoying a cyclical upswing, but the long-term task will be to make the EU fit for a global economy, which is increasingly dominated by other centres and with technology in constant and rapid evolution.

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This study maps and analyses current and future global trends in the fields of economics and society, covering the period to 2035. Drawing on and complementing existing literature, it summarises and analyses the findings of relevant foresight studies in relation to such global trends. It traces recent changes in the perceived trajectory of already-identified trends and identifies significant new or emerging trends. It also addresses potential policy implications of such trends for the European Union.

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