

THE FUTURE OF SKILLS EMPLOYMENT IN 2030

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Foreword

Given recent debates about automation and the future of work you'd be forgiven for thinking the job of policymakers was easy: governments should simply upskill workers to move from routine-intensive occupations in manufacturing and services that will be automated in the future to those that are not. However, the picture is considerably more complex and uncertain: not least because automation is just one of a number of technology trends - such as biotechnology, nanotechnology and the Internet of Things - that will have profound implications for the composition of the workforce. And technology change in turn is just one of multiple global trends that will impact on employment. Consider the ageing population, climate change, urbanisation and rising income inequality - each of which will have important sectoral implications.

As part of an ambitious study predicting the skills

mix required of the workforce in 2030, in late 2016 we held two foresight exercises in the UK and the USA. We brought together a group of leading domain experts, and asked them to reflect on the implications of global structural change in all its forms for the future labour market. Their task was to provide the human intelligence needed to train a machine learning algorithm that predicts the future demand for individual occupations. To enable a discussion of the workforce implications of these trends and their interactions, and to ground it in hard evidence, we produced a global trends slide deck, which we are publishing today. The positive reaction we received made us realise that we had produced a resource that could be of independent value in informing strategic labour market planning, whether that is in policy, education or business. We'd very much welcome your feedback.

Hasan Bakhshi, Executive Director, Creative Economy and Data Analytics, Nesta

Foreword

Predicting the future of work is one of the most exciting - and difficult - areas of research within education today. The implications of changing demand for particular skills on our education systems are enormous. This is why I was delighted to be a part of the foresight exercise to determine the changing demand for skills.

The discussions were rich and sophisticated, in large part because of the quality of the thought leaders convened. The discussion was made richer still because we were provided with what you now have: a rigorous catalogue of the trends that will shape the future of work.

Our aim in sharing this set of insights is twofold: one, to make visible as much of the research process as possible, and two, to provide you with insights that you can apply, build on, and, of course, critique.

I hope you will share my excitement for the eventual results of this research. Given that learners who are starting formal education now will be graduating into jobs in 2030, the implications of this work for learning are far reaching--meaning action is needed not in some distant future, but today.

That's why we think the future of jobs is one of the most important conversations in education.

**Amar Kumar, SVP Efficacy & Research,
Pearson**

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Automation: force for job destruction or creation?

Historically, over optimism about potential of new technology has sat alongside fears about impacts on jobs

- Perennial fears about impact of technology, particularly automation, on employment (especially in times of economic stagnation) (Mokyr et al., 2015).
- At the same time, predictions about future pace of technological change, especially artificial intelligence, repeatedly over-optimistic (Armstrong et al, 2014).
- Jobs and skills composition of workforce have changed only gradually over time (Handel, 2012).
- Most dramatic historical shift was from agriculture to industry rather than ICT-driven transformation.

This newspaper headline is from the New York Times in 1928



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Automation: force for job destruction or creation?

Jobs are a complex bundle of tasks, many of which are complementary with technology

Going forward

- Estimates of impact of future automation vary. Frey and Osborne (2013) estimate 47 per cent of US employment at risk.
- In contrast, using task-based analysis, share of automatable jobs estimated at 9 per cent (Arntz et al., 2016).
- For other jobs, specific tasks may be automatable but separating these from other tasks may also create coordination costs.
 - For example, lawyers carry out document reviews which could be automated in some contexts, such as discovery but they also perform factual investigation, client advice, legal writing and negotiation which are harder to automate.

Technology will also be complementary with some types of labour and amplify comparative advantage of human ability. For example, possible roles in marketing.

	How to add value	Example
Step up	You may be senior management material – you're better at considering the big picture than any computer is.	A brand manager orchestrates all activities required to position brand successfully.
Step aside	You bring strengths to the table that aren't about purely rational, codifiable cognition.	A creative can intuit which concept will resonate with sophisticated customers.
Step in	You understand how software makes routine decisions, so you monitor and modify its function and outputs.	A pricing expert relies on computers to optimise pricing on a daily basis and intervenes as necessary for special cases or experiments.
Step narrowly	You specialise in something for which no computer program has yet been developed (although theoretically it could be).	A wrap advertising specialist has deep expertise in using vehicles such as mobile billboards.
Step forward	You build the next generation or application of smart machines – perhaps for a vendor of them.	A digital innovator seizes on new way to use data to optimise some key decision, such as cable video ad buys.

Source – Kirkby and Davenport (2016)

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Organisational and job design affects whether technology complements or replaces labour

Routineness and susceptibility to automation are not inevitable features of occupations. (See chart on 'Share of jobs with high performance work practices (hpwp) and mean hpwp score').

Job and organisational design important too:

Even seemingly routine jobs can be designed in ways that permit and reward creativity, judgment and commonsense (Hendel and Spiegel, 2014).

High performance work practices include:

- Autonomy
- Task discretion
- Collaboration
- Mentoring
- Job rotation
- Application of new learning

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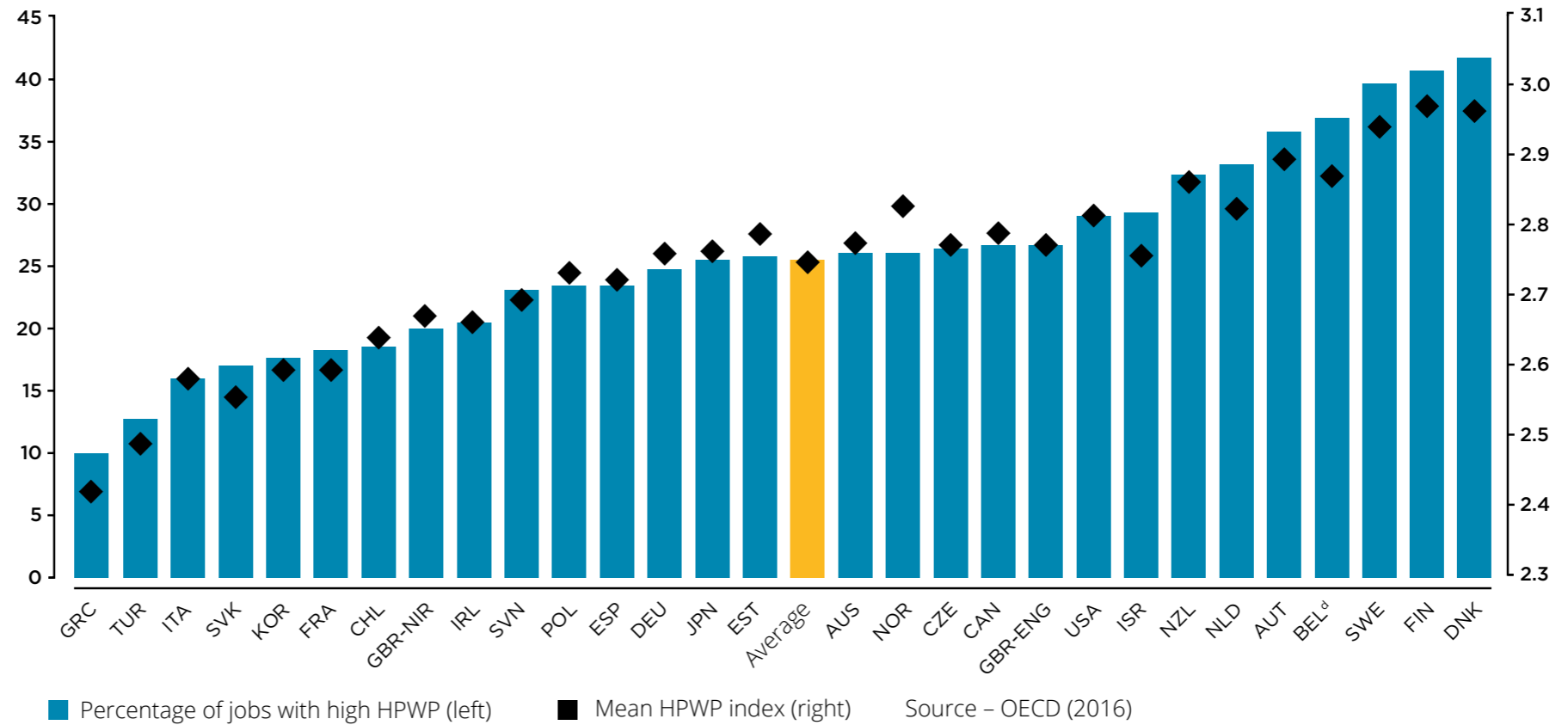
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Share of jobs with high performance work practices (HPWP) and mean HPWP score



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Technological progress and job creation

Technological progress gives rise to entirely new occupations and sectors

US employment growth faster in occupations with more novel tasks

Evidence from the US: In 1990, 8.2 per cent of US workers employed in occupations not catalogued in 1977.

More recently, this has decreased:

(See chart on 'Employment growth by decade plotted against the share of new job titles')

- In 2000, only 4.4 per cent of workers in jobs not catalogued in 1990.
- In 2007, <0.5 per cent of workers in jobs not catalogued in 2000 (Berger and Frey, 2016).

In parallel, stark reversal in demand for high skill occupations in 2000s, notwithstanding growth in the supply of high education workers (Beaudry, Green and Sand, 2016).

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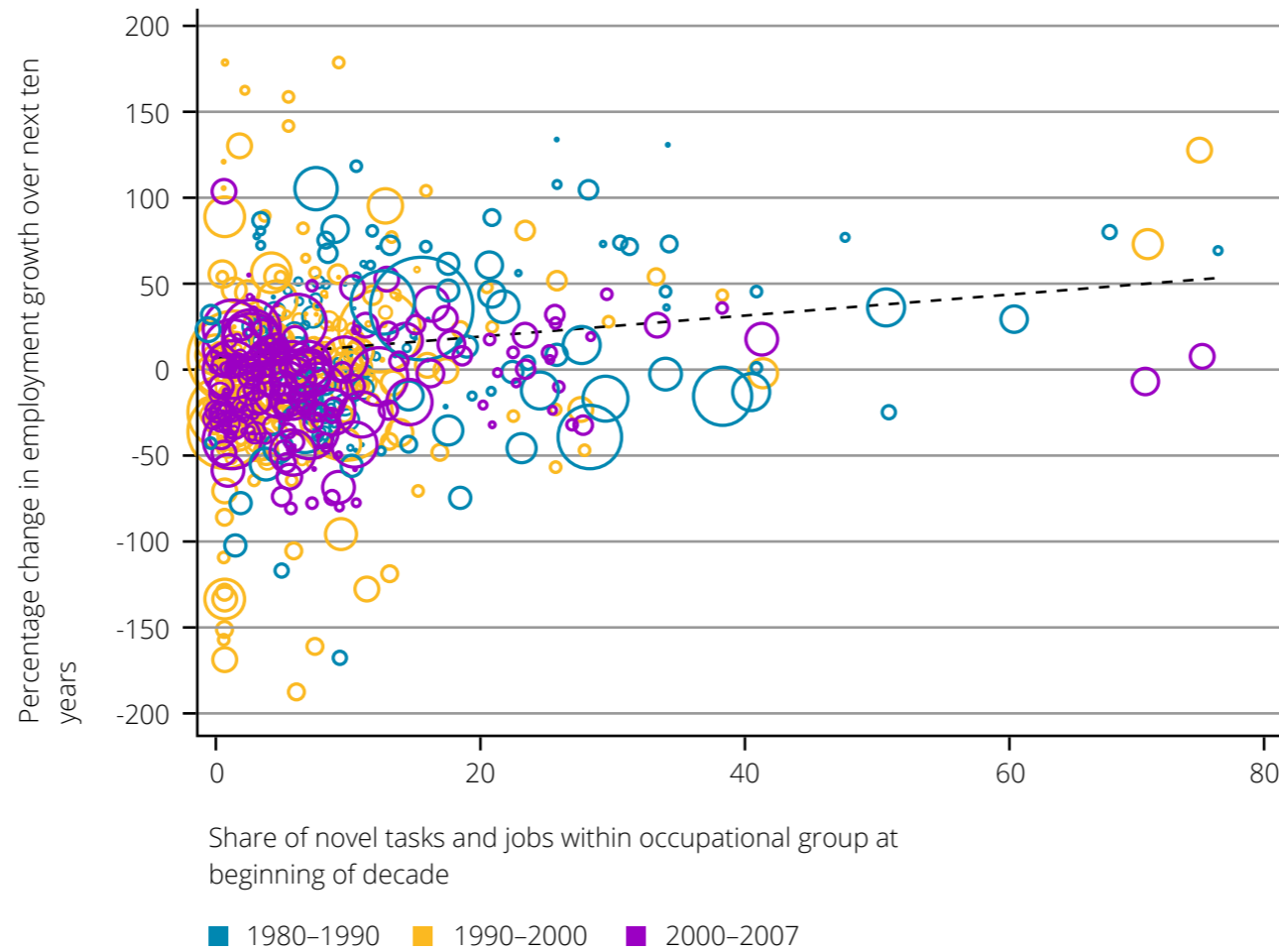
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Employment growth by decade plotted against the share of new job titles



Source – Acemoglu and Restrepo (2016). Methodology based on Lin (2011) which uses data on new occupational titles from revisions to the census occupation classification system.

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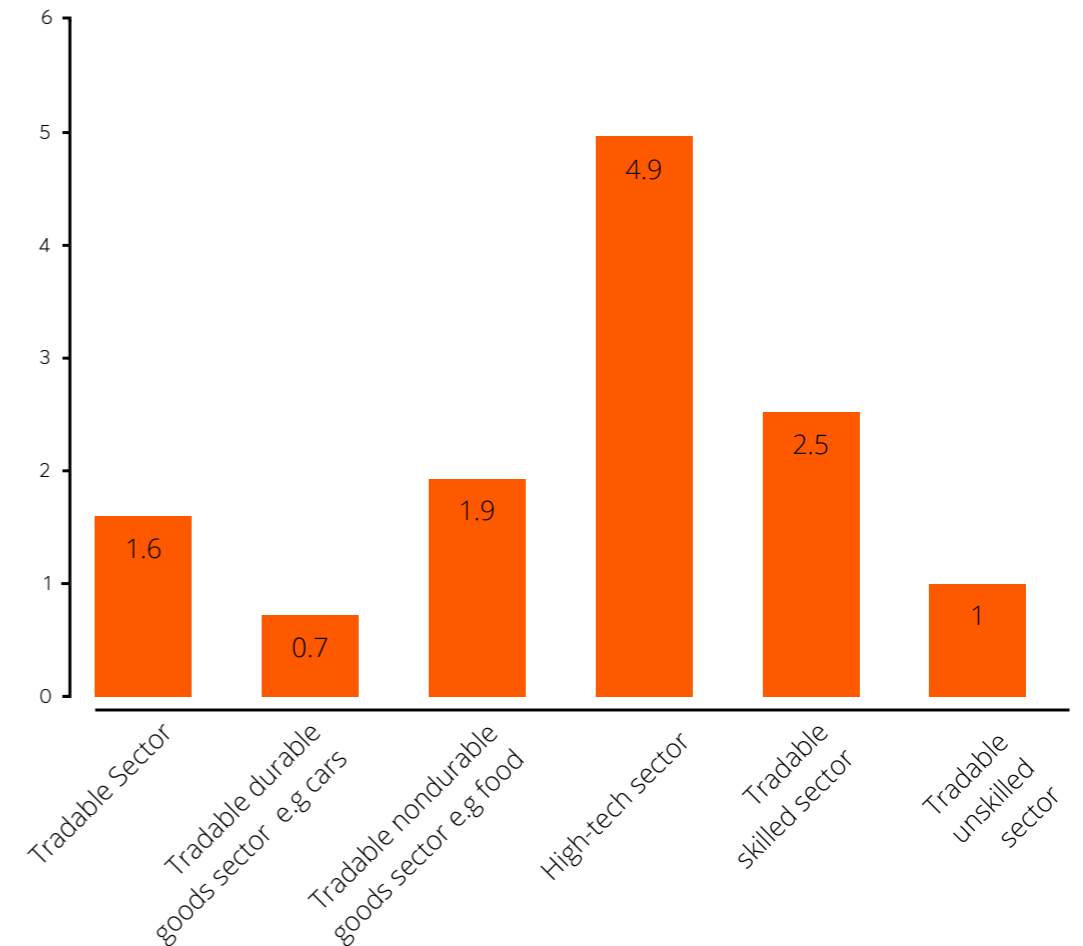
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Technological progress and job creation

Even in cases where technological change destroys jobs, it triggers offsetting market adjustments

- 1 Lowers production and distribution costs and therefore prices for some goods and services, stimulating aggregate demand.
- 2 Surplus income can be spent on healthcare, education and arts - 'cost disease' sectors that are resistant to automation and have consequently experienced sharply rising costs but demand for which is typically raised by growth in purchasing power. Smith et al. (2009) estimate that higher income accounts for 29 per cent-43 per cent of health spending growth in US between 1960 and 2007.
- 3 By helping to grow market, introduction of ATMs in 1970s actually boosted employment of human tellers in US even though number of tellers per branch fell.
- 4 Moretti (2010) estimates that each job created by US high-tech sector created five additional jobs through multiplier effects - higher than other industries. For European evidence, see Goos et al., (2015) and Gregory et al., (2016).

Number of additional nontradable jobs created by sector (US)



Source – Moretti (2010)

Note: Skilled sector represents workers with college education or greater.

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Adoption and diffusion

Are adoption lags decreasing?

- Evidence of accelerating consumer adoption. However, PCs, Internet, smartphones and music streaming services based on similar underlying technologies and infrastructure leading to lower learning and switching costs.
(See chart on 'US technology adoption rates (1900-2014)')
- Slower productivity growth suggests business adoption not as fast. OECD (2015) argues that problem lies in 'diffusion machine', not slowing of innovation by most advanced firms.

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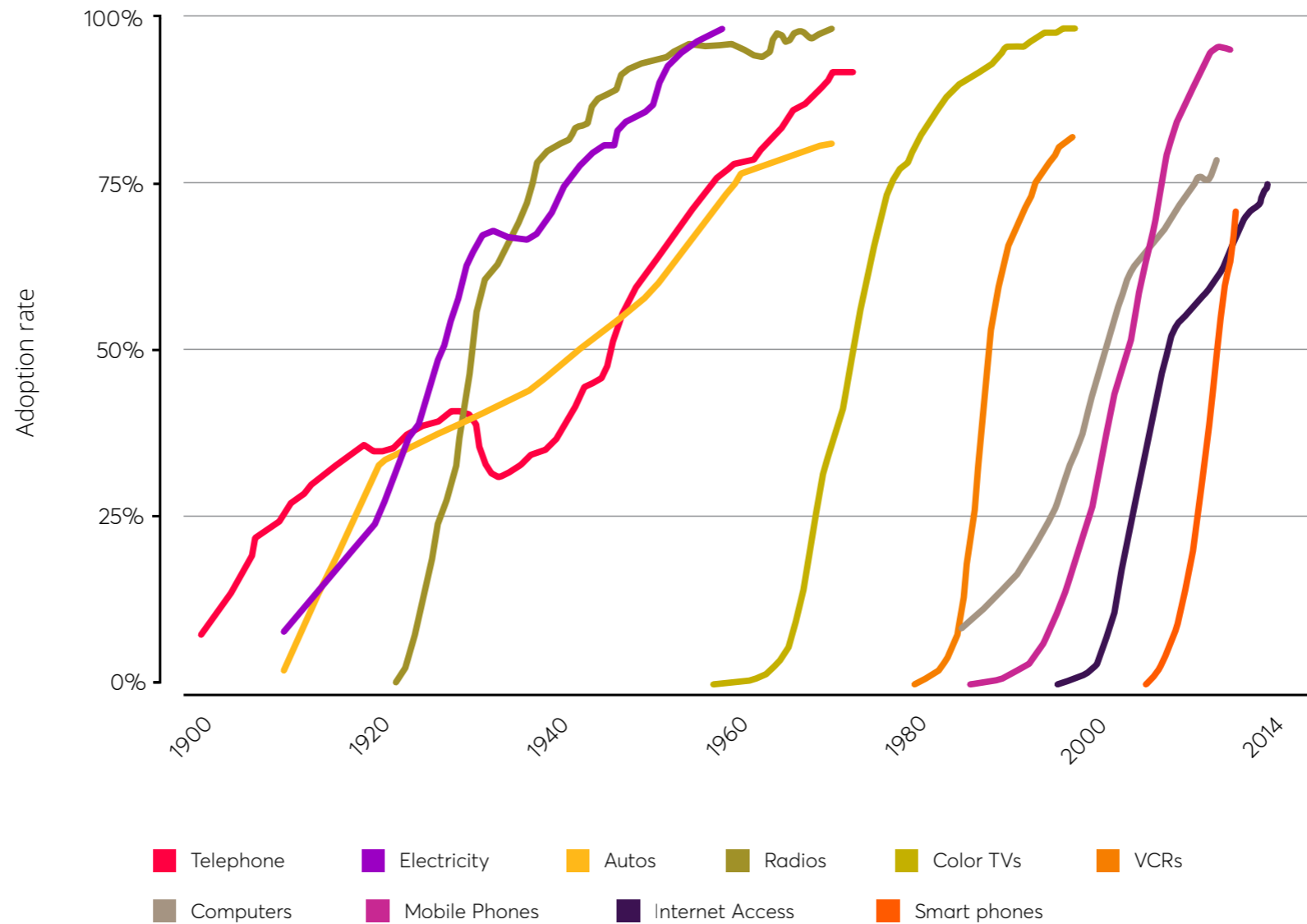
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US technology adoption rates (1900-2014)



Source – Blackrock Investment Institute (2014) (Adoption rates are based on household ownership except for cell phone and smart phones, which are based on ownership per capita.)

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Adoption and diffusion

Any number of microeconomic reasons why new technologies take time to diffuse

- 1** Behavioural reasons: potential losses tend to loom larger than potential gains. Value of new technologies lies in scope for long- rather than short-term improvement.
- 2** Organisational reasons: including need for complementary investments in management structures, incentive schemes and skills. Weaknesses in management practices may further prevent the trickle-down of innovation (Haldane, 2017).
- 3** Labour market institutional reasons: Unions may be sceptical about new technologies, fearing headcount cuts. (See chart on 'Trade union density by industry in US'). But reality is more complex. It has been suggested that countries with more regulated labour markets typically see less union resistance, in contrast to countries like UK and US with higher labour market flexibility (Doucouliagos and Laroche, 2012).

Adoption is also affected by wages which are endogenous e.g., automation might lead to falling wages making further substitution of capital for labour less attractive.

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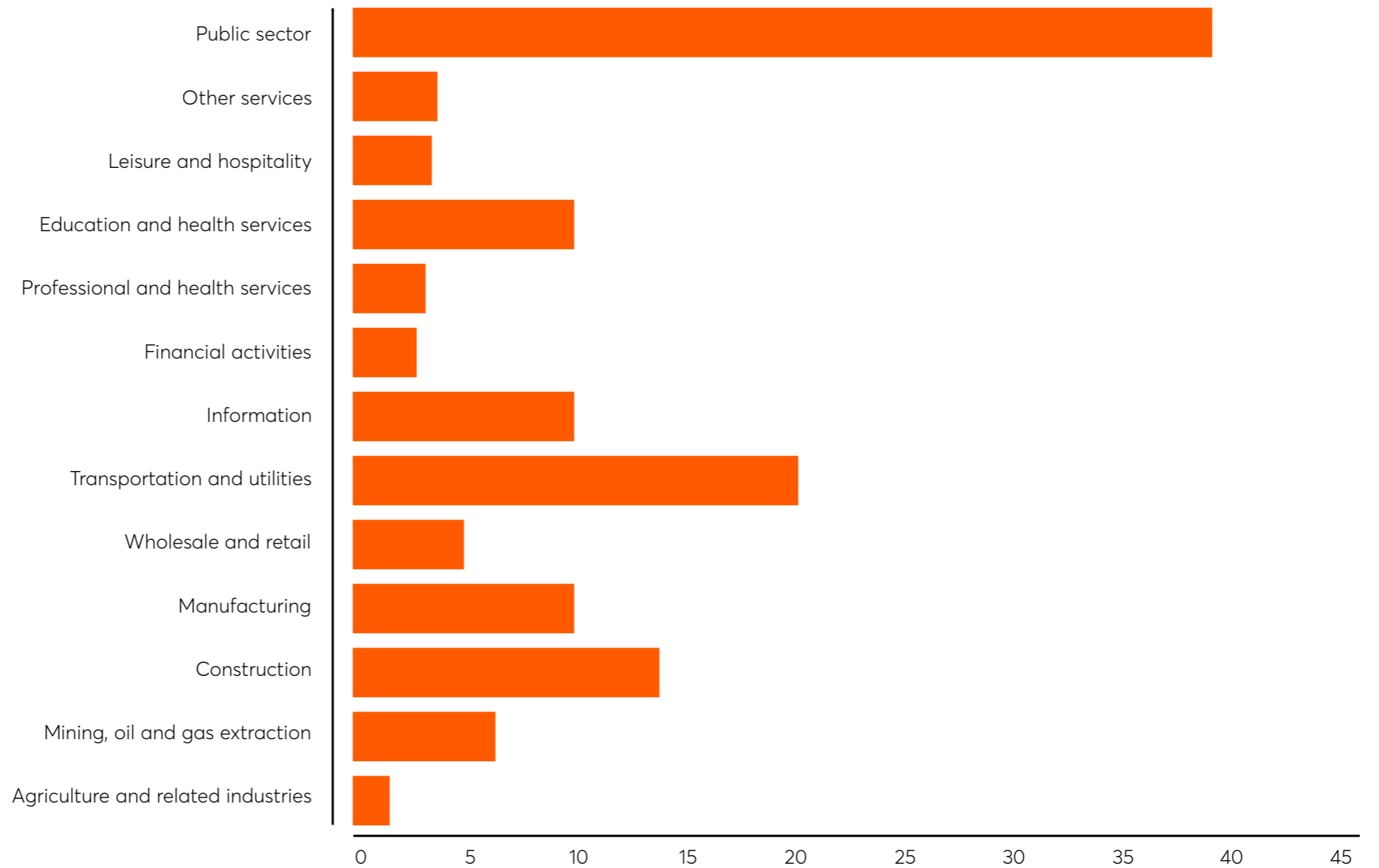
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Trade union density by industry in US (2015)



Source – Bureau of Labor Statistics data (2016)

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Adoption and diffusion

And there are macroeconomic barriers to diffusion too

1 Strong societal preferences: concerns about safety and growing power of Monsanto in 1990s led to bans on cultivating GM crops in almost 60 states, against advice of scientists. Autonomous vehicles face challenge of how to distribute liability in case of accident (e.g. algorithmic morality).

Public may also put special weight on ideals and values of certain occupations. (See pages 73, 82)

For instance, lawyering is deeply rooted in, and essential for, rule of law; nursing and caring entails respect for dignity and autonomy of patient - features which might be lost with greater use of technology.

2 Fast growth can lead society to value safety over further growth. New technologies, while raising growth, may also introduce small chance of catastrophe e.g. environmental disasters, bioengineered viruses, killer robots. Countries may value more days of life to enjoy their high consumption over prospect of still higher future consumption (Jones, 2016)

3 Vested interests can block innovation: UK rail companies used safety regulation - so-called Red Flag Acts in the 1860-1890s - to discourage people from using cars. Sharing economy platforms like Uber banned by states worried about impact on local firms. ([See figure on 'Uber bans worldwide'](#)).

Research finds that technologies diffuse more slowly in countries where legislative authorities have more flexibility; but also in nondemocratic regimes and ones with a weak judiciary (Comin and Hobijn, 2009).

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Uber bans worldwide



Source – Washington Post, TIME, Business Insider, NYTimes, Huffington Post, Reuters, Wall Street Journal, CNN and local news reports

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Specific technology trends – Digital technologies

Wave of new Information Technologies (ITs) since late 1960s to present

ITs and digital technologies recognised as General Purpose Technology (Bresnahan and Trajtenberg, 1996):

- Continual technological progress.
- Pervasive use in wide range of sectors.
- Complementary innovations and spillovers.

However, productivity may fall in short run as economy adjusts.

Media, retail, transport and hotels well down the road to full digitisation. Healthcare, financial services and capital goods relative laggards (Morgan Stanley, 2017).

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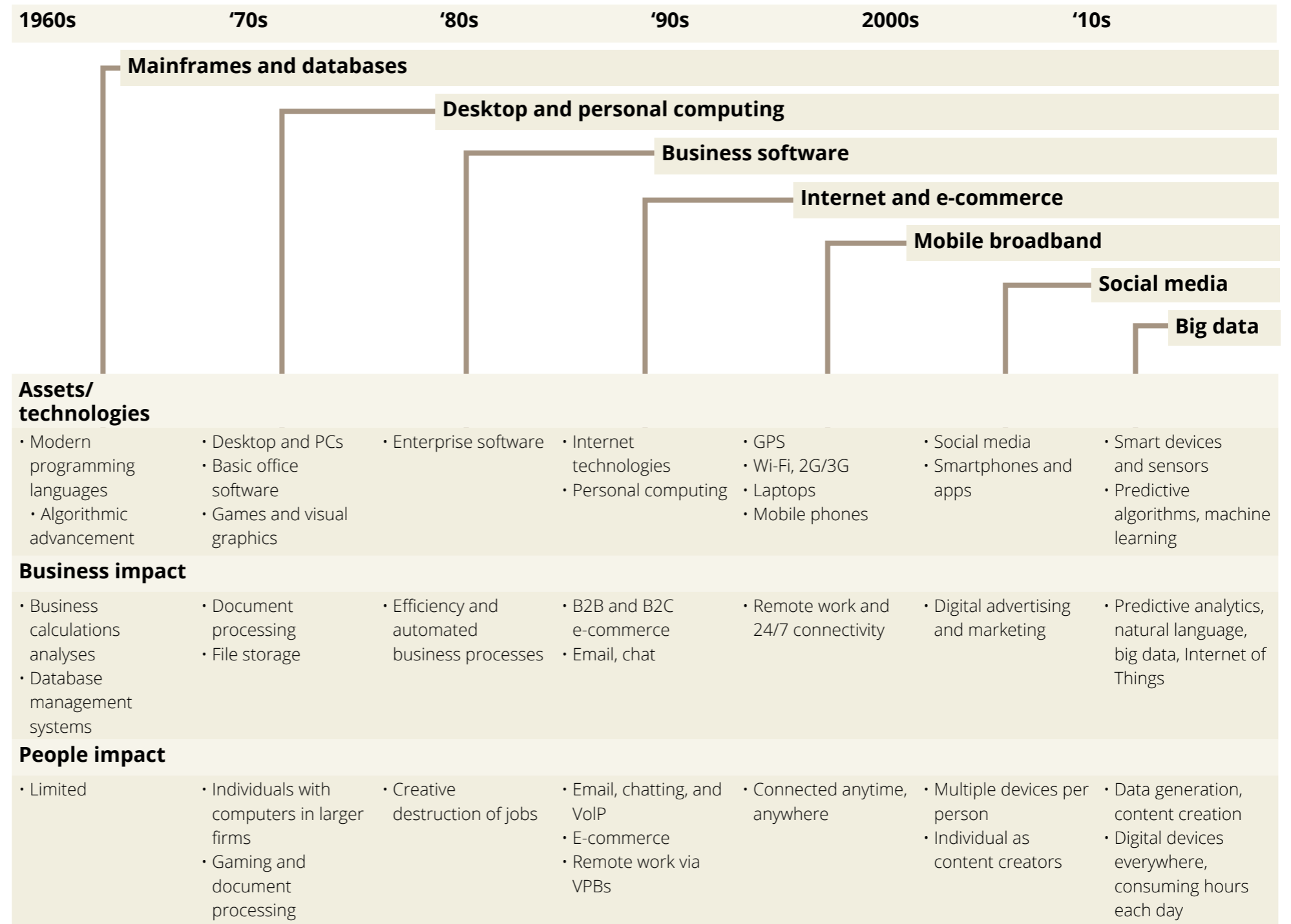
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Source – McKinsey Global Institute (2015)

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Specific technology trends – Digital technologies

Productivity impacts: Solow paradox renewed

- Increase in US labour productivity growth in mid-1990s largely reflected diffusion of ITs, resolving Solow Paradox: *'you can see the computer age everywhere except in the productivity statistics'*.
- However, productivity surge ended in 2000s prior to global financial crisis, especially in IT-producing and IT-using sectors (Fernald, 2014).
(See chart on 'Trend on labor productivity growth in the US (GDP per hour worked; average annual rate)')
- Moreover, Acemoglu et al (2014) shows for US manufacturing that where there is evidence of more IT-intensive industries having faster labour productivity growth, it is associated with falling output and even more rapidly falling employment. With employment declines in IT-intensive industries leveling off after 2000, so productivity growth returns to its earlier pace.

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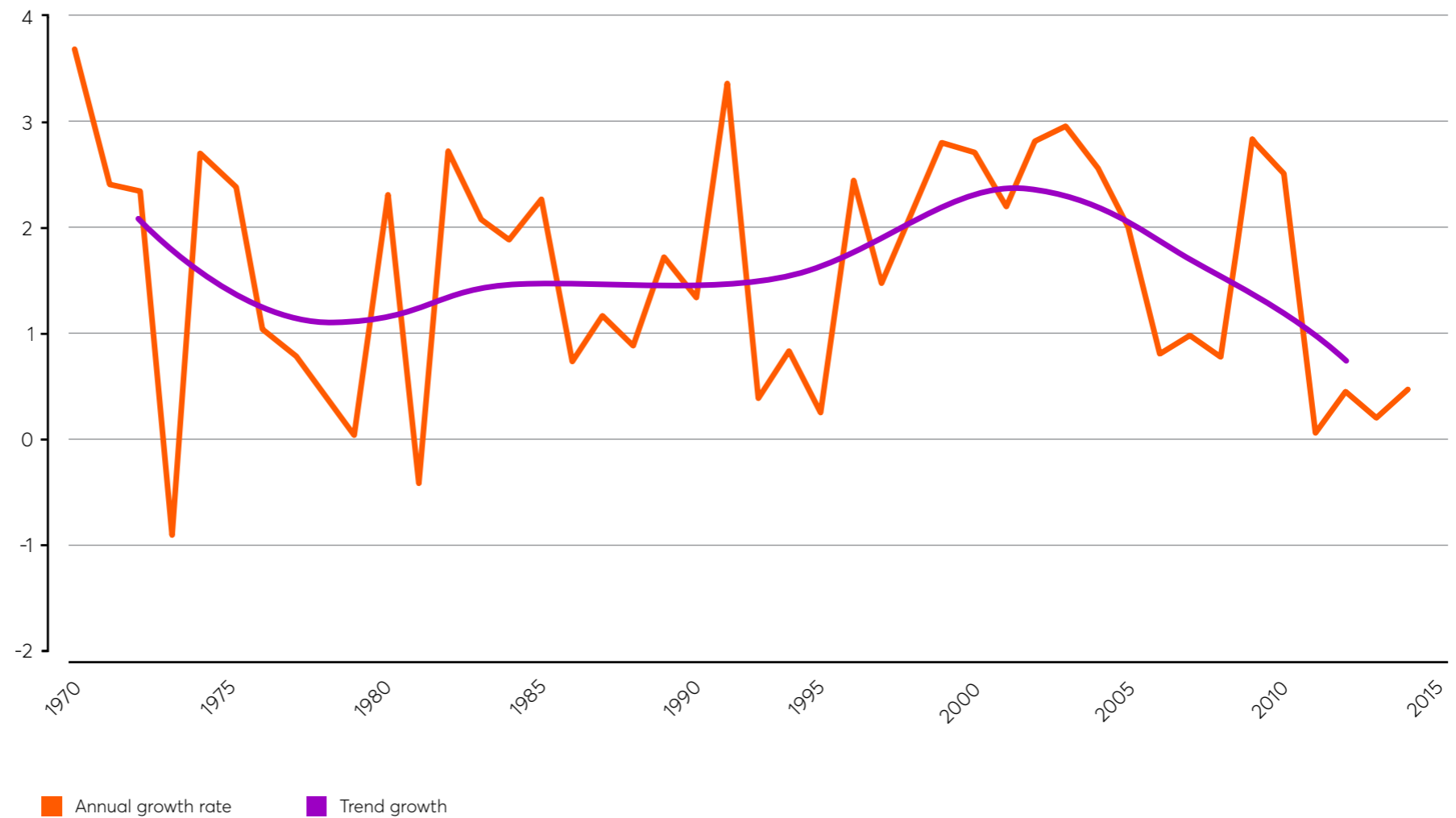
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Trend in labor productivity growth in the US (GDP per hour worked; average annual rate)



Source – OECD data (2016) with simple trend growth estimate

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Specific technology trends – Digital technologies

Digital debates and controversies

Pros

- Mis-measured productivity: consumers have free access to Google, Wikipedia and Facebook.
- Digital technologies enable experimentation and more rapid knowledge creation. Cost of sequencing human genome fallen sharply due to techniques such as polymerase chain reaction.
- Tech revolutions always proceed in fits and starts. Models such as S-curve, which implies technology bursts onto scene, gives what it has and then matures, simplistic. Productivity during electrification experienced acceleration, then slowdown (1924-32), then second boom (1932-1940).
(See chart on 'Labour productivity growth during the electrification era (1890-1940) and the IT era (1970-2012) in the US (1915=100 and 1995=100)')

Cons

- Consumer surplus from IT falls short of ~ \$2.9 trillion 'missing output' resulting from the productivity growth. Productivity associated with innovations has always been mis-measured. Alternative measures e.g. business startup rates also point to declining dynamism.
- With expanding knowledge base, innovators compelled to devote more time to keeping pace with, rather than pushing, technology frontier. To sustain constant growth in GDP per person, one estimate for US suggests that it must double amount of research effort searching for new ideas every 13 years to offset increased difficulty of finding them (Bloom et al., 2016).
- Comparisons with electrification should be treated with caution given data limitations and fact that productivity boom may have been driven by pressures to innovate during WWII and Cold War.

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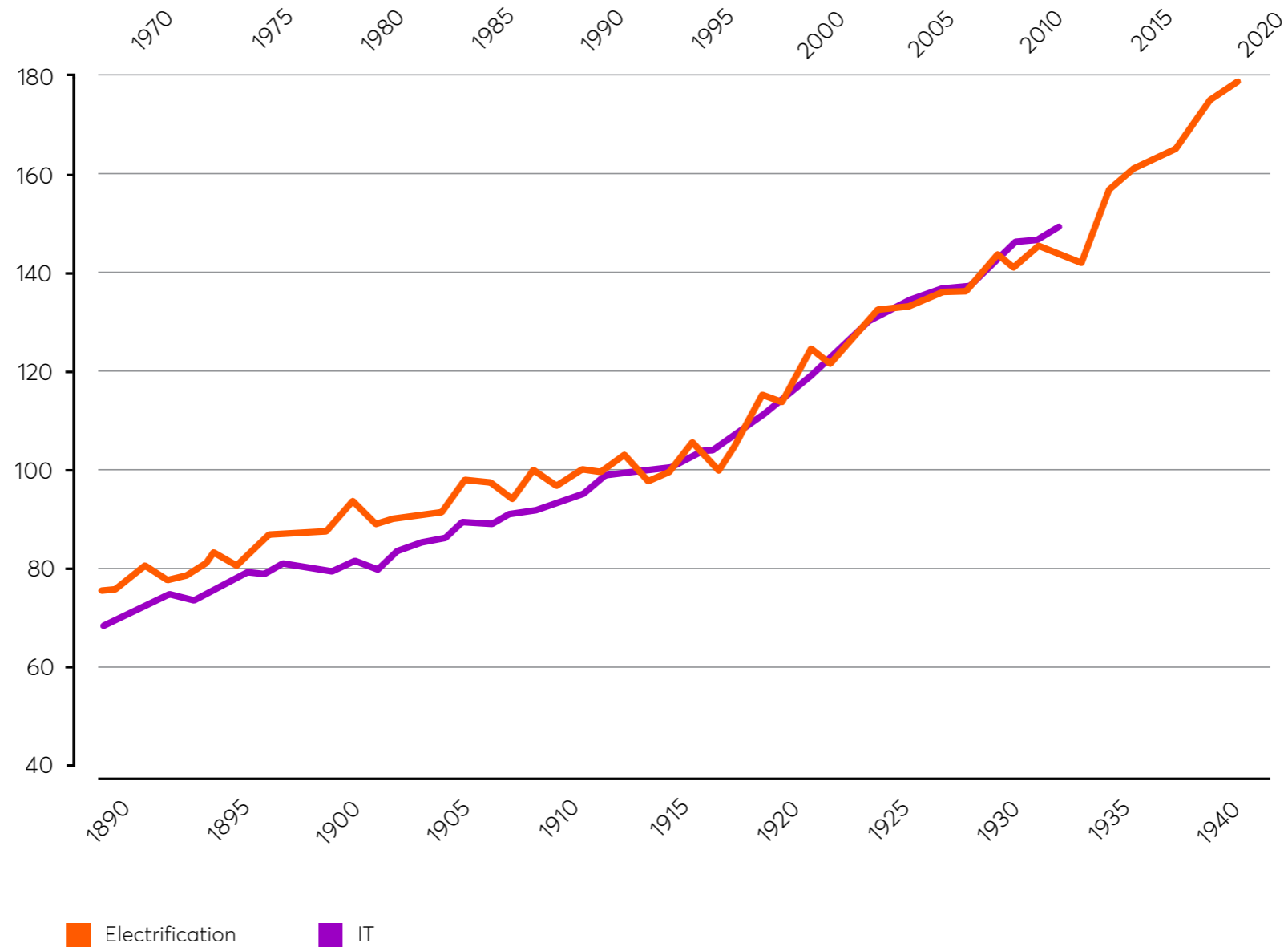
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Labour productivity growth during the electrification era (1890-1940) and the IT era (1970-2012) in the United States (1915=100 and 1995=100)



Source – Kendrick (1961); Byrne, Oliner, and Sichel (2013)

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Specific technology trends – Sharing economy

The rise of the sharing economy?

0.5 per cent of workers sell services through online platform (Katz and Krueger, 2016). Between 2012 and 2015, cumulative percentage of adults who had ever earned income through an online platform increased 47-fold (Farrell and Greig, 2016).

Market impacts

- Platforms like Airbnb highly differentiated from established providers - cannibalisation limited to particular market segments: net effect on supply positive (Zervas et al., 2016).
- Services like Uber and Lyft less differentiated from traditional ones, though may increase ease of access: net effect on supply less clear (Sundararajan, 2016).
- Even in cases of lower supply e.g. car production, secondary occupations e.g. car mechanics, may benefit as assets used more intensively require ongoing repair and maintenance.
- Sharing assets, such as cars, may leave consumers with more money to spend on things they enjoy (e.g. experiences).

Activity likely to due to

- Growth of micro-businesses and contract work.
- Changing attitudes to asset ownership.
- Greater role for platforms in buffering income and spending shocks.
- Revival of community-based exchange.

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Factors affecting sharing of goods and services

Price	The higher the price of a good/service, the more likely it is to be rented out.
Frequency of usage	Goods that are used frequently by owners are less conducive to being shared. Frequently rented goods can also entail significant transaction costs (for example costs of delivery).
Income	Rental markets may also emerge in areas where the latent rental value of the asset represents a higher percentage of its owner's income.
Depreciation rate	The more rapidly an asset depreciates, the more likely it will be rented as owners seek to maximise its value before it 'perishes'.
Predictability of usage	Goods for which usage can be planned in advance are typically easier to rent.
Ownership value	Where a product has personal significance or the act of ownership provides value in itself, it may be less well suited to peer-to-peer rental.
Customisation	Goods that are idiosyncratic or full value of which is realised through repeated use are more likely to remain owned than rented.

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Specific technology trends – Sharing economy

The risk of regulatory backlash

Employment terms e.g. in US, Californian court has given green light to Uber drivers to sue to establish legal status as employees (and so entitled to be reimbursed for expenses).

- Service quality e.g. the rowdy Airbnb guest disrupting neighbours or Uber driver with poor qualifications.

- Monopoly power because of platform network effects e.g. growing number of initiatives such as Platform Cooperativism movement seeking to reclaim power of platforms over decision-making and personal data for users.
- As many regulations were designed with traditional business in mind, open question whether policymakers can resolve these issues without stifling continued development of sharing economy. Other issues e.g. platform workers who cannot access credit because they do not earn a steady income also require consideration.

Different regulatory visions for sharing economy

	Regulation via Third Party online platform	Self-regulatory Organisation (SRO)	Government Direct Regulation
Definition	Regulation via sharing platforms' technology reducing information asymmetries	Regulation rests with privately-run SROs with no or limited govt. involvement	Government sets explicit rules for sharing economy
Example	Online feedback; digitally verified government IDs of providers	Medical Association, Bar Association (law)	Government's accreditation for online courses; health and safety standards
Enforcement	Reputational damage	SRO has audit and penalising powers	Government fines and sanctions, if rules are breached

Source – Morgan Stanley (2016)

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Specific technology trends – Internet of Things

Increasing computing power and smaller chips have allowed for advances in Internet of Things

New sensors, big data and cloud computing improve:

- Process efficiencies
- Understanding of customer behaviour
- Speed of decision-making
- Consistency of delivery
- Transparency of costs

Impacts on

- Industries with complex supply chains, short lead times and uncertain preferences, such as manufacturing, oil and gas, consumer packaged and fashion-led products.
- Business models: firms can monitor use of their products and provide customised pay-as-you-go services.
- Service-oriented occupations, such as customer advisors, account managers, marketing specialists, researchers and sales/business experts.

Pace of adoption will depend on

- Cheap and energy-efficient chips.
- Availability of good and unique datasets.
- Development of common standards for interoperability and solutions to privacy and cybersecurity concerns.

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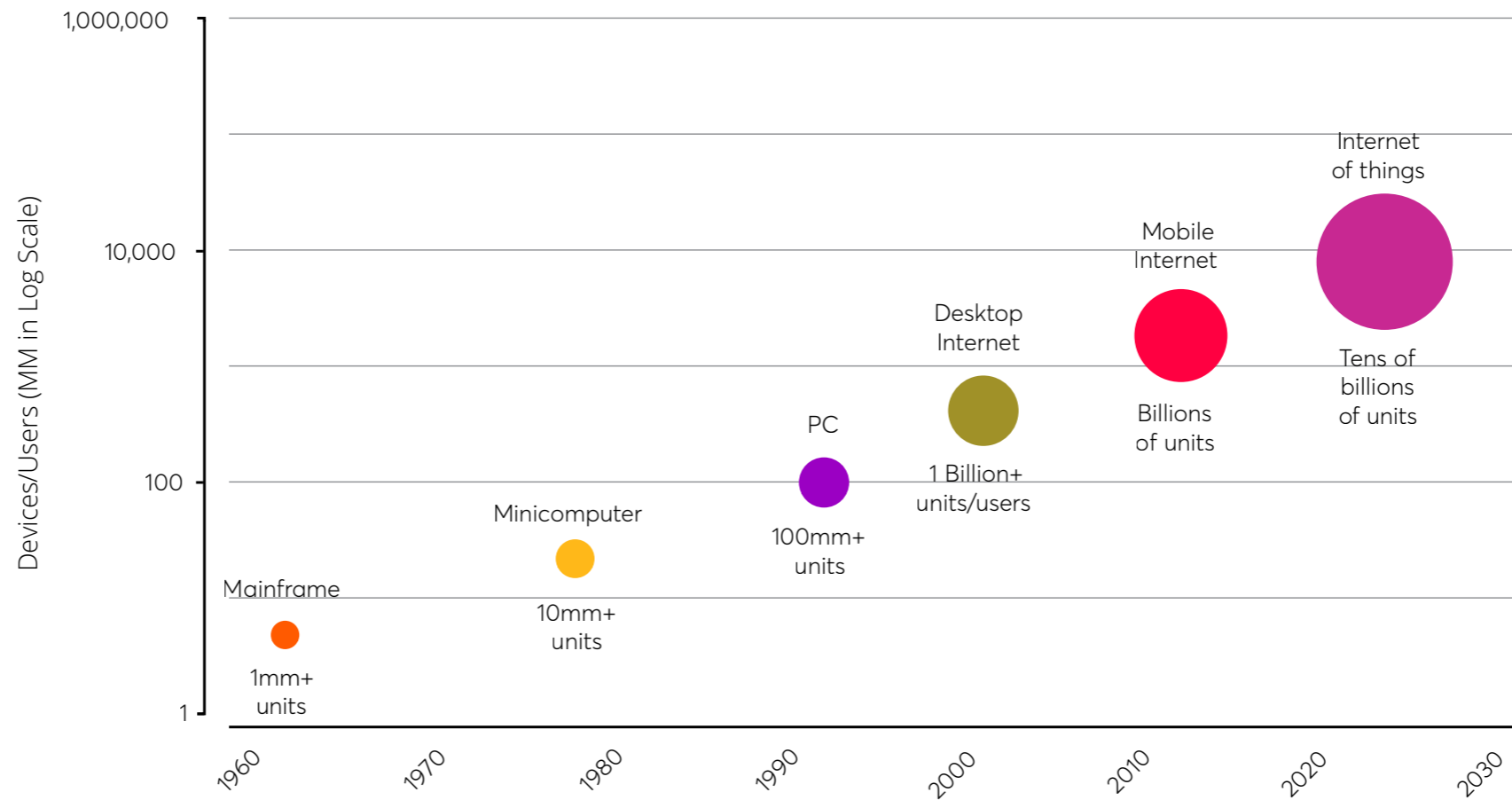
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Computing growth drivers over time (1960-2030)



Source – Morgan Stanley (2014)

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Specific technology trends – Hardware and materials

Commercial 3D printing could overhaul design and production in broad range of sectors

- 1** Large manufacturing companies are lead users of technologies like 3D printing to support distributed manufacturing e.g. GE reportedly uses 300 3D printers to produce 25,000 fuel nozzles p.a. for its LEAP jet engine. The assembly combines 18 different parts into one piece that is less prone to ice accumulation and joint and welding weakness and requires limited assembly labour.
- 2** Manufacturing, transport and medical industries present greatest opportunities for 3D printing: activities that rely on highly complex, low-volume, highly customisable parts e.g. prototyping, automotive tooling, aerospace and medical devices.
- 3** However, even in next decade, traditional manufacturing techniques likely to retain an advantage over 3D printing for most high-volume products due to differences in material costs and build speeds.

Impacts

McKinsey Global Institute (2013) estimates that 3D printing could generate economic impact of \$230 billion to \$550 billion by 2025 based on shorter production cycles, reduced waste and value of customisation.

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Specific technology trends – Hardware and materials

The rise of the robots

Estimated that 120,000 industrial robots sold in 2013, with China overtaking US.

Adoption lags in SMEs

They do not have production volumes to justify use. Only 36 per cent of medium-sized European companies use industrial robots, compared with 74 per cent of companies with >1,000 employees (OECD, 2016).

Adoption heavily concentrated in car industry

- Seven times greater than in other sectors.
- Increasing customisation and tasks requiring physical dexterity still dependent on human labor.

Evidence that industrial robots increase labour productivity and wages

Though diminishing marginal returns to use. Little effect of robots on overall labour share or total hours worked, though some reduction in low-skilled employment (Michaels and Graetz, 2015). Stronger effects tentatively found by Acemoglu and Restrepo (2016) for US local labour markets: each additional robot reduces employment by about seven workers with limited evidence of offsetting employment gains in other industries.

Going forward

- 1 Use of collaborative robots ('cobots') that work alongside humans small but growing fast (60 per cent growth in annual sales in 2014 vs. 27 per cent for traditional robots).
- 2 Use of mobile robots ('mrobots') to perform tasks like inventory management (Amazon and Kiva Systems). However, Google sold Boston Dynamics due to weak near-term earnings visibility.
- 3 Development of machine learning (ML) techniques that can generalise from learned concepts to solve related problems or use them to learn more complex concepts e.g. commonsense reasoning based on sparse data (Davis and Marcus, 2015; DARPA, 2016 on current limits of ML); debates around how to achieve sufficient computing power to scale ML for broad use.

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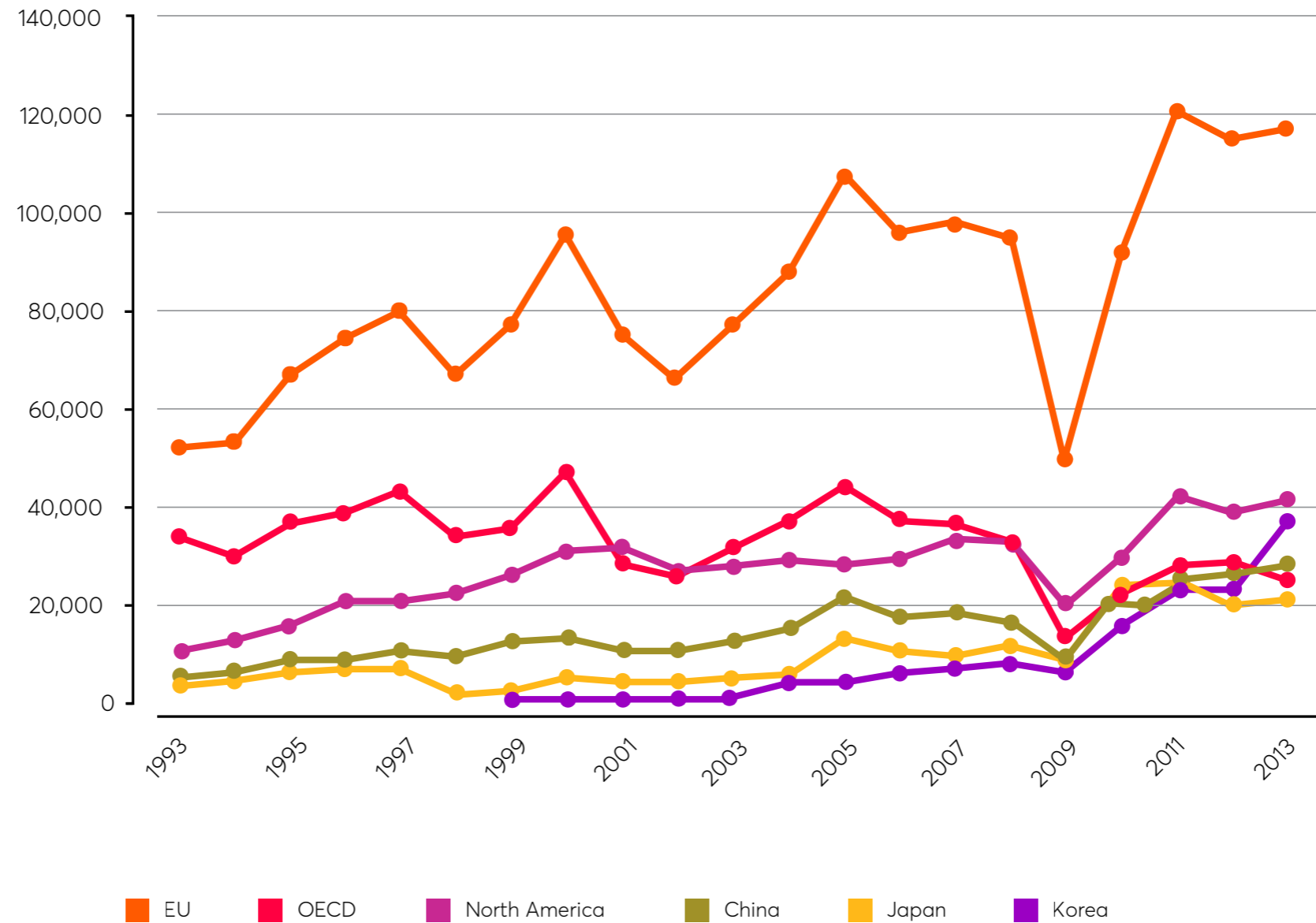
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Global sales of industrial robots (1993-2013)



Source – IFR Statistical Department at World Robotics, quoted in OECD (2016)

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Specific technology trends – Hardware and materials

New materials such as graphene have many potential applications but long lead times for commercialisation

Nanotechnology research has found that at dimensions of 1 to 100 nanometers, physical, chemical and biological properties of materials can differ in profound and valuable ways e.g. graphene:

- One-sixth weight of steel per unit of volume but more than 100 times as strong.
- Can be compressed without fracturing.
- 35 per cent less electrical resistance than copper.
- Ten times conductivity of copper and aluminum.

Going forward

Deloitte predicts graphene sales unlikely to pass \$100 million by end of decade. On average, commercialisation of advanced materials can take 20 years e.g. development of polyethylene applications beyond insulation and radar housing.

Factors slowing adoption:

- Current limited production volume.
- High production, storage and transport costs.
- Need for complementary processing techniques so that graphene can be integrated into final products.
- Uncertainty about health and safety issues (e.g. research suggests that nanomaterials exhibit widely varying levels of toxicity).

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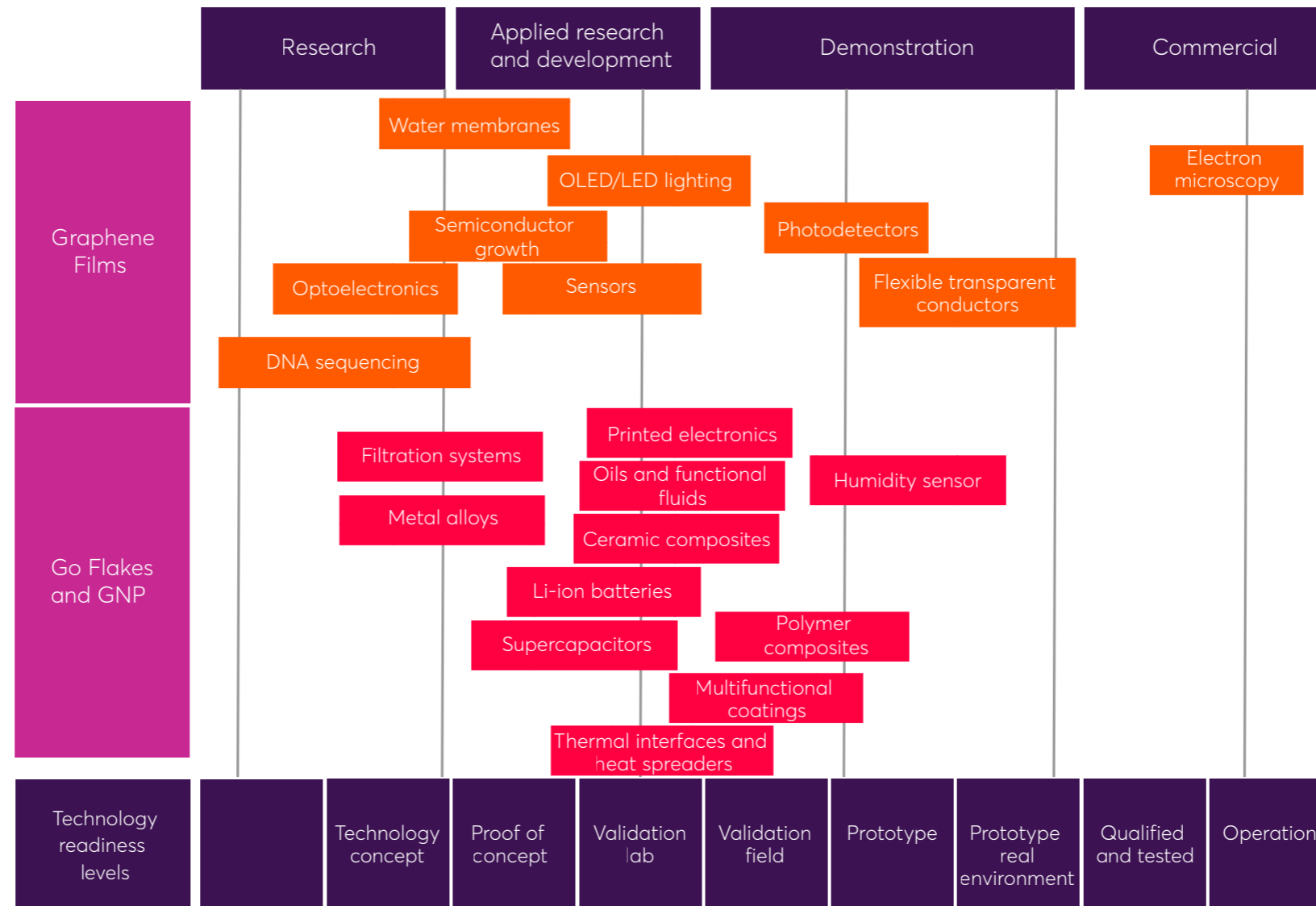
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Graphene applications classified by technology readiness level



Source – Zurutuza and Marinelli (2014)

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Specific technology trends – Biotechnology

Synthetic biology and gene editing, allied with modern genomics, are in place to begin a bio-based revolution

Fast and affordable DNA sequencing technology and better understanding of biological systems means it is increasingly possible to design and build biological parts, devices and systems.

For example, full genome synthesis, when combined with evolutionary screening or selection, can generate improved cellular strains for biomanufacturing while enabling 'reverse genetics' that underpin faster scientific discovery.

Impacts

Biggest impacts on chemicals, pharmaceuticals, energy and agriculture industries. Outside health, biotech has potential to improve environmental performance by decoupling activities such as agriculture from fossil fuels.

Challenges

- Fit for purpose government regulations.
- Ownership and Intellectual Property rights.
- Development of standards.
- Ethical and security concerns (e.g. controversy around H5N1 avian influenza research).

Going forward

Steady growth likely to continue, though applications more advanced at the molecular or cellular than the systems level. Advances in use of computer models as well as quick, accurate and cheaper DNA manipulation e.g. CRISPR and sequencing technologies opening up new application, with promise of higher productivity in other sectors.

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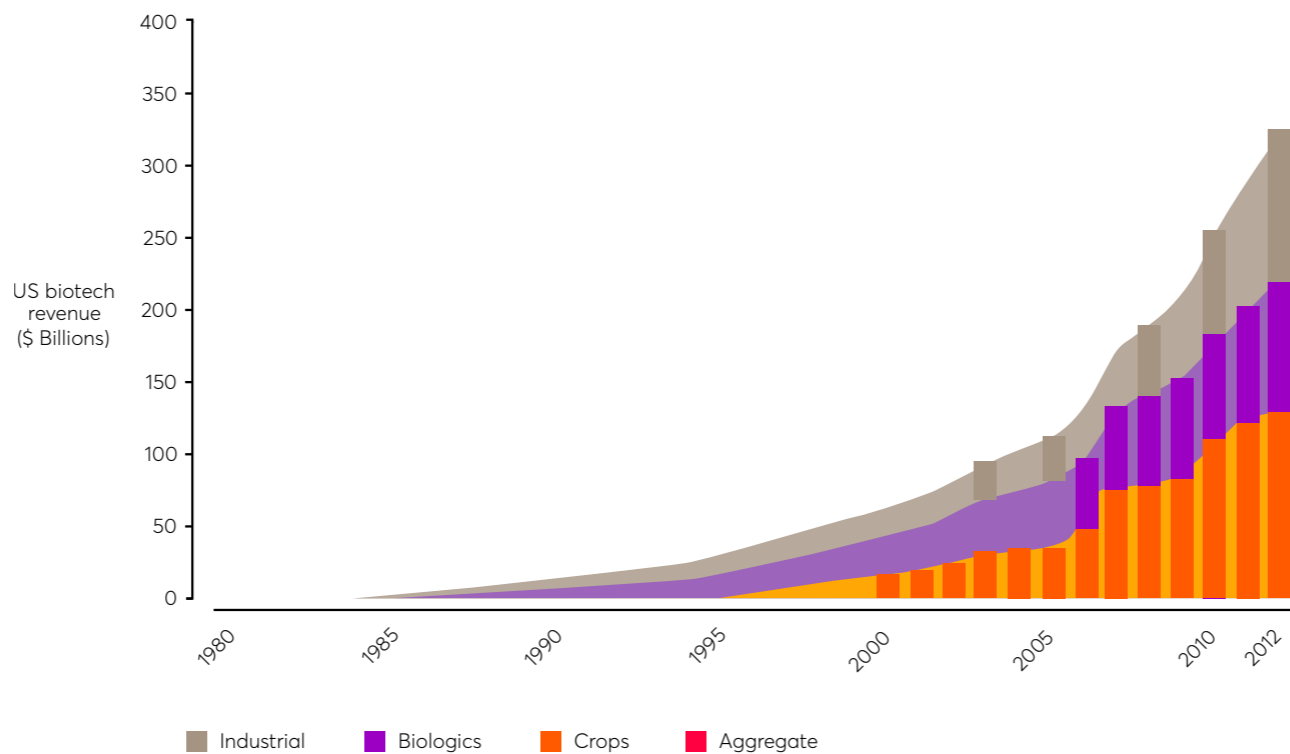
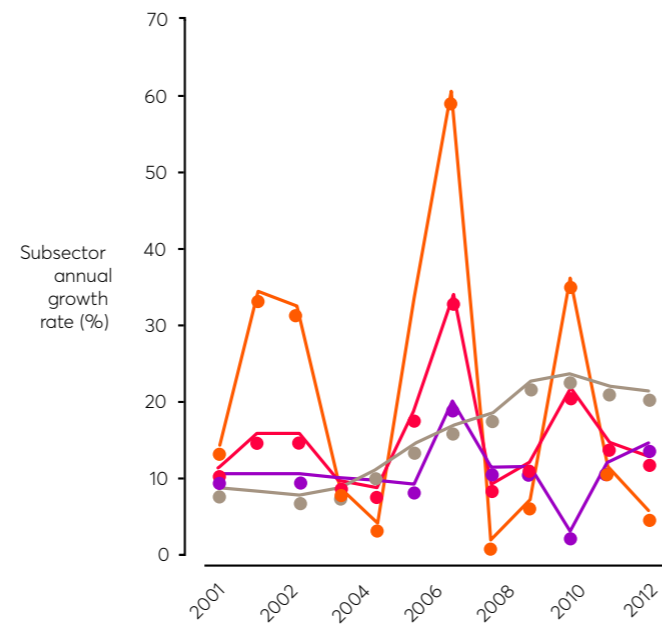
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Estimated total annual US biotech revenues from 1980 to 2012



Source – Carlson (2016)

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Globalisation is an important force shaping labour markets

Extent of globalisation:

- World trade growing twice rate of global GDP.
- Developing countries doubling share of exports to over 40 per cent.
- Global Foreign Direct Investment flows almost back at pre-financial crisis levels.
- Fourfold rise in effective world labour force.

Sizeable impacts on employment

Globalisation and job creation

- Access to more goods and services at lower prices.
- Efficiency savings.
- Increased innovation.

However, benefits not spread equally across population.

Globalisation and job destruction

- Acemoglu et al (2016): job losses from rising Chinese import competition (1999–2011) 985,000 in manufacturing and 2.0–2.4 million in all of US.
- Indirect effects through supply chains and second-round effects via reduced aggregate demand also affect employment opportunities.

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Unwinding trade imbalances

Unwinding of trade imbalances should increase output and employment in tradable sectors in deficit countries

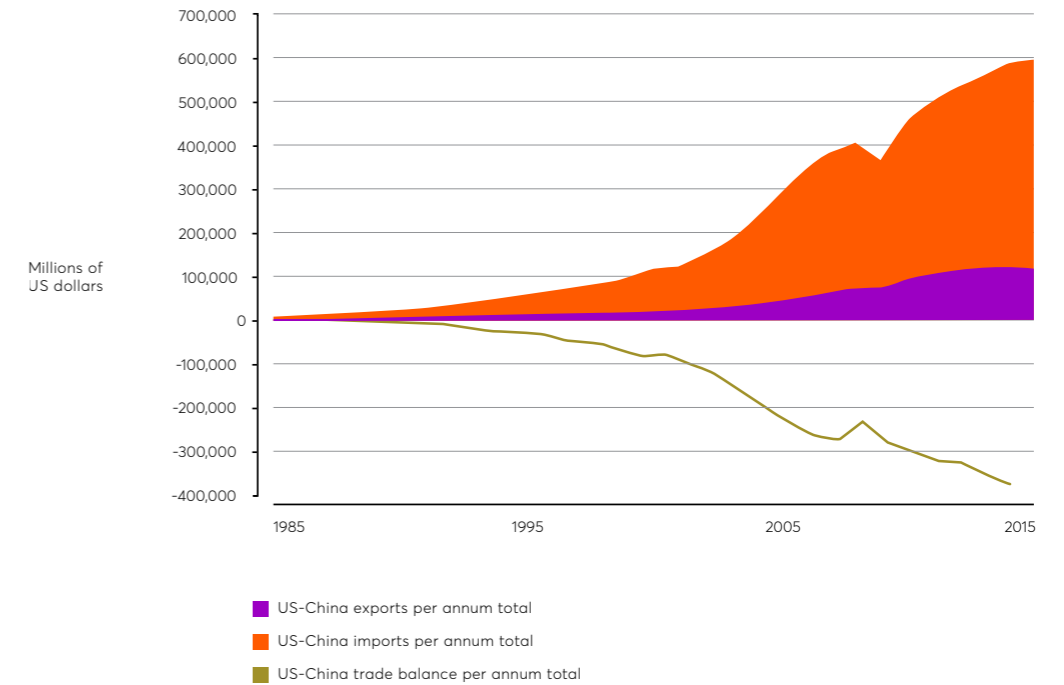
Persistent trade deficit between US and China has reduced employment in US tradable sectors like manufacturing and agriculture.

Rebalancing trade - looking ahead

McKinsey Global Institute (2013) estimates that deficit reduction from 2 per cent to 1.3 per cent of GDP in knowledge-intensive manufacturing alone could:

- Raise US GDP by \$200 billion annually by 2020 (~ 1 per cent of GDP);
- Create 600,000 new jobs (or ~0.4 per cent of workforce)

US trade in goods with China



Source: US Department of Commerce

Unwinding trade imbalances

Capital inflows have benefited US housing and construction

Capital inflows that have financed trade deficit countries have kept interest rates low, supporting sectors like housing and construction (Aizenman and Jinjarak, 2014; Sa et al., 2015).

(See chart on 'Construction employment and capital inflows')

House prices and the current account

Looking ahead, as trade imbalances unwind, other downward pressures on interest rates should protect these sectors from capital outflows.



Source – Sa, Towbin and Wieladek (2011) estimate a cross-country panel vector autoregressive model and identify monetary policy and capital inflows shocks to establish effects on housing

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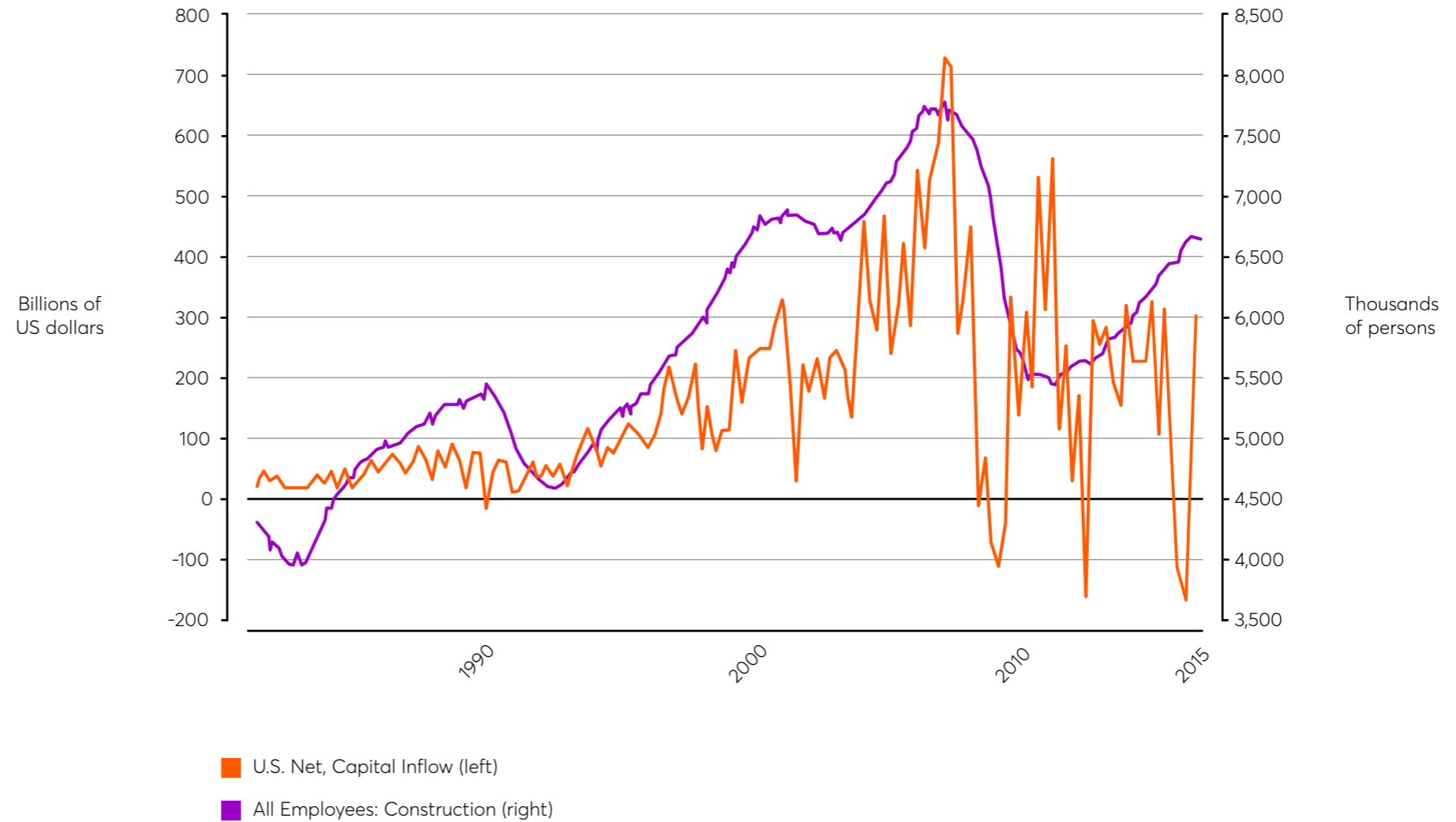
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Construction employment and capital inflows



Source – Federal Reserve Bank of St. Louis

Unwinding trade imbalances

Factors affecting rebalancing of trade

- Nature of real exchange rate movements.
- Fall in precautionary household savings in surplus countries with deepening social safety net.
- Financial development of surplus countries enabling the creation of financial instruments attractive for local savers.
- Improved corporate governance in emerging economies increasing dividends and reducing incentives for firms to retain earnings and save.
- Policy resistance in emerging economies to more flexible exchange rates.
- Rising capital flows with integration of emerging economies into global capital markets.
- Higher saving rates in surplus countries as larger share of population reaches 'prime savings' age.
- Later retirement dates in surplus countries with ageing populations boosting household saving.
- Households in deficit countries continuing to repair balance sheets.

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Peak globalisation?

Rapid expansion of global trade may have run its course

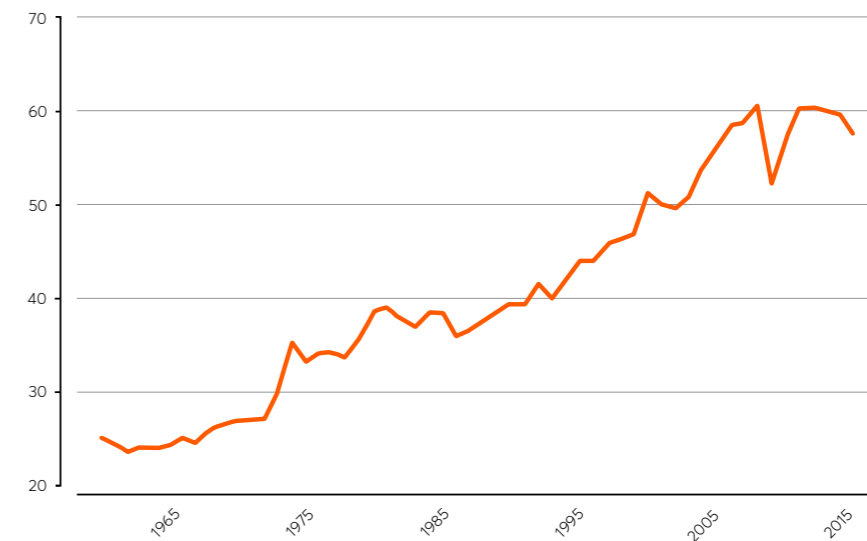
Evidence that trade has become less responsive to global GDP growth - suggesting that trade slowdown is not just a temporary phenomenon reflecting the crisis (Constantinescu, Mattoo and Ruta, 2014).

- Leveling off of offshoring?
- Stabilisation of China's manufacturing share
- Stronger domestic production base in emerging economies
- Weaker (trade-intensive) business fixed investment as percentage of GDP in advanced economies

Going forward

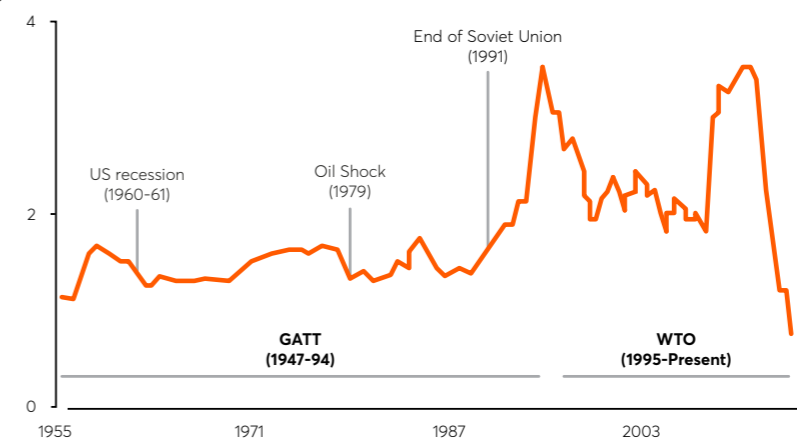
If trade slowdown is structural, impacts of trade on labour market will in future be very different from what they have been in past.

World trade (percentage of GDP)



Source - World Bank (2016)

Four year rolling sensitivity (elasticity) of global real-trade growth to global real-GDP growth



Source - Goldman Sachs (2016)

Peak globalisation?

Protectionist sentiment is rising, but impact on trade minimal so far

Protectionist, anti-immigration, anti-globalisation sentiment all on the rise, in part reaction to perception that globalisation does not benefit all and inability of social insurance policies to keep up with trade shocks.

Evidence that voters respond more to job losses caused by offshoring than to job losses from other causes, such as technological change or domestic competition (Margalit, 2011).

Growing number of restrictions

- Since 2008, new trade restrictions have outnumbered positive trade measures by factor of four (WTO, 2016).
(See chart on 'Number of discriminatory measures implemented November 2008 - May 2016')
- However, to date these measures have affected only 5 per cent of global imports and focus on commodities with clear supply glut such as steel and other metals (WTO, 2016).
- Evidence that threats to raise tariffs can reduce trade even if not followed through (Crowley et al., 2016).

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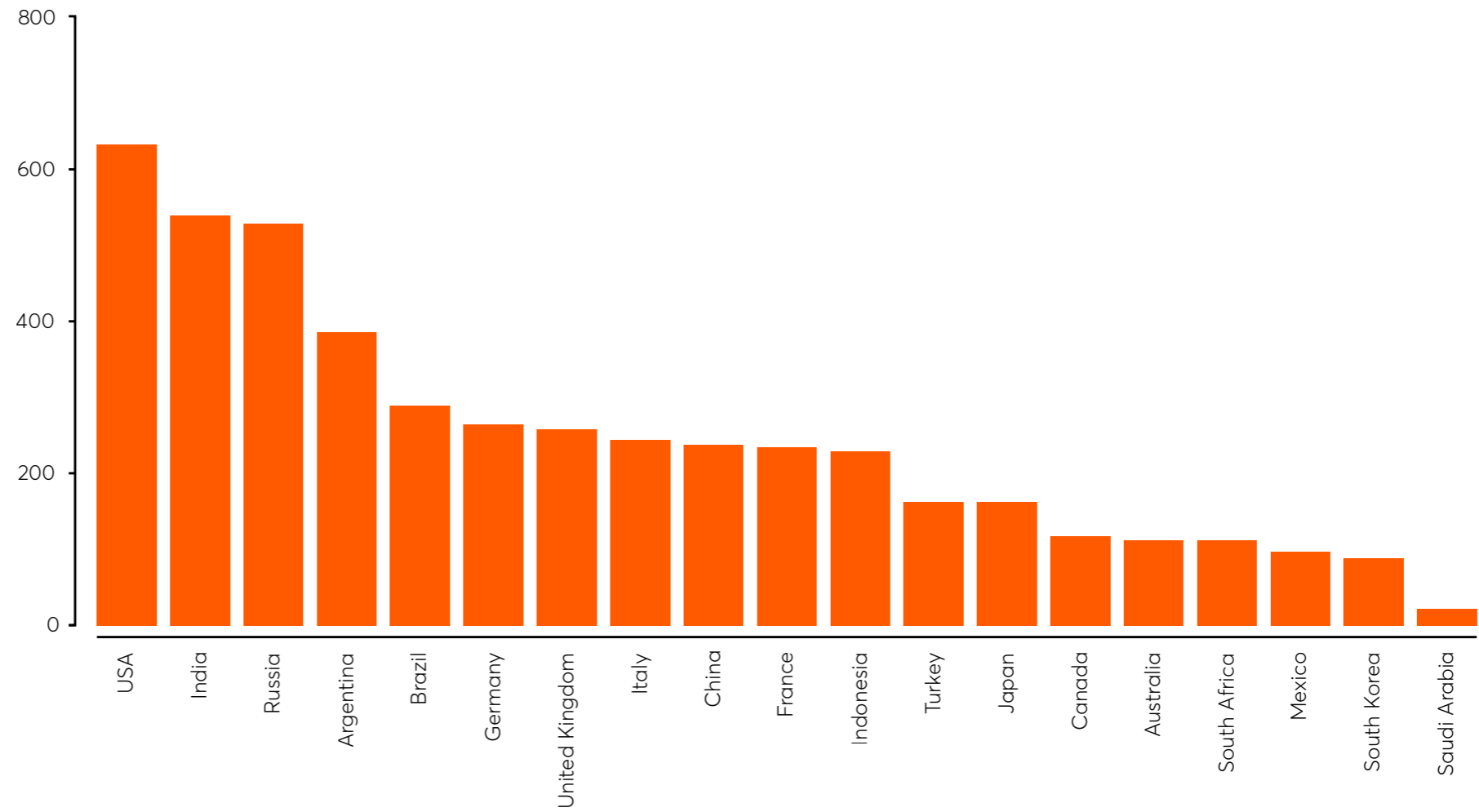
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Number of discriminatory measures implemented November 2008 - May 2016



Source – Global Trade Alert

The importance of place

Barriers to offshoring have limited employment losses in some manufacturing sectors

Limits to offshoring activities:

- Lack of capacity to manage high value-added activities in low-cost locations.
- Learning and coordination benefits from keeping production and R&D together.
- Poor access to raw materials, high transportation costs, and lack of proximity to demand limit tradability.



- Growing demand for customisation.
- Customer awareness and concern about supply chain and inventory risks.
- Emerging markets losing manufacturing cost advantage over developed economies domestic competition (Margalit, 2011).

Regional producers e.g. food, printing and sectors that are R&D-intensive and need close proximity to markets e.g., cars, chemicals have only seen modest decline in employment over last two decades compared with other industries (McKinsey Global Institute, 2012).

Percentage change in emerging and developed market manufacturing cost differential; 2014 vs. 2004

	US	UK	Germany
China	9 per cent	8 per cent	5 per cent
South Korea	5 per cent	4 per cent	1 per cent
Mexico	0 per cent	-1 per cent	-3 per cent
India	0 per cent	-1 per cent	-2 per cent

Source – BCG (2014)

-  = emerging costs higher than developed market
-  = emerging market has closed part of the gap with developed market

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Going forward, could this lead to manufacturing renaissance in advanced economies?

Following recession, US manufacturing (particularly in durables), has gained four times as many jobs as would be expected from cyclical factors alone, supported by falling unit labour costs and depreciating real \$ exchange rate.

Other 'catalysts' could help favour reshoring:

- Progress in extracting natural gas promises cheaper energy and new investment, even if unlikely to be transformative in itself.
- Policy could help boost skills and finance for manufacturing supply chains.
- Digital manufacturing, 3D printing and Internet of Things could all reduce supply chain costs.
(See pages 31, 33)

Evidence to date of manufacturing renaissance limited

But companies likely to add new production capacity at home rather than abroad or relocate previously offshored activities to neighbouring countries e.g. Mexico - 'nearshoring'.

Unlikely to see large number of low-skilled manufacturing jobs, insofar as production simultaneously becomes more digital, intelligent and technology-intensive.

Specific trade opportunities

Trade creates employment opportunities in sectors where advanced economies enjoy comparative advantage

For example, advanced manufacturing and knowledge-intensive services

Small number of products typically dominate country's exports. Globally, country's top export on average accounts for 23 per cent of all exports, with top 3 exports at 46 per cent, though concentration ratios typically decline with country's income (Hanson, 2012).

(See chart on 'Net export of mature economies percentage of GDP')

Top 10 US exports, 2015 (source: ITC)

- 1** Machinery, mechanical appliances, nuclear reactors, boilers; parts thereof (\$205.8 billion).
- 2** Travel (\$178.3 billion).
- 3** Electrical machinery & equipment & parts thereof; sound recorders and reproducers, television (\$170.0 billion).

4 Other business services (\$132.5 billion).

5 Aircraft, spacecraft, & parts thereof (\$131.1 billion).

6 Vehicles other than railway or tramway rolling stock, & parts & accessories thereof (\$127.1 billion).

7 Charges for the use of intellectual property (\$126.2 billion).

8 Mineral fuels, oils, products of their distillation (\$106.1 billion).

9 Financial services (\$86.3 billion).

10 Transport (\$84.2 billion).

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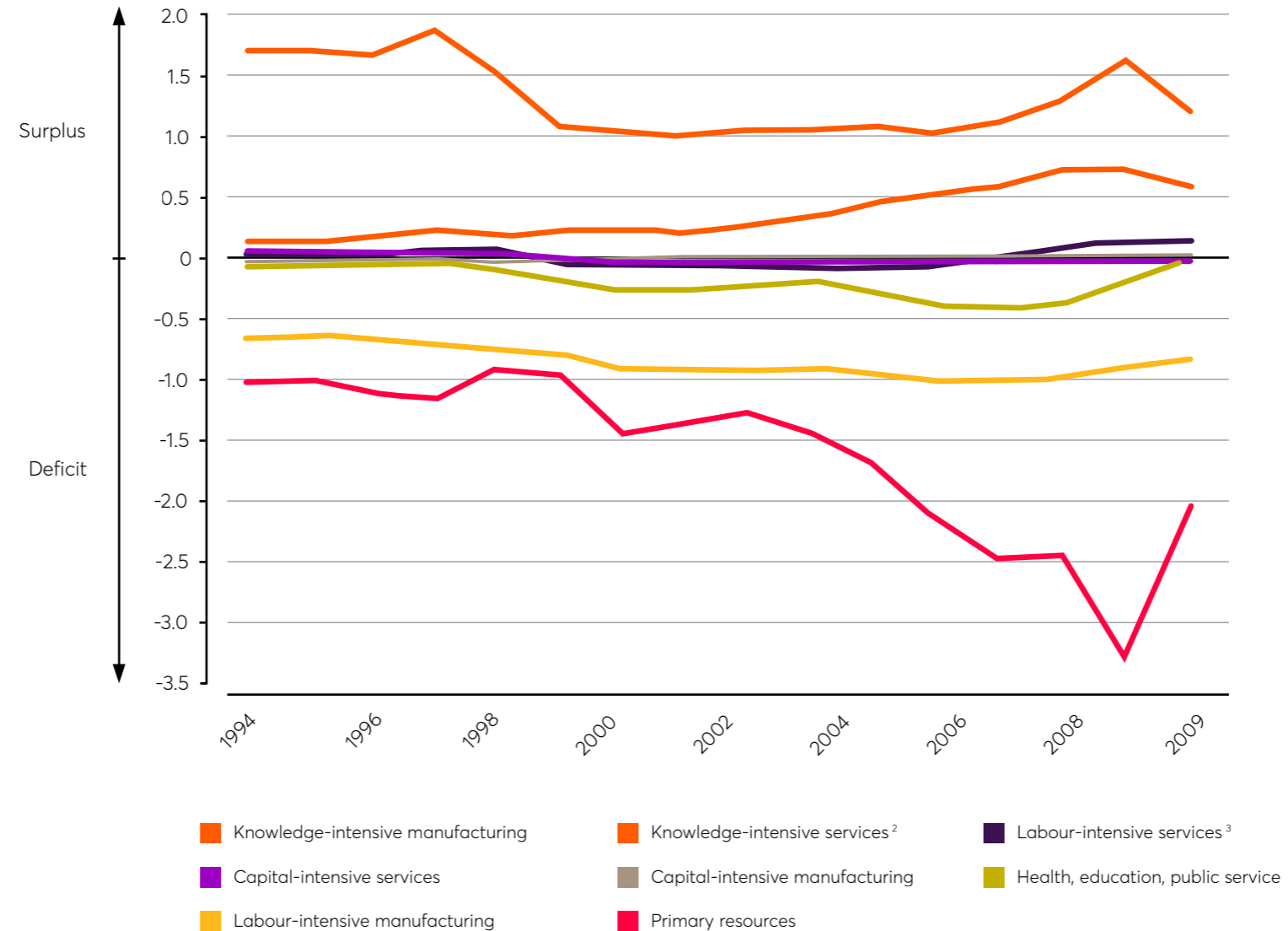
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Net export of mature economies¹, percentage of GDP



Source – OECD; McKinsey Global Institute analysis

1: Mature economies; United States, Japan and EU-15 excluding Luxembourg.

2: Knowledge intensive; Services and businesses heavily reliant on professional knowledge.

3: Labour intensive; Services and businesses reliant on large workforce or large amount of work in relation to output.

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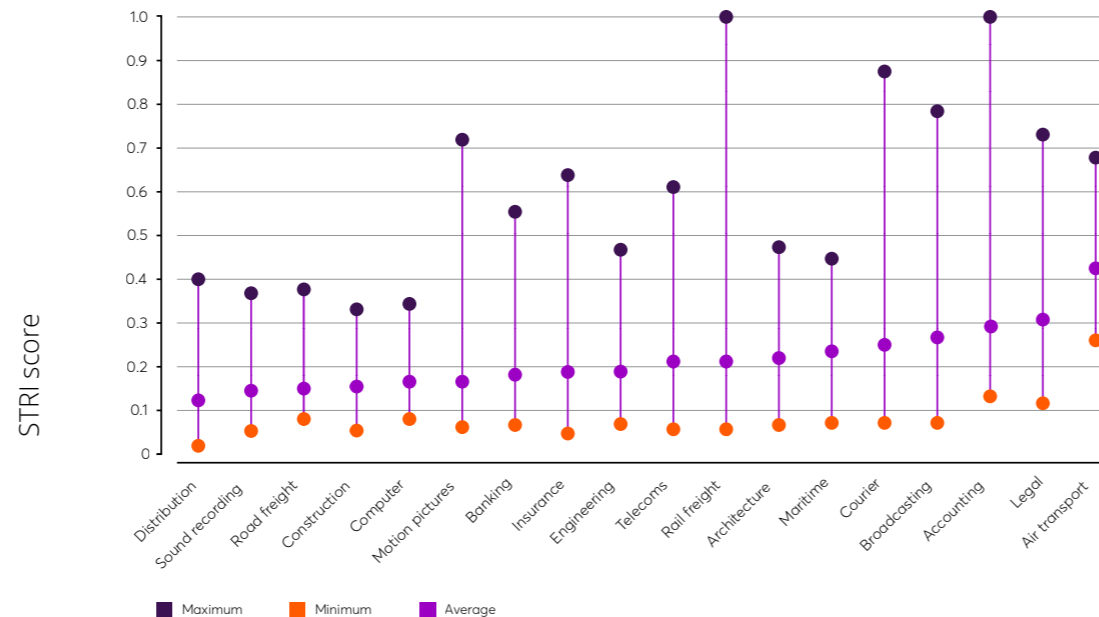
However, there are barriers to growth of global market in services

Services still five times less likely to be exported than manufacturing products (Jensen, 2011).

Non-trade barriers such as licences, quotas, standards and other regulatory constraints prevent efficient provision of services across borders.

Tackling these barriers would deliver substantial benefits, but progress patchy: trade in services virtually neglected in Doha Round and increasing reliance on bilateral and plurilateral efforts.

STRI average, minimum and maximum scores by sector



Source – OECD Services Trade Restrictiveness database (2014).

The indices cover 40 countries.

STRI = Services Trade Restrictiveness Index

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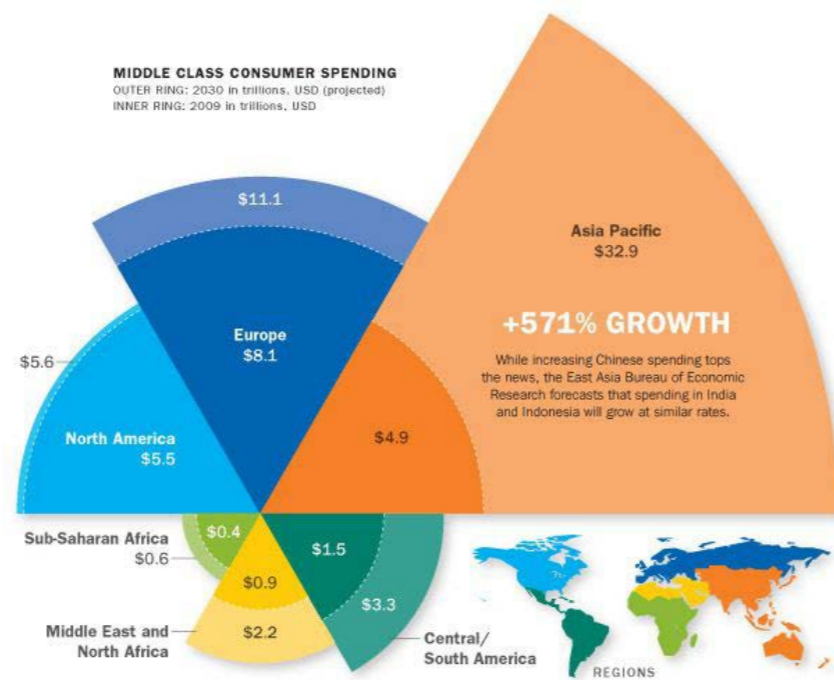
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Growing global middle class

Rise of emerging market middle class globally will lead to growth in spending and consumption

- Emerging market economies have produced three-quarters of global growth in recent years.
- Consumption in Asia Pacific region set to increase seven-fold to 2030 and its share of global consumption swell to 60 per cent.



Source – Kharas (2010) Middle class is households with daily expenditures between USD10 and USD100 per person in purchasing power parity (PPP) terms

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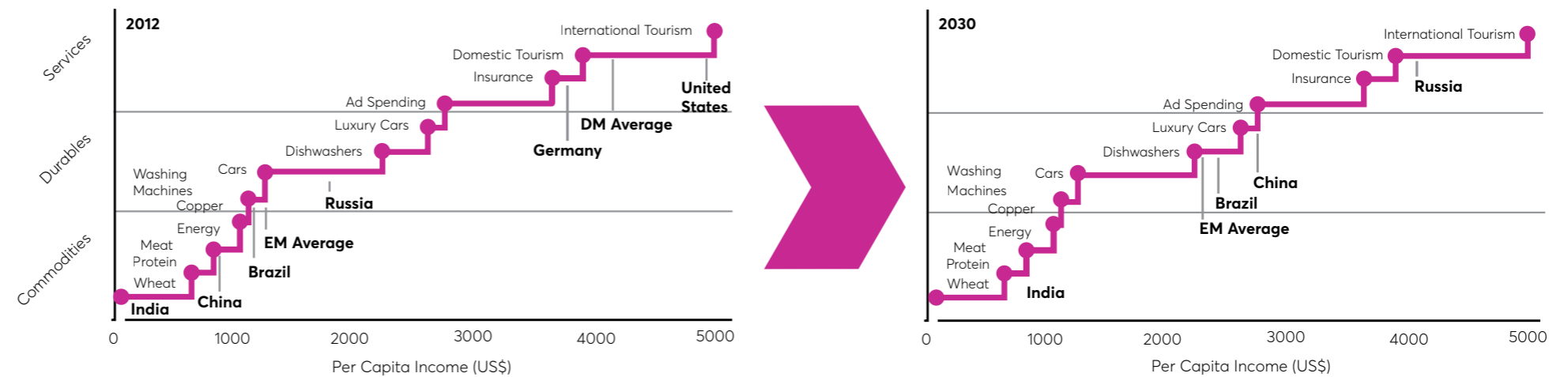
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Growing global middle class

Growth in middle class consumption associated with demand for specific goods and services

Looking ahead, commodity spending may have peaked but global demand for consumer durables, particular high-end durable goods such as dishwashers or luxury cars will increase.

Ladder of spending in 2012 and 2030



The marker for each spending category denotes the 'sweet spot' or income level at which per capita demand is at its maximum (income level associated with peak spending impact)

Source – Goldman Sachs (2013)

Growing global middle class

Emerging markets face hurdles in fulfilling growth expectations

- Growth in emerging economies has slowed since financial crisis.
- Transitioning from resource-driven growth to growth based on innovation and high quality institutions is difficult. Of 101 middle-income economies in 1960, only 13 became high income by 2008 (World Bank, 2012).
- Premature industrialisation - manufacturing's share of output and employment peaking at much earlier per capita GDP levels than advanced economies, shutting off a historically potent engine of growth. Latin American and African countries particularly hard hit (Rodrik, 2015).
- Emerging economies vary greatly in terms of productivity, demographics, debt levels, commodity reliance, trade openness and political stability.
- Forecasts only extrapolating recent performance miss important sources of heterogeneity and tend to be over-optimistic, particularly at longer horizons (Ho and Mauro, 2014).
(See chart on 'Average GDP growth in large emerging economies')

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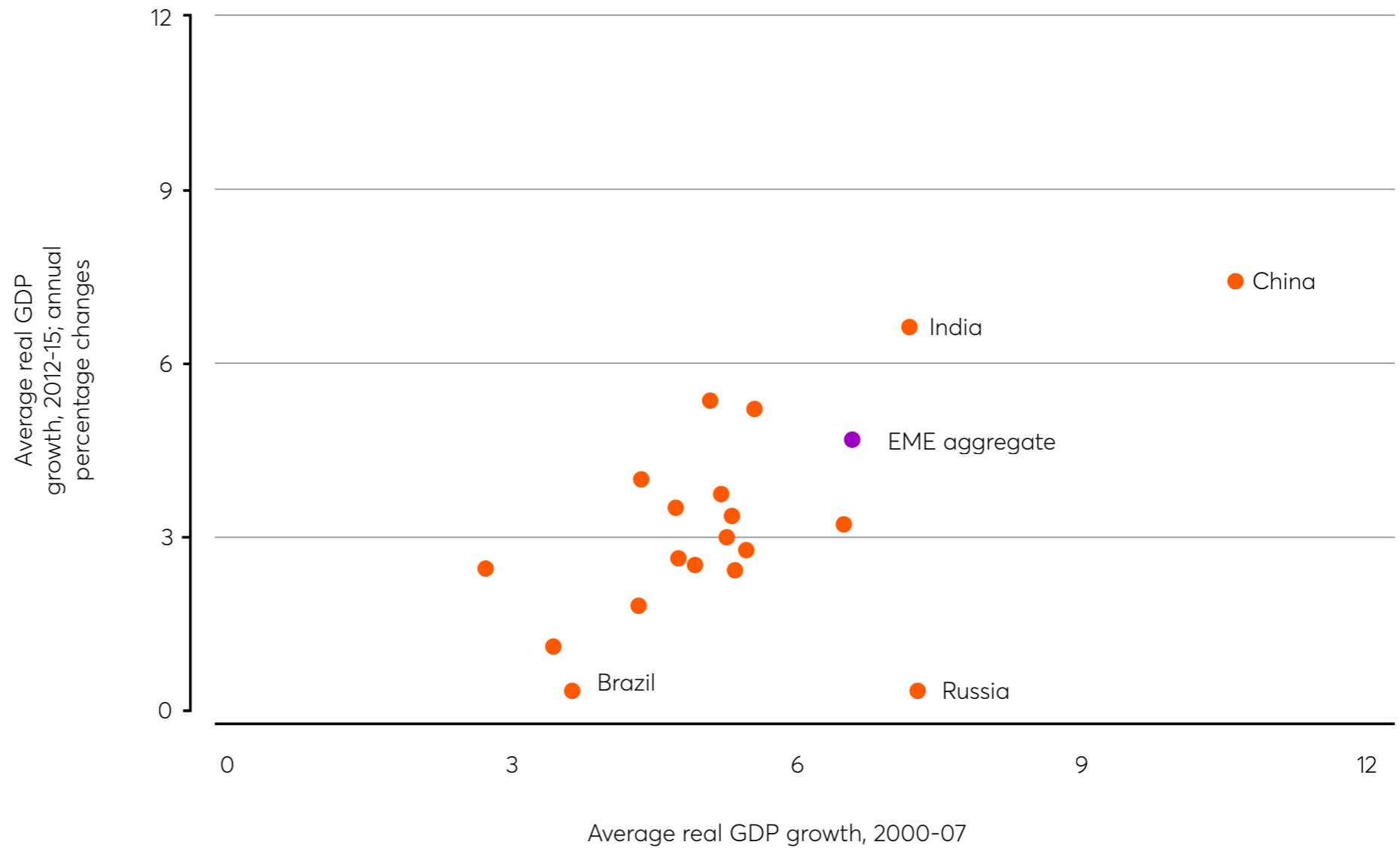
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Average GDP growth in large emerging economies



Source – ECB (2016)

Note: The sample includes Argentina, Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hong Kong, Hungary, India, Indonesia, Malaysia, Mexico, Poland, Russia, Saudi Arabia, Singapore, South Africa, South Korea, Taiwan, Thailand, Turkey and Venezuela.

The EME aggregate is a GDP-weighted average of these countries.

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US in stronger position than many to benefit from growth of emerging markets:

- US exporters expected to look to faster-growing Asian economies for expansion opportunities.
- US exports to China and India expected to grow by 9 per cent p.a. on average in decade to 2030 (HSBC, 2015).
- By 2030, China will have surpassed Mexico as second largest market for US exporters.
- Established export markets such as Canada likely to become less important.

Growing global middle class

Emerging markets face challenges in competing with advanced economies in their traditional areas of export strength

- Despite growth in R&D spending, composition of exports from emerging economies still different from advanced economies and pace of convergence has slowed (Fontagne, Gaulier and Zignago, 2008; Edwards and Lawrence, 2013).
- Even when exports classified in same product category, differences in unit values suggest that emerging market exports are more standardised and thus only imperfect substitutes for advanced economy exports.
- History suggests specialisation patterns will converge when emerging economies approach advanced economy per capita income levels - unlikely for many years yet (Edwards and Lawrence, 2013).
- Emerging economies will also find it harder to move up value chain if they cannot retain their young, educated workforce (Gaulé 2010; Breschi et al., 2015). (See figure on 'Ten largest South-North migration corridors for inventors (net), 2001-2010').

- Rather than head-to-head competition in global markets, most likely change is rise of credible local competitors within emerging markets.

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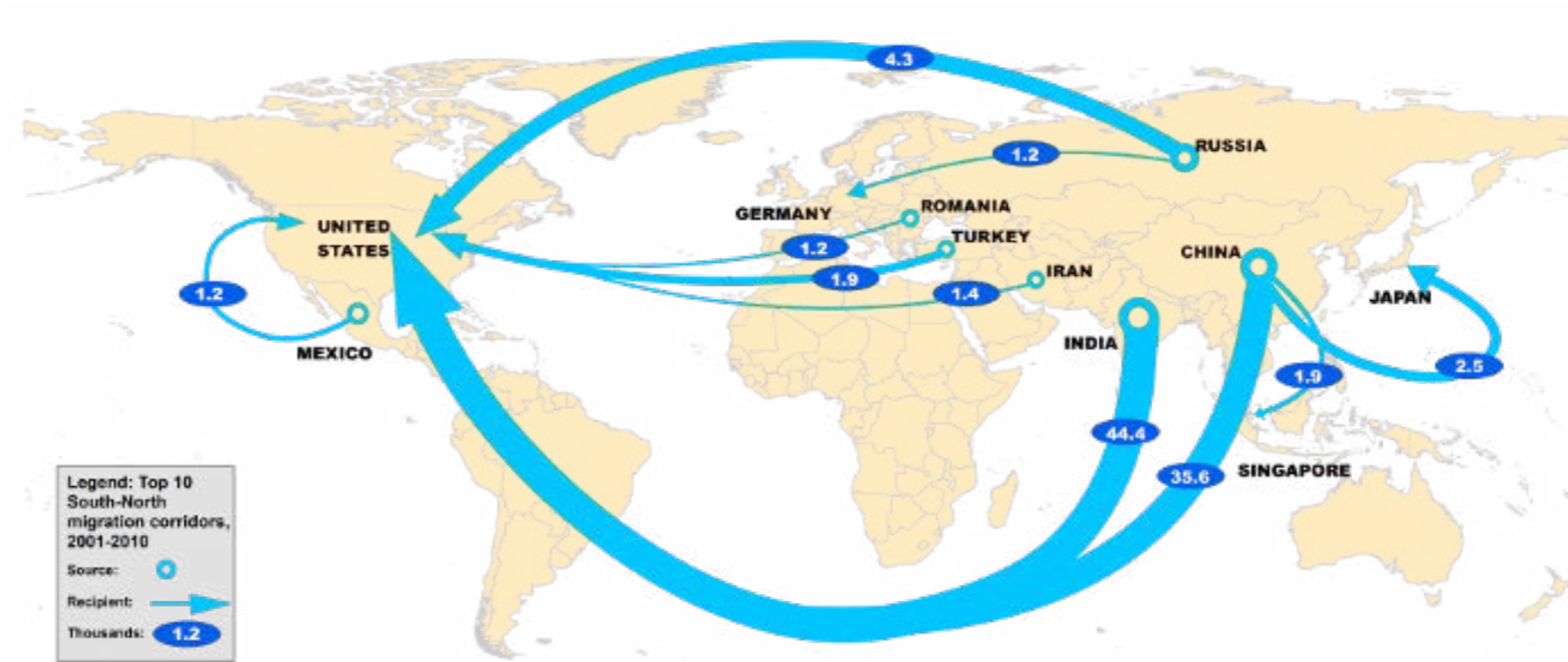
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Ten largest South-North migration corridors for inventors (net), 2001-2010



Source – Miguelez and Fink (2013) map migratory patterns of inventors, extracted from residency and nationality information included in patent applications filed under the Patent Cooperation Treaty. Note UK, France and Germany saw more inventors emigrating than immigrating over this period.

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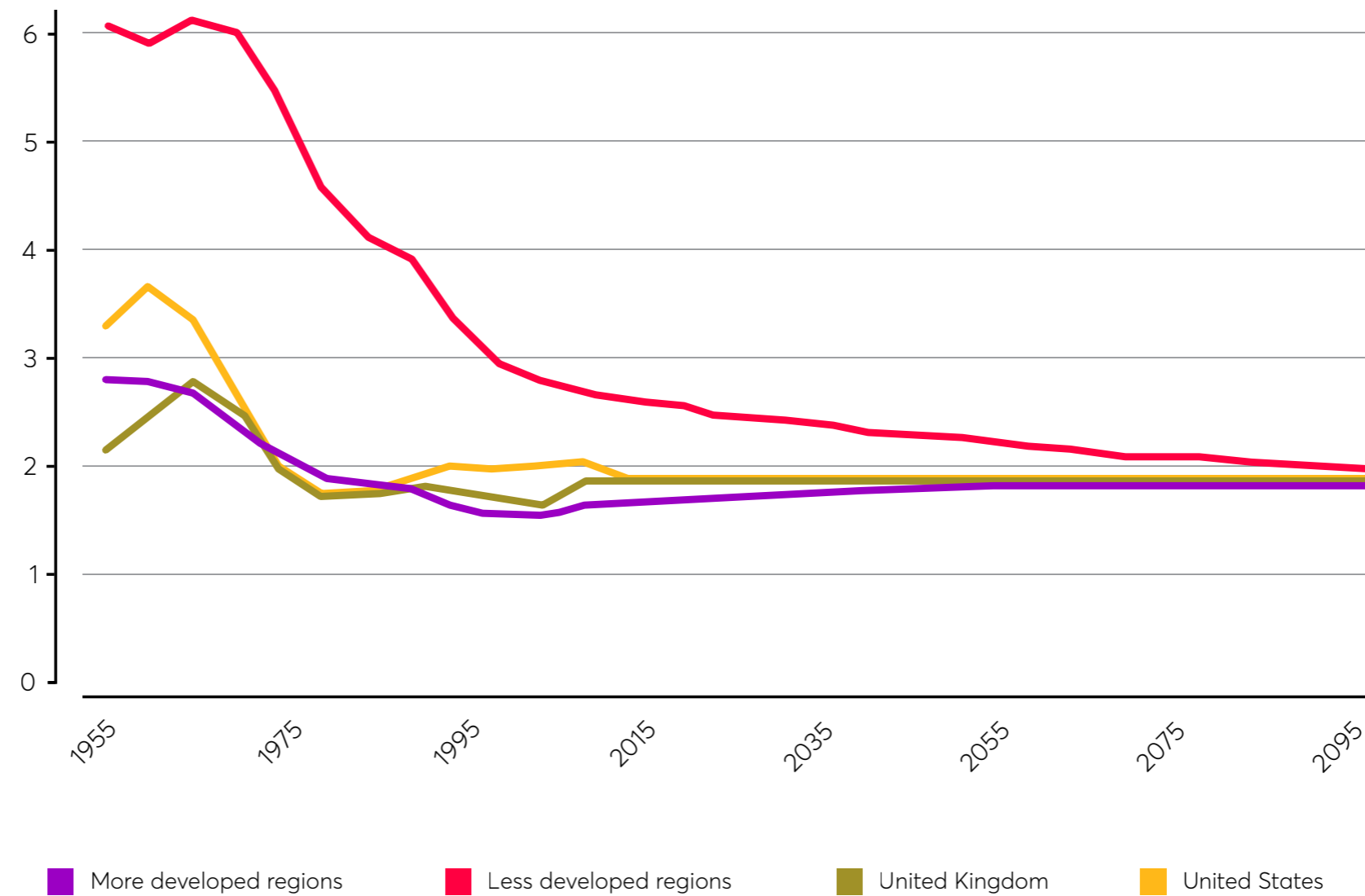
References

Demographic change

Ageing population – Macroeconomic impacts

Slowing population growth, and population ageing due to low fertility rates and increasing life expectancy

Total fertility (children per woman)



Source – United Nations Population Division (2015)

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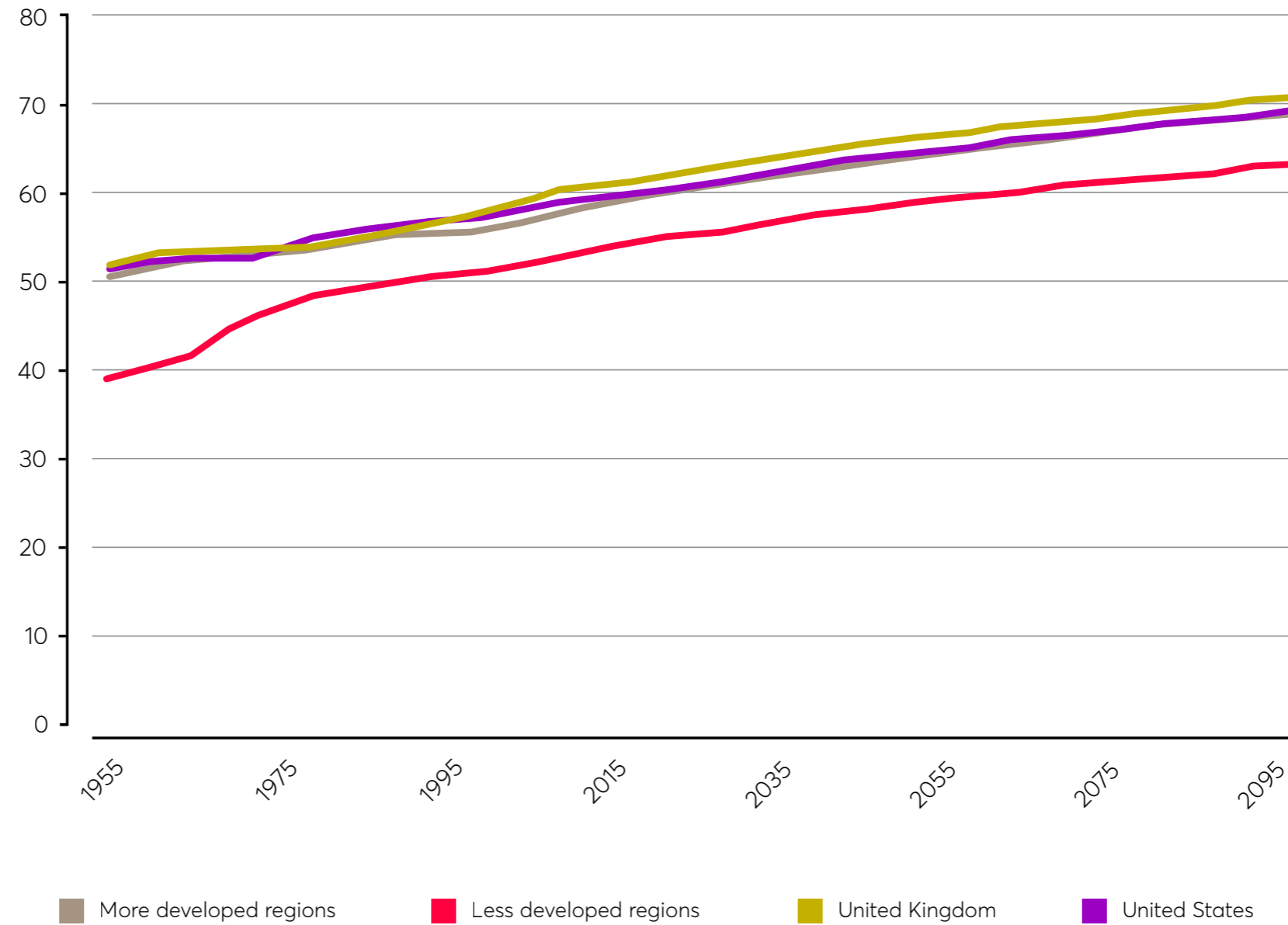
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Longevity (life expectancy at age 20)



Source – United Nations Population Division (2015)

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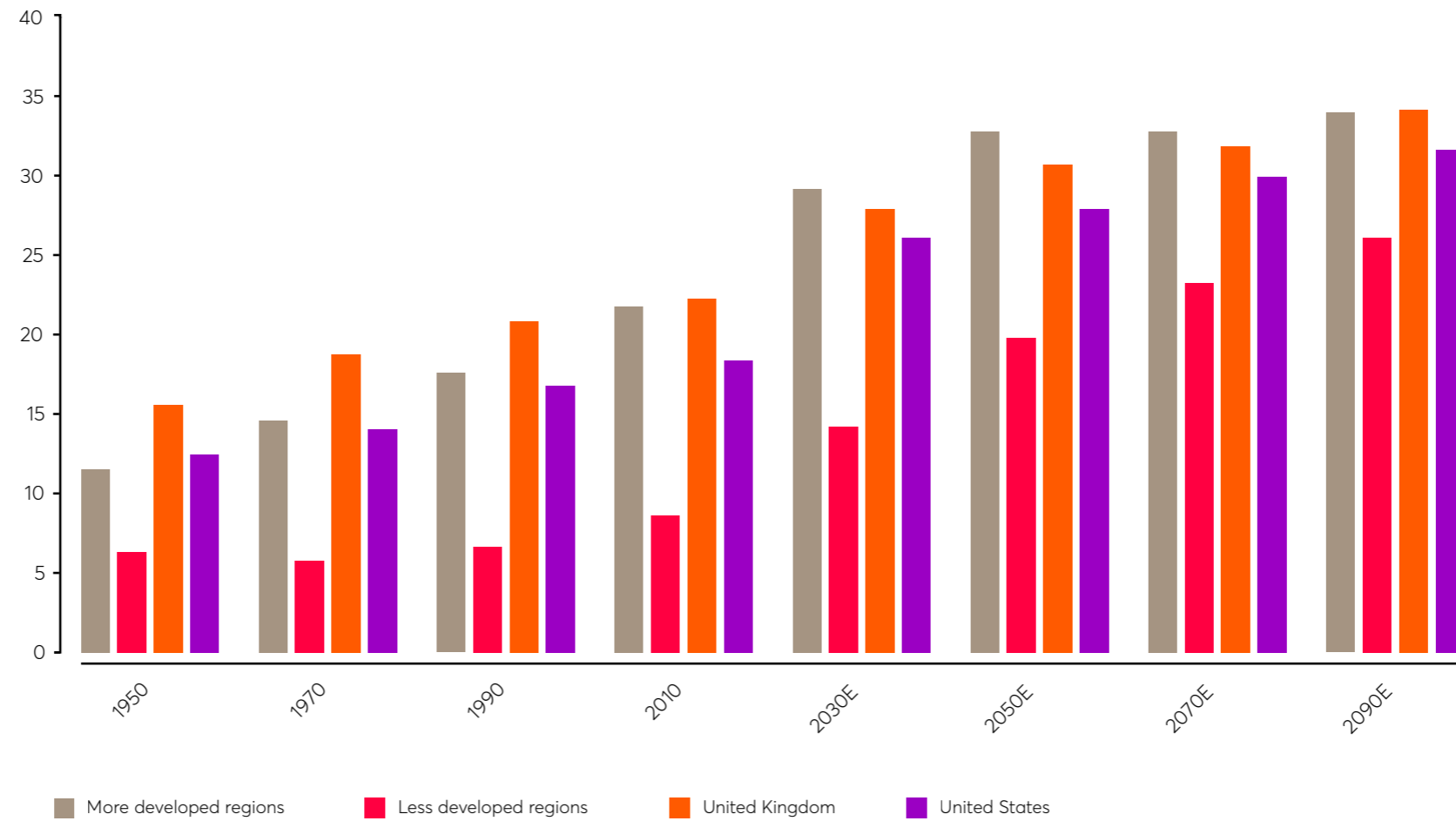
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Proportion of population >60 years old



Source – United Nations Population Division (2015)

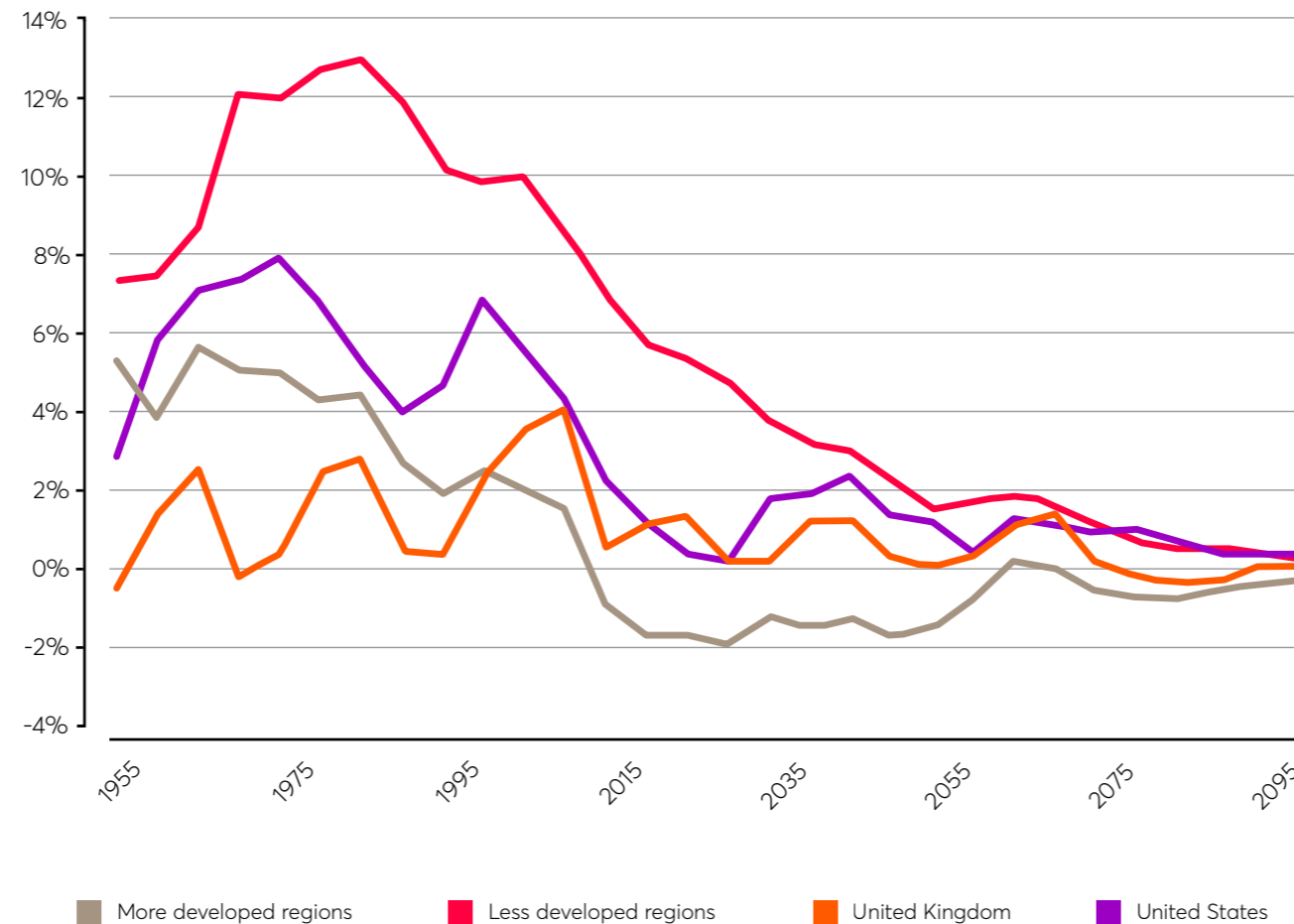
Ageing population – Macroeconomic impacts

Ageing reduces labour force growth: a 'headwind' for economic growth

- Working-age population already contracting in some advanced countries, including Japan, Italy, and Germany, but set to accelerate in many large emerging economies, such as China.

- Increasing dependency ratios mean smaller proportion of population entering productive years, reducing saving and therefore investment.

Working age (15-64) population growth by regions



Source – United Nations Population Division (2015)

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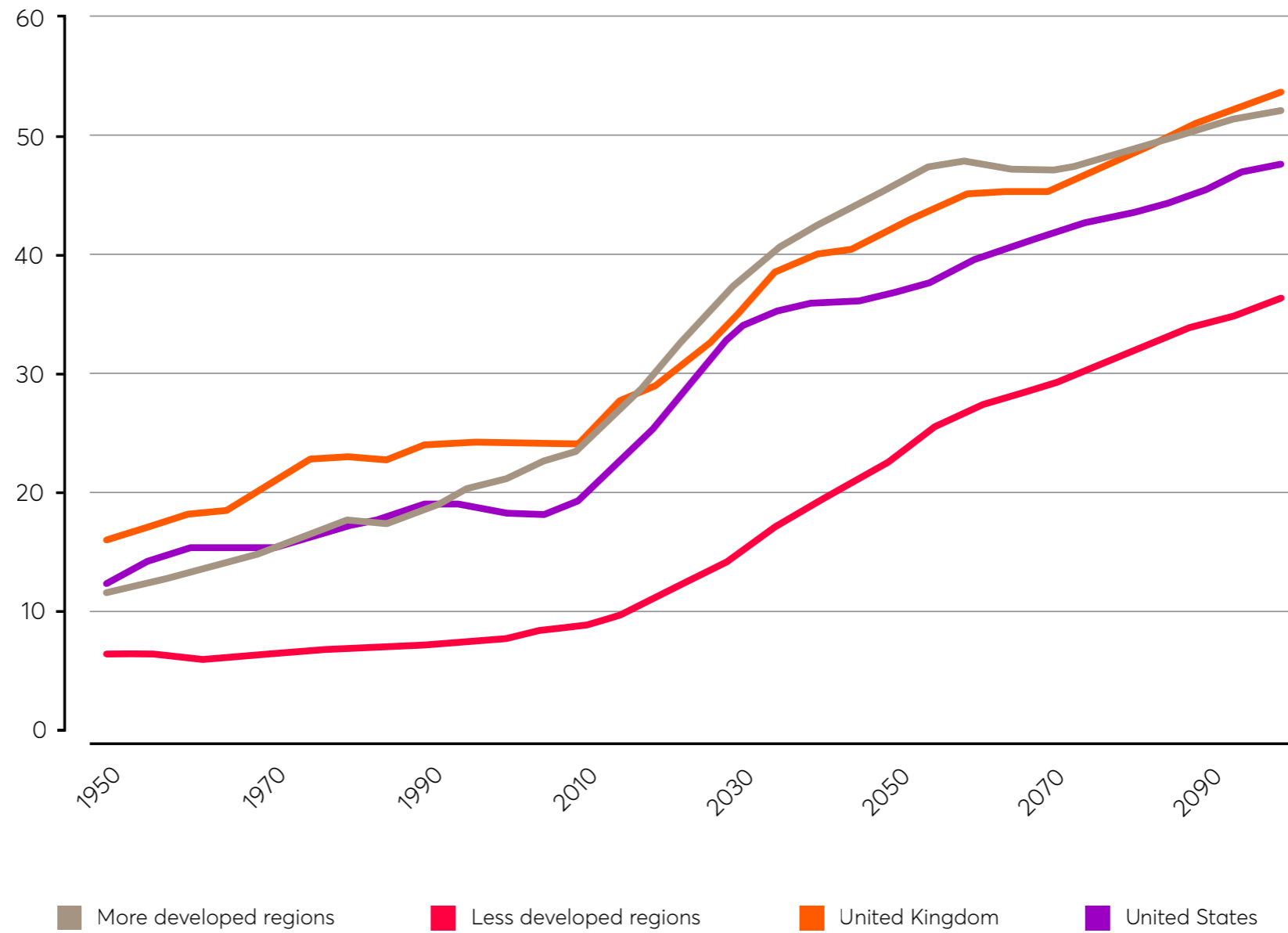
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Dependency ratios across regions (ratio of population aged 65+ per 100 population 15-64)



Source – United Nations Population Division (2015)

Ageing population – Macroeconomic impacts

Weaker labour force growth means that without faster labour productivity growth, GDP growth is slower.

Looking ahead, McKinsey (2015) predicts global GDP growth will be 40 per cent lower over next 50 years, because of population ageing:

- Productivity would need to grow 80 per cent faster over next 50 years than historical average to negate effect.
- However, older people slower at adopting new technologies so productivity growth may also be lower.

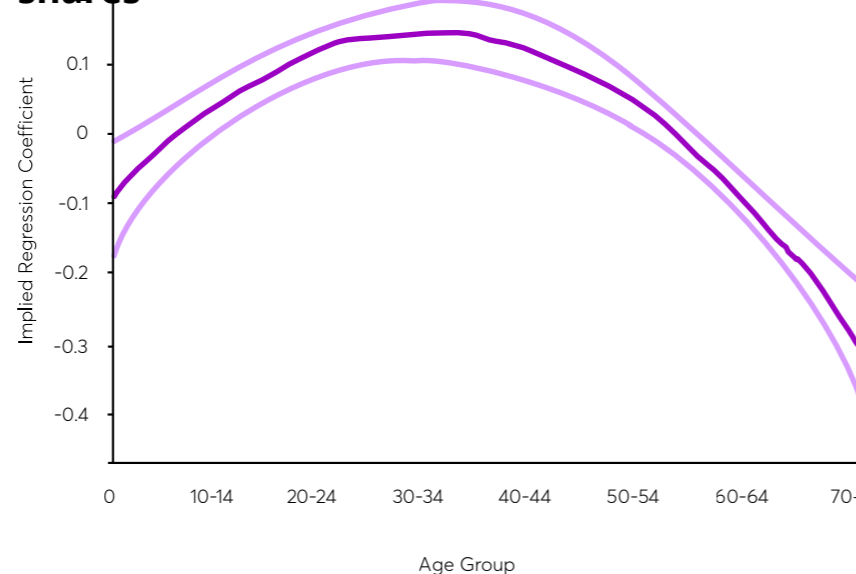
Arnott and Chaves (2012) show that larger populations of retirees (65+) erode economic growth.

From a purely supply perspective, automation may be less a threat than a solution as it compensates for a shrinking workforce.

Accordingly, it is found that countries undergoing more rapid population ageing adopt more robots (Abeliansky and Prettner, 2017; Acemoglu and Restrepo, 2017).

This does not address risk of lower household demand (robots do not buy things), adding to the question ‘who owns the robots’ and the pathways to widened ownership e.g. employee stock ownership plans (Freeman, 2016).

GDP growth and demographic shares



Source – Arnott and Chaves (2012)

Ageing population – Macroeconomic impacts

Policymakers can take steps to mitigate economic risks from demographic change

- Increase incentives and remove barriers to older people staying in workforce.
- Further raise female participation e.g. affordable childcare - participation rate of women at all education levels declining since 1990s.
- Interventions to assist prime age men - Italy only other OECD country with lower labour participation rate of prime age men.
- Strengthen lifelong learning and flexible work opportunities.
- Immigration (Krueger, 2016).

But political obstacles:

- Older people consider public pensions and healthcare higher priority than public education. Particular risk for countries with high youth unemployment (US=11.6 per cent; OECD=13.9 per cent). (See chart on 'First or second priority for extra government spending: Western Europe')
- Voter participation increases with age up to 60, further skewing political incentives.
- Ageism in workplace.
- Backlash against immigration.

Silver lining

Need to replace retiring workers will support jobs even in occupations where demand will otherwise fall.

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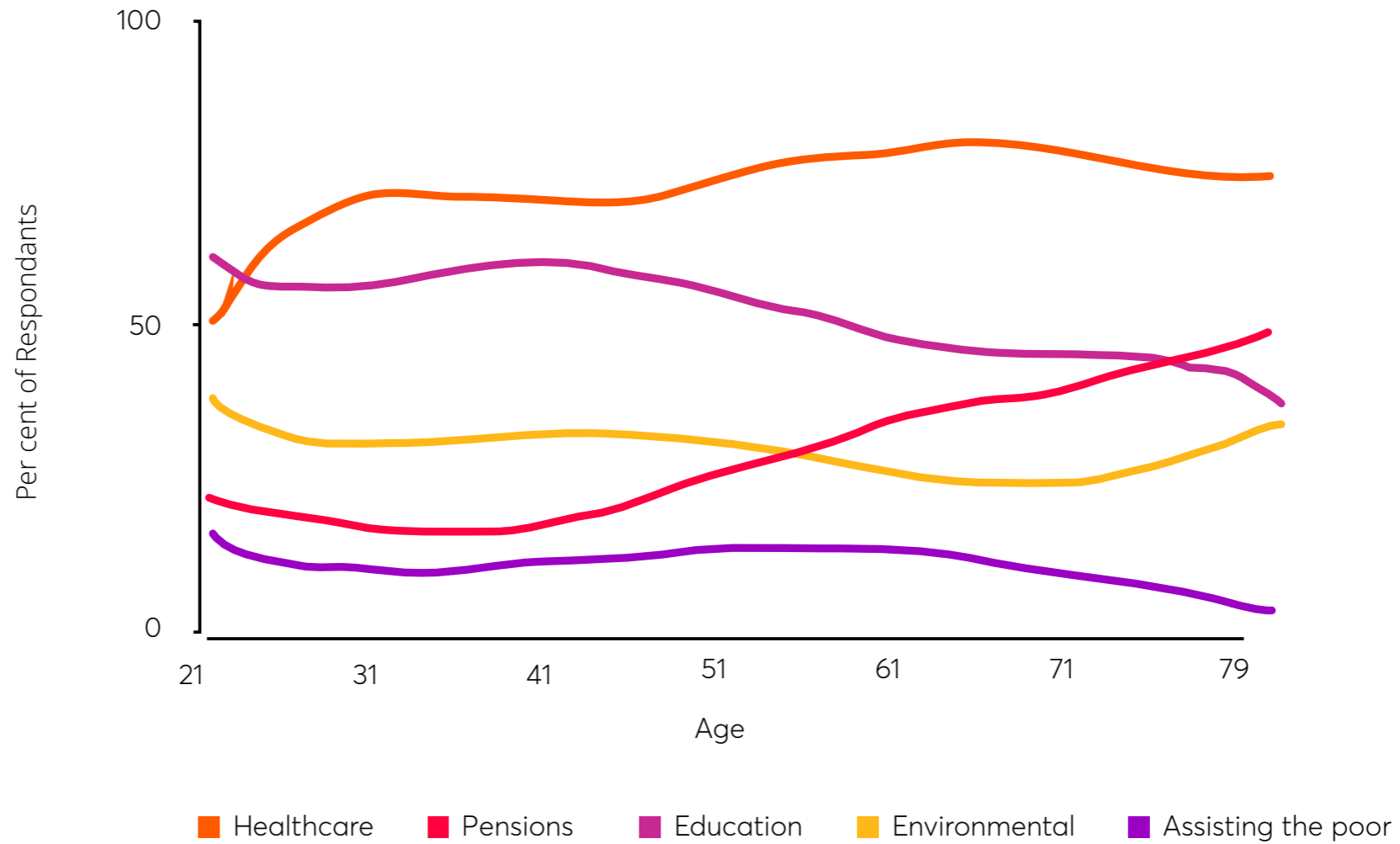
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References

First or second priority for extra government spending; Western Europe



Source – De Mello, Schotte, Tiongson and Winkler (2016)
using Life Transition Survey 2010

Ageing population – Macroeconomic impacts

Pressure on public finances, intensifying need for reforms

Age-related spending like pensions, healthcare, long-term care and education projected to rise by 3.4 per cent of GDP 2015-2050 in advanced economies, though with country variation (UK=2 per cent of GDP) (Standard & Poor's, 2016).

Without policy action, S&P estimates net general government debt will rise to ~135 per cent of GDP by 2050 in these countries (UK=~175 of GDP per cent).

US will need both to consolidate budgetary position and make changes to welfare and publicly-funded healthcare system.

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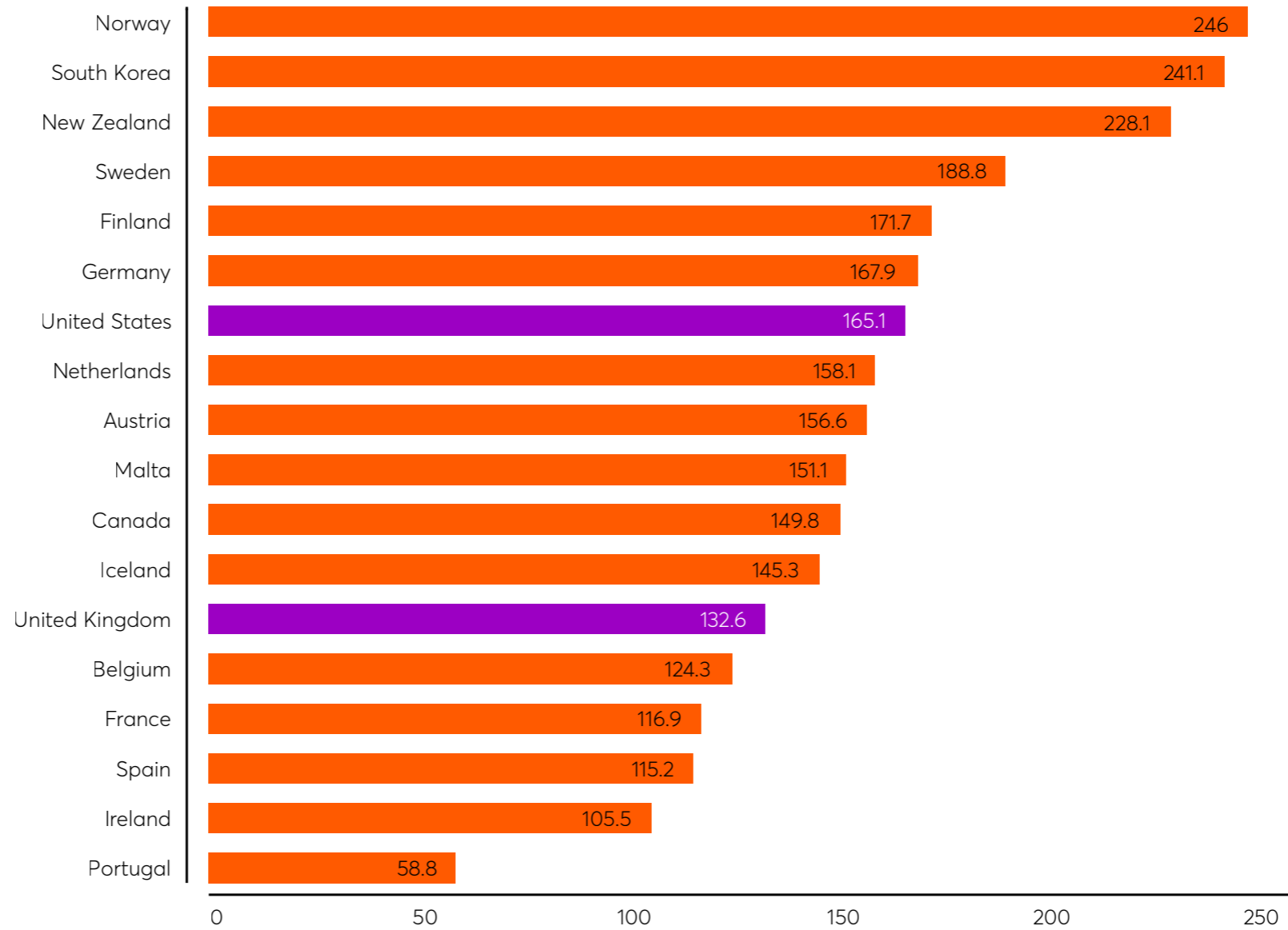
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Fiscal space: distance to country-specific limits on debt (debt/GDP ratio, ppts)



Source – IMF (2015)

This figure highlights wide estimates in room for manoeuvre between current debt ratios and public debt limits; however, with already high debt levels there may be more limited scope for policy to support growth and employment than in the past.

Ageing population – Sector impacts

How ageing population spends disposable income has implications for sectors and occupations

- 50+ generation has substantial economic sway in terms of wealth and income e.g. in US, it controls almost 80 per cent of aggregate net worth while 60 per cent of those earning \$200,000+ p.a. are baby boomers.
- So, ongoing shift in consumption shares towards this group:
 - Now makes up majority of consumption spending in US, Japan and Germany.
 - UK an exception: consumption expenditure share for 50+ group only 42.8 per cent, but growing.

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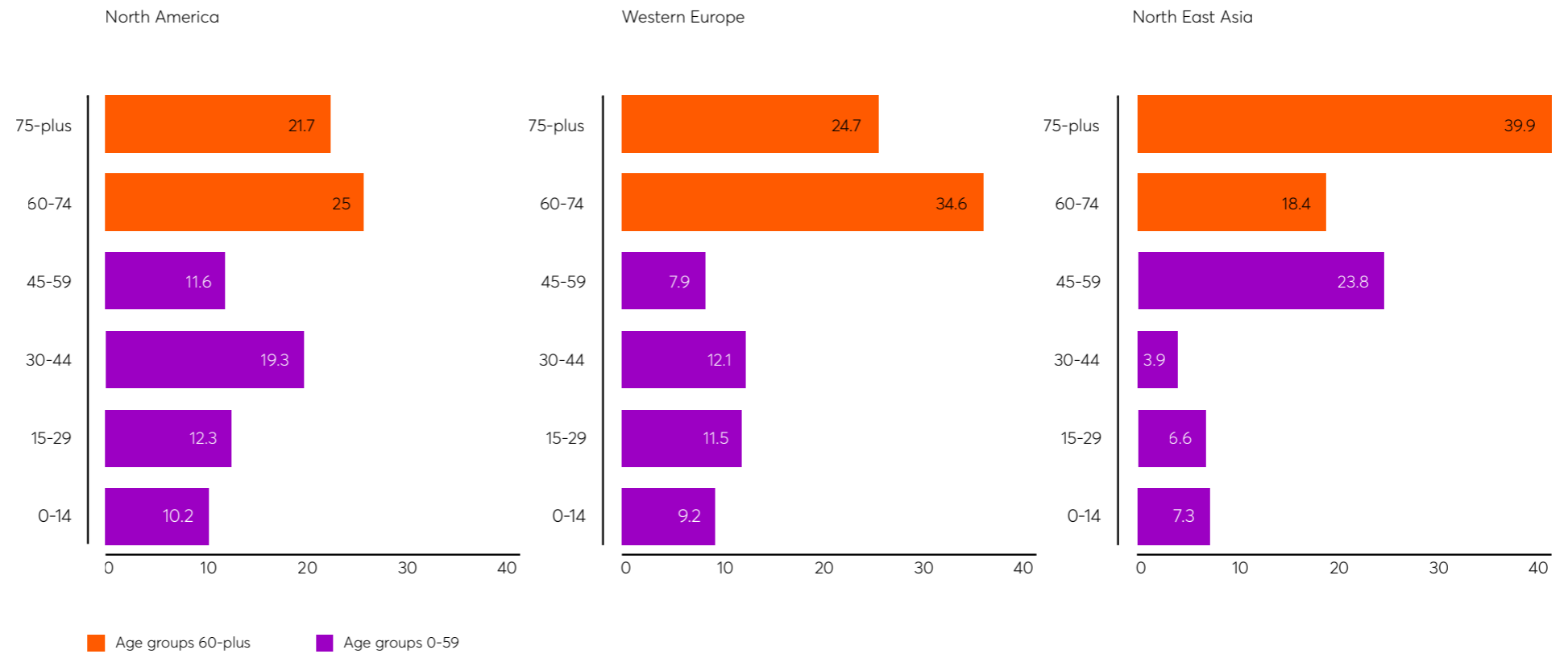
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2015-30 projected consumption growth (percentage)



Source – McKinsey Global Institute (2016)

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Changing age-specific consumption expenditure shares: 2005-2013

	Japan		USA		Germany		UK	
	2005	2013	2005	2013	2005	2013	2005	2013
Under 20	0.5 per cent	0.4 per cent	0.2 per cent	0.2 per cent	0.3 per cent	0.3 per cent	0.2 per cent	0.2 per cent
20-29	8.1 per cent	6.3 per cent	9.2 per cent	8.7 per cent	10.9 per cent	9.9 per cent	9.4 per cent	11.0 per cent
30-39	16.6 per cent	14.8 per cent	19.1 per cent	17.3 per cent	15.3 per cent	11.5 per cent	24.4 per cent	20.7 per cent
40-49	18.4 per cent	20.1 per cent	23.6 per cent	19.7 per cent	19.8 per cent	18.7 per cent	24.6 per cent	25.3 per cent
50-59	22.9 per cent	18.1 per cent	20.5 per cent	21.7 per cent	19.9 per cent	23.4 per cent	20.3 per cent	19.7 per cent
60+	33.5 per cent	40.3 per cent	27.4 per cent	32.5 per cent	33.9 per cent	36.2 per cent	21.1 per cent	23.1 per cent

Source – Credit Suisse (2015)

Ageing population – Sector impacts

That people live for longer and more healthily has implications for industries traditionally targeted at younger consumers

Living for longer increasingly defined as being younger for longer, not older for longer. Three-stage view of life - education, career and retirement - giving way to something more fluid. As more people from different age groups pursue similar life stages, greater potential for cross-generational understanding? (Gratton and Scott, 2016)

Also viewed as a time when people pursue creative interests and grow emotionally

e.g. spending by 50+ Americans on food and clothing fell 11 per cent and 35 per cent from 1990-2010, while that on recreation and education rose by 23 per cent and 90 per cent respectively.

Consistent with evidence that relationship between wellbeing and age is U-shaped: high in youth, falling in midlife, and rising again in old age. Socio-economic drivers, though evidence that relationship is rooted in biology: similar pattern exists in great apes (Weiss et al., 2012).

Time spent on leisure and sports each day in US expected to increase by 210 million hours by 2030, with 65-plus age group accounting for 195 million hours (MGI, 2016). Beneficiaries include not only occasional, higher cost activities e.g travel but also affordable and habitual activities e.g. video and music streaming subscriptions. Leisure time also used to invest in skills, health and relationships.

Ageing population – Sector impacts

Elderly are the largest consumers of healthcare; expanding costs means healthcare sector ripe for innovation

- Ageing has outsized impact on healthcare spending: in US, average spending for 65+ 2.6 times national average.
 - Health problems such as neurodegenerative disorders do not sharply curtail patient lifespans and likely to remain labour-intensive.
 - US spends more on healthcare than other high-income countries (16.4% of GDP vs. OECD average of 8.9% in 2013); yet has considerable unmet health needs; half of Americans with below-average income forewent doctor visits/ treatments in 2013.
 - Science-based and organisational innovation e.g. better utilisation of patient data has potential to boost productivity. However, history suggests innovation also expands scope of healthcare: what can be done, in what way and to whom?
- Cost-containment may prompt move away from inpatient and outpatient care (currently ~two-thirds of healthcare spending in OECD) to home health and skilled nursing facilities while calls to restrain drug costs and pricing may also grow louder.
 - US employer-based health insurance system, an accident of history and unique in the industrialized world, is ripe for reform; however, change is contentious and complex, even dividing major parties (Blumenthal and Monroe, 2016; Oberlander, 2017).

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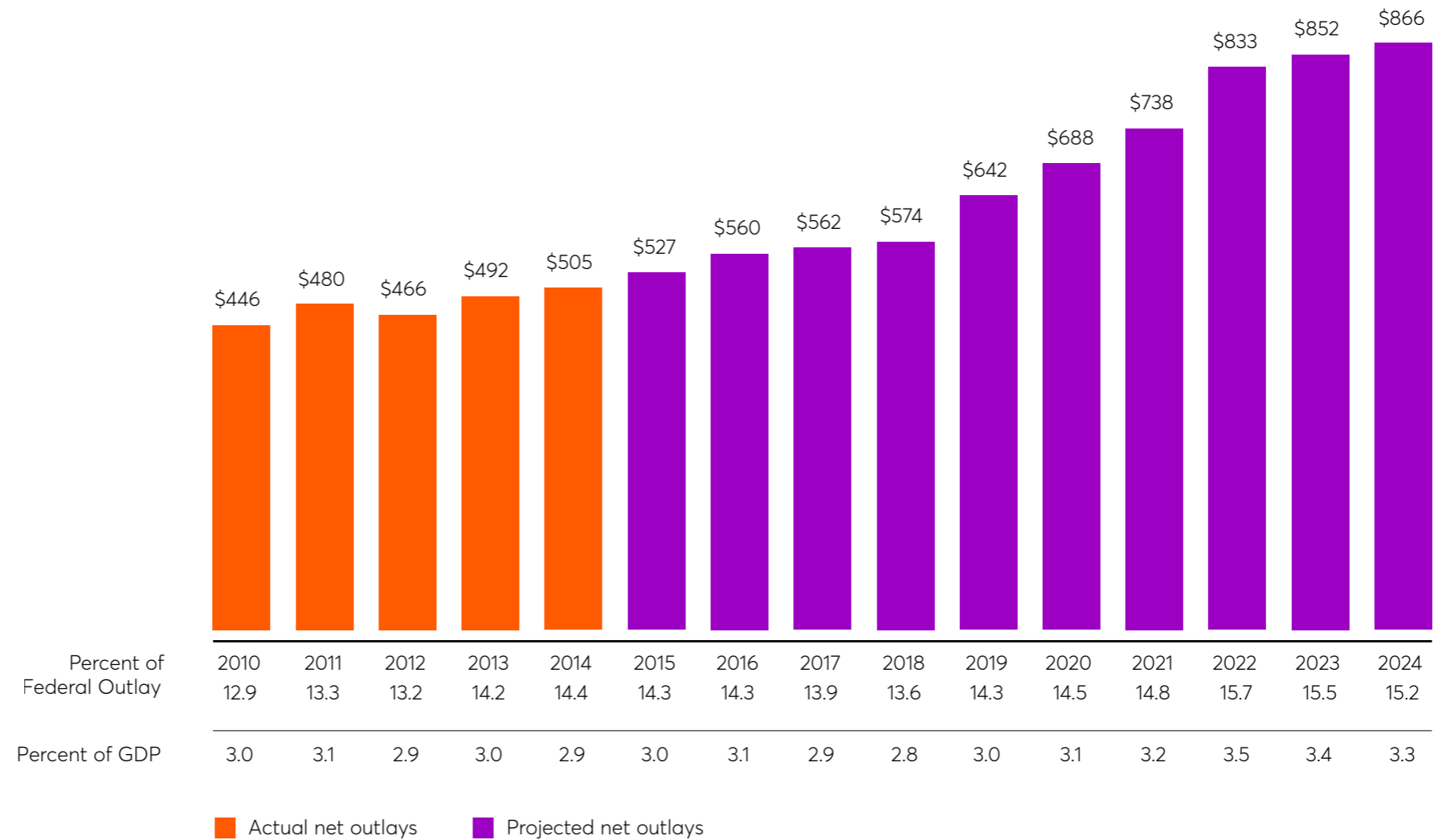
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Actual and projected net medicare spending, 2010-2024



Source – Congressional Budget Office, Updated Budget Projections: 2015 to 2025 (March 2015); The 2015 Long-Term Budget Outlook (June 2015), The Henry J. Kaiser Family Foundation

Ageing population – Sector impacts

Growing preference among older people to 'age in place' has implications for housing-related sectors

- Current housing stock does not support households in ageing comfortably and safely in place e.g. in parts of US, 4/10 older households with accessibility needs will have demand unmet by new construction (Harvard Joint Center for Housing Studies, 2015).
 - Older homeowners already account for nearly half of total home improvement spending today, compared with historical share of 30 per cent.
 - May give rise to important market in retrofitting and remodelling of housing stock: from 'Do it Yourself' to hire someone to 'Do It For Me'.
 - 'Ageing in place' may also be associated with shift in demand from rental to owner-occupied housing at aggregate level, as elderly substitute owner occupation for renting, which will in turn have implications for sectors like construction, legal and financial services.
- May also raise demand for long-term care which currently accounts for 2 per cent of employment in OECD. In Japan, number of long-term workers more than doubled since 2001 following introduction of long-term care insurance programme.
 - Current housing stock does not support households in ageing comfortably and safely in place e.g. in parts of US, 4/10 older households with accessibility needs will have demand unmet by new construction (Harvard Joint Center for Housing Studies, 2015).

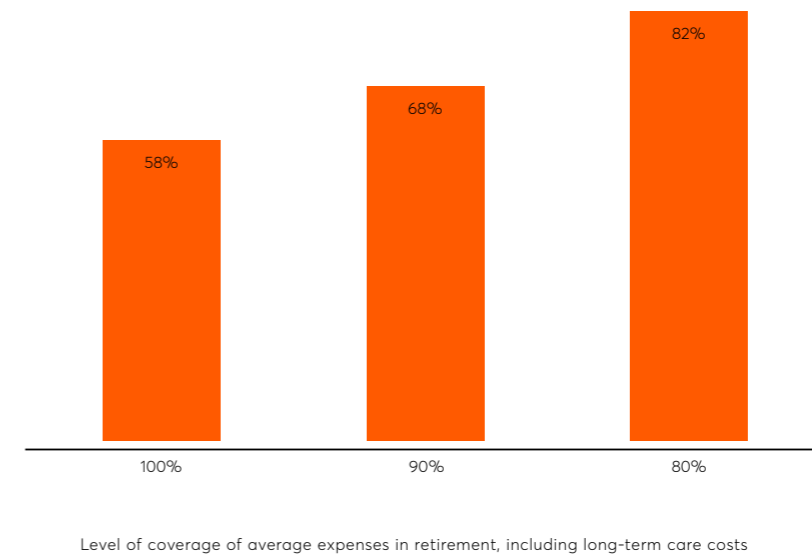
Ageing population – Sector impacts

Population ageing creates major opportunities for financial savings industry

- With longer lives, individuals face greater risk of outliving savings: estimates of global annuity and pension-related longevity risk exposure \$15-\$25 trillion (BIS, 2014).
- Even in optimistic scenarios, individuals face considerable shortfall in retirement saving. With closure of defined benefit pension schemes, more onus on individuals who may have trouble planning for retirement because of behavioural and cognitive barriers. This could mean higher demand for financial advisors, though scope for self-service tools too.
- Low interest rate environment poses risks for savers, retirees, and pension funds and insurance companies that cannot meet funding liabilities e.g. 30 per cent of government bonds have negative yields.
- Doubts whether investors can continue to rely on past investment performance to justify future return prospects (Deutsche Bank, 2013; McKinsey Global Institute, 2016).

- Search for yield and uncorrelated returns present opportunities for alternative investments, such as real assets.
- Will more money in retirement savings and demand for predictable returns steer investee companies away from risk and innovation? (Erixon and Weigel, 2016).

Percentage of baby boomers and Generation X households that would be adequately prepared for retirement (US, 2015)



Source – Employee Benefit Research Institute (2016)

Millennials

Millennials show different consumption behaviours which create new market opportunities and risks

- Millennials - the cohort born between 1980 and mid-2000s - largest segment of US population at ~1/3. Will emerge as main source of wealth and spending as they inherit assets over next few decades.
- Millennials first group to come of age after Internet, social media, mobile and video gaming became widespread. They have more information and choice than previous generations, but have heightened expectation of immediacy, participation and transparency that is driving innovation in many industries.
- Technology may have increased the value of leisure time: among lower-skilled male millennials, evidence in US of weakening attachment to the labour force due to allure of video games (Aguiar et al., 2016).
- Millennials postponing major life decisions, such as getting married and having children and preferring 'experiences' (e.g. travel, culture and artisanal products) over 'ownership' (e.g. housing and cars). Millennials devote more time and money to exercising and eating than previous generations. (Some choices may reverse as they grow older and become wealthier).
- Not all industries can respond to these preferences without major disruption, however e.g. survey evidence identifies banking as industry most likely to be transformed by millennials given perception it is excessively transactional and poorly aligned with their personal values.

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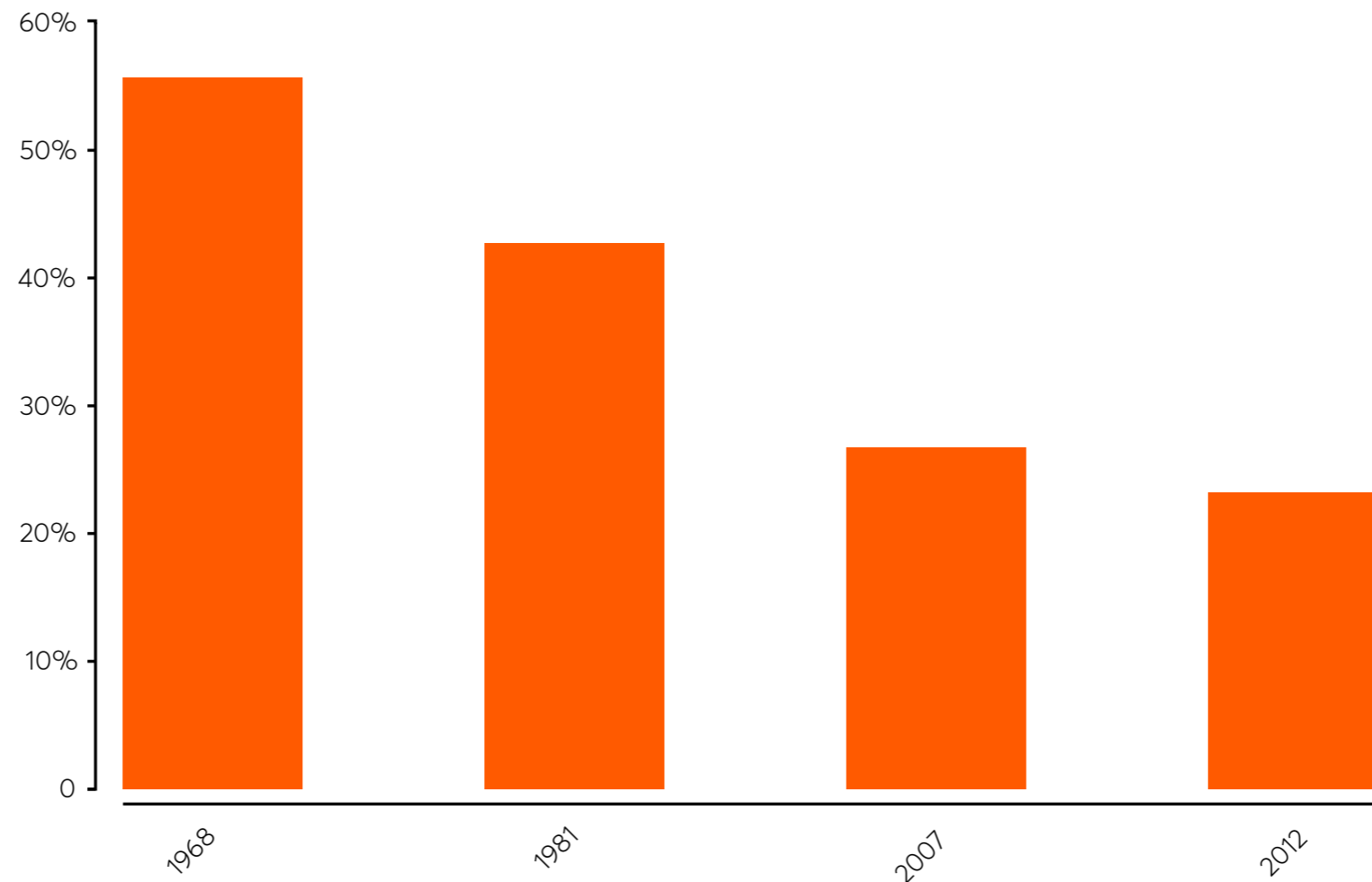
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Percentage of adults 18-31 married and living in their own household



Source – Pew Research Centre (2014), Current Population Survey

Millennials

Mixed evidence that millennials are embracing alternative weekly arrangements

Despite popular view that millennials especially likely to avoid traditional careers (WEF, 2016), US evidence suggests they stay longer with employers than Generation X workers did at same age. (See chart on 'Job tenure in years for millennials and Generation X at age 18 to 30 (percentage)')

One explanation is that labour markets have become less fluid since 1990s with fewer employer switches, reflecting predominance of older, larger firms that do not contract or expand as rapidly (Hyatt and Spletzer, 2013; Davis and Haltiwanger, 2014).

Another explanation stems from finding that cohorts like Millennials which experience recession during their formative years tend to:

- Adopt more conservative attitudes to risk.
- Believe individual success depends more on luck than hard work.

- Support more government redistribution and have less confidence in public institutions and democracy (Giuliano and Spilimbergo, 2009; Malmendier and Nagel, 2011).

Benefits of job security, better matches and on-the-job learning accompanied by costs: switching jobs important determinant of wage growth for younger workers while increased job tenure across the economy can raise long-term unemployment.

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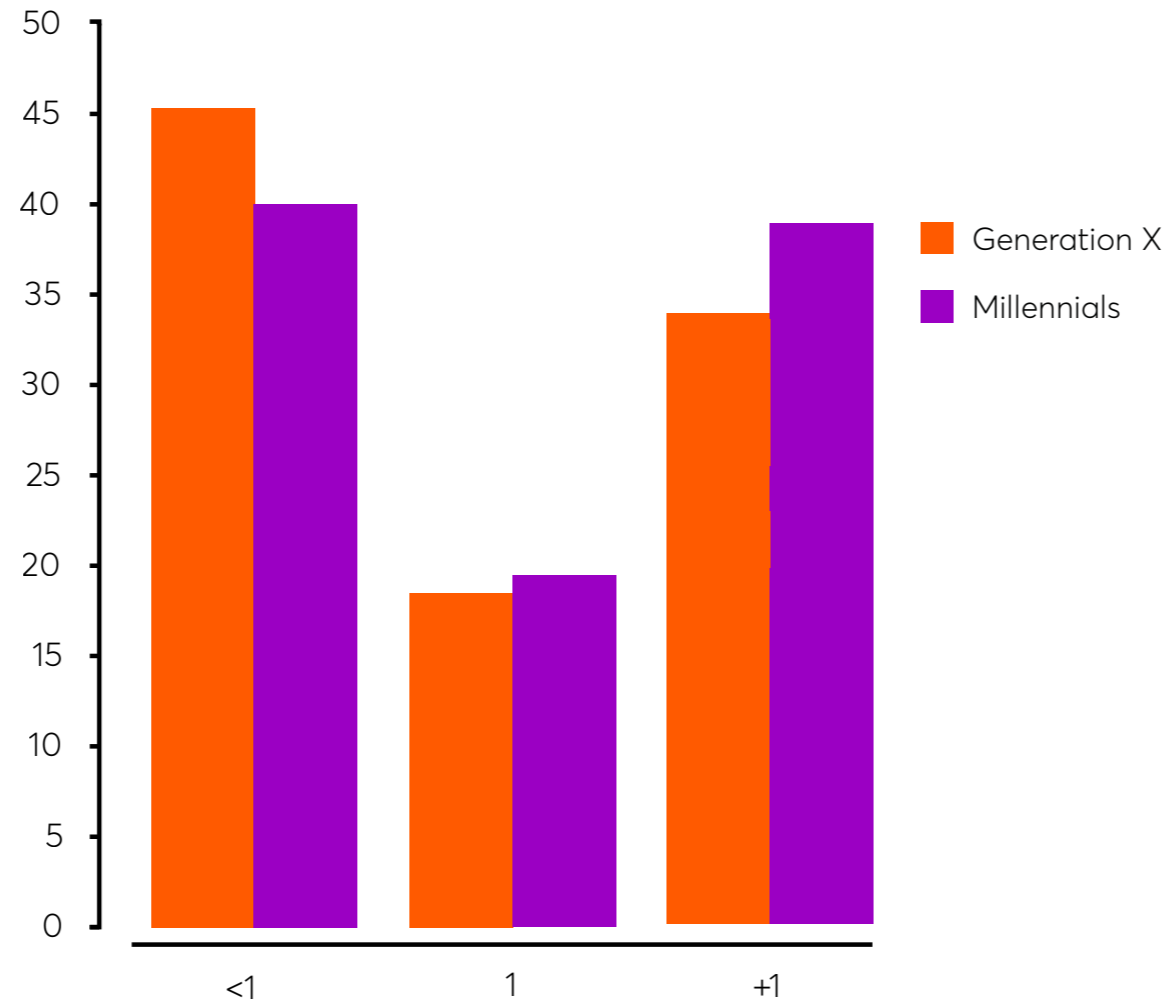
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Job tenure in years for millennials and Generation X at age 18 to 30 (percentage)



Source – Council of Economic Advisors (2014)

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Global warming: 1983-2012 warmest 30-year period for Northern Hemisphere in 1,400 years and accompanied by rise in extreme weather and climate events

Signatories to Intergovernmental Panel on Climate Change now 95 per cent certain that warming of climate system attributable to human influences. To keep average global temperature rise below 2°C - the de facto target for global policy - cumulative CO2 emissions need to be capped at one trillion metric tons above levels of late 1800s. Global economy has already produced over half that amount.

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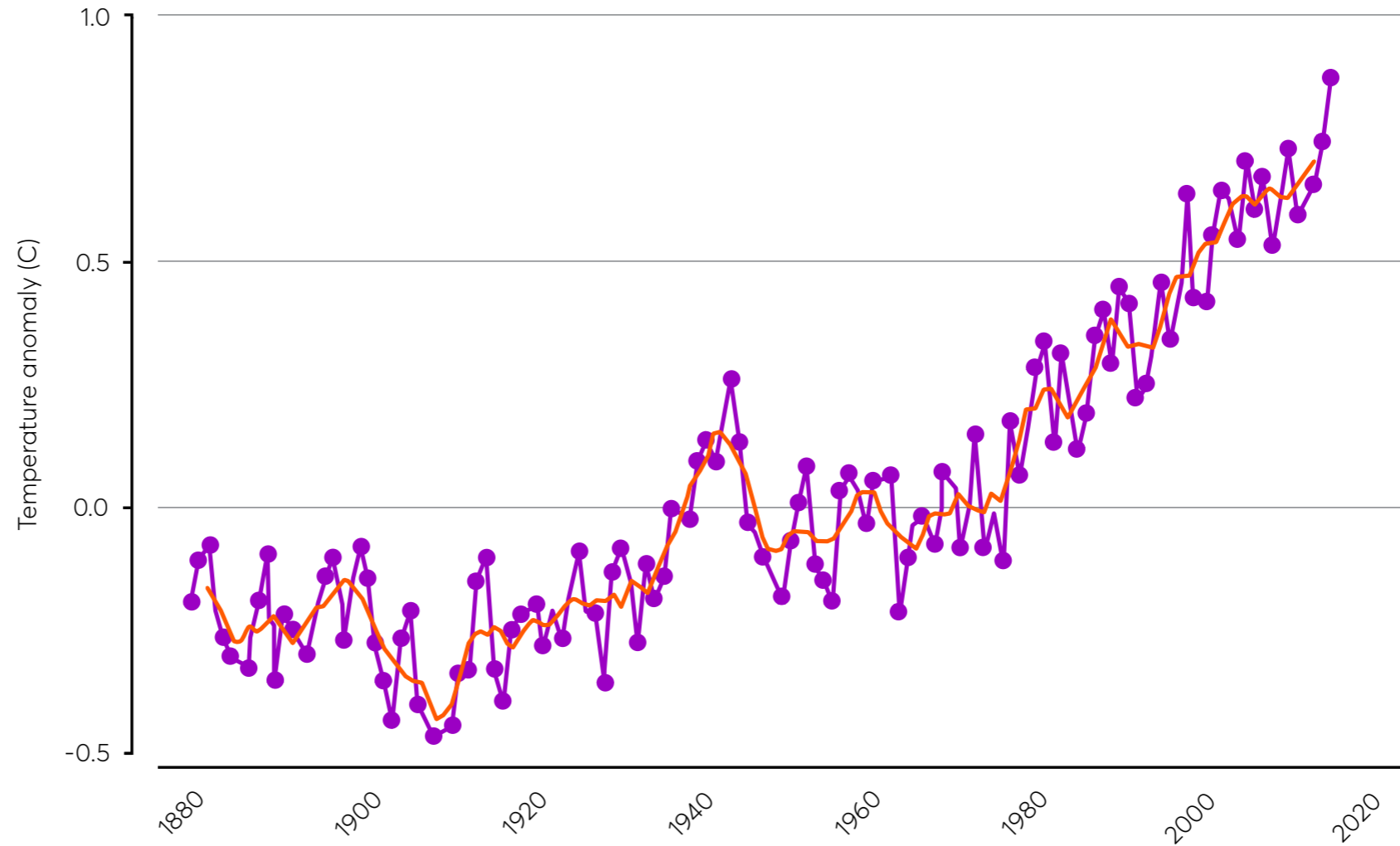
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Global land-ocean temperature index



Temperature anomaly refers to the departure from 1951-1980 average temperatures

■ Annual mean ■ 5 years mean

Source – NASA's Goddard Institute for Space Studies (GISS)

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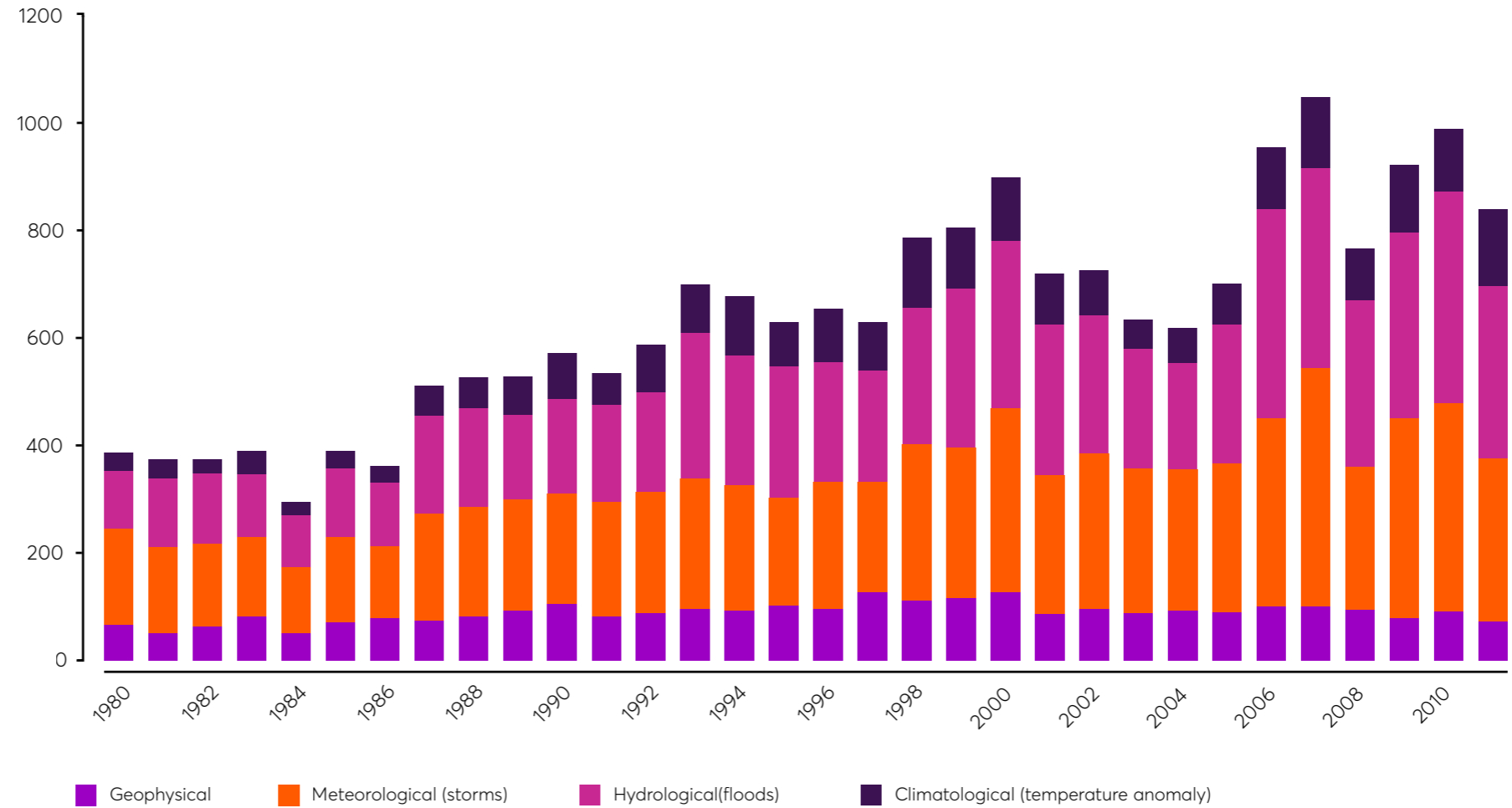
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Number of natural disasters in the world (1980-2012)



Source – Munich Re (2012)

Impact of climate change

Climate change has wide-ranging consequences which impact on many industries.

- Increased severity of natural disasters.
- Environmental changes like desertification and loss of biodiversity.
- Higher heating and cooling costs.
- Declines in labour productivity.

Agriculture, tourism, insurance, forestry, water, infrastructure and energy directly affected, though linkages with socio-economic and technological systems mean that risks can accumulate, propagate and culminate in larger impacts. (See figure on 'Global risks interconnections map').

Economic stakes huge: damage from climate change could shave 5 per cent-20 per cent off global GDP p.a. by 2100 according to Stern Review, though estimates vary depending on sector, assumed damage function and discount rate.

Lower, more uncertain food production could hit US employment with nearly 15 per cent workforce still employed in production, processing and sale of food and fibre. US exports account for >30 per cent of global wheat, corn, and rice sales.

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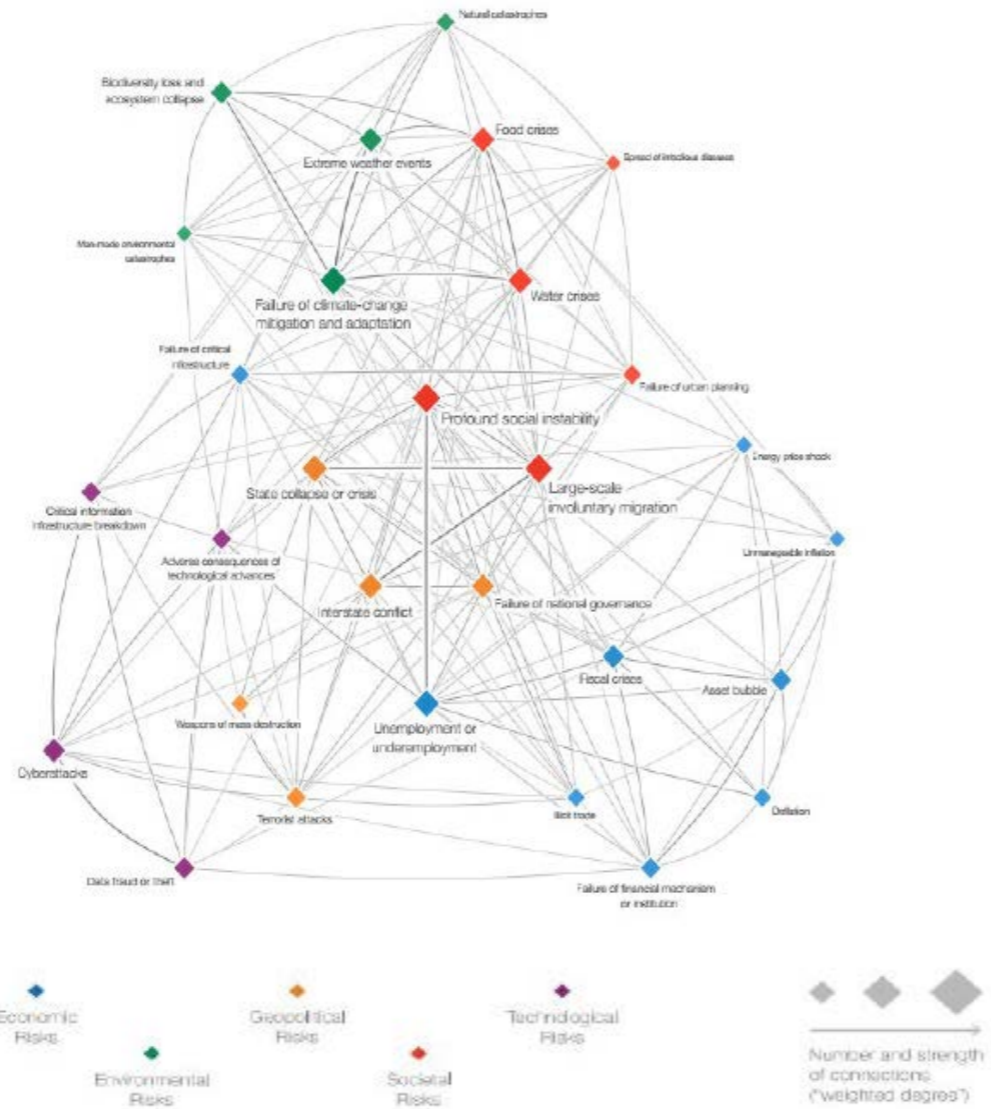
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Global risks interconnections map



Source – WEF (2016)

Impact of climate change

Massive implications for insurance strategies

- Some regions may be able to adapt to changes in temperature and precipitation by adopting farming practices from warmer or drier climates i.e. more tolerant crops. May not be feasible for regions already at climate thresholds.
- Increase in extreme weather events may lead to higher insurance premia in vulnerable regions. Natural catastrophe reinsurance demand could increase by 50 per cent in mature markets and 100 per cent in emerging markets by 2020 vs. 2012 (Swiss Re, 2016).

(See chart on 'Increasing trend of natural catastrophes over the last four decades')

Opportunities but also challenges for insurers, notably capacity to assess and price financial risk (Bank of England, 2015; Bank of Canada, 2016). US federal insurance programs' funds strained because of increasing adverse weather events e.g, overall risk exposure of US National Flood Insurance Program increased four-fold from 1980 to \$1 trillion in 2005.

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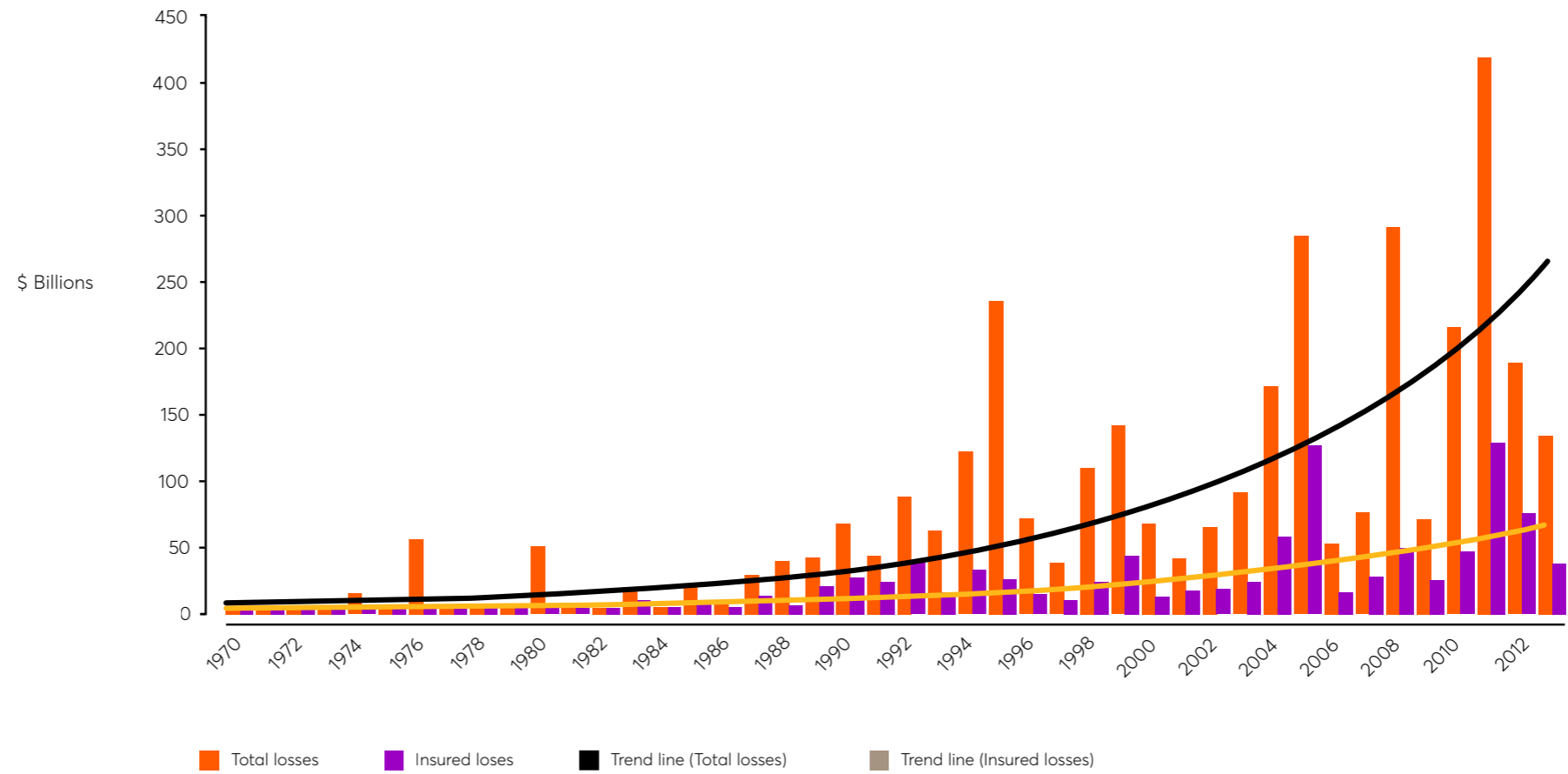
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Increasing trend of natural catastrophes over the last four decades



Source – Swiss Re Sigma

Transition to low carbon economy

Meeting emissions reduction targets requires investment in low carbon technologies and reducing fossil fuel subsidies

LED lighting, onshore wind, solar PV, and hybrid and electric vehicles stand out as technologies with most potential to disrupt markets and lower emissions in next 10-15 years. Adoption driven by falling costs e.g. global electricity generation costs for new onshore wind farms and large solar panel plants fell by ~30 per cent and 65 per cent respectively between 2010 and 2015 (IEA, 2016). Prospect of large scale, distributed storage capacity promises further efficiencies.

Investments in green technology and infrastructure (~\$93 trillion through 2030E) present opportunities for finance e.g. \$50-60 billion of green bonds issued in 2016.

However, 'dirty' technologies continue to have structural advantages:

- Network effects and switching costs direct innovation efforts to improving dirty technologies and intermediate sources of energy e.g. carbon capture and storage, geoengineering and extraction of shale gas.
- Incumbent fossil fuel companies politically influential and make up sizeable proportion of public pension funds.
- Entrenched consumer behaviour particularly in areas such as heating and transport.
- Market and policy support for new technologies volatile e.g solar PV.
- Technology and sector-specific factors e.g. bioenergy operates at major production levels at comparable costs to fossil fuels, but causes pollution and puts pressure on land devoted to producing food crops.

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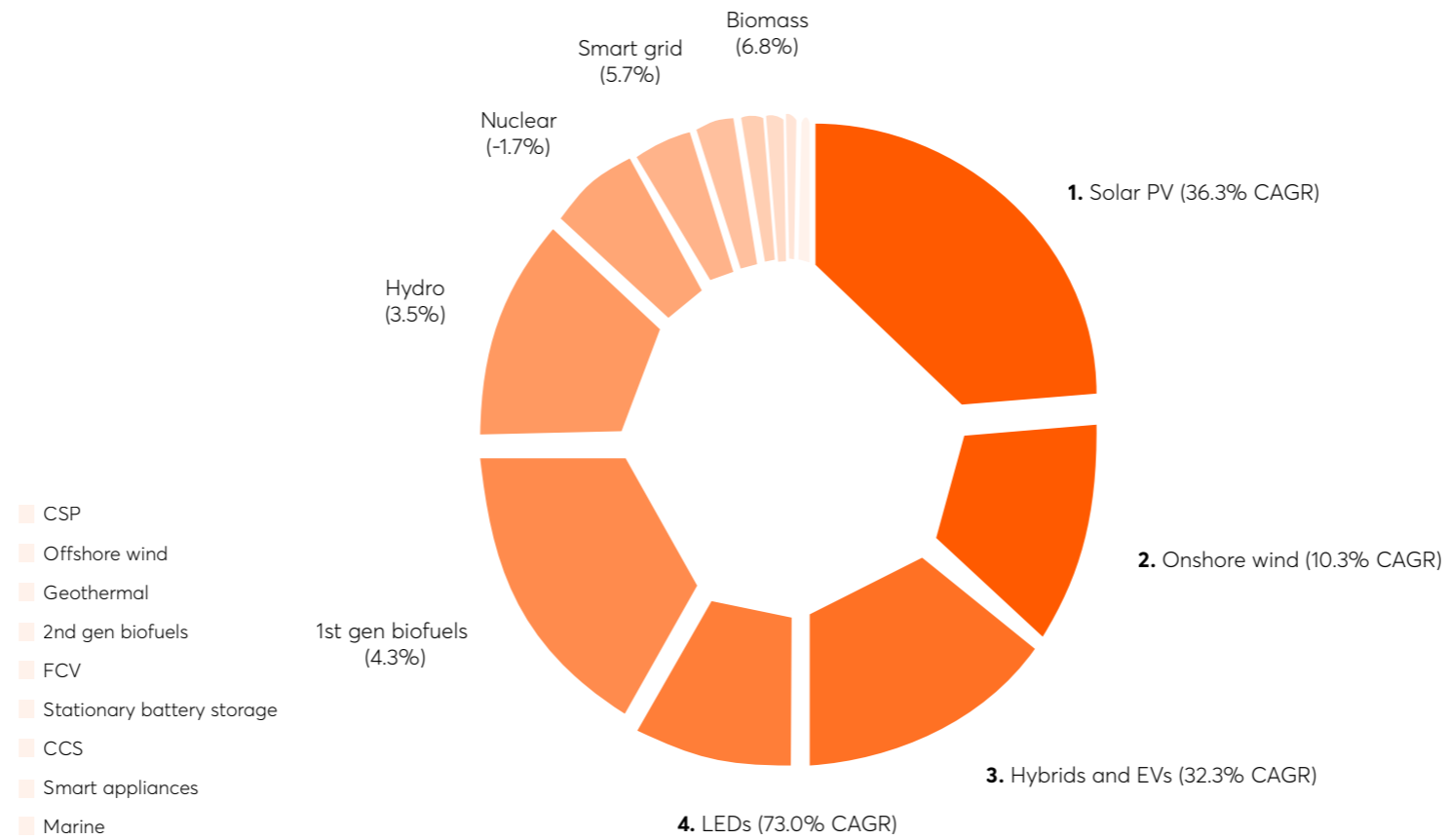
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Low carbon technologies by market size and the three-year compound annual growth rate (CAGR)



Source – Goldman Sachs (2016)

Transition to low carbon economy

The implications for employment are ambiguous

1 Will the green economy create more jobs than it destroys?

For

Evidence that job gains in green sectors exceed losses in polluting sectors due to higher labour intensity of green activities, particularly in construction, manufacturing and installation. Many activities non-tradable e.g. retrofitting buildings, implying greater share of overall spending and job creation remains within country. Benefits especially large for countries relying on imported oil and gas (Pollin, 2015).

Against

Higher prices and costs for clean energy in medium term could reduce purchasing power of consumers, lowering aggregate demand.

2 How much of the economy and employment will be affected?

For

Firm-level evidence that environment-related innovation has substantially larger spillovers than fossil-fuel technologies and even emerging fields such as robotics, biotech and 3D printing, meaning wider impacts for the economy (Dechezleprettre et al., 2013; Gagliardi et al., 2016).

Against

OECD (2012) estimates that by 2030, change in sectoral composition of employment will be minor (c.1-2 per cent of all jobs).

Transition to low carbon economy

3.1 million 'green jobs' as of November 2011 and growing faster than overall workforce. Green jobs unevenly distributed across US (BLS/Economic Policy Institute 2012).

Green jobs include

- Production of environmental goods such as windmills and energy-efficient buildings.
- Services such as recycling and work related to reducing emissions and energy and resource consumption, such as environmental and work safety and facilities and logistics management.

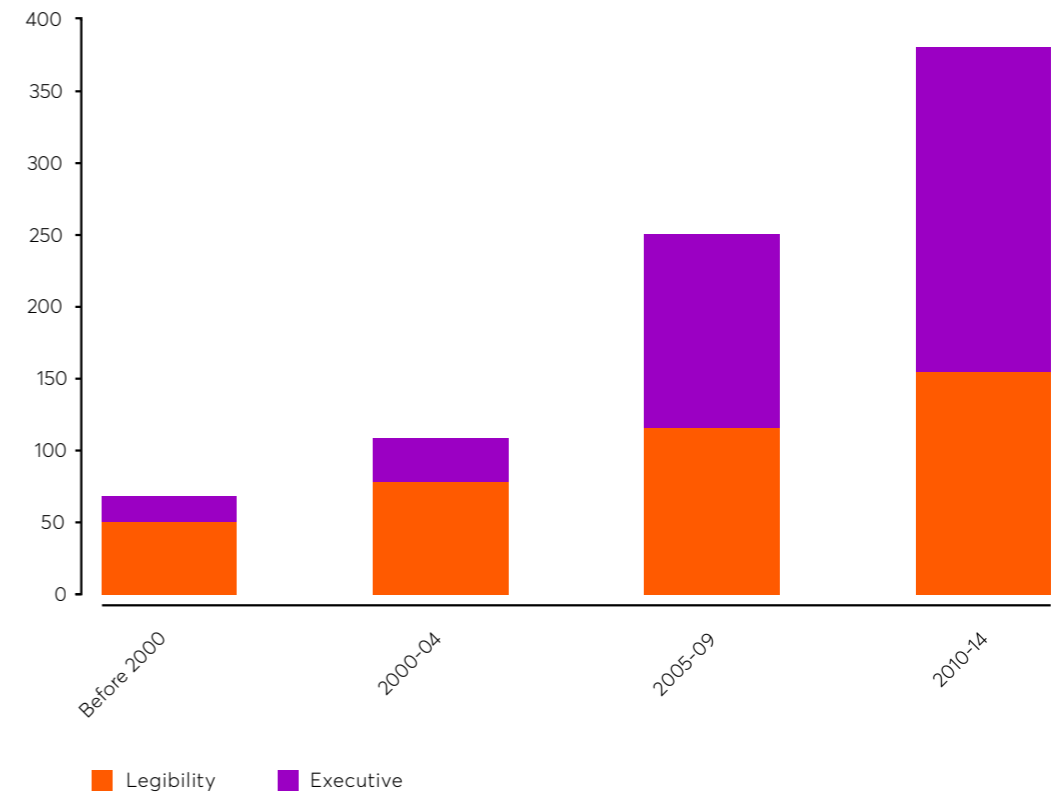
Transition to low carbon economy

Tackling climate change and transitioning to low-carbon economy is fundamentally dependent on government

Supportive regulation has grown across major advanced and emerging economies.

US's Greenhouse Gas emission reduction targets historically modest. However, in 2014, US announced additional target to reduce emissions by 26-28 per cent from 2005 levels by 2025. More ambitious targets recently set for federal government emissions. As yet, no dedicated climate change legislation: numerous attempts to pass comprehensive climate change laws (i.e. the 'Waxman-Markey Bill') have failed to obtain both House and Senate approval.

National laws and regulations related to CO₂ emissions



Source – Grantham Research Institute/LSE (2015)

Database covers 99 countries (33 developed countries and 66 developing countries)

Transition to low carbon economy

Policies for low carbon economy likely to remain piecemeal over next 15 years

Efforts are likely to be:

- Set nationally rather than multilaterally with China, EU and US key veto players.
- Sector- and technology-specific, rather than supported by comprehensive measures such as carbon pricing. Where carbon pricing arrangements operate, they suffer from low price levels and limited emissions coverage.
- Politically controversial and subject to change (Pew 2015).

International Energy Agency modelling of impact of Paris Agreement - most important global deal since Kyoto Protocol - suggests that while commitments will slow global, emissions growth, will continue to rise towards 2030.

Price of EU carbon emission allowance



Source – Goldman Sachs (2016)

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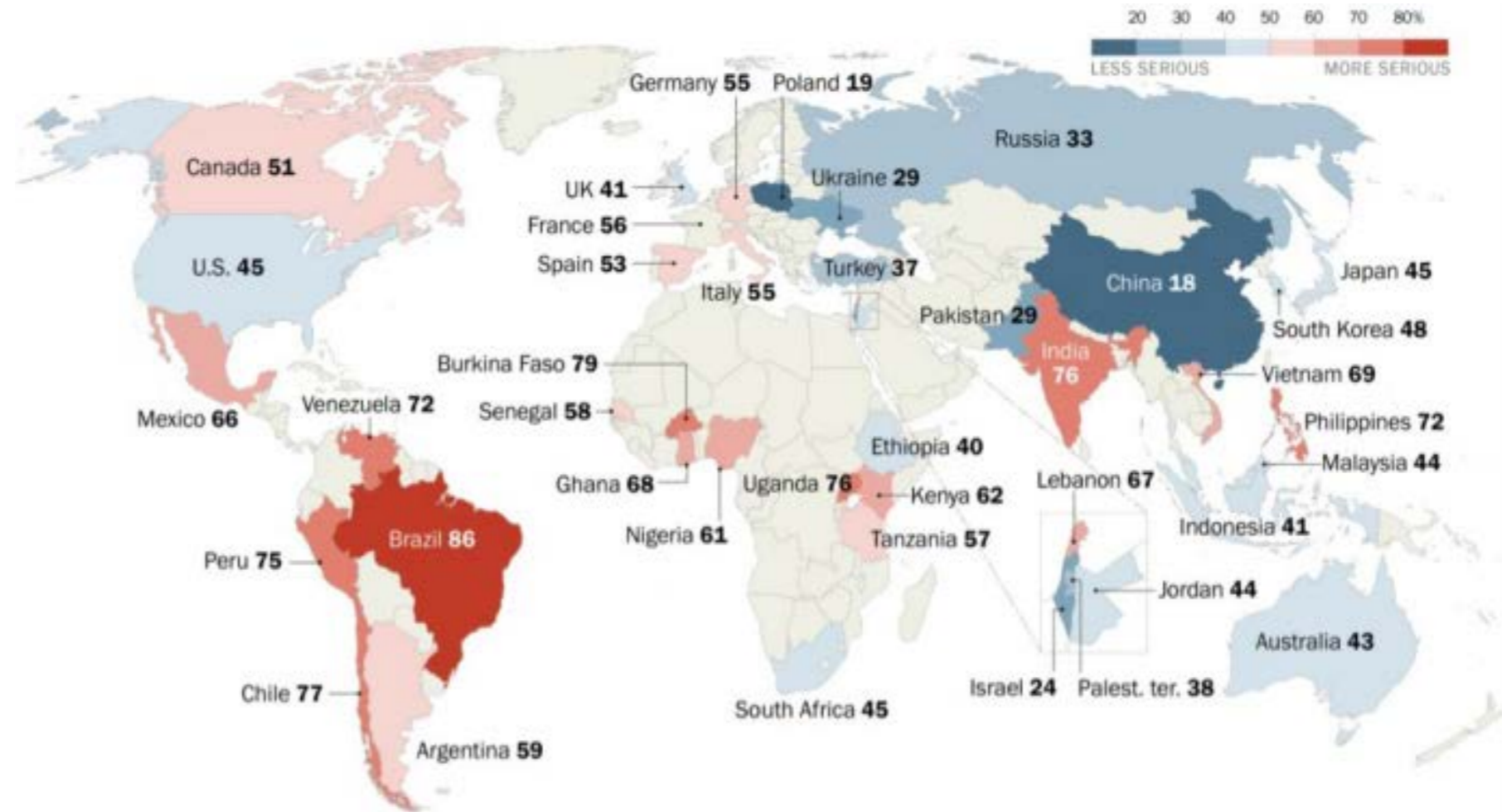
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Is climate change a very serious problem?



The chart shows the per cent of respondents across 40 countries who consider climate change is a very serious problem. A global median of 54 per cent consider it a very serious problem, compared with only 45 per cent in US and 41 per cent in UK. Pew (2015).

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Latest wave of urbanisation

Over half of world's population now lives in urban areas, up from 30 per cent in 1950

Context: pace of current wave of urbanisation without precedent - population in cities risen by average of 65 million people p.a. over past 30 years.

Led by emerging economies:

- 17 of world's 22 megacities – with >10 million populations – are in emerging economies;
- By 2030, eight of world's 10 largest cities will be in emerging economies (UN, 2013).

Cities also playing more important role in advanced economies:

In US, large metropolitan areas (>1 million inhabitants) have grown twice as fast as smaller metropolitan areas (<250,000 inhabitants), while population living in non-metropolitan areas has seen overall decline in recent years (Frey, 2013).

COMPARISON IMAGES OF SHANGHAI



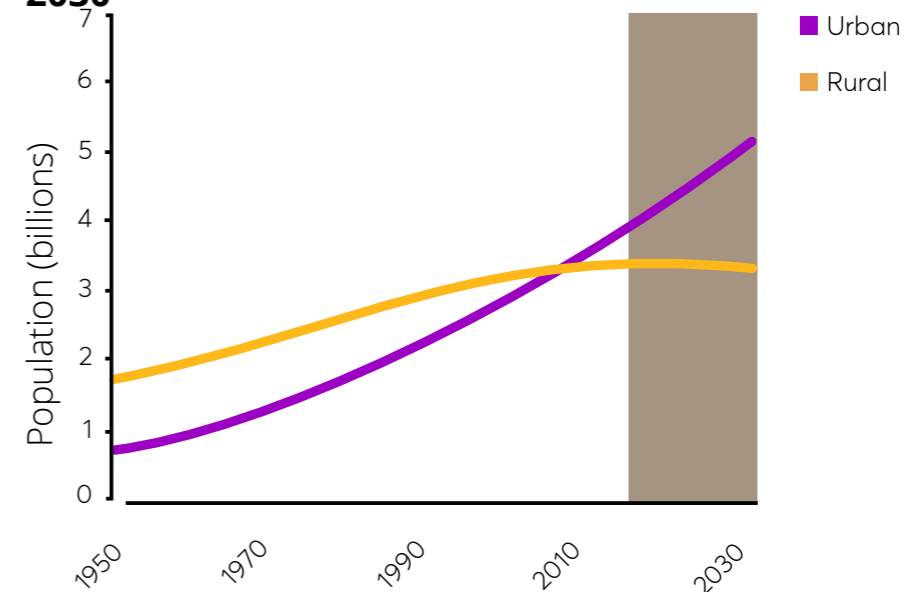
Shanghai in 1990 vs. 2010

Traditionally magnets for young, cities are greying:

Number of over 65s in urban areas in OECD countries grew 23.8 per cent over 2001-2011 vs 18.2 per cent in non-urban areas. Growth in older population contrasts with total population increase in cities of just 8.8 per cent over same period (OECD, 2015).

Cities need to review urban design to be attractive for older populations e.g. greater emphasis on public transport vs. private automobiles.

The world's urban and rural populations, 1950-2030



Source – UNDP (2014)

Latest wave of urbanisation

Urbanisation brings with it important changes in industrial structure, employment, living environment and lifestyle

- Urban life offers greater and more varied consumption and employment opportunities.
- Lack of decent affordable housing means opportunities not even evenly distributed. McKinsey Global Institute (2014) estimates that city dwellers around world pay \$650bn more in housing costs than they can afford annually. (See figure on 'The affordability gap')
- For some this means foregone spending on other essentials; for others it limits affordable housing choices to low income cities or older suburbs that often centre around declining industries (Dix-Carneiro, 2014).
- Growing calls for authorities to build low cost new homes or introduce rent controls and improve public transport so that individuals can commute to high-growth areas. (See figure on Percentage change in the number of jobs near the typical resident 96 largest metro areas, 2000 to 2012').
- Medical conditions such as obesity and diabetes also linked to features of urban environments: more high-calorie foods, more passive transportation, less open space, more mass media and less work-related physical activity (worldwide obesity more than doubled over past 30 years).
- Higher stress exposure may be risk factor for mental illness (Meyer-Lindenberg et al., 2011 find greater activation of amygdala brain region that regulates fear and anxiety among urban inhabitants).

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The affordability gap



McKinsey Global Institute (2014): housing affordability gap is defined as the difference between the cost of an acceptable standard housing unit which varies by location and what households can afford to pay using no more than 30 per cent of income.

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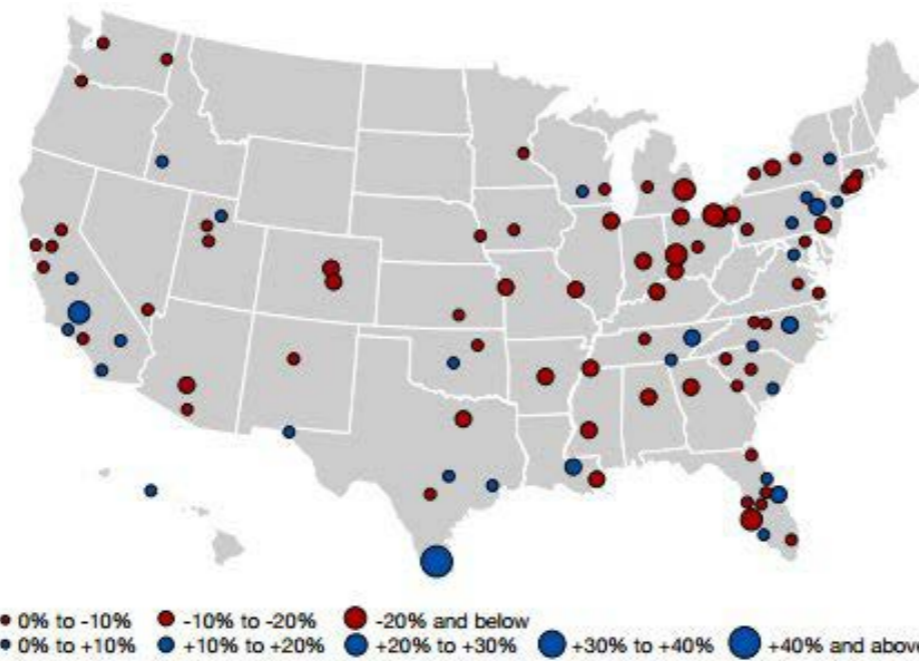
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Percentage change in the number of jobs near the typical resident 96 largest metro areas, 2000 to 2012



Proximity ('near') is defined by the number of jobs that fall within the typical commute distance of the centre point of each census tract (Kneebone and Holmes, 2015)..

Latest wave of urbanisation

New innovation districts build on strengths of cities

Cities conducive to high-value, knowledge-intensive sectors:

- Proximity allows trust, collaboration and flow of ideas - benefits that dissipate rapidly with distance.
- Large numbers of firms and workers for improved labour pooling and matching.

These features of cities particularly valuable in periods of 'combinatorial innovation' where different inputs - digital, material, process and artistic - can be combined to create new applications.

Urban planners are building these elements into fabric of cities via investment in innovation districts that seek to integrate work, housing, and recreation. These include:

- Offices configured with flexible work spaces e.g. hackable buildings.
- New forms of micro-housing (private spaces typically 300 to 600 square feet) with easy access to larger public spaces.
- Growth of cafes, concerts and art shows providing social context for interactions.

To date innovation districts remain a hypothesis, not a proven development strategy; though with increasing competition for talent between cities, interest is likely to grow – along with potential for blind duplication and overinvestment.

Progress also depends on significant devolution of budgetary and other powers to city-regions, including a greater say for local employers in shaping training and apprenticeships - an agenda that has been impeded by high levels of political and economic centralisation (Emmerich, 2017).

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Models of innovation district

Name	Characteristics	Examples
Anchor plus	Mixed-use developments centered around major institution i.e. research university or research-oriented medical hospitals and supportive base of firms, entrepreneurs and spin-off companies. Typically found in city downtowns and mid-towns.	<ul style="list-style-type: none">• Kendall Square, Cambridge, Massachusetts• Philadelphia's University City• St Louis
Reimagined urban areas	Transformation of once industrial or warehouse areas, enabled by availability of historic building stock, access to transport and proximity to downtown in high rent cities. Sometimes found near or along historic waterfronts.	<ul style="list-style-type: none">• South Lake Union, Seattle• San Francisco's Mission Bay• Brooklyn Navy Yard
Urbanised science park	Leveraging innovation capabilities in suburban and ex-urban areas that have traditionally been isolated and effectively 'urbanising' them with introduction of businesses, housing and restaurants.	<ul style="list-style-type: none">• Research Triangle Park, North Carolina• University Research Park at Wisconsin-Madison• University of Arizona Tech Park in Tucson

Adapted from Katz and Wagner (2014)

Growing demand for infrastructure

Cities becoming 'smarter', leveraging information generated by infrastructure to optimise performance

History shapes design of cities e.g. European cities established mass rail transit systems at turn of 20th century while Australia and US built automotive and suburban cities after WW2.

Today, cities are gearing up for more data-led development:

- Intel and San Jose (US) installing air quality, sound and microclimate sensors to measure particulates in air, noise pollution, and traffic flow.

- Bristol (UK) has introduced two city-wide projects - Bristol is Open and SPHERE to monitor interactions, opening up ~200 of city's data sets on traffic flows, energy use, crime and health. It has also built tools to simulate other cities to improve learning.

Smart cities likely to raise demand for digital infrastructure, technology and engineering services and urban planning (UK government expects global smart cities market to be over £245 billion by 2020).

This may imply lower fixed investment relative to previous episodes of urbanisation as technology enables assets to be used more efficiently.

Smart cities may need less commercial real estate per capita e.g. retail, offices and bank branches owing to online alternatives and telecommuting. In areas such as digital infrastructure, greenfield cities may be able to leapfrog to cheaper and newer technologies.



Transport and energy will still likely require significant capital outlays, notwithstanding changes in materials, civil construction and better information flow. Cities with legacy investments may find it harder and costlier to upgrade.

Growing demand for infrastructure

The Smart Cities agenda has increasingly come to focus on sustainability and resilience

- This is often played out through environmental consideration and innovations.
- European cities produce most waste per capita at 511kg compared with 465kg in Latin America and 405kg in Africa.
- US and Canadian cities recycle more than European cities at 26 per cent compared with 18 per cent of waste.
- Scope for additional policy focus and investment in 'greening' of both US and Canadian and European cities.

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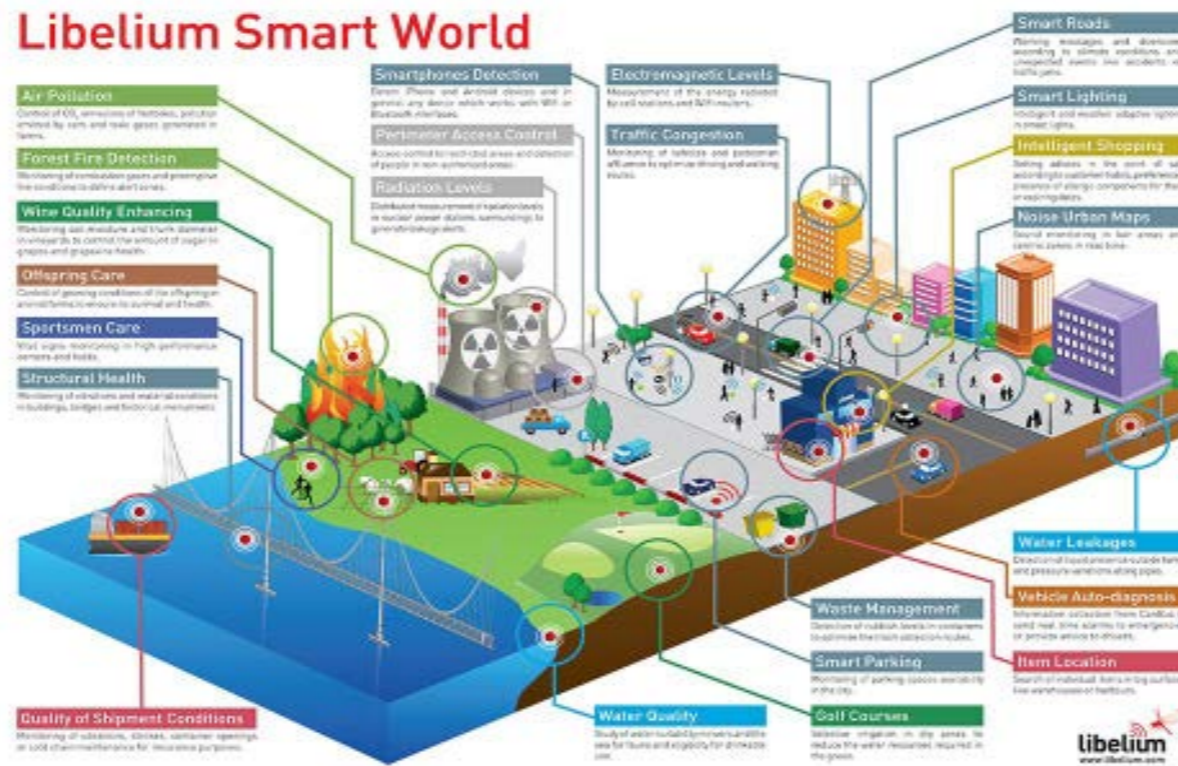
→ Growing demand for infrastructure

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Libelium Smart World



CO₂ emissions per person (in metric tons)

Source – Siemens Green City (2015)
CO₂ Emissions: The US & Canada Index cities have higher per capita CO₂ emissions the Europe and Asia combined

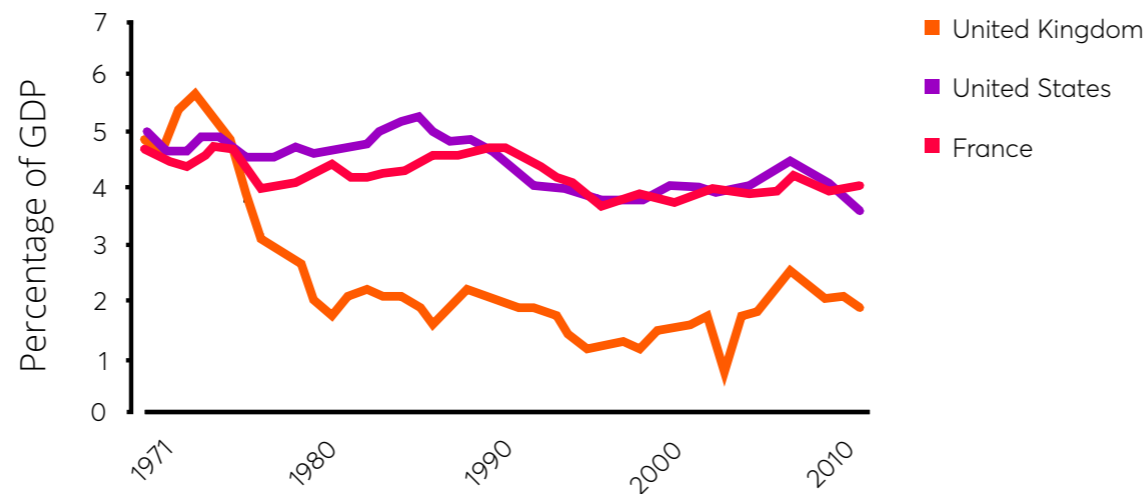
Growing demand for infrastructure

Infrastructure investment as per cent of GDP has declined in UK and US

Emerging economies projected to account for 60 per cent of global infrastructure investment (~\$2 trillion per annum) 2016-20; however, advanced economies also face challenges.

US public infrastructure spending as share of GDP trending downwards for several decades, falling sharply since financial crisis. Average age of public capital stock 27 years in 2015 versus 13 years in 1925 (BEA, 2015). Issue given salience by number of high-profile scandals e.g. lead seepage into drinking water in Flint, Michigan.

Gross government fixed capital formation



Source – OECD (2015)

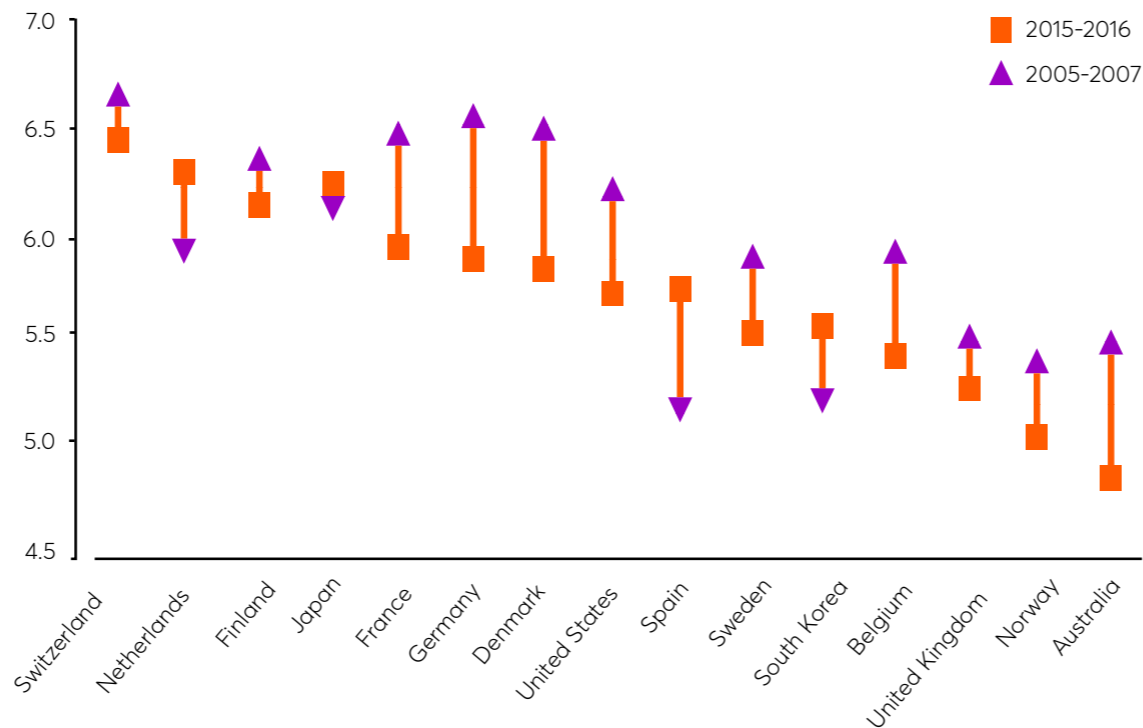
Growing demand for infrastructure

Quality of infrastructure deteriorating too

American Society of Civil Engineers 2014 report card gives US infrastructure a D+ with only solid waste earning good marks. Build out of high-speed rail networks remains slow while broadband costs very high.

McKinsey Global Institute (2016) estimates that US and UK will need to raise infrastructure spending by 0.7 and 0.4 percentage point of GDP respectively each year to support current growth projections.

Quality of overall infrastructure, 2015-2016, 1 to 7 (best)



Source - WEF

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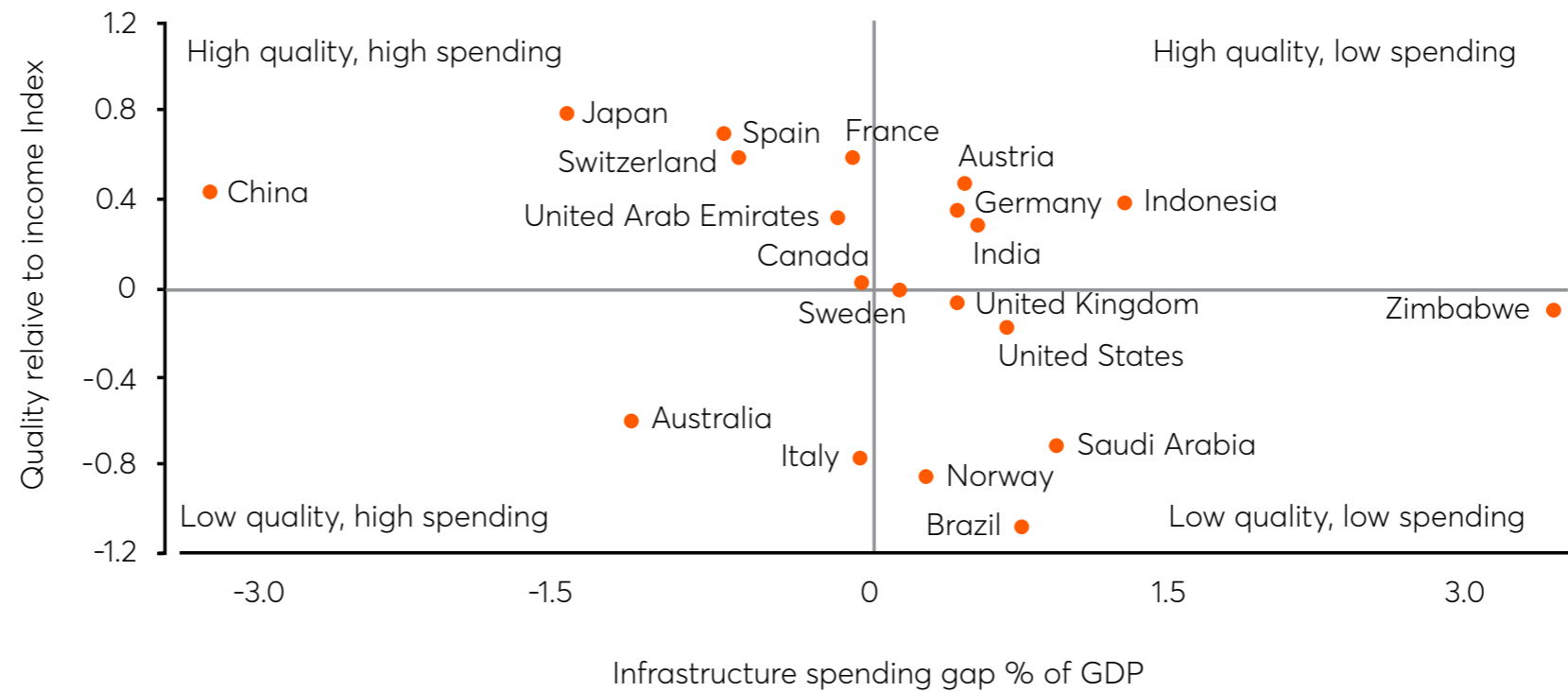
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Infrastructure quality vs. Spending



Source – McKinsey Global Institute (2016)
Difference between historical spending levels from 2008-13 and the investment spending as a share of GDP that will be needed in 2016-30

Growing demand for infrastructure

Over next 15 years, ongoing debates about role of fiscal policy will shape outlook for infrastructure investment

Austerity and concerns about debt sustainability have limited scope for fiscal policy. However, signs that fiscal easing is moving up political agenda, prompted by:

- Continued slow growth.
- Low borrowing costs.
- Recognition of limits and risks of further monetary stimulus.
- Growing appetite for infrastructure projects from institutional investors.

Impacts:

Closing US infrastructure gap in next 15 years will have powerful stimulus effect, assuming project pipeline and regulatory barriers are addressed (McKinsey Global Institute, 2016). In short term, could create 1.3-1.5 million jobs, boosting employment in construction, transport, utility and energy sectors.

However, looking ahead, how much investment occurs constrained by competing calls on public purse, lack of political consensus and difficulties in making cost-benefit case for next-generation infrastructure. History suggests fiscal policy is more expansionary following elections in periods of single-party control but tighter under divided government.

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Inequality and its drivers

Gap between rich and poor in advanced economies highest in decades: ex-President Obama's 'defining challenge of our times'

Measures of overall inequality based on Gini coefficients of incomes have increased since mid-80s in most developed economies, though have levelled off more recently. Evidence finds that two-thirds of this increase arises from growing wage gap between high-paying and low-paying firms.

Top 1 per cent has experienced largest gains:

In UK and US, share of income more than doubled since 1980 to around 15 per cent.

Picture even starker with respect to wealth:

Top 1 per cent's share of wealth now around one-third – more than bottom half of population put together. Wealth dynamics are driven largely by increases in house prices.

Middle class squeeze:

Distribution of labour income has shifted towards higher and lower ends of distribution, squeezing income share going to middle.

Being in work not necessarily a guarantee against poverty:

In UK, two-thirds of children growing up in poverty live in household where at least one parent works (Institute of Fiscal Studies, 2016).

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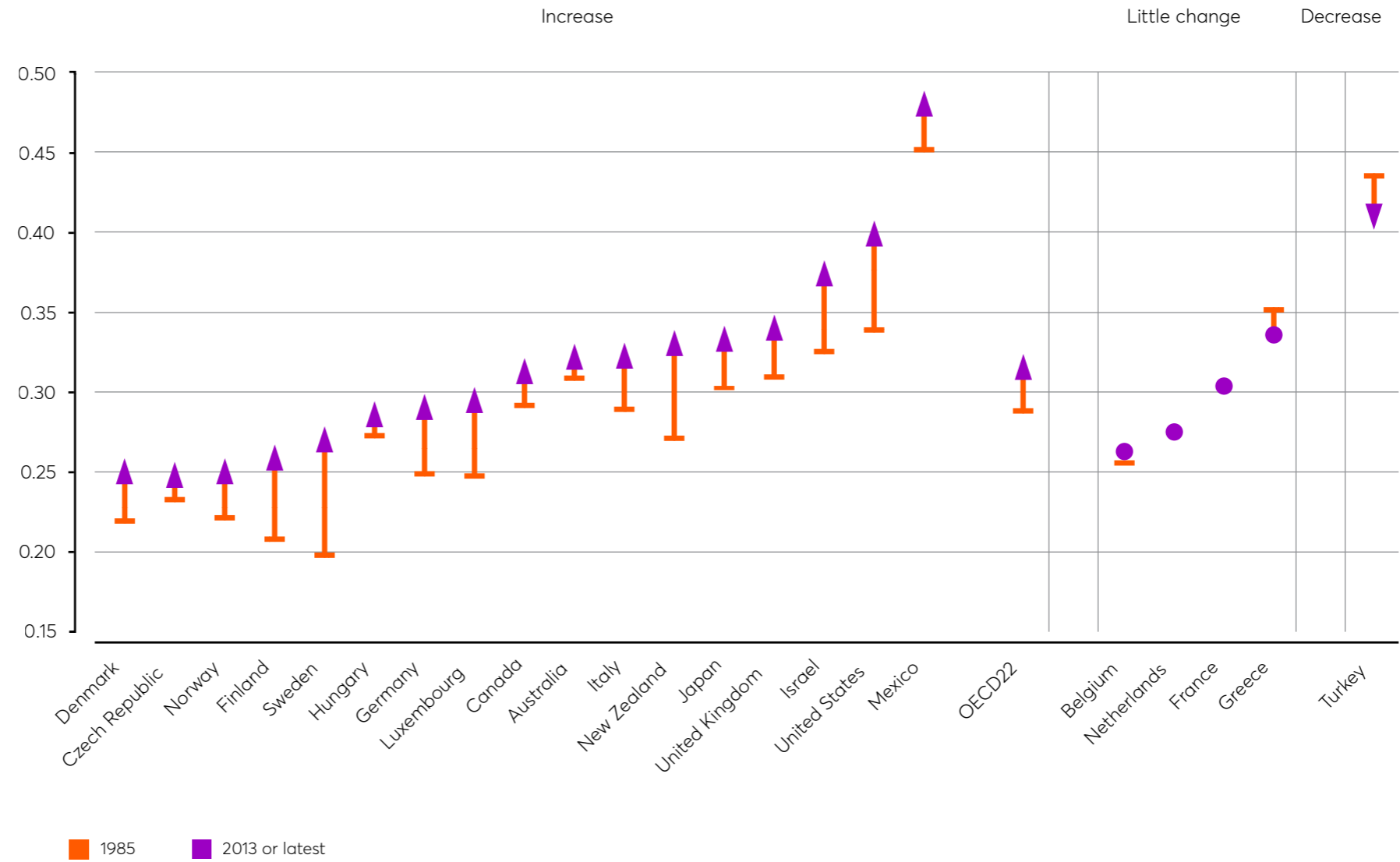
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Gini coefficients of income inequality, mid-1980s and 2013, or latest date available



Source – OECD

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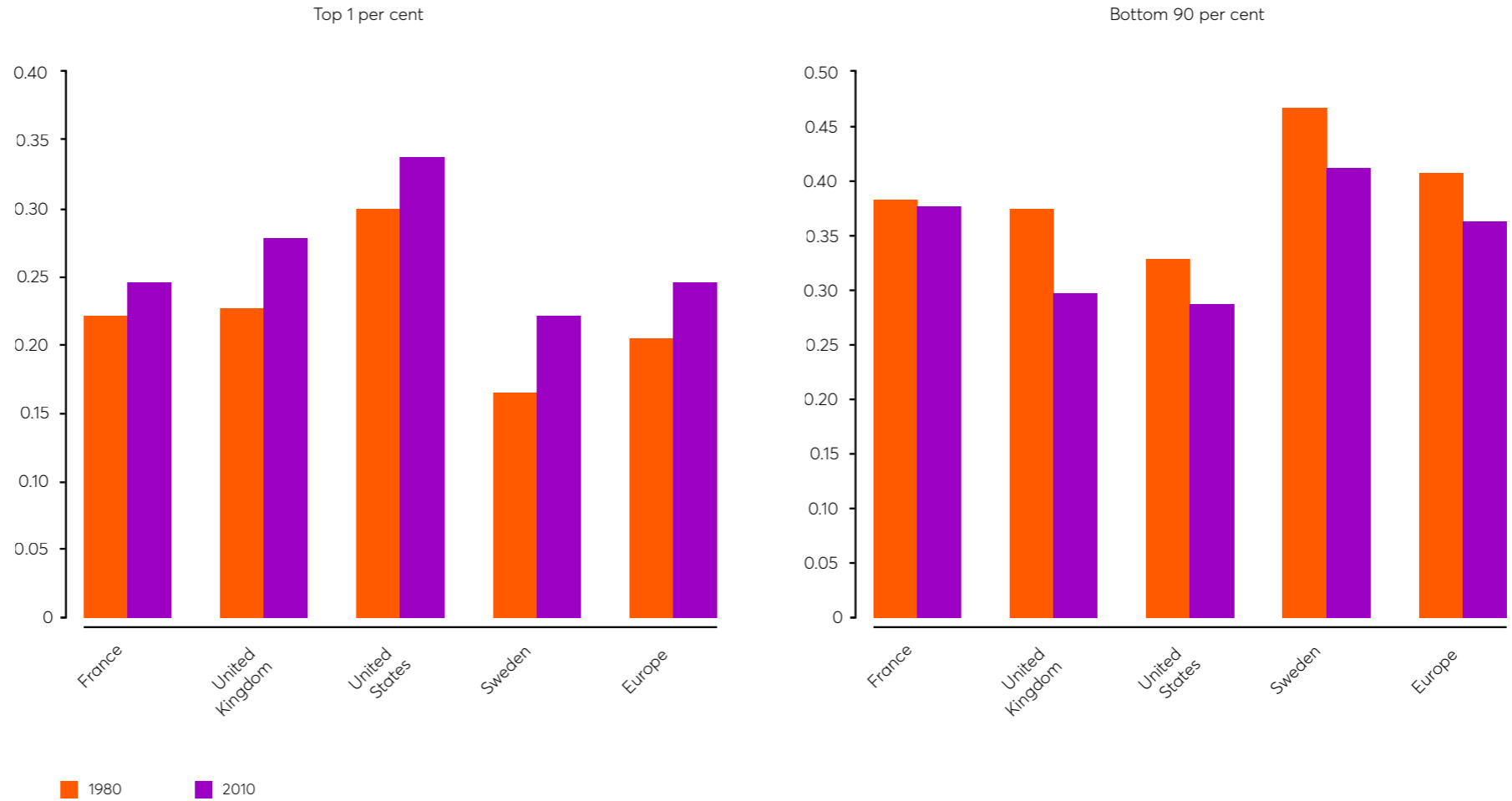
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Top 1 per cent and bottom 90 per cent of wealth distribution, 1980-2010



Source – IMF (2015)

Inequality and its drivers

A number of factors have driven this higher inequality

- Rising skills premia.
- Superstar effects supported by technology allow top performers to capture larger share of returns.
- Rising concentration and monopoly power in sectors like finance and insurance, retail and transport accounting for higher profit share, and supported by lower rates of firm entry.
- Declining unionisation.
- Regressive taxation.
- Changes in corporate governance favouring executives.

However, changing demographics may work against rising inequality in future:

- Larger labour force in 1970s and '80s, underpinned by integration of low- and middle-income countries into global economy, drove real wages lower and inequality higher in advanced economies. As labour force ages and labour force growth weakens, real wage growth may increase.

Uncertain outlook for future investment returns may also limit inequality (financial and real assets disproportionately owned by the rich).

Overall, good reasons to think inequality will persist - history suggests delivering deep and lasting reductions in inequality may be difficult in the absence of violent shocks (Scheidel, 2017).

Still inequality is becoming harder to ignore politically:

- Consider growing interest in radical ideas such as basic income e.g. pilots in Finland and Utrecht.

Macro and microeconomic impacts

Macroeconomic relationship between inequality and growth contested - recent studies highlight costs of rising inequality

Channels highlighted in literature include:

Sustainability:

Unequal societies can enjoy spells of rapid growth; however, these tend to be shorter-lived. Regions and countries with high levels of inequality may be more divided and less able to deal with external shocks. (See chart on 'Effect of increase of different factors on growth spell duration')

Demand:

Affluent households have lower propensity to consume which means that higher inequality may dampen aggregate consumption, which may in turn disincentivise innovation. This economic drag may have been concealed in past by unsustainable expansion in credit among lower income groups.

Social mobility:

Lower-income households may be unable to afford higher education resulting in less human capital accumulation. Countries with higher levels of income inequality tend to have lower levels of mobility between generations with implications for efficient allocation of talent.

(See chart on 'Income equality and social mobility')

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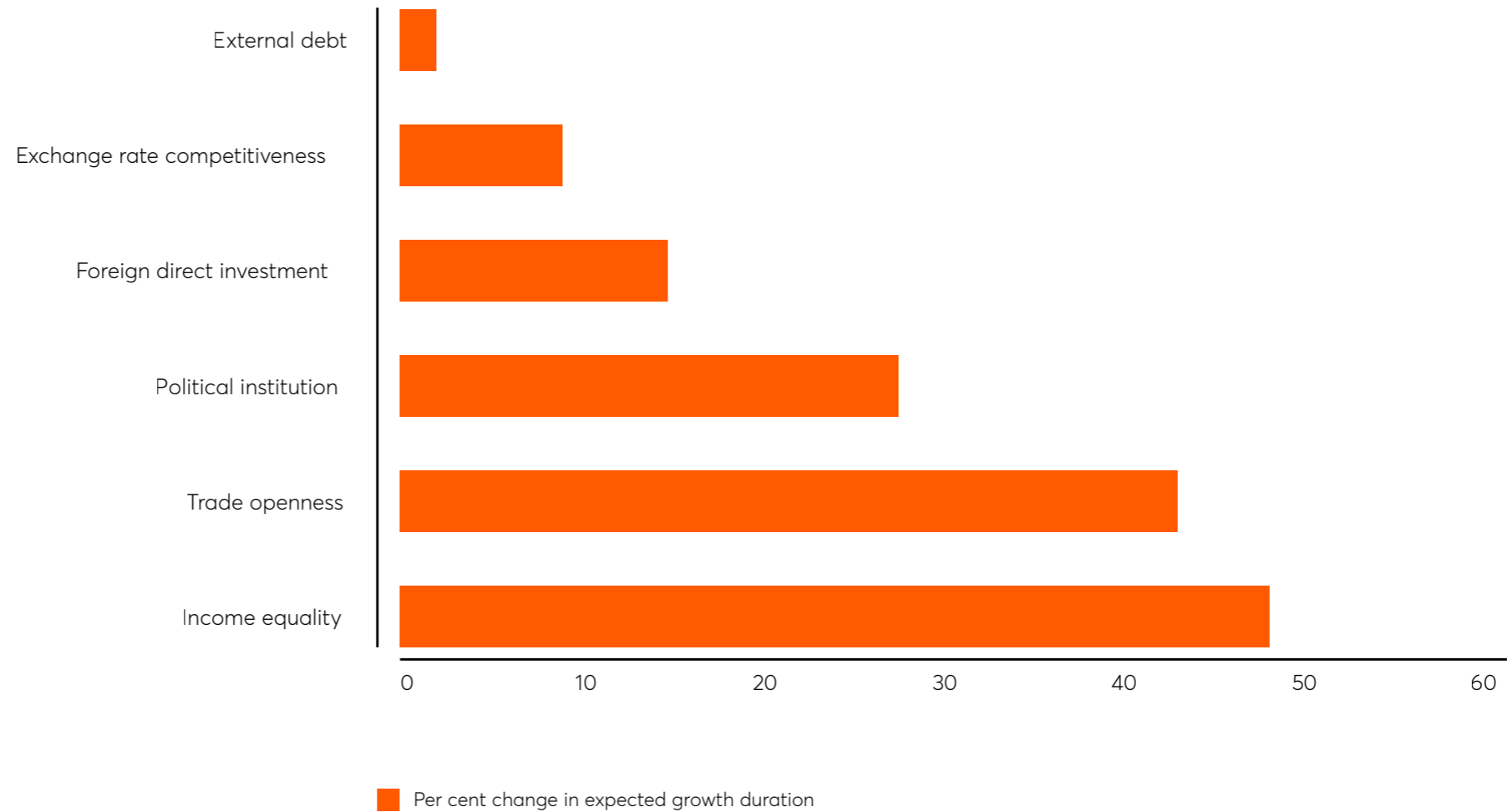
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Effect of increase of different factors on growth spell duration



Source – Berg and Ostry (2011)

For each variable the length of the bar shows the per centage increase in growth spell duration resulting from an increase in that variable from the 50th to the 60th per centile, with other variables at the 50th per centile. A 10 per centile improvement in the Gini coefficient from 0.40 to 0.37 increases the expected length of a growth spell by 50 per cent.

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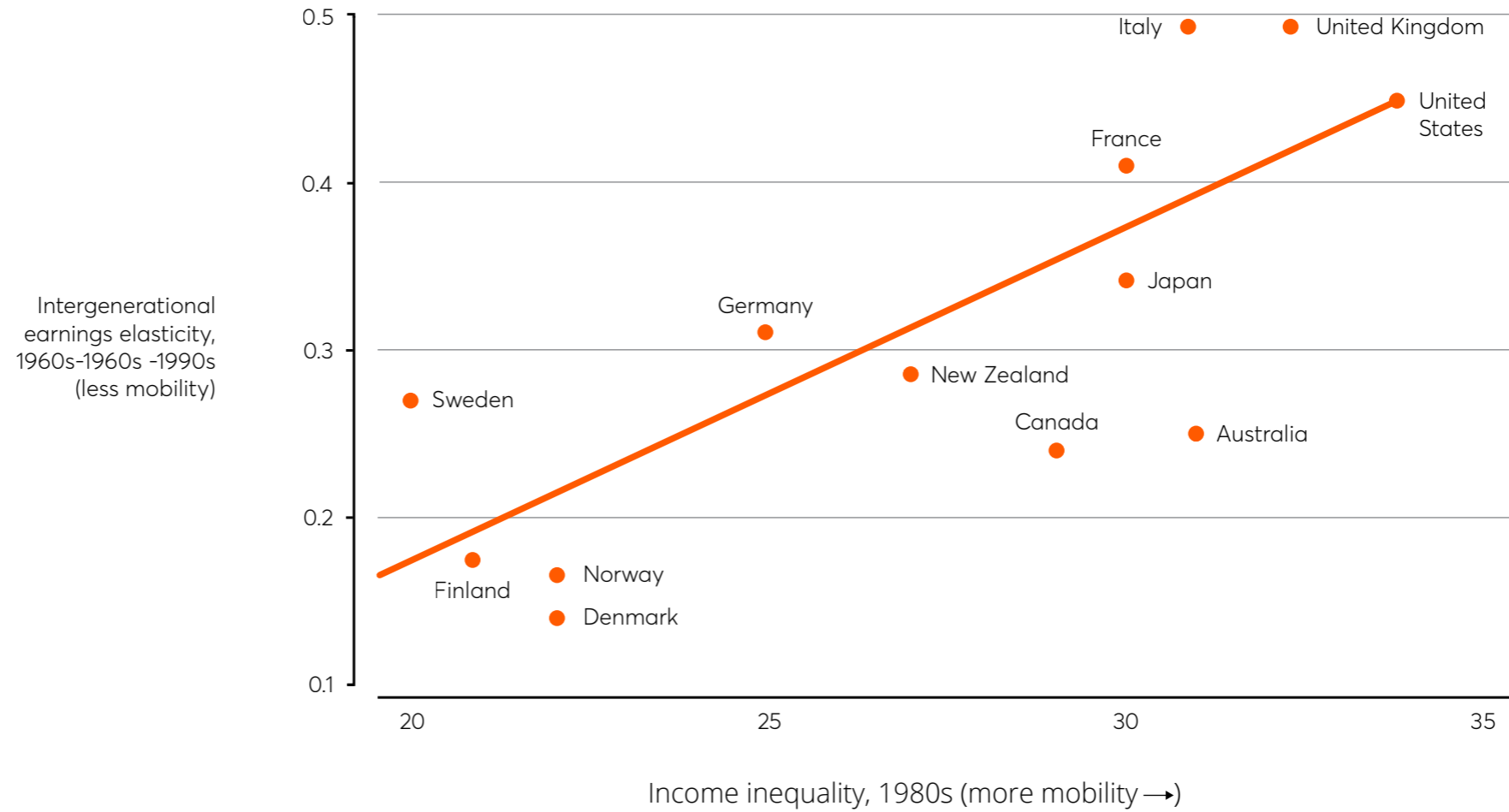
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Income equality and social mobility



Source - Corak (2013)

Macro and microeconomic impacts

Increasing inequality will have microeconomic implications too

- Increasing inequality and poverty may contribute to greater health and social problems (e.g. opioid epidemic), raising demand for healthcare and social services.
- Occupations dedicated to protecting property rights and managing conflict like police, lawyers and security larger in countries with higher levels of income inequality (Bowles, 2012).
- Increasing disparities in income mirrored by disparities in consumption, particularly of non-durables and services such as education (Aguar and Bils, 2015). (See chart on 'Relative expenditure growth for 20 goods (high income vs. low income households)').
- Recovery of spending has been sluggish among lower income US consumers since financial crisis. Product categories that would benefit most strongly from any recovery include food for off-premise consumption, housing/furnishings, vehicles, recreational goods, healthcare, clothing and footwear. (See chart on 'Yearly change in annual consumption spending by income quintile').

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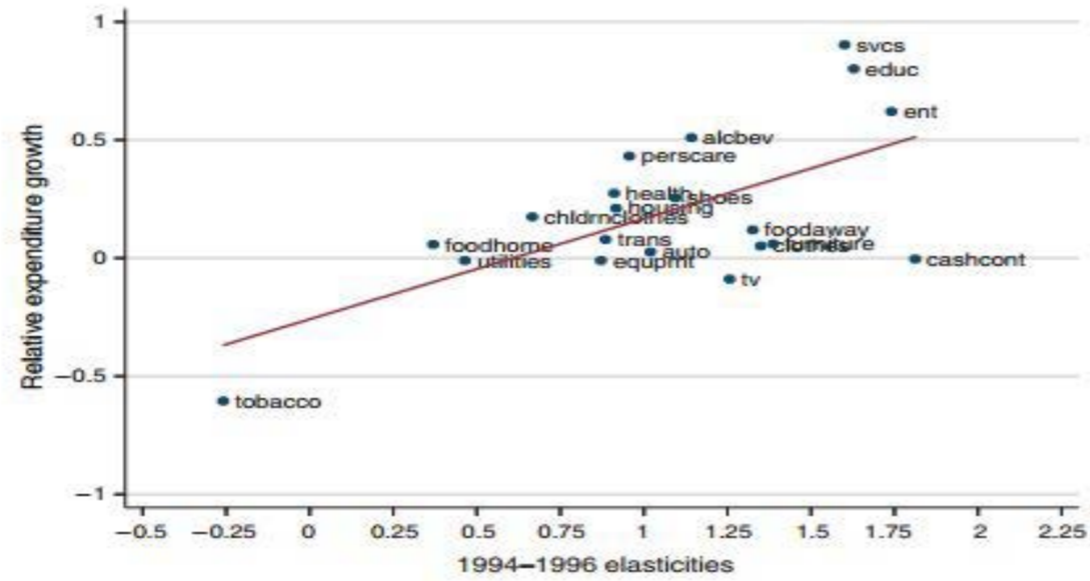
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Relative expenditure growth for 20 goods (high income vs. low income households)



Source – Aguiar and Bils, 2015.

The figure is a scatter plot of relative consumption growth on 20 goods versus the respective expenditure elasticities for low and high income group. For example, food at home ('foodhome') has an elasticity of 0.37, meaning high-income households spent 37 per cent more on food at home than low-income households in 1980-1982, and 43 per cent more in 2008-2010. This relative shift of 0.06 is presented on the vertical axis.

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Yearly change in annual consumption spending by income quintile



Source – Morgan Stanley (2015)

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Decisions that impact on labour markets sensitive to domestic political and geopolitical uncertainty

- Uncertainty increases cost of capital, which lowers desired capital stocks and investment.
- Uncertainty also creates an option value for agents of waiting to invest in cases where economic decisions involve sunk costs, such as when firms delay investing in new technologies, households put off purchasing big ticket items and individuals are reluctant to invest in cutting-edge skills. Decisions that can be more easily reversed will be less affected: uncertainty tends to have greater impact on business investment than employment.
- Uncertainty also harms productivity by hindering reallocation of resources from low to high productivity firms.

- Way in which managers are remunerated may amplify negative effects of uncertainty. Evidence suggests that when equity-based compensation becomes more important - exposing managers to greater firm-specific risks - investment falls (Panousi and Papanikolaou, 2012).

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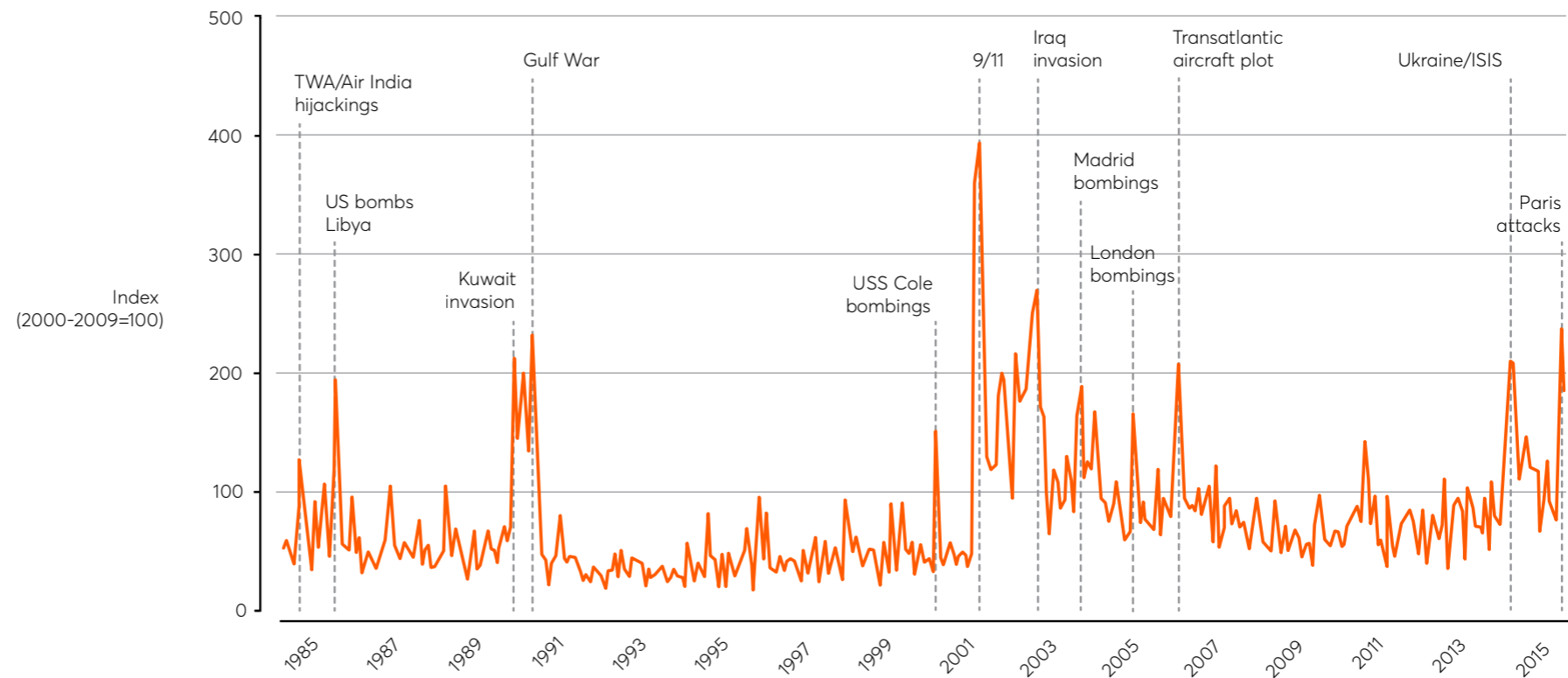
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Rising political uncertainty?

Indicators of geopolitical uncertainty have doubled after 9/11

Heightened geopolitical risks even if terms related to terrorism and Middle East are excluded. Sectors like oil and gas, aviation and tourism particularly exposed to geopolitical instability.

Benchmark Geopolitical Risk Index



Source – Caldara and Iacoviello (2016). Index based on references in 11 newspapers to 99 phrases related to actual geopolitical events and geopolitical threats

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Rising political uncertainty?

Policy uncertainty rising too?

Policy uncertainty - relating to the remits, frameworks and institutional structures that enable authorities to act credibly and consistently - is around 1¼ times pre-crisis average, comparable with levels seen in 1930s/40s.

President Trump's election has reinforced this trend: uncertainty around US support for the global economic and security order and whether administration can deliver on pro-growth campaign promises (e.g. corporate tax reform and fiscal stimulus).

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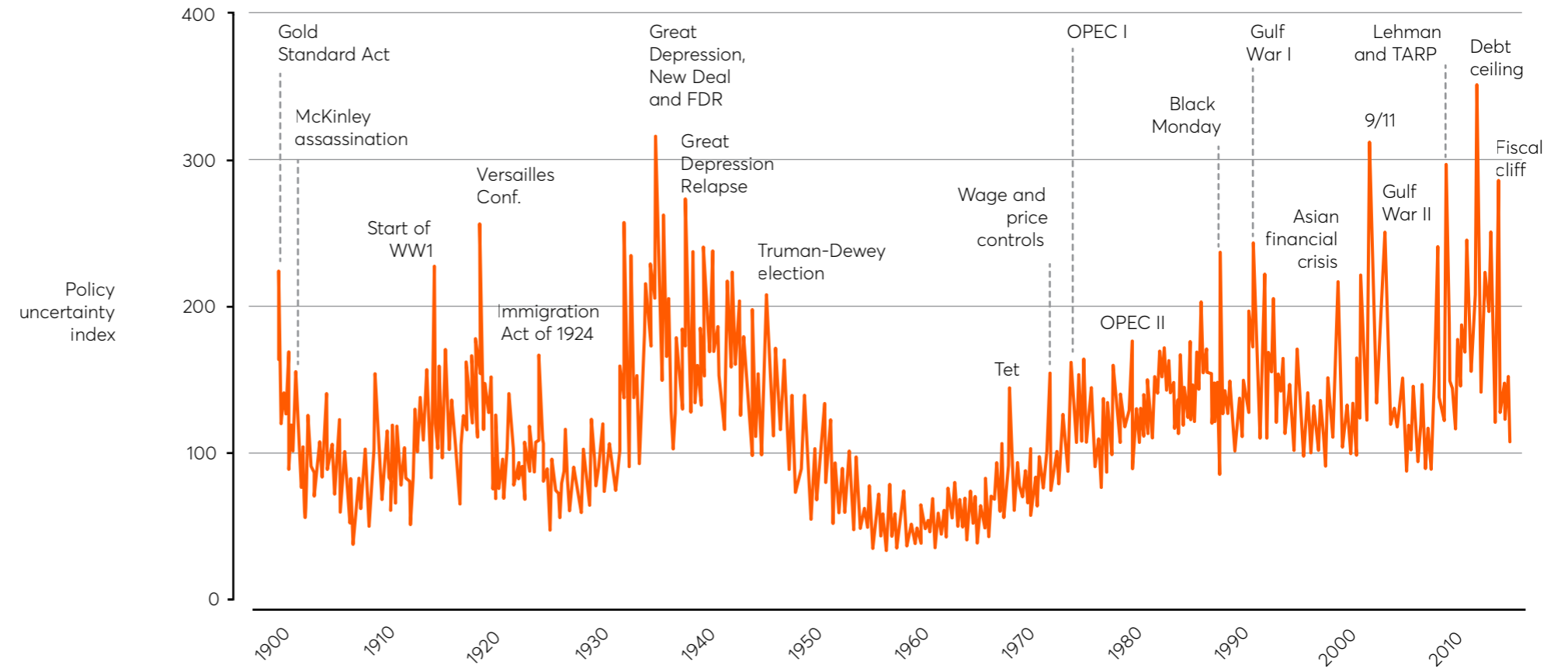
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United States historical index of economic policy uncertainty



Source – Baker, Bloom and Davis (2016)

Index constructed from three components: newspaper coverage of policy-related economic uncertainty, tax code expiration data and cross-sectional dispersion in economic forecasts. Historical measures derived from newspaper coverage only.

Rising political uncertainty?

This depresses economic activity in sectors that are capital-intensive and/or exposed to government

An increase in policy uncertainty comparable to that experienced from 2005 to end-2011 is associated with the following impacts:

- 1.2 per cent decline in industrial production.
- 6 per cent decline in gross investment.
- 0.5 per cent decline in employment (Baker, Bloom and Davis, 2016).

Declines bottom out after 12-18 months and converge only slowly back to trend.

Impacts of increased uncertainty largest in sectors like defence, finance, construction, engineering and healthcare that require extensive investment commitments and/or have high government exposure e.g. uncertainties surrounding the passage, implementation and durability of the Affordable Care Act.

Policy uncertainty may also threaten trade: 1 per cent increase in uncertainty is associated with a 0.02 pp. reduction in goods and services trade volume growth (Constantinescu et al., 2017).

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Drivers of policy uncertainty

Growth in government spending, taxes, and regulation, while often beneficial, can raise policy-related uncertainty by adding to complexity of environment in which businesses make decisions.

Policymakers' actions can become more uncertain in times of trouble. When economy doing well, governments prefer to stick with policies which appear successful. When conditions weaken, they may look to experiment with new ways to restore growth.

Growing interconnections and interdependencies in global economy mean there are multiple pathways through which risks can spread when systems fail. The ubiquity of communications mean that people can mobilise and ideas spread across borders with much greater speed e.g. Arab Spring.

Geopolitical landscape characterised by a greater distribution of power that has strained the capacity of the international system to provide public goods and respond effectively to a host of security and economic challenges.

Sources — OECD (2011)
Pastor and Veronesi (2012)
Davis (2015)

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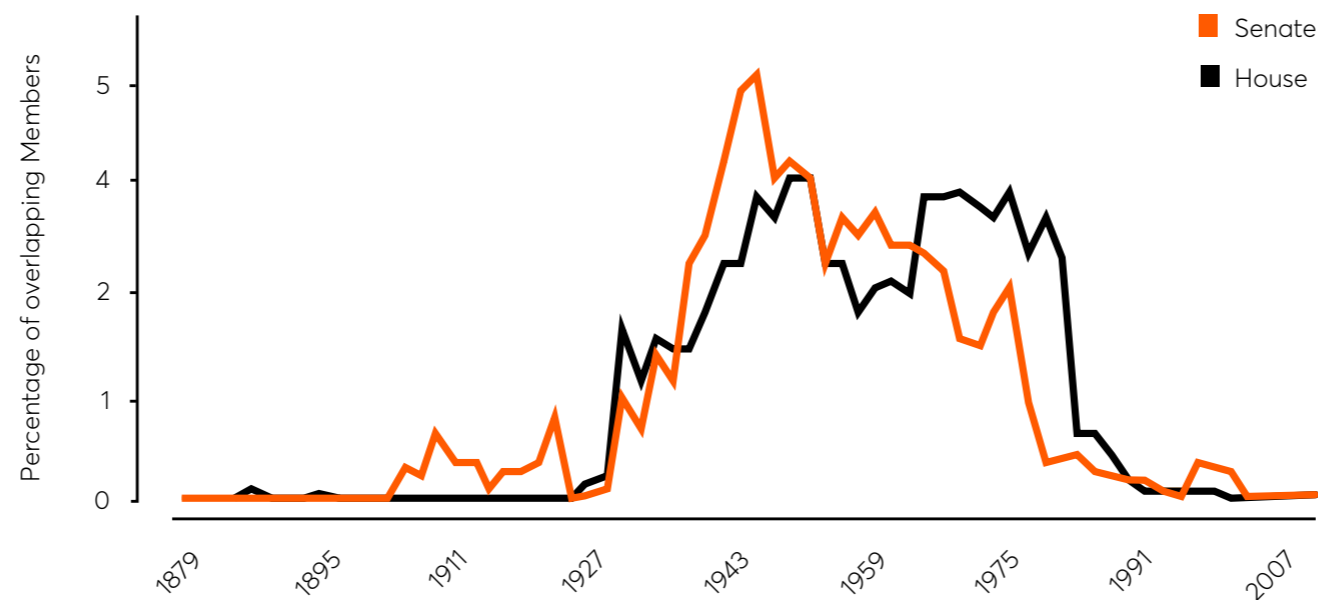
Drivers of policy uncertainty

Political institutions can drive policy uncertainty

In US, policy uncertainty can be traced to increasing political polarisation which creates gridlock and makes it difficult to respond to structural challenges.

Polarisation has been norm in Congress throughout most of American history; however, it has got worse owing to rising inequality, changes in electoral districting, campaign finance, media environment, geographic realignment, party competition and democratisation within parties (Barber and McCarty, 2015).

Percentage of overlapping members in the House of Congress and Senate (1879-2014)



Source — voteview.com, affiliated with the University of Georgia. Low numbers of moderates in Republican and Democratic party means there is no longer overlap between most liberal Republican and most conservative Democrat.

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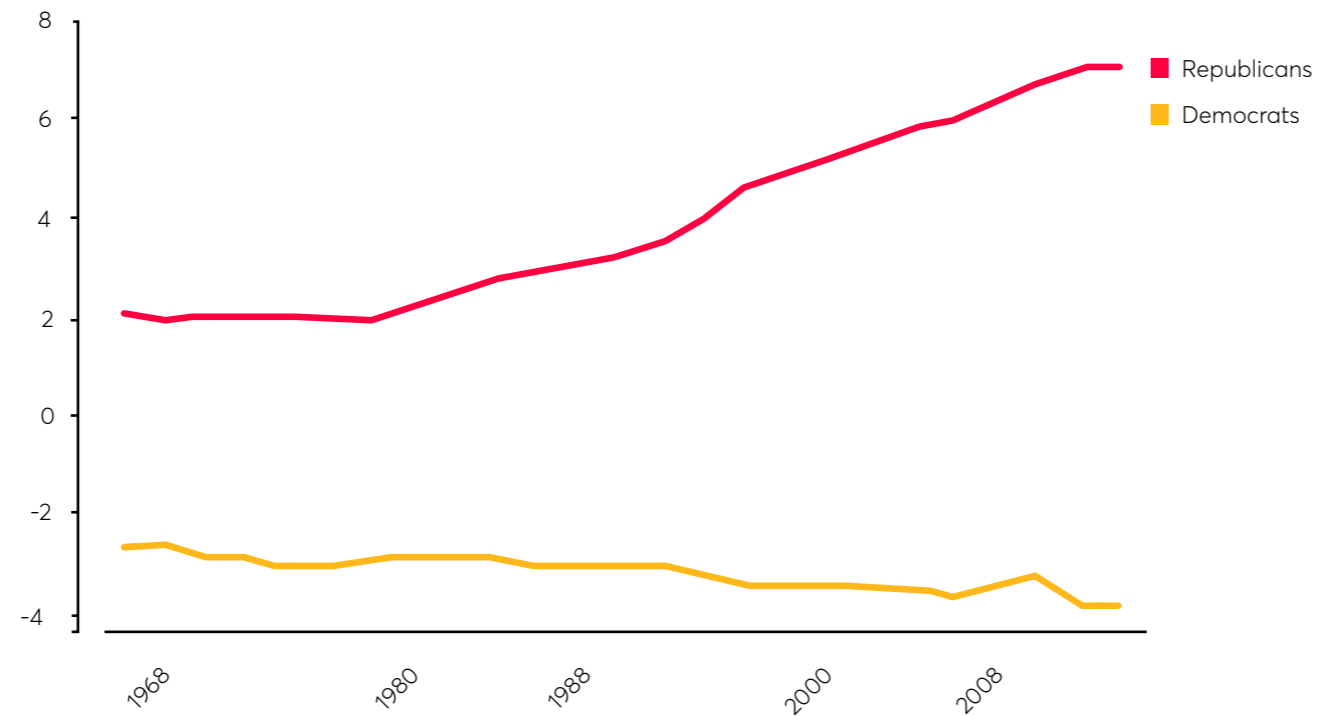
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Mean voting behaviour by party in the house



Source — voteview.com, affiliated with the University of Georgia
Nominate scores rank congressional representatives on a liberal-conservative scale according to their roll-call votes where 1.0 is a strong conservative position and -1 is a strong liberal position. Polarisation could become more extreme if Democrats begin to emulate the Republicans' retreat from centre.

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