THE LITTLE BOOK OF DATA

BOOK OF DATA

3

WAYS OF
SEEING

The Little Book of Data 3

Ways of seeing

December 2020

If ever there was a year for data visualisation, 2020 was it. The global coronavirus pandemic that cascaded its way through the interconnected global system, causing devastating loss of life and bringing countries to a standstill, made us all experts in exponential charts. Armchair statisticians popped up aplenty and reminded everyone of the importance of timely, accurate and transparent data.

First and foremost, COVID-19 is a global health crisis, but the importance of real-time data to understanding events and making informed decisions has perhaps never been so vital. Policymaking is reliant on the quality of information fed into decision-making and visualising it in a way that allows for effective understanding is essential. Investing is no different.

Another topic that rightly grabbed the public's attention this year was the Black Lives Matter movement, sparked by the tragic killing of George Floyd on May 25 in Minneapolis, Minnesota. It therefore seems fitting that this edition includes a chart by W. E. B. Du Bois, a sociologist, historian and human rights activist, who was an early pioneer of data visualisation. His exhibit at the Exposition Universelle in Paris in 1900, which aimed to challenge the racist caricatures and stereotypes of the day, contained many creative charts, graphs and maps.

We do not have space to cover every corner of the globe or every important story that unfolded in 2020. Instead, as with previous editions of the Little Book of Data, we try to lay out insightful and provocative charts and data visualisations that will get you thinking about the world and where we are headed. Our investment philosophy is grounded in the humility that comes with understanding the limits to knowledge and the endless quest to conquer it. This year's book marks another part of that journey.

Enjoy.

Euan Munro
CEO, Aviva Investors
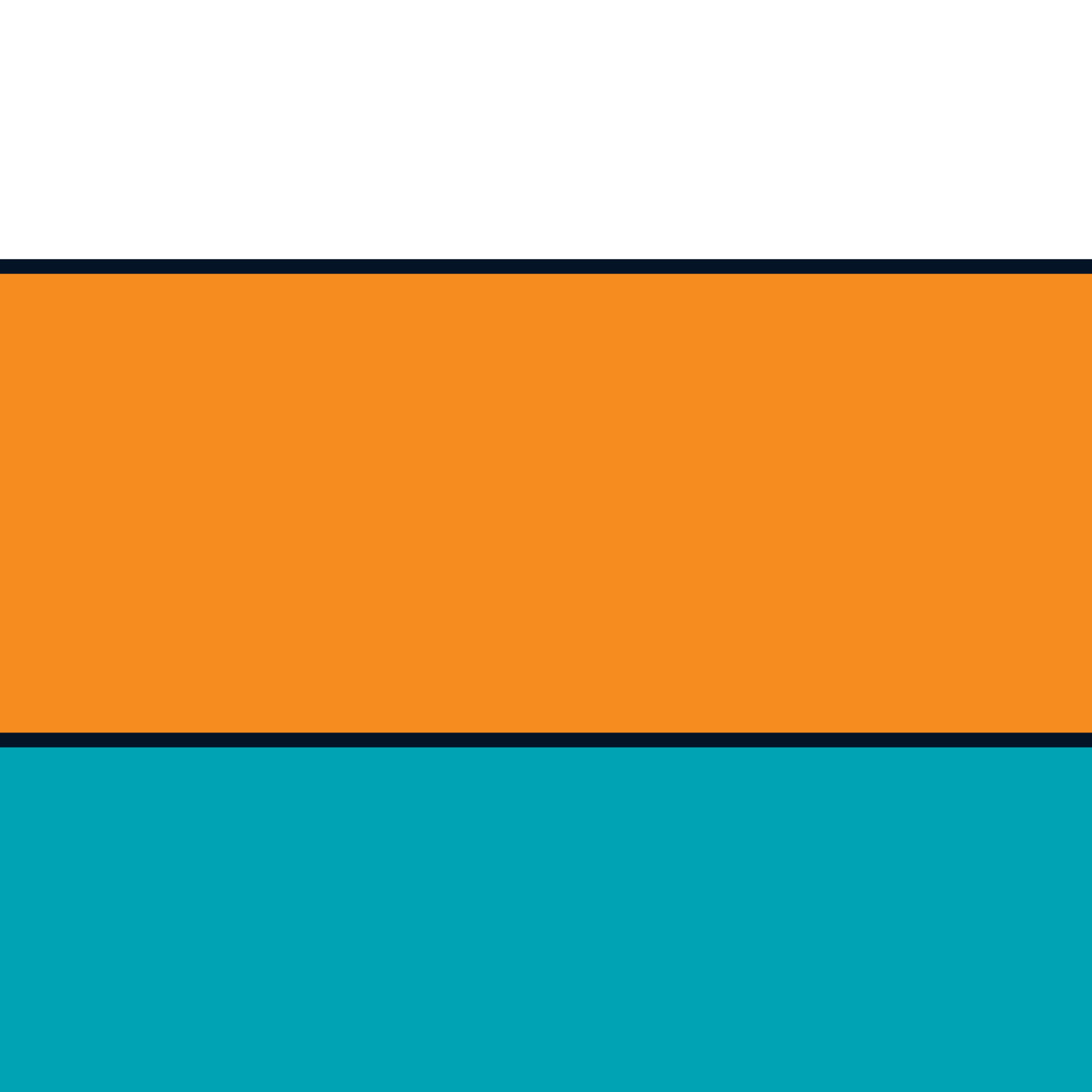
CONTENTS
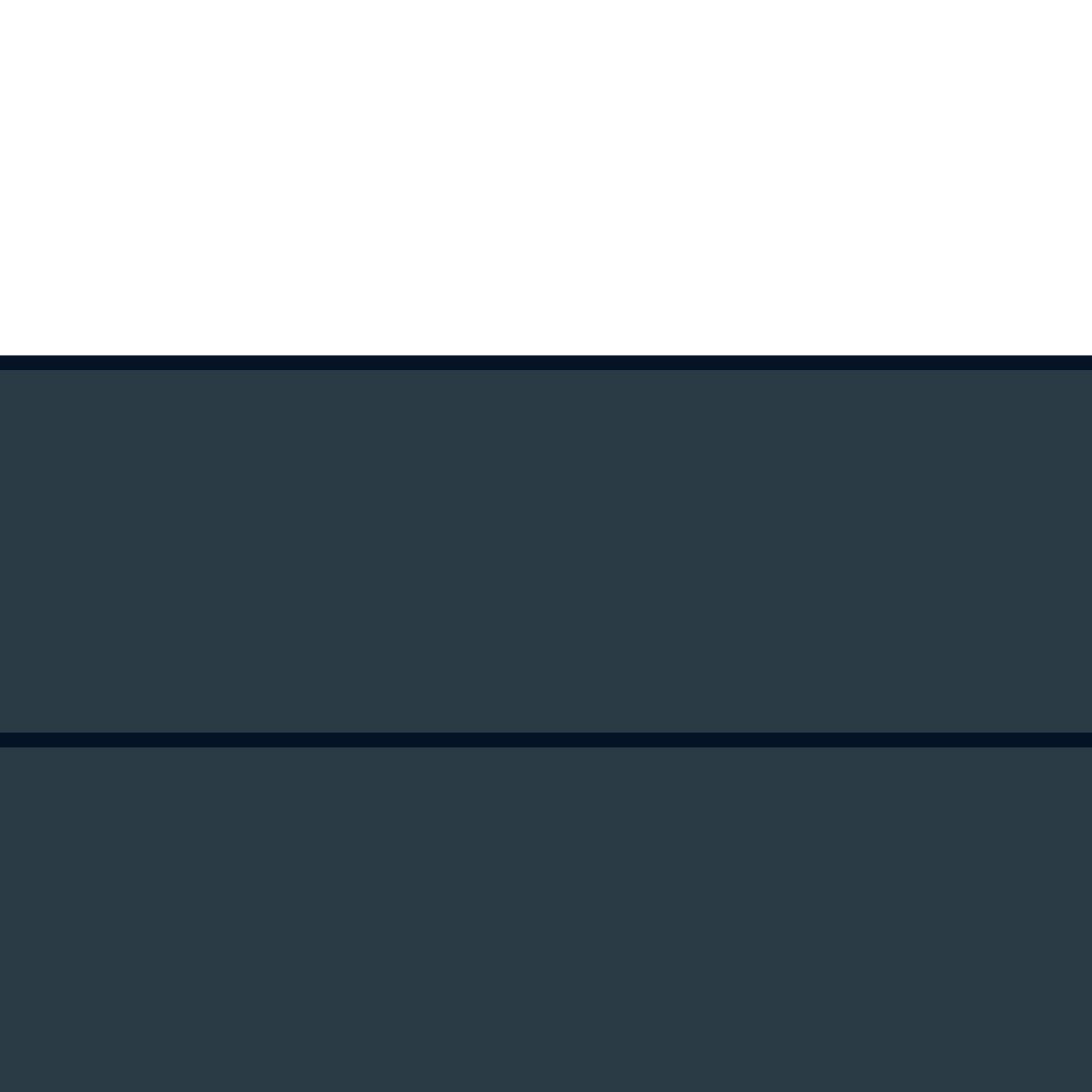
The bigger picture

Major macro trends and key developments taking place across the globe.

A visual history of pandemics

Why did the coronavirus surprise us?

Densely clustered populations pressing into new habitats, closely connected by fast transport links, increase the risk of new infections emerging and spreading around the world.

Epidemiologists know the pattern well. For centuries, different pathogens have emerged, disrupted society and unsettled their human hosts. In some cases, millions have died, and the details are etched in cultural history.

Year	100	200	400	500	600	700	1100	1200	1300	1400	1450	1500	1550

5m
Antonine Plague
165-180

30-50m
Plague of Justinian
541-542

1m
Japanese Smallpox Epidemic
735-737

200m
Black Death (Bubonic Plague)
1347-1351

56m
Smallpox
1520

1m
The Third Plague
1855

1m
Hong Kong Flu
1968-1970

200k
Swine Flu
2009-2010

1m
Russian Flu
1889-1890

770
SARS
2002-2003

11.3k
Ebola
2014-2016

1600	1650	**1700**	1750	**1800**	1825	1850	**1900**	1925	1950	1975	**2000**	2025					Year

100-150k
Yellow Fever
Late 1800s

1.1m
Asian Flu
1968-1970

850
MERS
2012-
present

3m
17th Century
Great Plagues
1600

600k
18th Century
Great Plagues
1700

1m
Cholera 6 Outbreak
1817-1923

40-50m
Spanish Flu
1918-1919

25-35m
HIV/AIDS
1981-present

1.2m
COVID-19
2019-ongoing
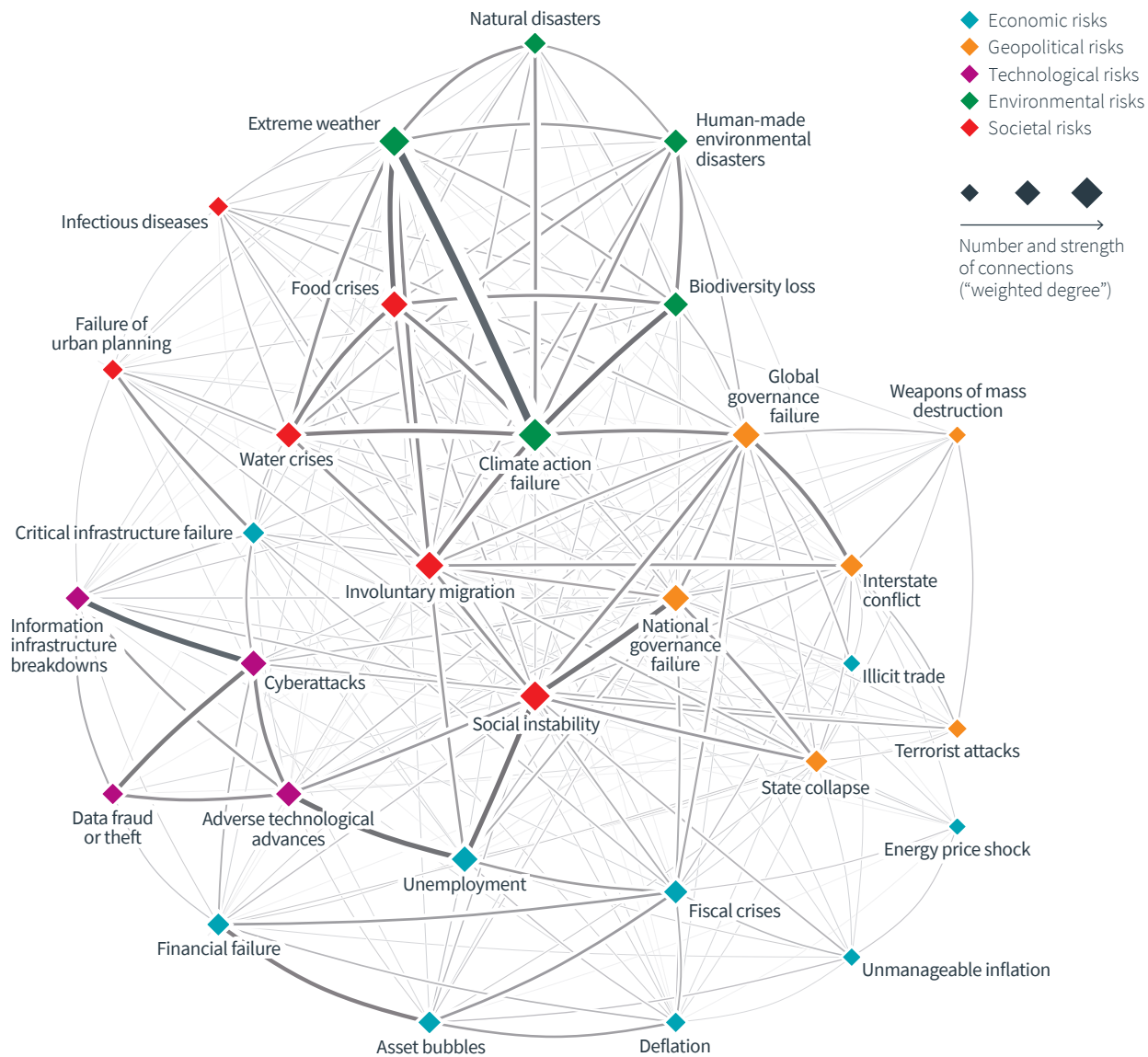(as of 31/10/20)

The bigger picture **9**

Under threat: The interconnectivity of the biggest global risks

With the world more connected than ever, the majority of key risks listed in the World Economic Forum's Global Risks 2020 report are interlinked. The materialisation of one risk could have unintended and unpredictable knock-on effects elsewhere.
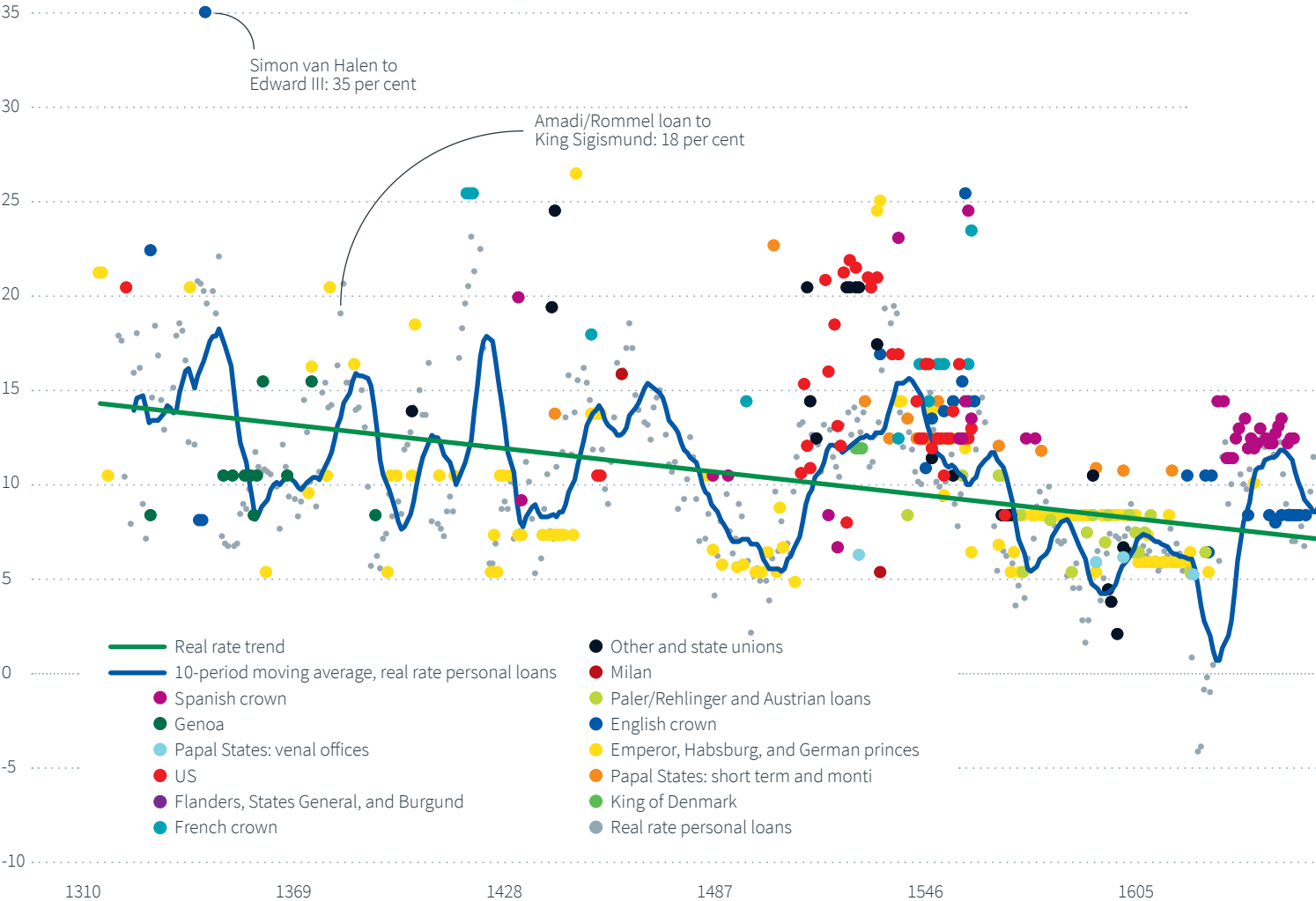
Although the top five risks in 2020 are environmental, they could lead to governance failures, food crises and involuntary migration, destabilising entire societies.

Natural disasters

Extreme weather

Human-made environmental disasters

Infectious diseases

Food crises

Biodiversity loss

Failure of urban planning

Global governance failure

Weapons of mass destruction

Water crises

Climate action failure

Critical infrastructure failure

Involuntary migration

National governance failure

Interstate conflict

Information infrastructure breakdowns

Cyberattacks

Social instability

Illicit trade

Terrorist attacks

Data fraud or theft

Adverse technological advances

State collapse

Energy price shock

Unemployment

Financial failure

Fiscal crises

Unmanageable inflation

Asset bubbles

Deflation

Economic risks
Geopolitical risks
Technological risks
Environmental risks
Societal risks

Number and strength of connections ("weighted degree")

Just when you think interest rates can't go lower

Nominal loan rates and resulting falling real rate trend over past 700 years

Per cent

Simon van Halen to
Edward III: 35 per cent

Amadi/Rommel loan to
King Sigismund: 18 per cent

Legend:
- Real rate trend
- 10-period moving average, real rate personal loans
- Spanish crown
- Genoa
- Papal States: venal offices
- US
- Flanders, States General, and Burgund
- French crown
- Other and state unions
- Milan
- Paler/Rehlinger and Austrian loans
- English crown
- Emperor, Habsburg, and German princes
- Papal States: short term and monti
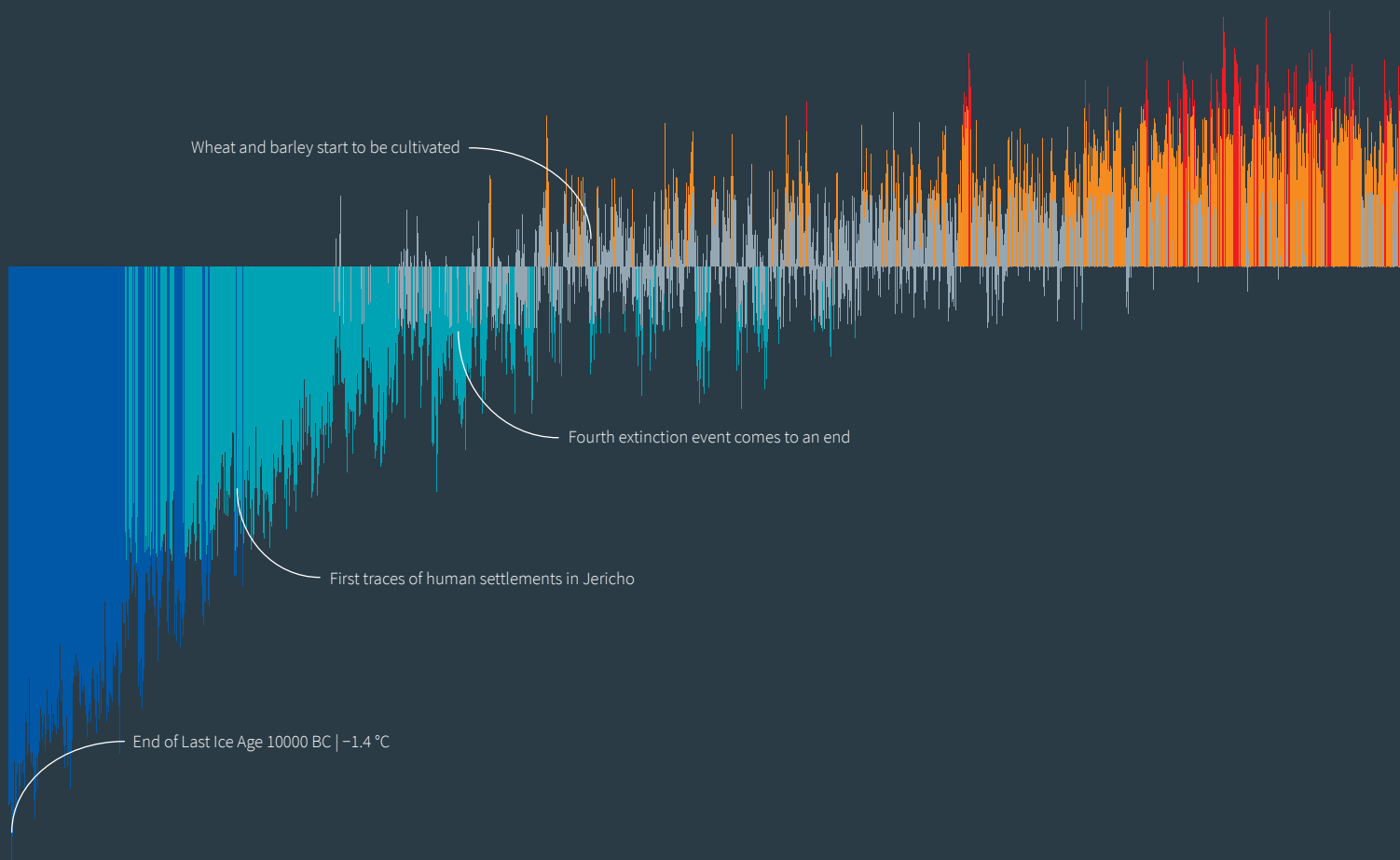- King of Denmark
- Real rate personal loans

Ever since then Federal Reserve chief Paul Volcker began taming inflation in the early 1980s, nominal and real interest rates have been in near uninterrupted decline across the developed world. That trend has helped fuel spectacular returns for investors in government bonds and, in turn, most other asset classes.
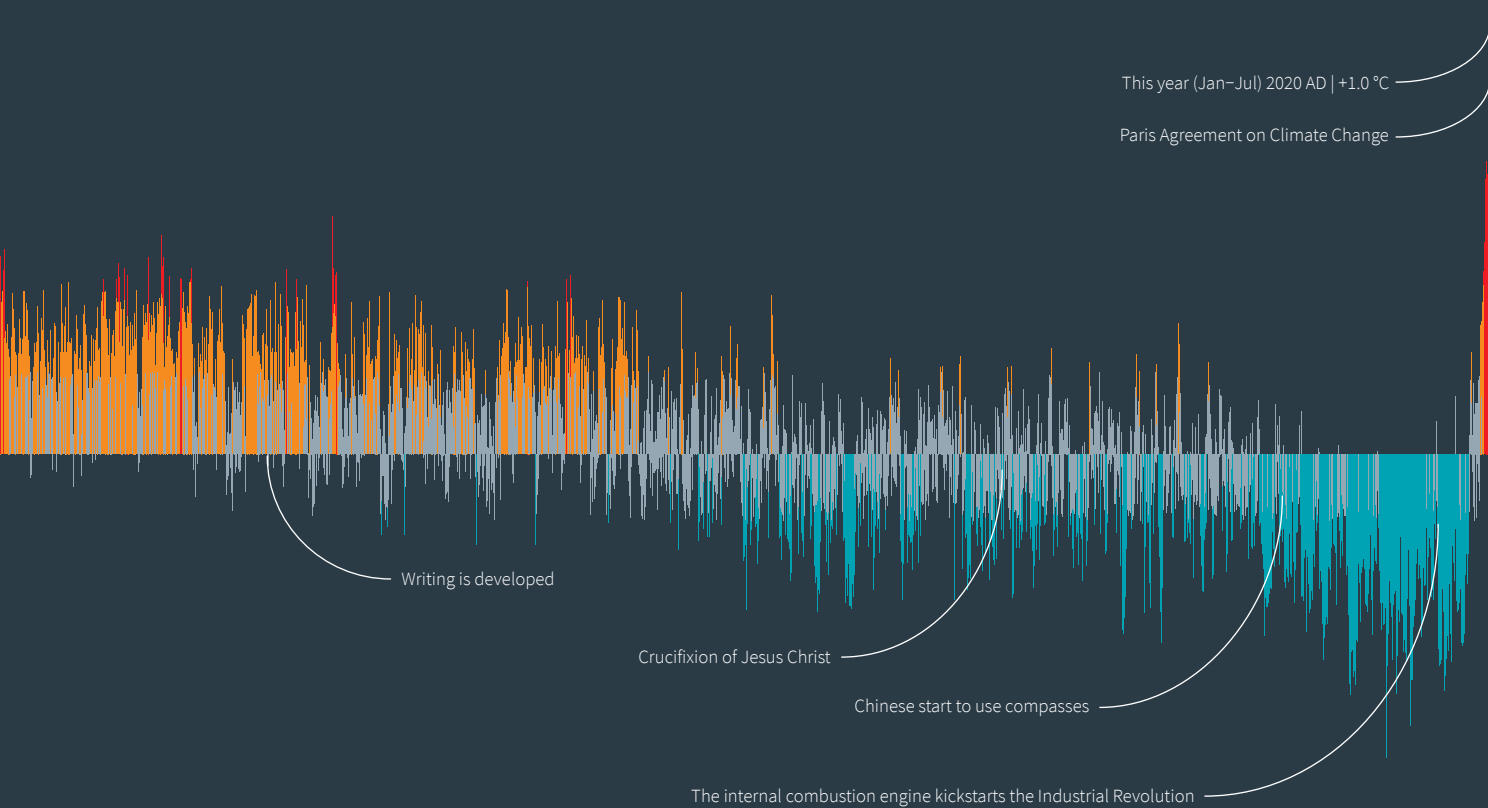
However, while there may seem little prospect of yields rising for the foreseeable future, the golden age for bonds is unlikely to to be repeated. That presents a big challenge for investors: how to secure satisfactory returns without loading up portfolios with excessive levels of risk.

Charles II Dunkirk sale and cash discount: 16 per cent

Rothschild loan to Beni dell Appannaggio (Papal Treasury): 6 per cent

Annual real rate trend: -1.96bps p.a.

2018 actual real: 0.51 per cent
Trend-implied: 0.19 per cent

US savings bonds, series EE

1664   1723   1782   1841   1900   1959   2018
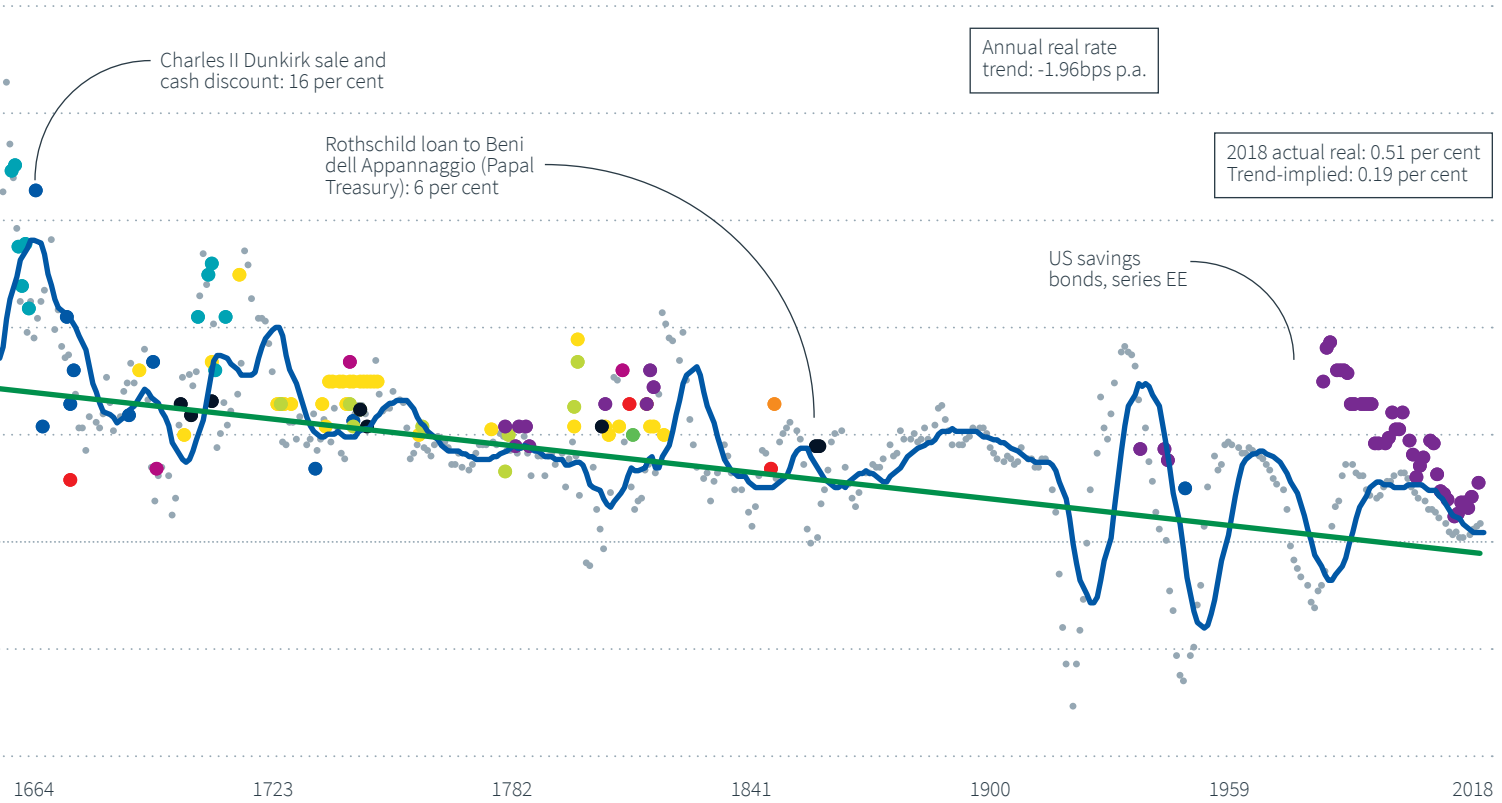
Boiling point: The last 12,000 years of global temperatures

In challenging the scientific evidence for human-driven global warming, climate deniers often cite fluctuations in temperatures that occurred before the advent of civilisation. It is true the planet has heated and cooled throughout history. But as this chart (showing the annual mean temperatures compared to the 20th Century average) starkly indicates, the sudden spike that has occurred over the past century is completely unprecedented.

Wheat and barley start to be cultivated

Fourth extinction event comes to an end

First traces of human settlements in Jericho

End of Last Ice Age 10000 BC | −1.4 °C

This year (Jan–Jul) 2020 AD | +1.0 °C

Paris Agreement on Climate Change

Writing is developed

Crucifixion of Jesus Christ

Chinese start to use compasses

The internal combustion engine kickstarts the Industrial Revolution

I spy: What Big Tech knows about you

In her recent book *The Age of Surveillance Capitalism*, the academic Shoshana Zuboff argues that we have entered a new phase of economic history, in which powerful companies' business models depend on gathering and monetising vast quantities of user data.

This graphic shows the types of information collected, as stated in privacy policies, by the "big five": Amazon, Apple, Facebook, Google and Microsoft. From our birthdays and credit card details to our political views and even the tone of our voices, these firms know more about us than we might like to think.

	Name	Gender	Birthday	Phone number	Email address	Location	Credit cards	IP addresses	Contacts
Microsoft	✓	✓	✓	✓	✓	✓	✓	✓	✓
Amazon	✓			✓	✓	✓	✓	✓	✓
Twitter				✓	✓	✓ (Only your time zone)	✓	✓ (Only the IP address used to open the Apple ID account)	✓ (After you've given Twitter permission)
Apple	✓			✓	✓	✓	✓	✓	✓
Facebook	✓	✓	✓	✓	✓	✓	✓ (If you've made purchases on Facebook)	✓	✓
Google	✓	✓	✓	✓	✓	✓	✓	✓	✓

	Chat messages	Calendar events	Search history	Likes	Purchase history	Photo uploads	Status updates/posts	Websites visited	Facial recognition data	Voice data	Political views
Microsoft	■	■	Bing	Bing	■		Bing		■		
Amazon	a	a	a	a	a	a	a	a		Amazon Alexa	
Twitter / Apple	Apple			Twitter	Apple	Twitter	Twitter				
Facebook	f	f	f	f		f	f		f		f
Google		Google Calendar	G			G		G			

Callouts:

Including a personal photograph in your profile

Including discussion boards, community features, and reviews

Only the metadata on when the text messages (in iMessage) were made

Only Apple device purchases and maintenance

Including both what you've joined and what you've been invited to

Including photo metadata

The POTUS effect
Stock market performance under recent US presidents

Dow Jones Industrial Average returns, rebased to zero from first month in office

— Donald Trump
— Barack Obama
— George W. Bush
— Bill Clinton

Per cent
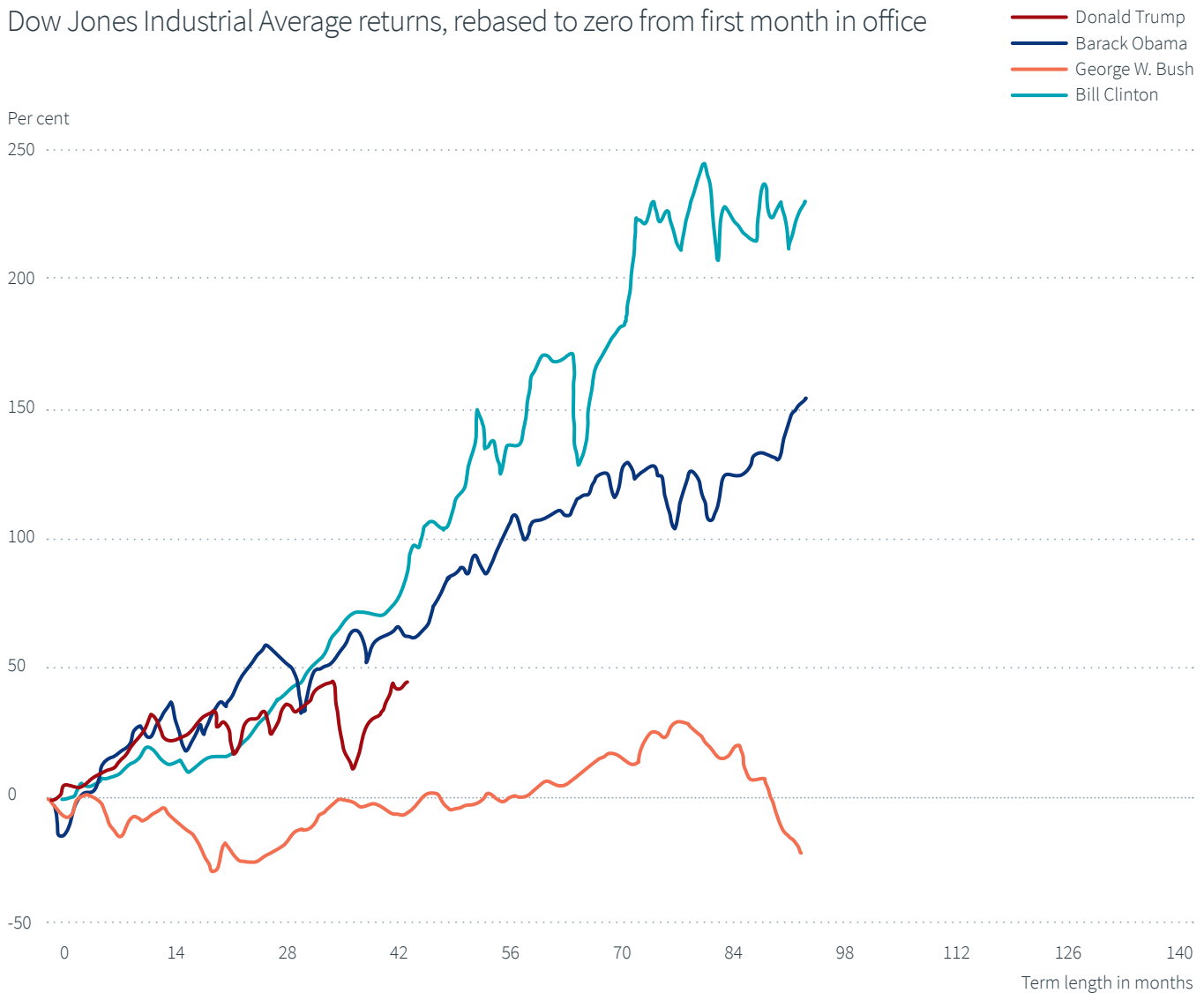
What moves a stock market is complex. It involves a range of financial factors, such as corporate earnings, and non-financial ones, such as climate change. President Trump, however, has 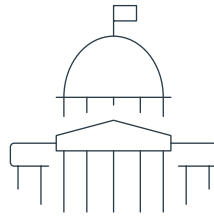often claimed personal credit for the rises, although some of his late night Twitter ramblings have been quickly followed by a fall. But how much of an impact do leaders really have on market valuations?

Despite his administration's many efforts to influence markets, Donald Trump still trails his predecessor Barack Obama, at least as measured by the performance of the Dow Jones Industrial Average. Maybe when it comes to markets, presidents have much less influence in the long term than investors believe in the short term. This belief was especially relevant during the 2020 US elections.

COVID-19

Despite the warnings, few saw it coming. We look at how communities, companies, industries and nations have fundamentally changed in its wake.

Pandemonium

How modern transport hastened the spread of COVID-19
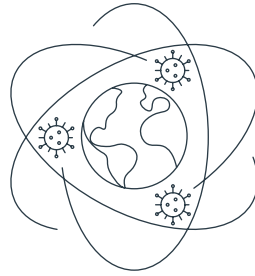
The rapid spread of coronavirus around the world in early 2020 illustrates the connectedness and complexity of the modern world.

We know COVID-19 first emerged in Wuhan in central China, but tracking its subsequent spread with any precision is almost impossible. This graphic shows the most likely routes of transmission, based on air connections to the Chinese city. Every circle represents an airport, and size correlates to traffic.

Seoul

Dubai

Frankfurt

Guangzhou

Chicago

Tokyo

Singapore

Beijing

Wuhan

Shanghai

London

Hong Kong

Paris

Atlanta

Los Angeles

Spreading routes for
COVID-19, based on
effective distance*
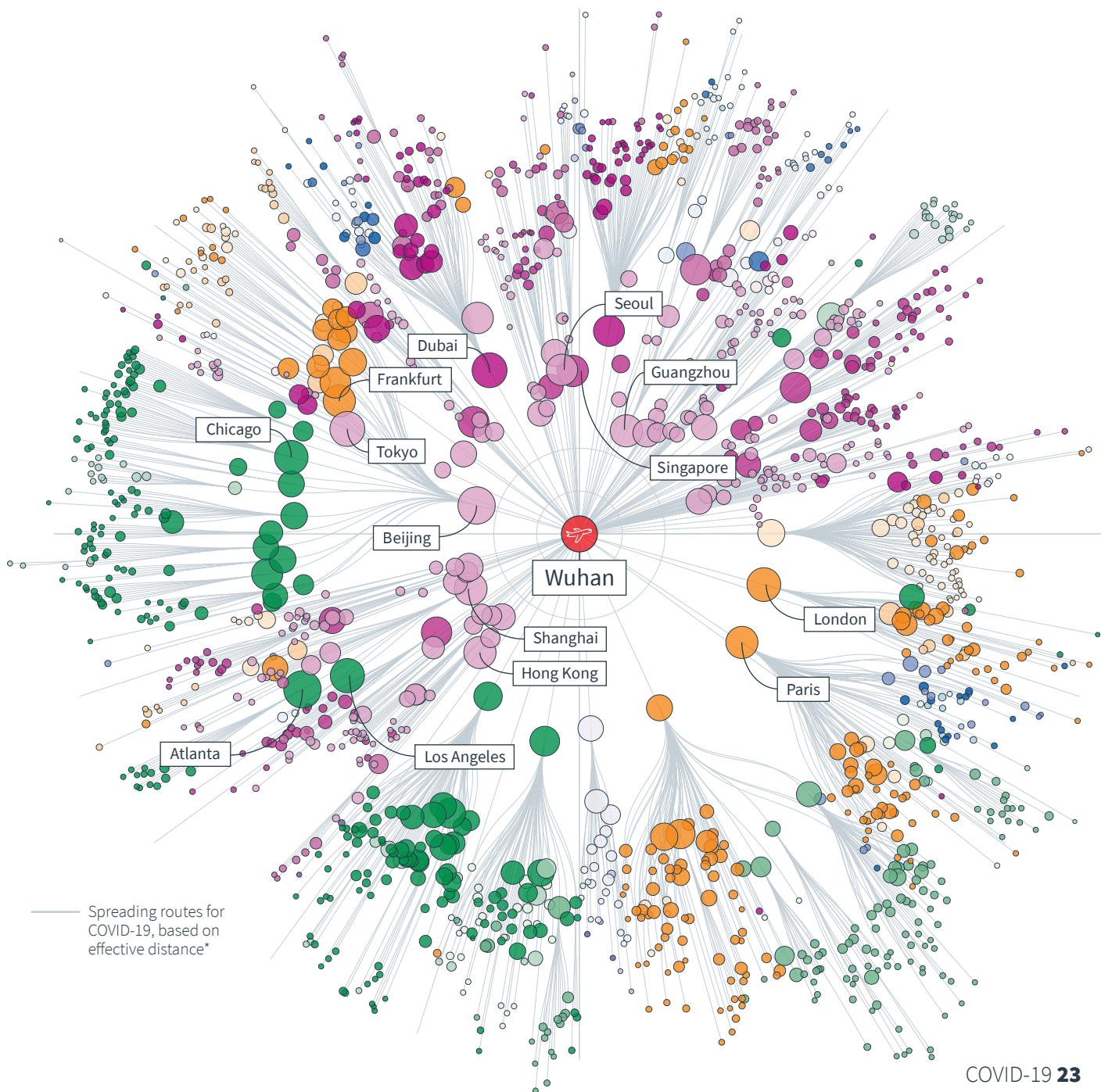
The lockdown trade-off: Public health versus the economy

Risk and cost versus benefits of re-opening businesses, by sector

Governments around the world have this year walked a fine line between protecting citizens and economic growth, with a key ingredient being when to impose and lift lockdown measures. For investors in real assets, such decisions are having significant ramifications for their portfolios.

In this chart, the benefits of returning to the normal place of work in various sectors are weighed against the risk of doing so. The more attractive risk-reward profile for sectors such as logistics, grocery stores and utilities is due to their higher likelihood of reopening first or remaining open during lockdowns. Retail and leisure businesses, in contrast, not only face prolonged revenue losses during a lockdown, but also higher risks to society upon reopening.

How much fiscal support is enough?

Pressure on governments in advanced countries to get finances under control suddenly evaporated with the pandemic. While policymakers no doubt felt they had little option but to respond in dramatic fashion, many commentators are wondering how such vast sums will ever be paid back and what the long-term impact on economic growth will be.

COVID-19 relief bills passed by US Congress as of June 2020

14%
Other

26%
Paycheck Protection Program (Small Business Administration)

6%
Coronavirus Relief Fund (Department of the Treasury)

9%
Public Health and Social Services (Department of Health and Human Services)

$2.6 trillion

11%
Internal Revenue Service's Economic Impact Payments (Department of the Treasury)

19%
Economic Stabilization and Assistance to Distressed Sectors (Department of the Treasury)

15%
Unemployment Insurance (Department of Labor)

Change in fiscal balance as a percentage of global GDP

- ● China
- ● Rest of world
- ● Euro area
- ● US
- ● Emerging markets

Per cent

↑ Expansions

World

↓ Contraction

2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0

2006 2008 2010 2012 2014 2016 2018 2020
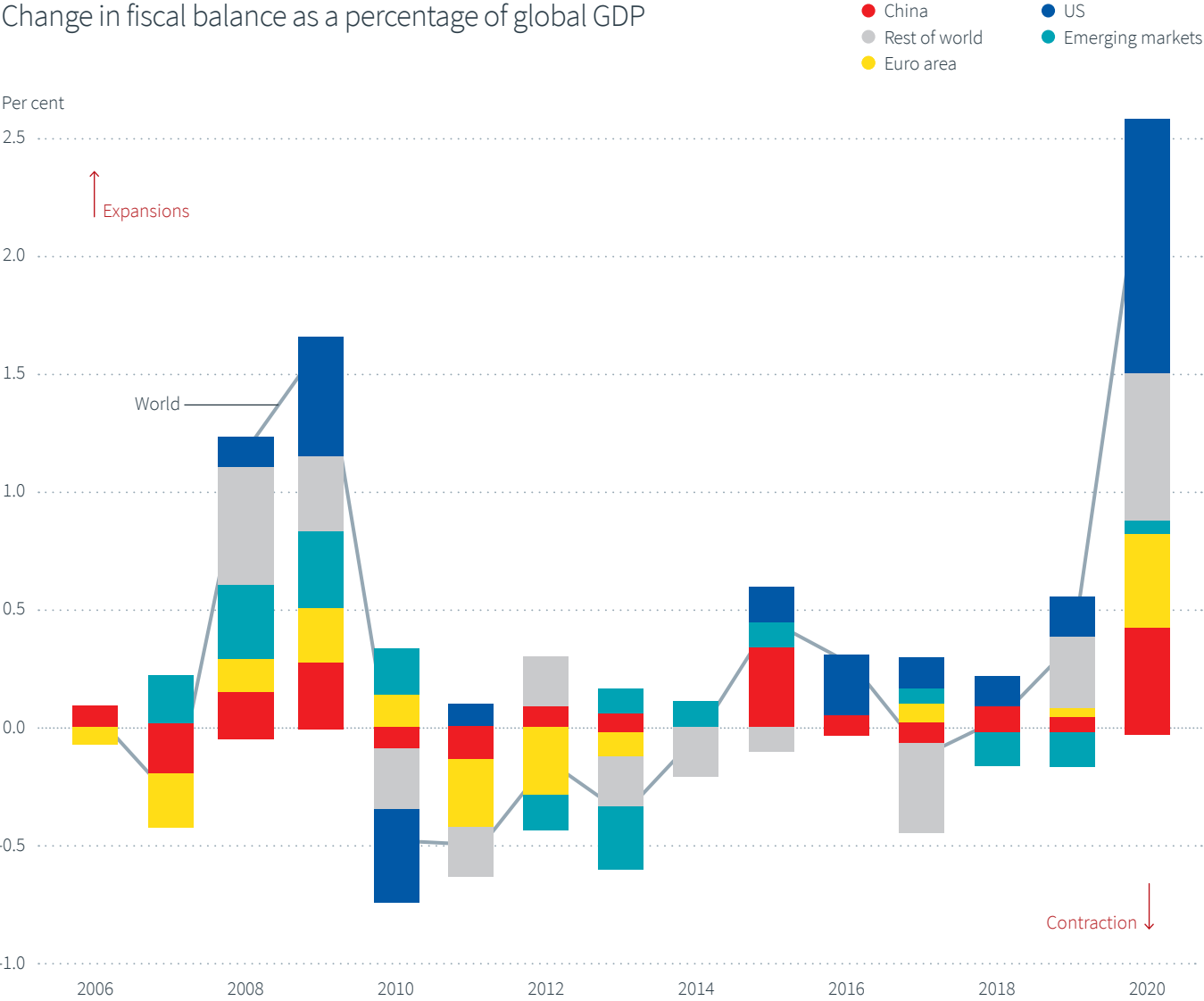
How have our spending habits changed?

What a difference a year makes. US retail research firm Stackline analysed online consumer trends in March 2020 compared to March 2019 and found consumer stockpiling of products including personal protection equipment (PPE), cleaning supplies and lockdown food staples accounted for the fastest sales increase.

Meanwhile, summer travel essentials such as luggage, swimwear and rash guards were among the worst-hit categories. Notably, bridal wear and men's formal wear also decreased as about 650,000 weddings were postponed in the US alone, as estimated by wedding planning app Bridebook.

The pandemic has tested markets, as well as relationships.

Fastest growing categories

- +99% Pain relief
- +159% Dog food
- +166% Vitamins
- +170% Fitness goods
- +190% Toilet paper
- +275% Dish washing supplies
- +279% Milk and cream
- +307% Weights
- +326% Fruit cups
- +377% Packed foods
- +386% Rice and dried grains
- +397% Soups
- +535% Cough medicine
- +652% Bread machines
- +670% Disposable gloves

Fastest declining categories

- -70% Luggage
- -70% Briefcases
- -64% Cameras
- -64% Men's swimwear
- -63% Bridal wear
- -62% Men's formal wear
- -59% Women's swimwear
- -59% Rash guards
- -59% Boy's athletic shoes
- -57% Gym bags
- -55% Party and event supplies
- -50% Store fixtures and displays
- -50% Drones
- -33% Golf clubs
- -30% Coolers

Trump versus coronavirus

Speed is critical in the response to COVID-19. Yet for many governments around the world, including the United States, delays to their response in the first three months of the COVID-19 outbreak were caused not by a lack of information, but how the information was either misinterpreted or, worse, played down.
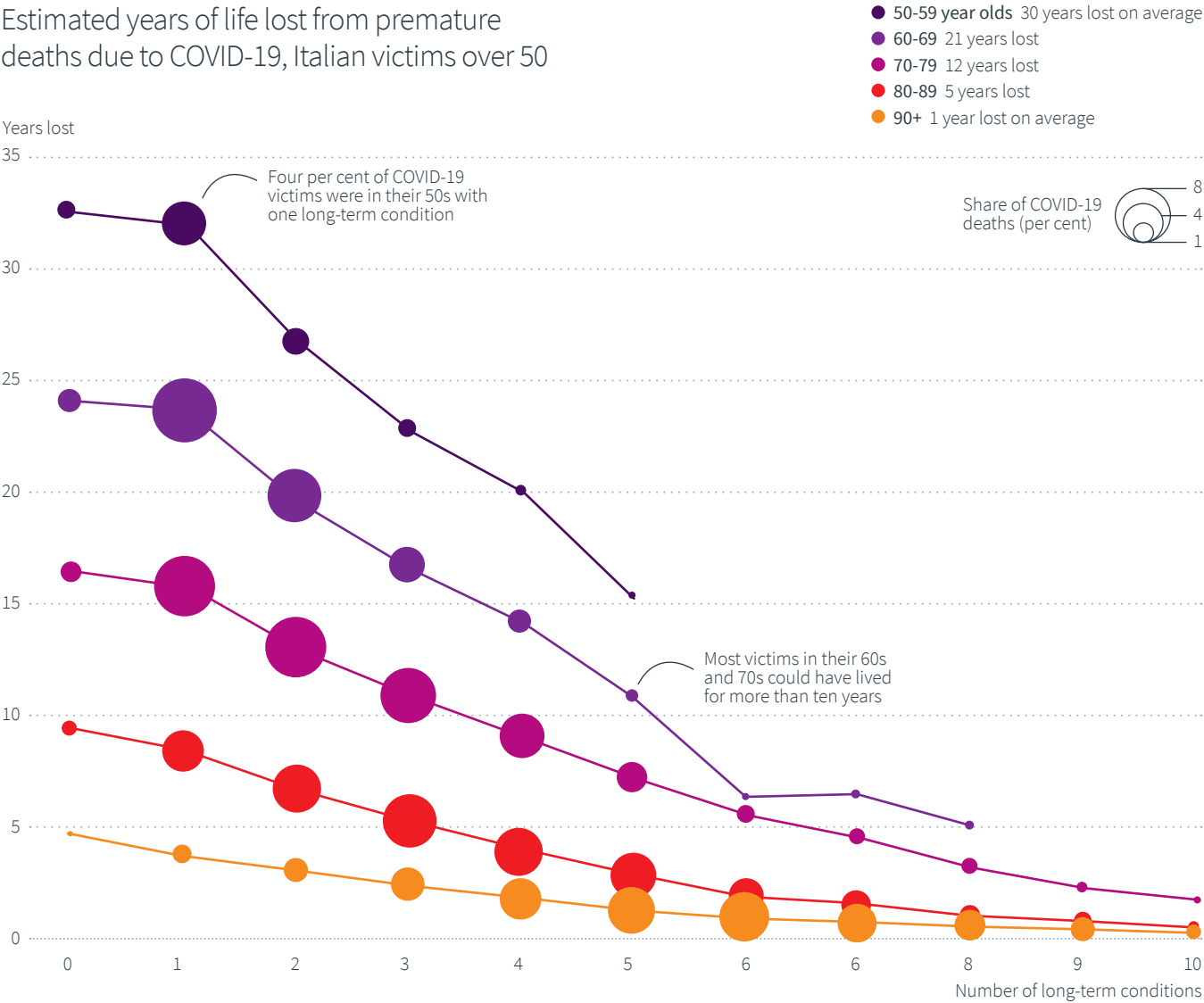
New reported cases

16,000 ···

"We pretty much shut it down coming from China. It's gonna be fine"

12,000 ···

"We have it totally under control"

8,000 ···

Wuhan lockdown

4,000 ···

China alerts WHO of unusual pneumonia cases in Wuhan

First US case is announced in Washington state

Trump restricts entry into US from China

0 ···

January 2020

February 2020

"The coronovirus is very much under control in the USA"

"It will go away. Just stay calm. It will go away"

"I've always known this is a real – this is a pandemic"

"CDC and my administration are doing a GREAT job at handling Coronavirus"

"We're going substantially down, not up!"

"Yeah, no, I don't take responsibility at all"

"Stock market starting to look very good to me!"

US declares national emergency

Stock market plummets, DJIA plunged by more than 1,000 points

First batch of CDC tests shown to be faulty

WHO declares COVID-19 as pandemic

● Events related to COVID-19

— Daily reported cases trend

March 2020

How many 'years' have we lost?

Estimated years of life lost from premature
deaths due to COVID-19, Italian victims over 50

● **50-59 year olds** 30 years lost on average
● **60-69** 21 years lost
● **70-79** 12 years lost
● **80-89** 5 years lost
● **90+** 1 year lost on average

Years lost

Four per cent of COVID-19
victims were in their 50s with
one long-term condition

Share of COVID-19
deaths (per cent)

Most victims in their 60s
and 70s could have lived
for more than ten years

Number of long-term conditions

The elderly and immune-compromised have been the most vulnerable in the coronavirus pandemic. But how much life has been lost?

One study by academics at Scottish universities combined mortality data with information on patients' underlying health and concluded that in Italy, one of the worst-hit countries initially, the average person who died of COVID-19 lost more than a decade.
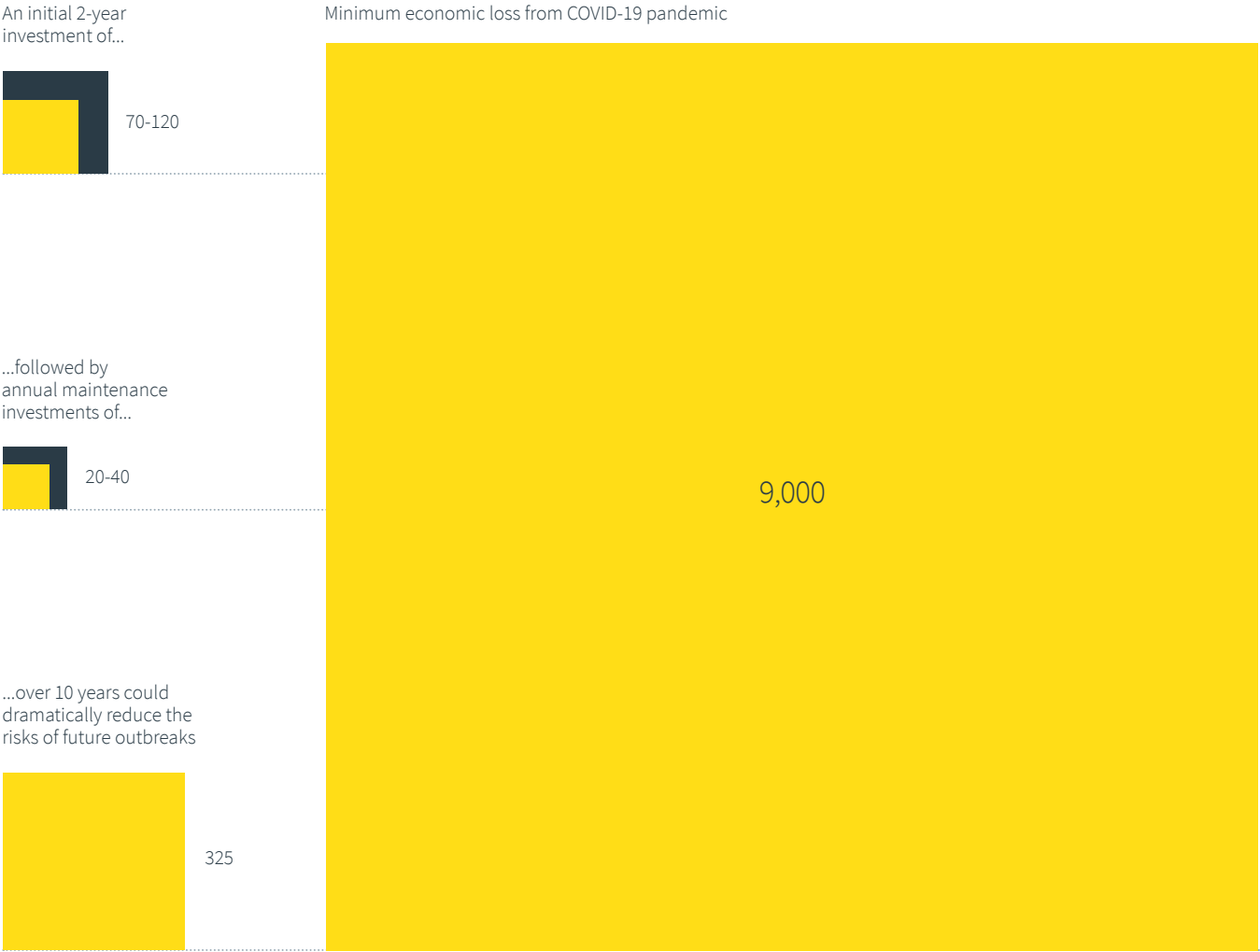
Will we be more prepared next time?

As Bill Gates said in a 2015 TED Talk, "We're not ready for the next epidemic. The greatest risk of global catastrophe looks [like a virus]. Not missiles, but microbes". Public health preparedness prior to COVID-19 was patchy at best worldwide, as shown in the left-hand chart.
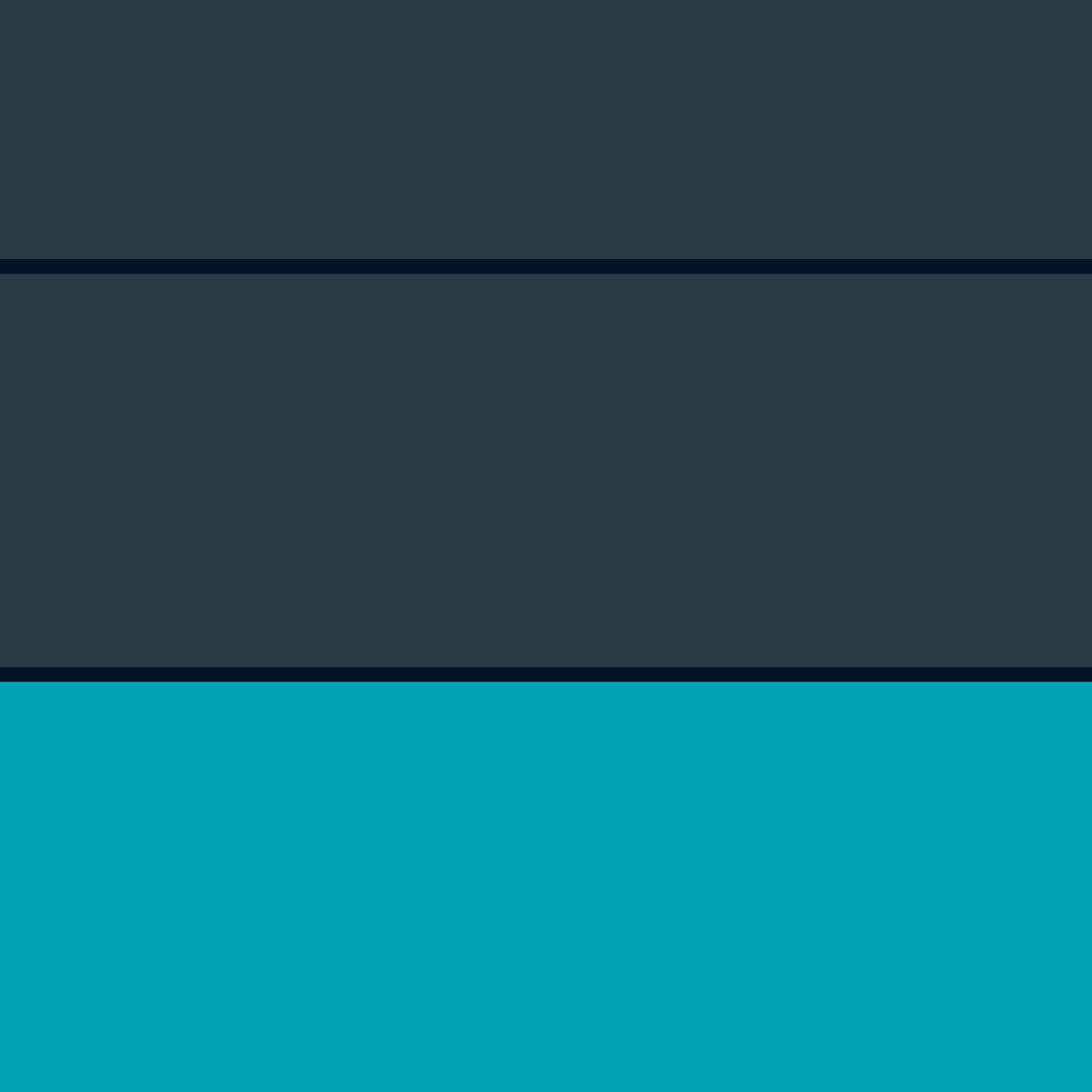
With the growing realisation that COVID-19 will not be the last pandemic, what can be done to prepare for the next global health crisis? In the right-hand chart, McKinsey suggests an adequate sum spent on prevention will likely pay off numerous times over in the future if we act now.

Health emergency preparedness capacity prior to COVID-19 (per cent)

WHO region

Africa

Americas

Eastern Mediterranean

Europe

Southeast Asia

Western Pacific

Global

0   10   20   30   40   50   60   70   80

Per cent
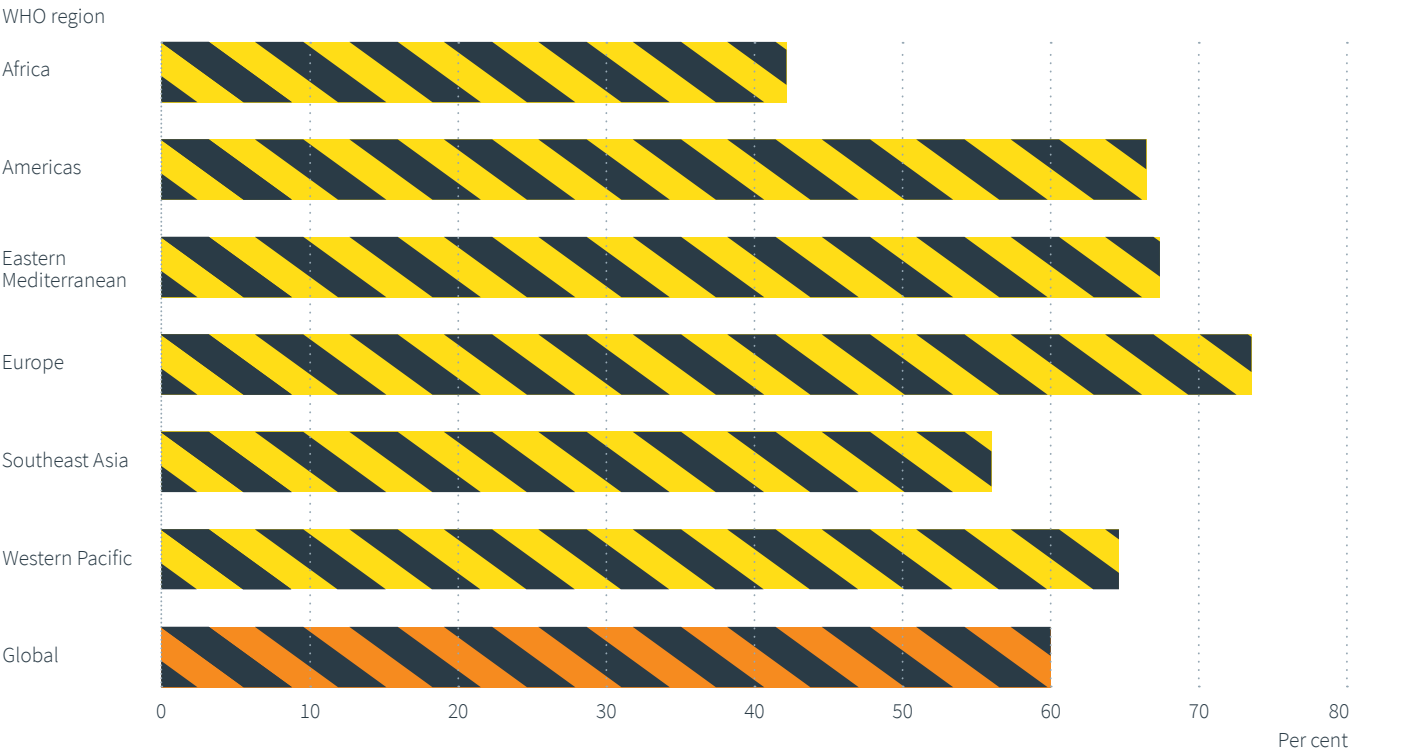
Estimated cost of preparing for future epidemics versus estimated economic loss from COVID-19 ($USbn)

An initial 2-year
investment of...

70-120

...followed by
annual maintenance
investments of...

20-40

...over 10 years could
dramatically reduce the
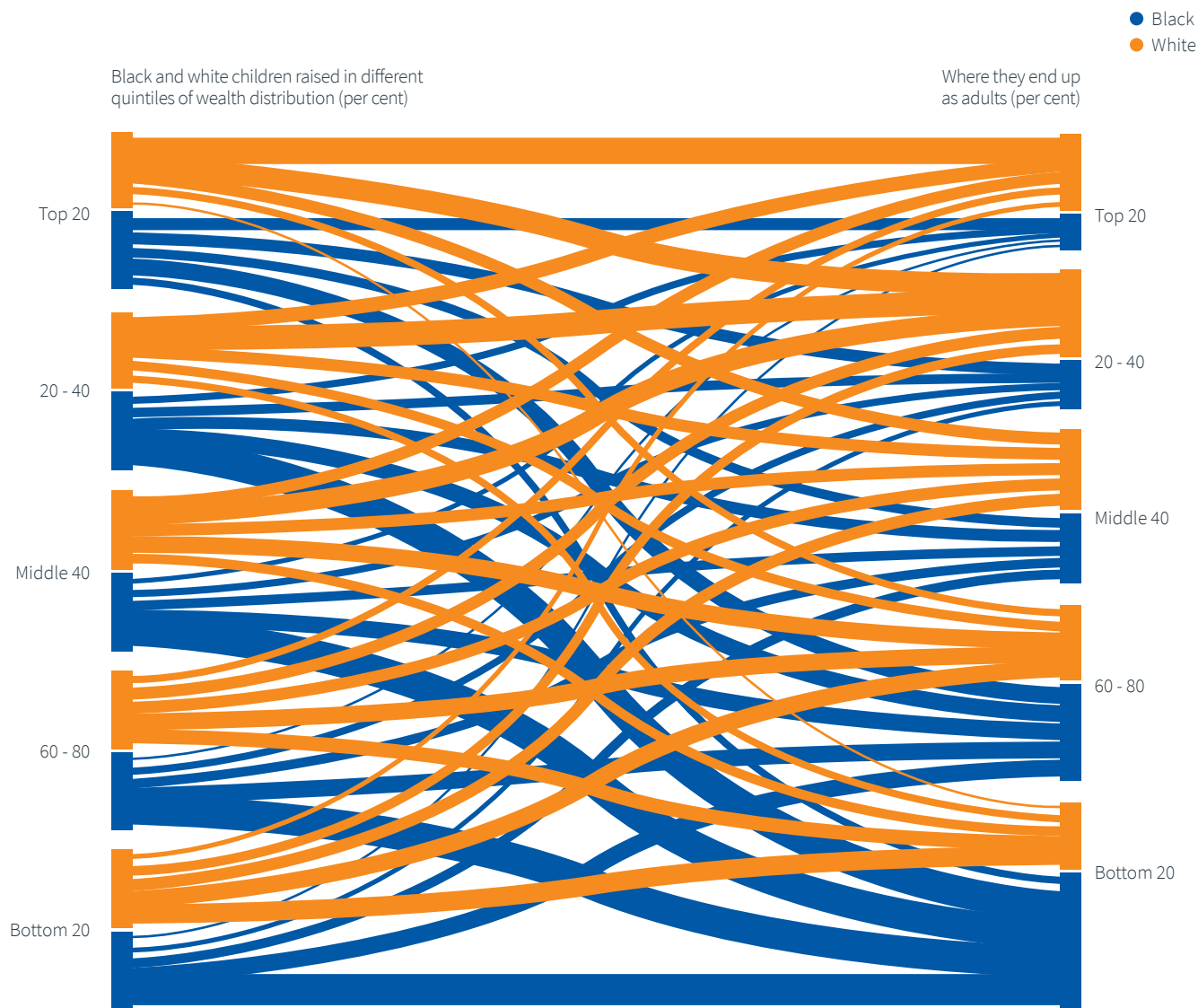risks of future outbreaks

325

Minimum economic loss from COVID-19 pandemic

9,000

Justice and inequality

Social challenges in place long before COVID-19 came home to roost during the pandemic.

Unequal opportunities

The heredity of the black-white wealth gap

Black and white children raised in different
quintiles of wealth distribution (per cent)

Where they end up
as adults (per cent)

● Black
● White

Top 20

20 - 40

Middle 40

60 - 80

Bottom 20

Top 20

20 - 40

Middle 40

60 - 80

Bottom 20

The wealth structure in the US is marked by large racial gaps, with the average black household holding less than one tenth the net worth of the average white household. The extent to which these gaps persist depends on how many children move up, down, or remain in the same wealth position as their parents.

Whatever their parents' wealth, black American children are more likely than white American children to fall below their parents' position. This reaffirms their disadvantage in attaining wealth.
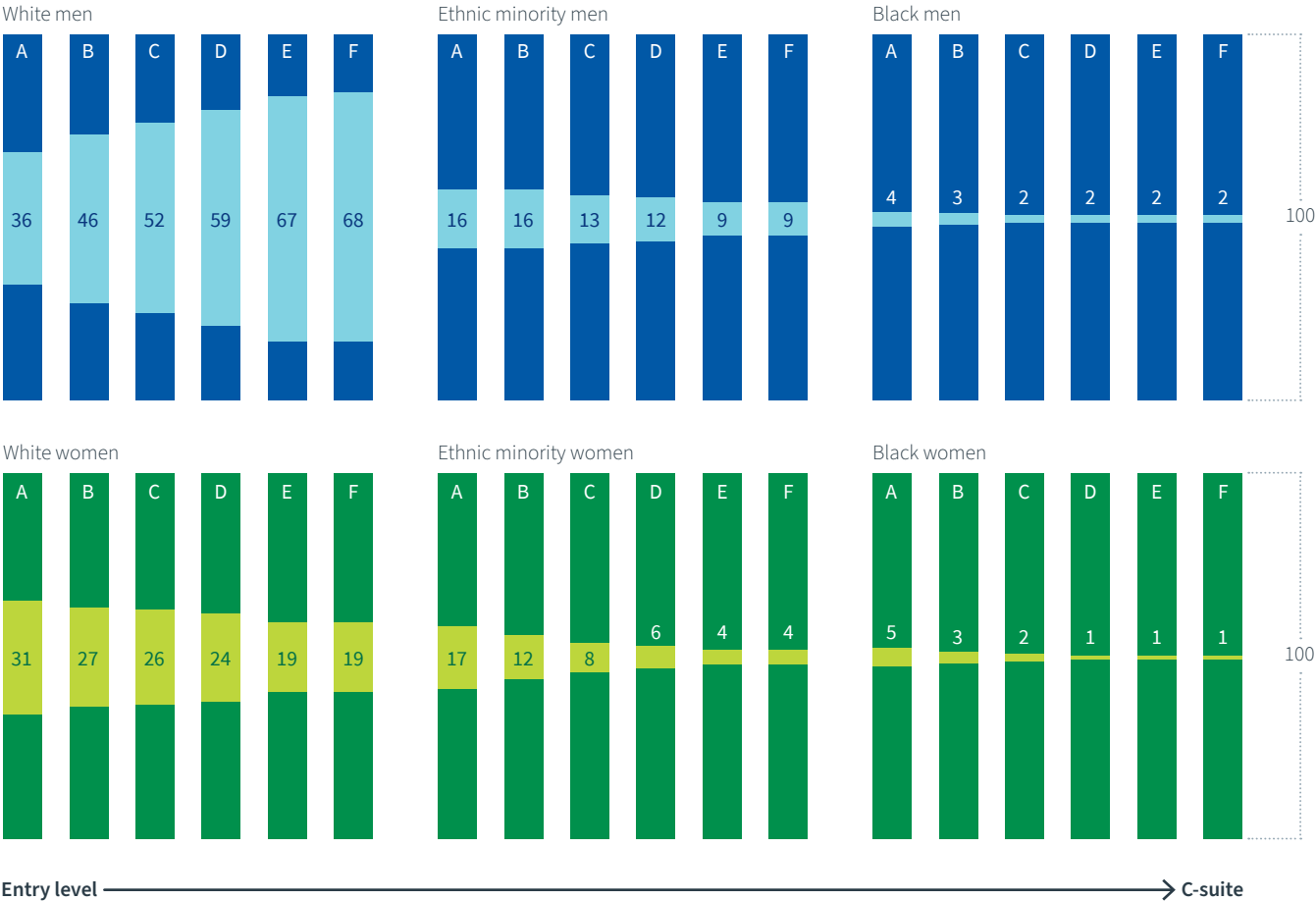
The colour ceiling
Racial barriers to career progression

In North America, black workers commonly experience lower rates of progression – and compensation – than white workers throughout their career.

This is true at each successive level of responsibility, so that by the time they get to the top, white men make up 68 per cent of the C-suite, up from 36 per cent of entry-level jobs.

Share of professionals by role category (per cent)

- ● Men
- ● Women

A Entry-level professional
B Manager
C Senior manager/director
D Vice president
E Senior vice president
F C-suite professional

White men

A	B	C	D	E	F
36	46	52	59	67	68

Ethnic minority men

A	B	C	D	E	F
16	16	13	12	9	9

Black men

A	B	C	D	E	F
4	3	2	2	2	2

100

White women

A	B	C	D	E	F
31	27	26	24	19	19

Ethnic minority women

A	B	C	D	E	F
17	12	8	6	4	4

Black women

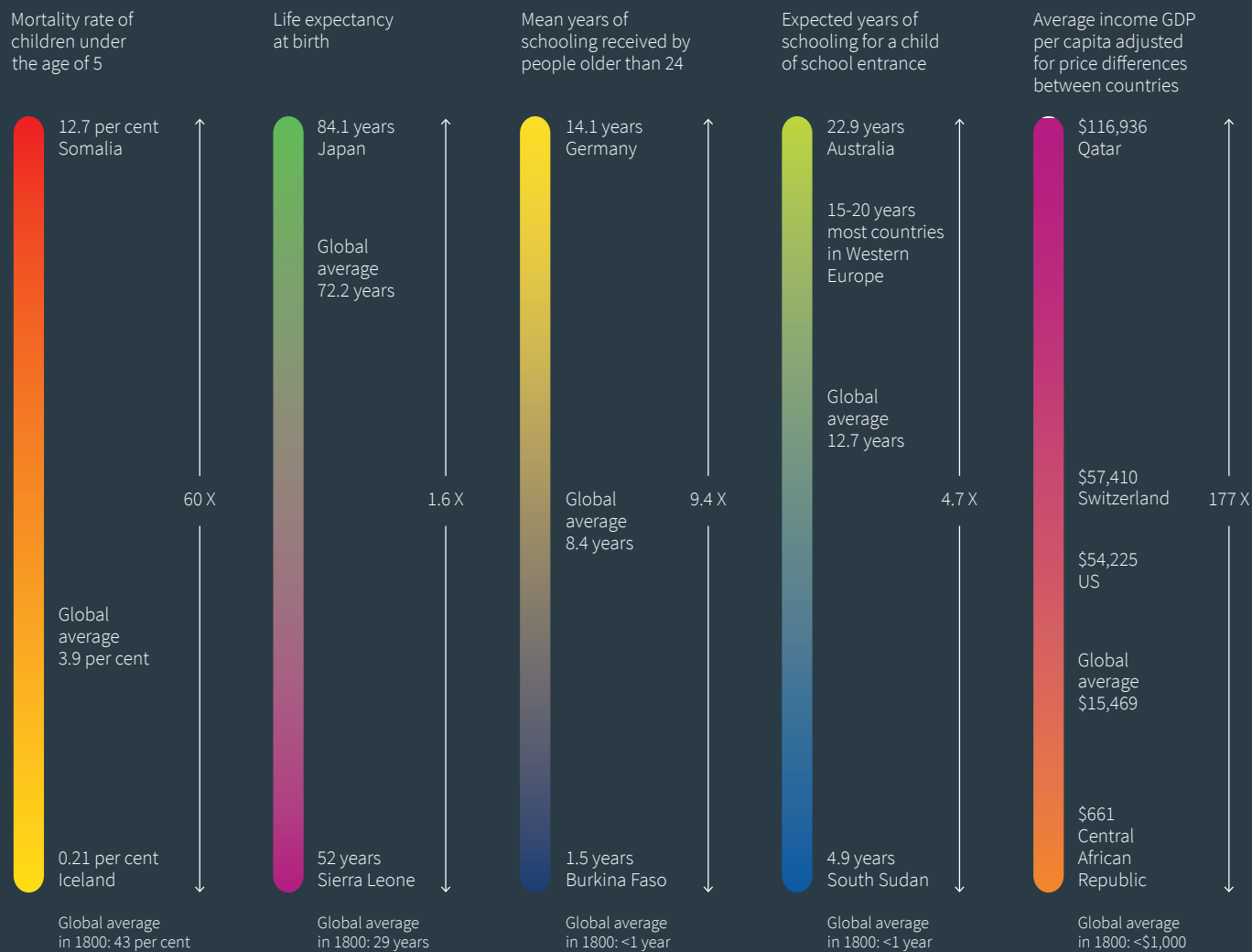| A	B	C	D	E	F
5	3	2	1	1	1

100

Entry level ⟶ **C-suite**

Destiny's child
How birthplace determines success in life

No-one has any say in where they are born. But when it comes to the factors that determine the quality of someone's living conditions, their place of birth isn't just more important than all their other characteristics; it's more important than all their other characteristics put together.

In a place where the average child can only expect five years of education, it will be incredibly hard for them to obtain the 15 or 20 years the average child gets in a rich country.

People's life chances increase when their whole country develops; so what was only attainable for the lucky few comes within reach for the majority.

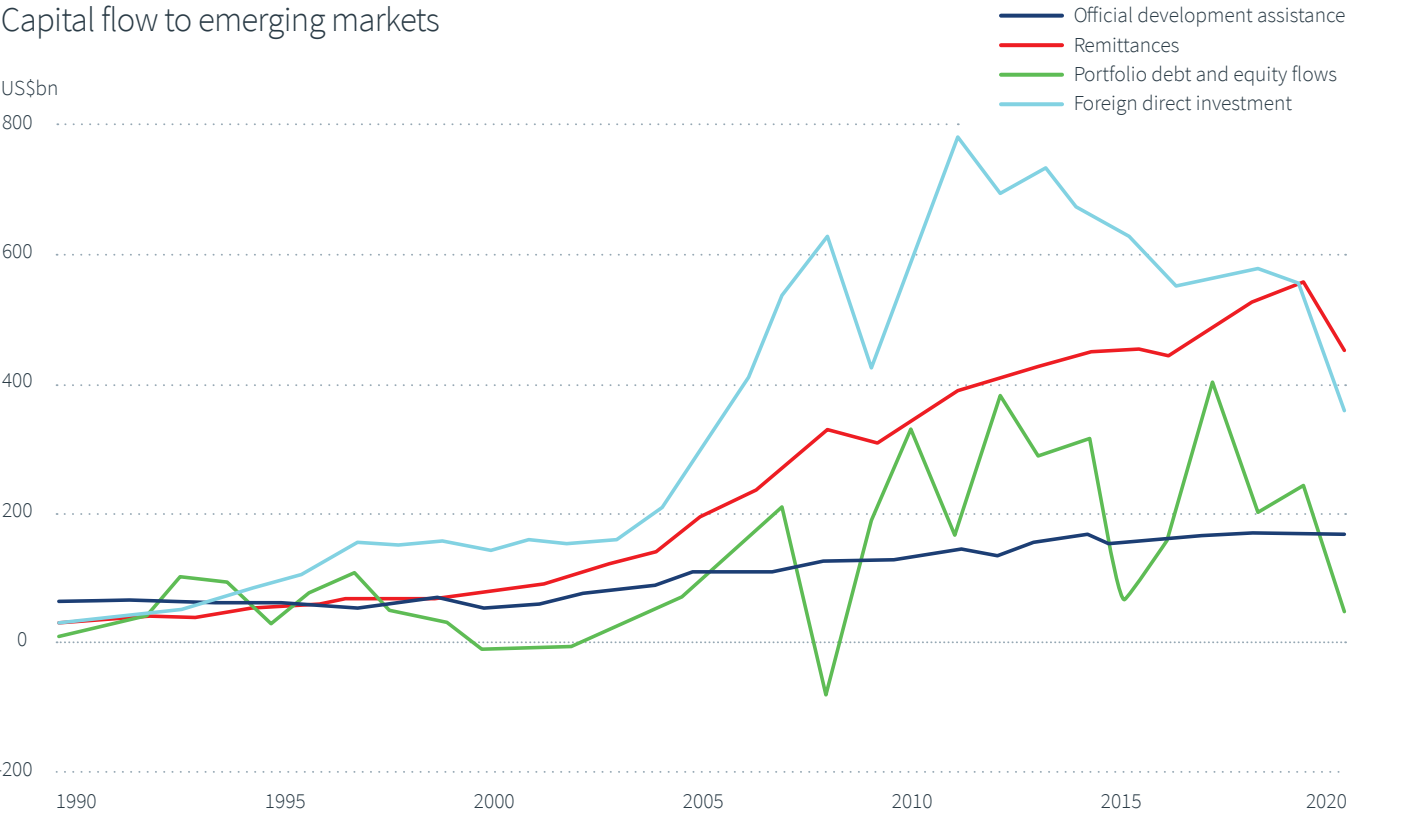# Living conditions between the world's worst-off and best-off countries

Mortality rate of children under the age of 5

12.7 per cent
Somalia

Global average
3.9 per cent

0.21 per cent
Iceland

Global average
in 1800: 43 per cent

60 X

Life expectancy at birth

84.1 years
Japan

Global average
72.2 years

52 years
Sierra Leone

Global average
in 1800: 29 years

1.6 X

Mean years of schooling received by people older than 24

14.1 years
Germany

Global average
8.4 years

1.5 years
Burkina Faso

Global average
in 1800: <1 year

9.4 X

Expected years of schooling for a child of school entrance

22.9 years
Australia

15-20 years
most countries
in Western
Europe

Global average
12.7 years

4.9 years
South Sudan

Global average
in 1800: <1 year

4.7 X

Average income GDP per capita adjusted for price differences between countries

$116,936
Qatar

$57,410
Switzerland

$54,225
US

Global average
$15,469

$661
Central African Republic

Global average
in 1800: <$1,000

177 X

Remittances: Trickle-down economics

Money sent home by migrant and guest workers is one of the most important sources of income in many emerging markets, surpassing foreign direct investments, debt and equity inflows, and foreign aid. The US is the world's top originator for remittances, with Mexico the largest recipient nation.

Generally, remittances are uncorrelated to specific country risks and therefore help cushion emerging nations against the impact of economic shocks. During the COVID-19 crisis, however, foreign direct investments, portfolio inflows and remittances all dried up at the same time, as shown in the chart below, adding pressure on organisations such as the International Monetary Fund to take up the slack.

Capital flow to emerging markets

US$bn

Legend:
- Official development assistance
- Remittances
- Portfolio debt and equity flows
- Foreign direct investment

Top ten remittance routes, by value (US$bn)

From		To
US **103**		**14**
United Arab Emirates **19**		**19** India
Hong Kong **15**		**13**
Saudi Arabia **13**		**37** Mexico
Russia **9**		**19** China
		15 Philippines
		14
		10 Guatemala
		9 Vietnam
		9 Ukraine

Power to the people
Social unrest spikes in the past decade

Across the world, anti-government demonstrations are increasing in frequency, scope and size. In 2019 alone, mass protests were reported across 114 countries, having risen annually by 11.5 per cent between 2009 and 2019, according to the Center for Strategic and International Studies.

In the US, millions marched against police brutality following the tragic deaths of black Americans, most notably George Floyd, Breonna Taylor and Ahmaud Arbery. Uprisings in Belarus called for the removal from office of President Alexander Lukashenko. Meanwhile, students in Hong Kong resumed fresh rounds of demonstrations against policies imposed by the People's Republic of China. While the protests differ in context, they shared a common theme of a deteriorating relationship between governments and their citizens.

Percentage change in quarterly civilian anti-government protests, by region

Legend:
- Middle East and North Africa
- Asia
- North America
- Sub-Saharan Africa
- Europe
- Rest of world

Per cent

800

600

400

200

0

Start of Arab Spring

Occupy Wall Street

Ukranian revolution

Anti-Trump protests

Mass protests in 37 countries

2009   2011   2013   2015   2017   2019
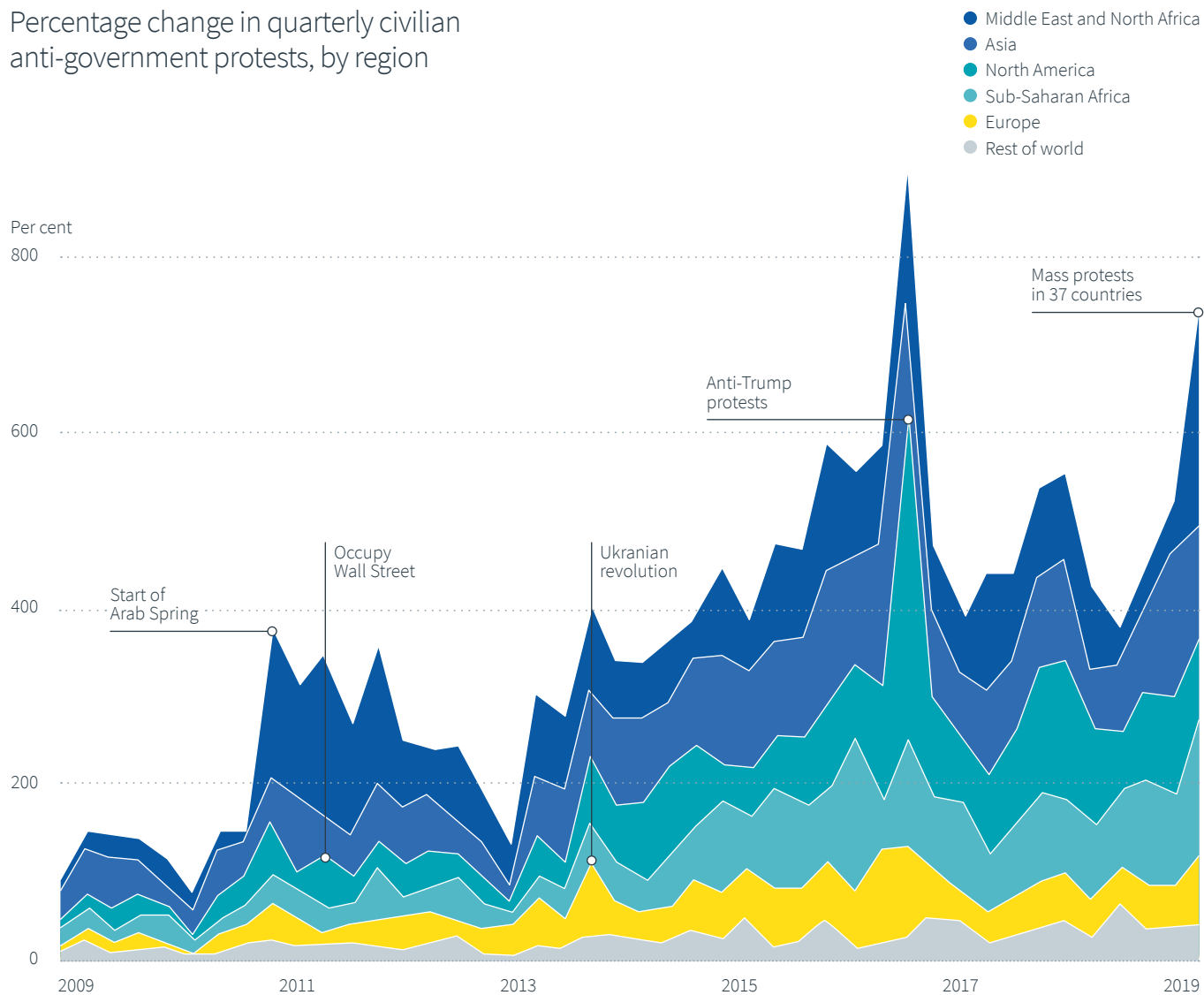
Social purpose: Putting your money where your mouth is

In August 2019, in a new 'Statement on the Purpose of a Corporation', 181 CEOs from many of America's largest companies committed to "lead their companies for the benefit of all stakeholders – customers, employees, suppliers, communities and shareholders".

Yet companies have been steadily reducing their fiscal contributions for years. Global value chains and the rise of the digital economy mean firms can easily shift production to lower-tax jurisdictions, pushing countries to compete by lowering tax rates and granting incentives.

This raises a serious question: are corporations that shy away from paying their taxes really the "upstanding citizens" they claim to be?

Corporate income tax rates, G-7 countries, 2012 and 2018

● 2012
● 2018

Per cent

[Bar chart showing corporate income tax rates by country. Y-axis ranges from 0 to 40 per cent. For each country, green bars represent 2012 and blue bars represent 2018:
- *Japan: 2012 ≈ 39.5, 2018 ≈ 29.5*
- *US: 2012 ≈ 39, 2018 ≈ 25.5*
- *France: 2012 ≈ 36, 2018 ≈ 25*
- *Germany: 2012 ≈ 30, 2018 ≈ 29.5*
- *Italy: 2012 ≈ 27.5, 2018 ≈ 24*
- *Canada: 2012 ≈ 26, 2018 ≈ 26.5*
- *United Kingdom: 2012 ≈ 24, 2018 ≈ 19]*
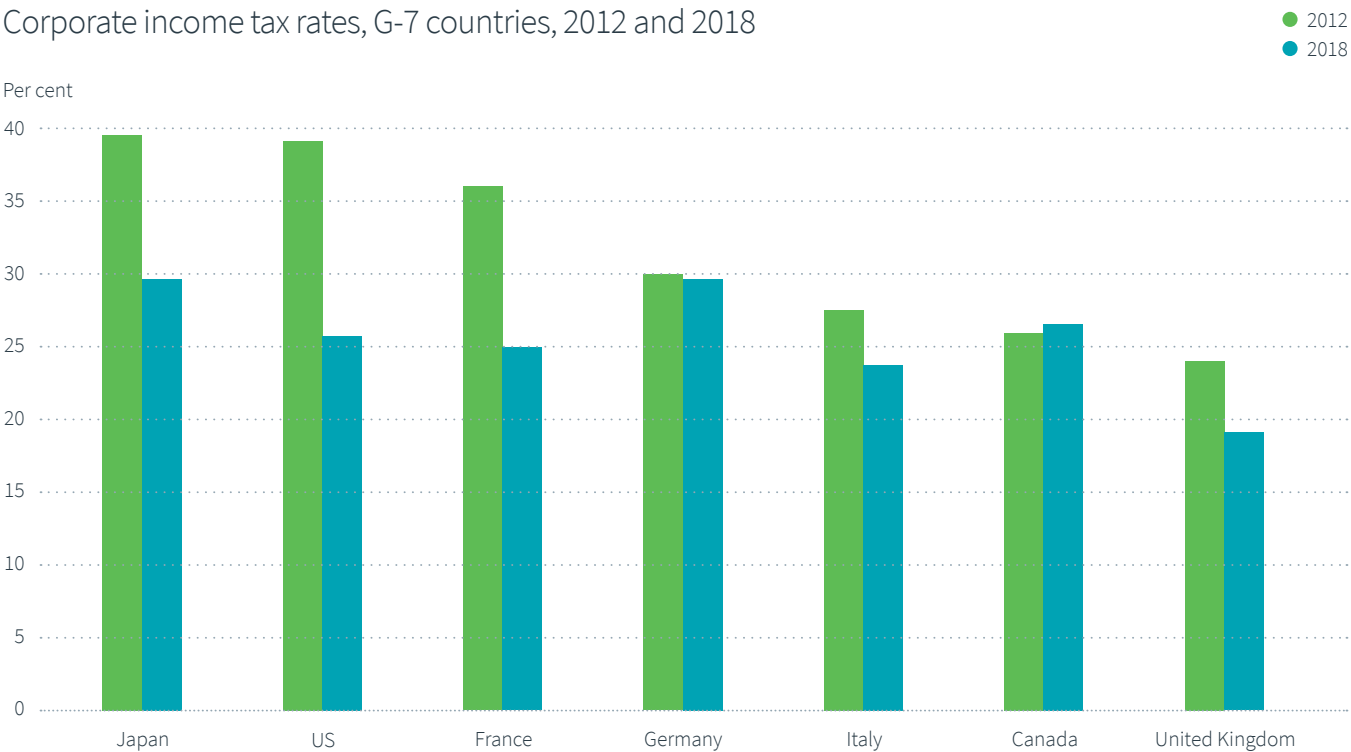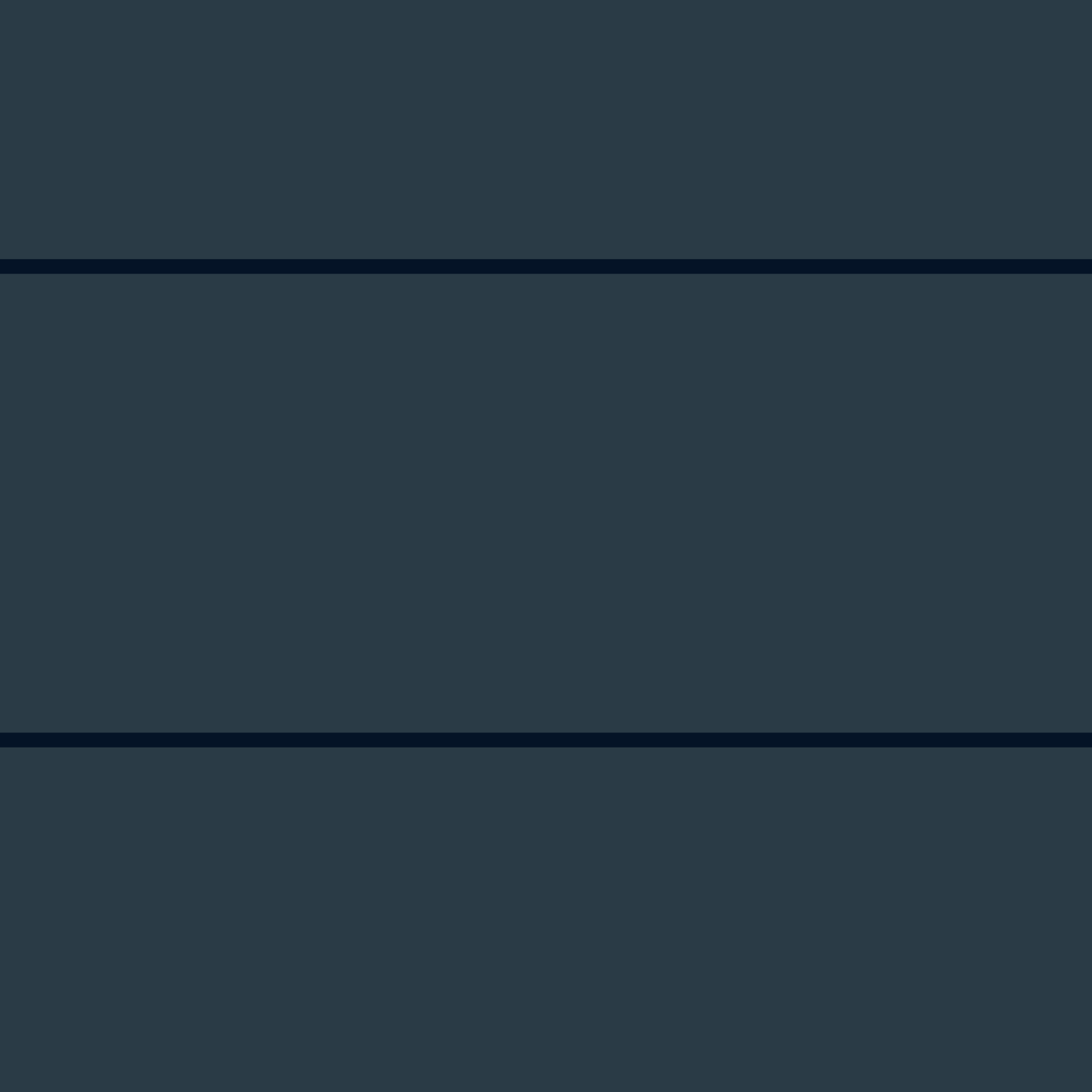
Average corporate income tax rates, by country income group, 1990-2018

Per cent

Legend:
- Low income
- Middle income
- High income
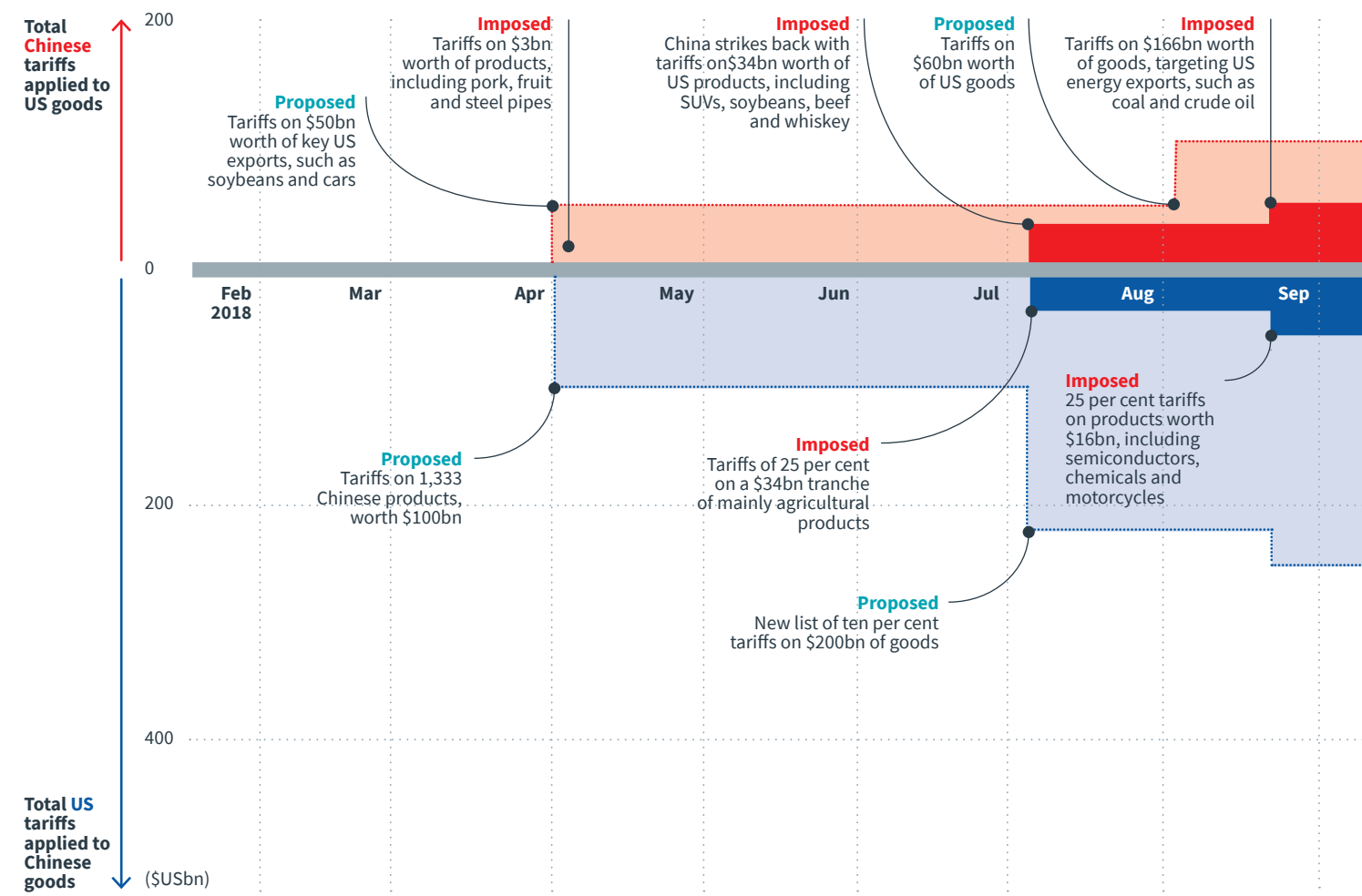- OECD (Europe)
- OECD (ex-Europe)
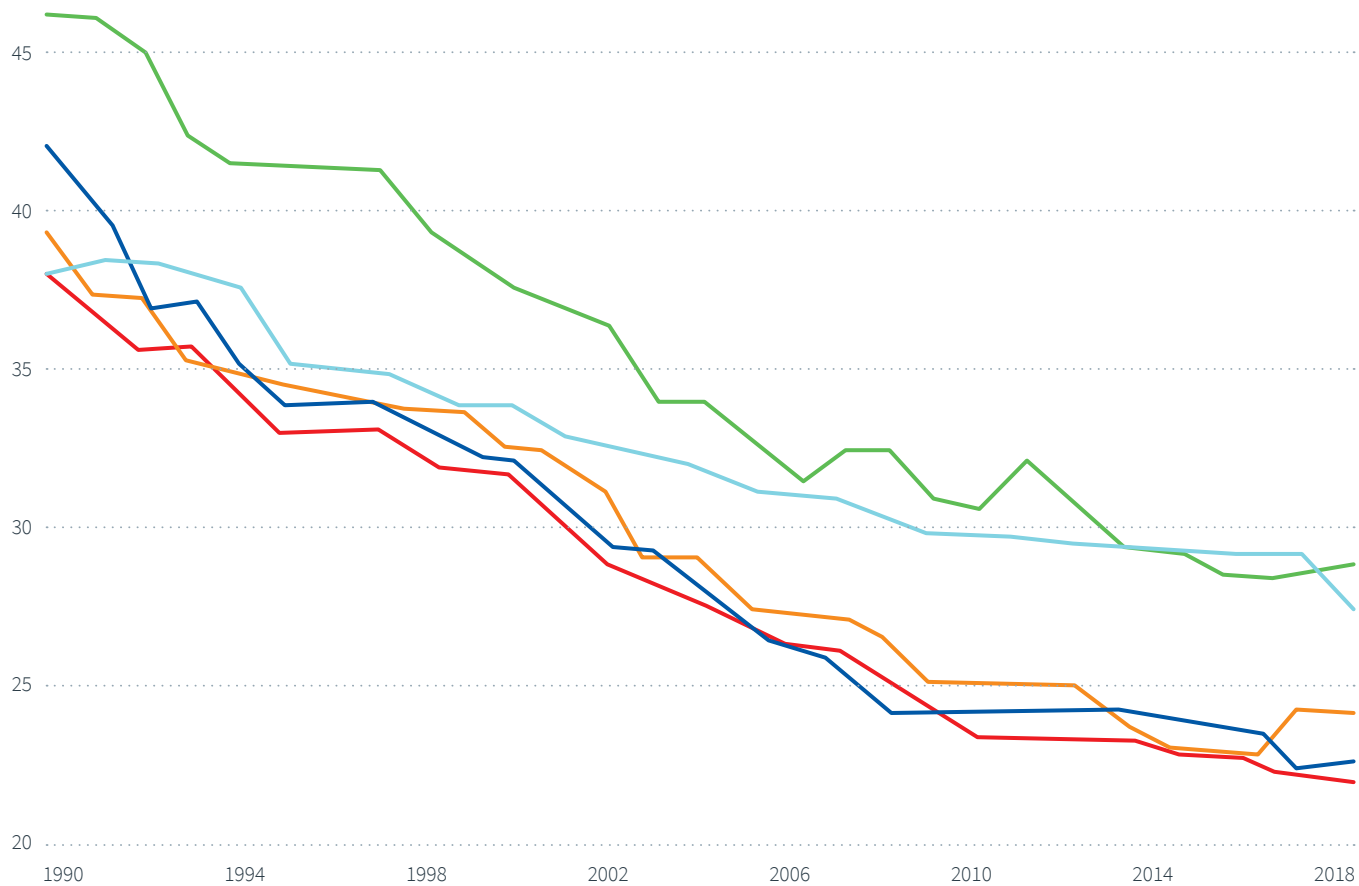
US-China tensions

Relations between the world's two superpowers stretched to breaking point in 2020. Some commentators went as far as declaring a new cold war, with far-reaching implications for the global economy and beyond.
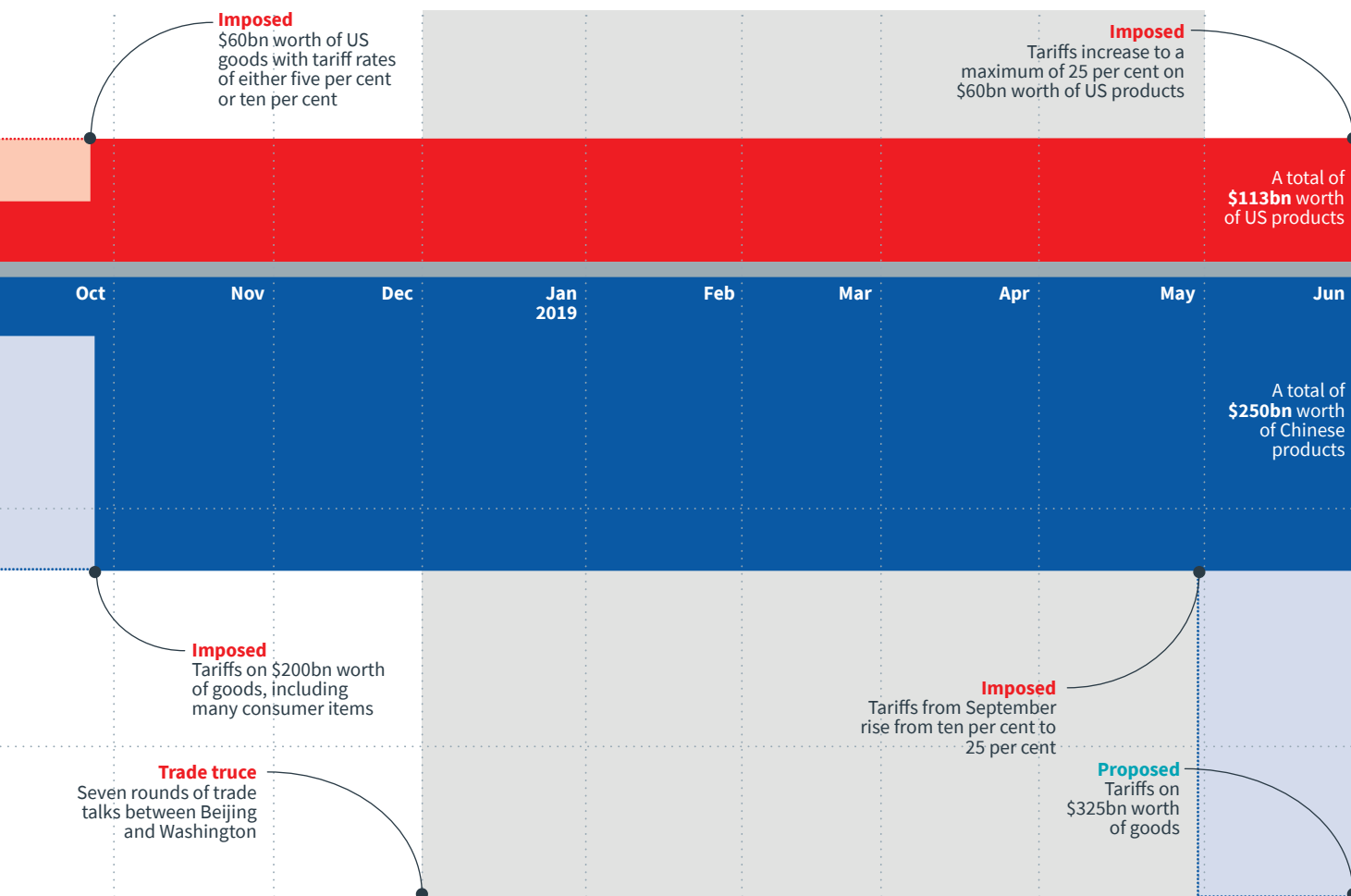
Tit for tat

How the US-China trade war escalated

The US-China trade war began in earnest in 2017, when the new Trump administration started imposing new tariffs on Chinese goods, ostensibly to rectify a trade imbalance and to retaliate for the alleged theft of intellectual property from American firms. This graphic shows how each side took turns ramping up tariffs in the initial 16 months of the conflict.

Total Chinese tariffs applied to US goods

200

0

Proposed
Tariffs on $50bn worth of key US exports, such as soybeans and cars

Imposed
Tariffs on $3bn worth of products, including pork, fruit and steel pipes

Imposed
China strikes back with tariffs on$34bn worth of US products, including SUVs, soybeans, beef and whiskey

Proposed
Tariffs on $60bn worth of US goods

Imposed
Tariffs on $166bn worth of goods, targeting US energy exports, such as coal and crude oil

Feb 2018 | Mar | Apr | May | Jun | Jul | Aug | Sep

Proposed
Tariffs on 1,333 Chinese products, worth $100bn

Imposed
Tariffs of 25 per cent on a $34bn tranche of mainly agricultural products

Imposed
25 per cent tariffs on products worth $16bn, including semiconductors, chemicals and motorcycles

200

Proposed
New list of ten per cent tariffs on $200bn of goods

400

Total US tariffs applied to Chinese goods

($USbn)

A phase one trade deal in January 2020 was designed to bring an end to the spat, but the agreement now looks vulnerable as tensions escalate in the wake of the COVID-19 pandemic.

Imposed
$60bn worth of US goods with tariff rates of either five per cent or ten per cent

Imposed
Tariffs increase to a maximum of 25 per cent on $60bn worth of US products

A total of **$113bn** worth of US products

Oct	Nov	Dec	Jan 2019	Feb	Mar	Apr	May	Jun

A total of **$250bn** worth of Chinese products

Imposed
Tariffs on $200bn worth of goods, including many consumer items

Imposed
Tariffs from September rise from ten per cent to 25 per cent

Trade truce
Seven rounds of trade talks between Beijing and Washington

Proposed
Tariffs on $325bn worth of goods

Patent power
The rise of Asia's intellectual property prowess

The accusation that China steals technology from Western firms has exacerbated trade tensions between China and the US. But China is becoming an increasingly sophisticated technological superpower in its own right.

This bubble chart shows the proportion of the average number of internationally filed patents awarded annually to different countries between 1980 and 1999 (on the left) and between 2000 and 2018 (on the right). While China still lags the US in innovation, it is catching up fast – and its neighbour South Korea is not far behind.

119,689
Average patents awarded annually, 1980-1999 (per cent)

United Kingdom 5%

France 5%

Italy 2%

Japan 29%

US 24%

Russia 2%

Germany 16%
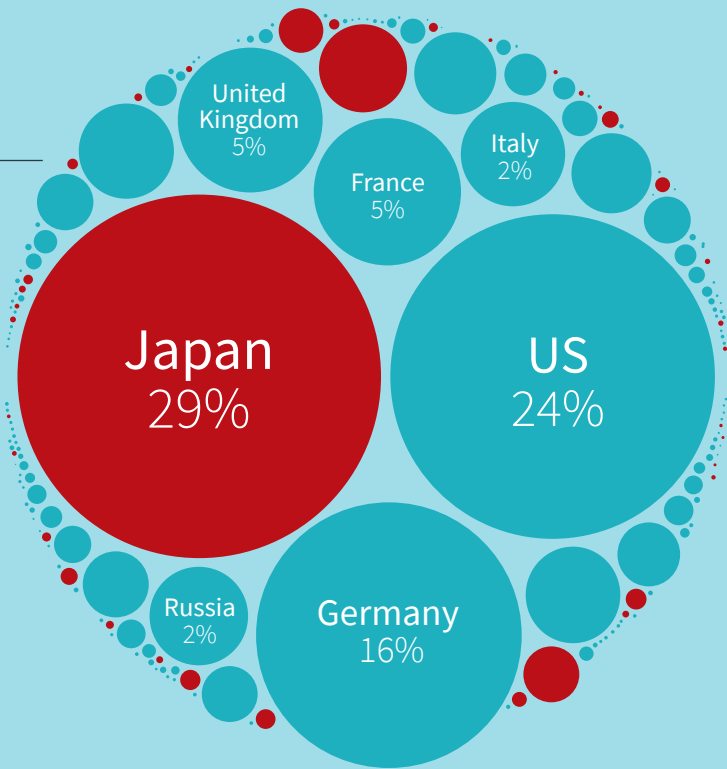
283,248
Average patents awarded annually, 2000-2018 (per cent)

- Asia (inc. Israel)
- Rest of the world

South Korea 7%

China 10%

Israel 1%

United Kingdom 3%

Switzerland 1%

Sweden 1%

Japan 24%

US 22%

Netherlands 1%

Germany 11%

Canada 2%

Italy 2%
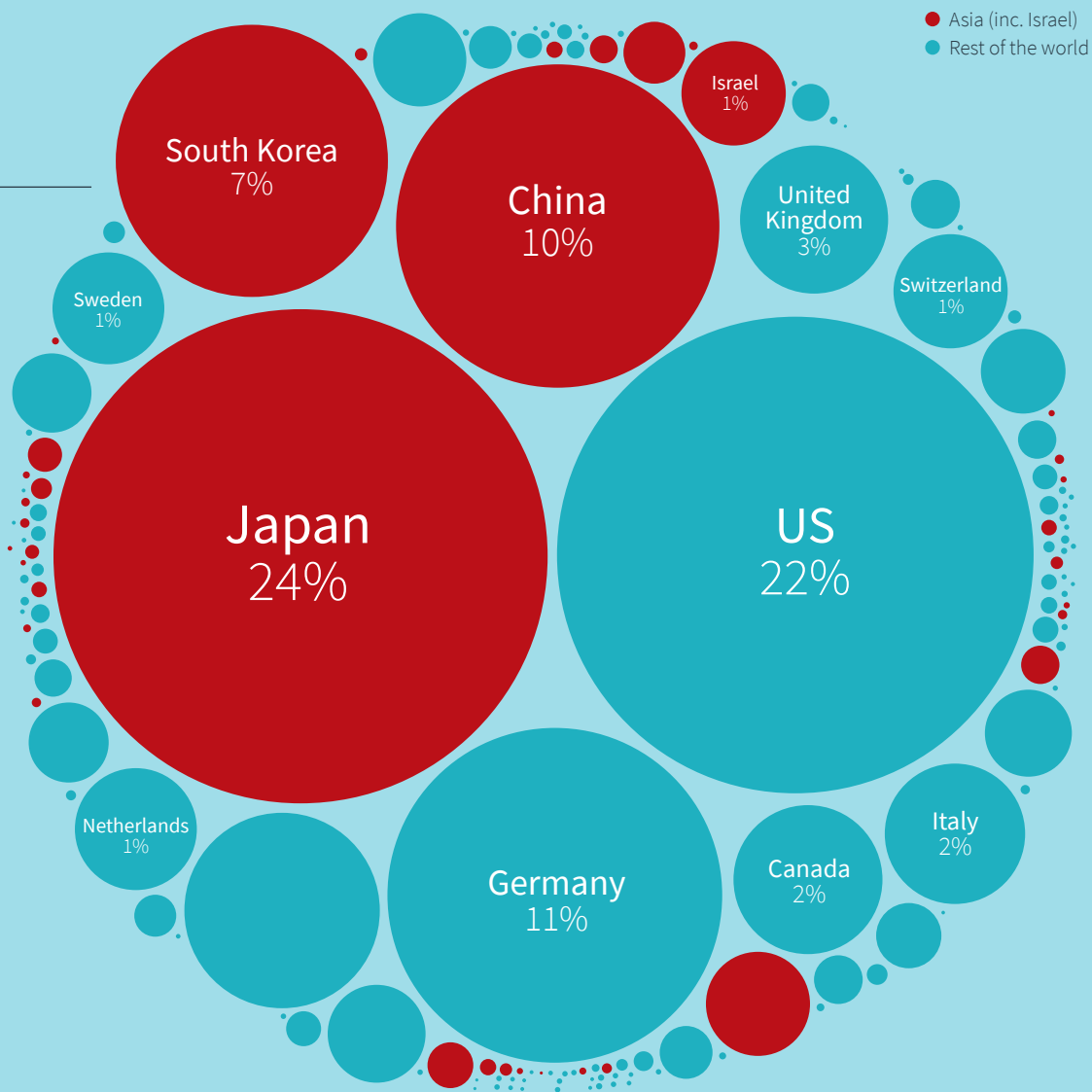
Supply chained
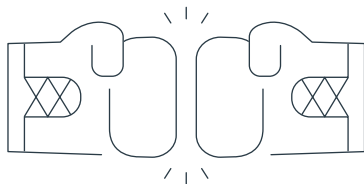
As the US-China dispute has escalated, some commentators have argued trade links between the two partners and their respective allies could be unwound. But this is easier said than done. This graphic highlights China's embeddedness in the global trade network.

Trade network of global goods*

United Kingdom

Rest of Europe

Canada

Euro area

US

Rest of Asia

China

Australia

Mexico

Japan

South America

Hong Kong
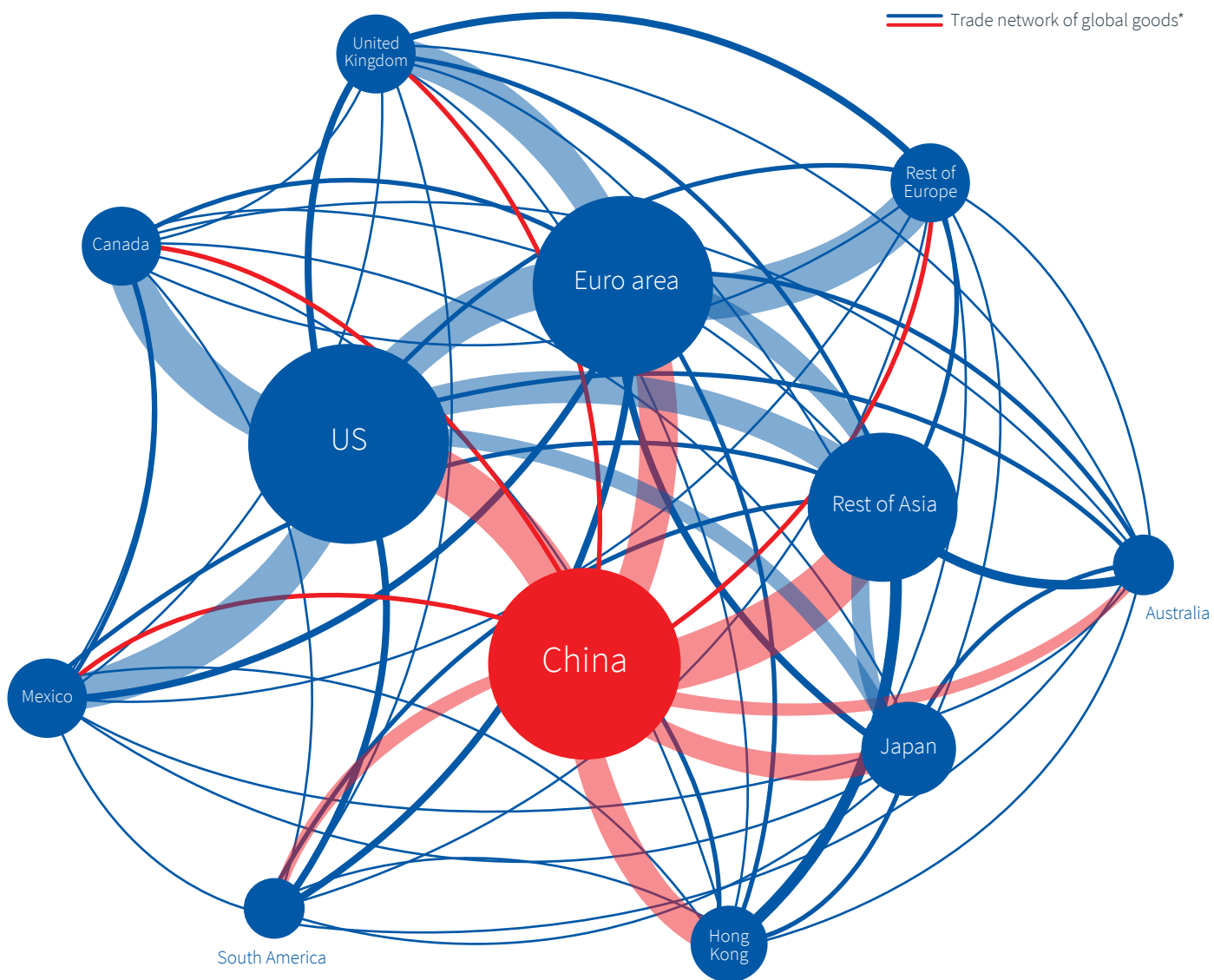
Money talks: China extends its influence

China has extended cheap loans to poorer governments as part of its plan to extend its influence and cement alliances abroad. Such is the scale of this programme, China is now the world's largest official creditor, according to a 2019 study from the Kiel Institute for the World Economy and Harvard University. Sub-Saharan Africa has been the chief recipient of Chinese loans, as this map shows.

In per cent of debtor GDP
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 25
- 25 - 100
- No data
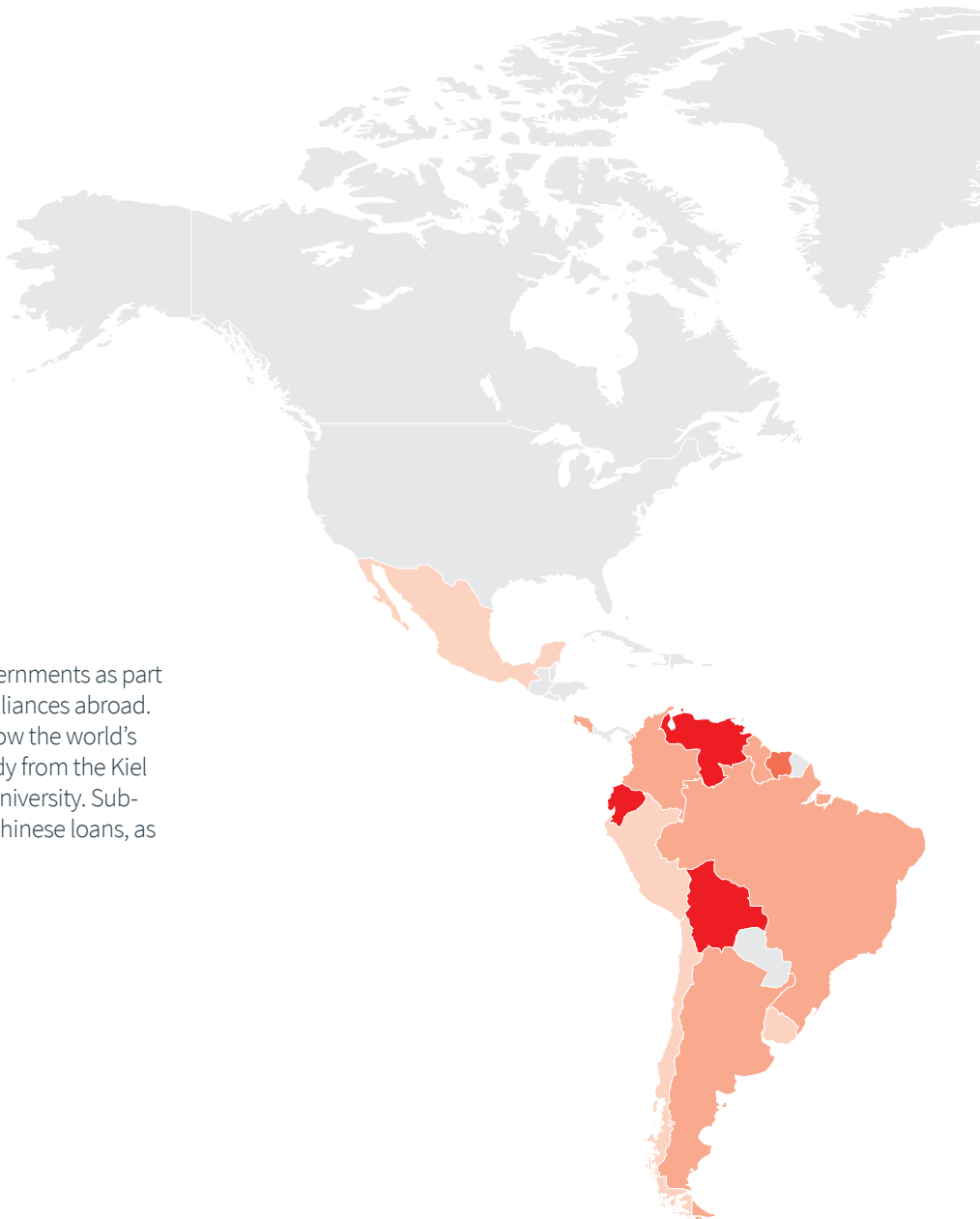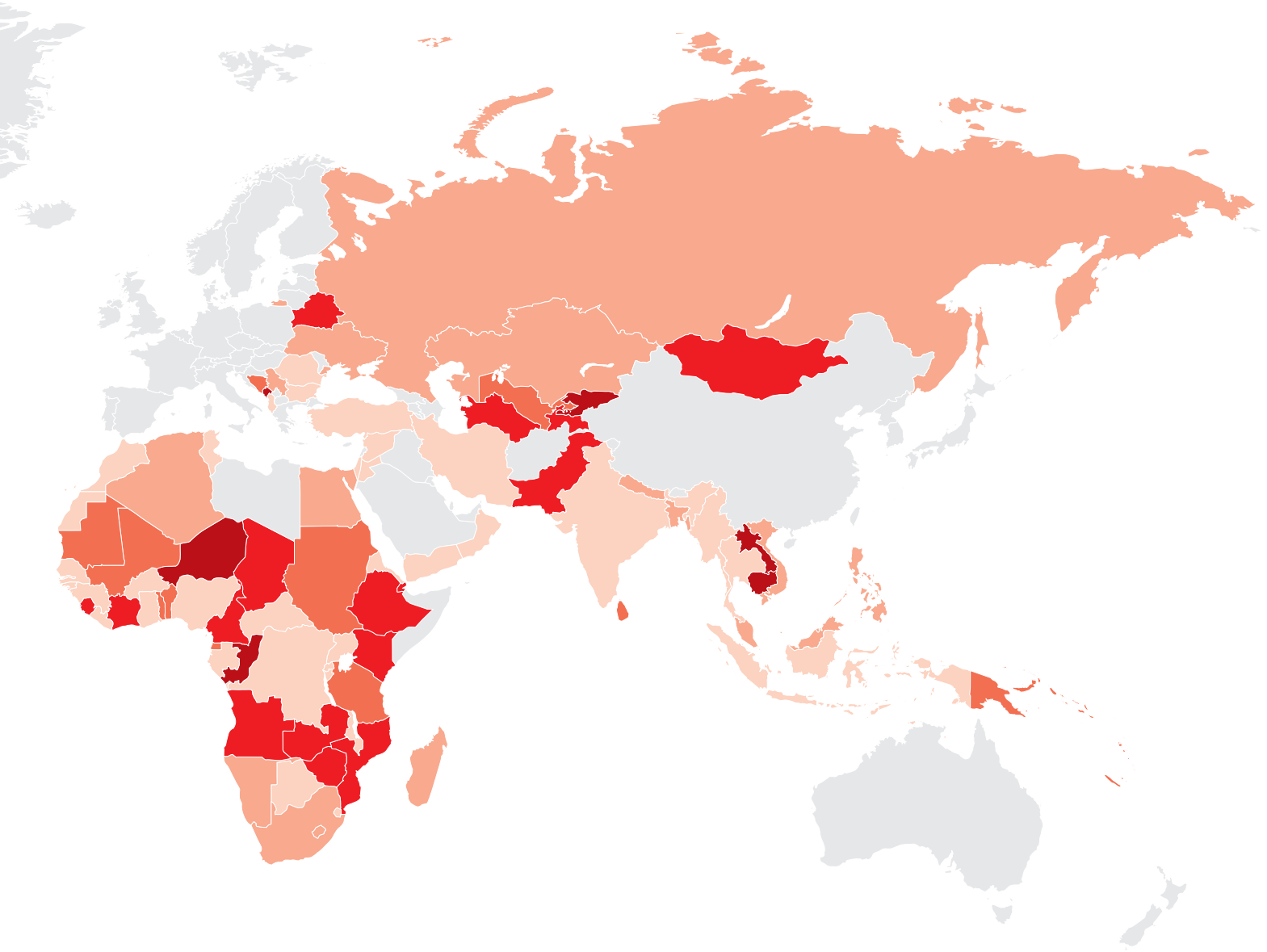
IOU: Global holdings of US Treasuries

China has the world's largest foreign currency reserves, while the US is the world's most indebted country. About 40 percent of US sovereign debt is held by foreign entities, with China dominating the list in 2019, according to the US Department of the Treasury.

US-China trade tensions, however, appear to have reduced China's appetite for US bonds just as COVID-19 has forced Uncle Sam to borrow at an unprecedented rate. The US Treasury issued about $3 trillion of new debt in the second quarter alone to fund fiscal programmes in response to the pandemic. But if China stays on the sidelines, more of the burden of buying Treasuries may fall to domestic buyers – including the Fed.

Foreign holders of US debt, 2019

- Taiwan $171.1bn 2.7%
- India $155.3bn 2.4%
- Hong Kong $205.9bn 3.2%
- Singapore $139.3bn 2.2%
- Korea $115.1bn 1.8%
- Thailand $82.2bn 1.3%
- Mexico $47.7bn 0.7%
- Cayman Islands $217.2bn 3.4%
- Brazil $306.7bn 4.8%
- Canada $102.1bn 1.6%
- Bermuda $66.4bn 1%
- Japan $1,064bn 16.5%
- China $1,113bn 17.3%
- France $124.5bn 1.9%
- Ireland $269.7bn 4.2%
- Norway $97.1bn 1.5%
- Luxembourg $223.7bn 3.5%
- Germany $72.8bn 1.1%
- Belgium $179.8bn 2.8%
- United Kingdom $300.8bn 4.7%
- Switzerland $226.9bn 3.5%
- Other Countries $555.5bn 8.6%
- Saudi Arabia $176.6bn 2.7%
- Australia $39.1bn 0.6%
- Poland $37.2bn 0.6%
- Spain $41bn 0.6%
- Italy $43.7bn 0.7%
- Netherlands $45bn 0.7%
- Sweden $46.5bn 0.7%
- Iraq $35.4bn 0.6%
- Israel $36.2bn 0.6%
- Kuwait $40.2bn 0.6%
- United Arab Emirates $55.7bn 0.9%

Arms race

Why the US remains the one true military superpower

US
$732bn

The war of words between the US and China has led to speculation the two powers could be heading towards outright conflict. This block chart shows that the arms race is – for the time being – one-sided. While Chinese military spending has risen in recent years, US investment in defense is still larger than the next ten nations combined.

China
$261bn

Russia
$65.1bn

Saudi Arabia
$61.9bn

France
$50.1bn

Germany
$49.3bn

South
Korea
$43.9bn

United Kingdom
$48.6bn

India
$71.1bn

Japan
$47.6bn

Brazil
$26.9bn

$726bn
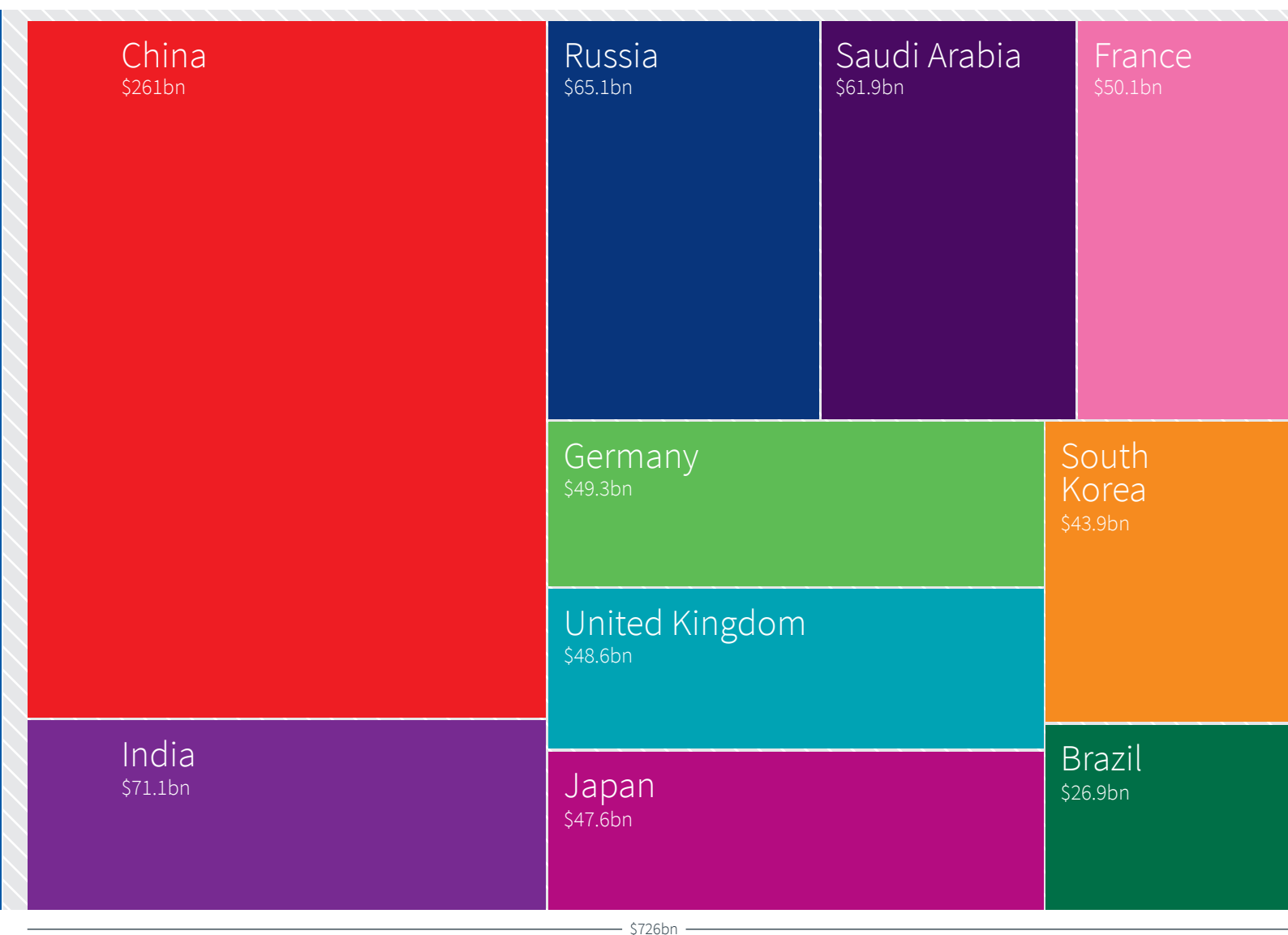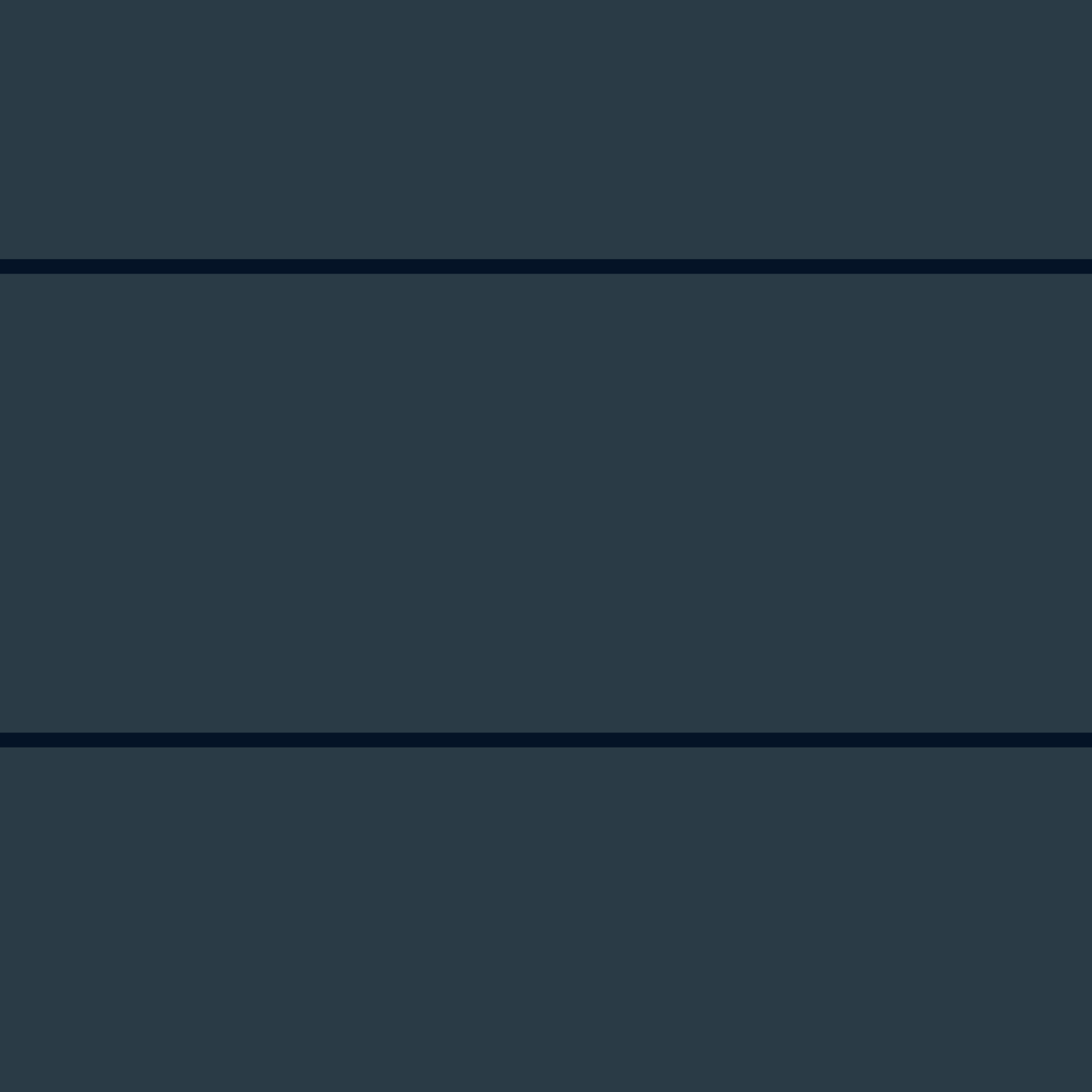
Sustainability

COVID-19 brought into sharp focus what can happen if warnings go unheeded, serving as an important lesson for the environmental challenges facing the world.

Green lining
The impact of COVID-19 on decarbonisation

Estimates from a May 2020 study showed significant cuts to emissions from air and road travel as a result of public health measures to curb the spread of COVID-19. However, the drop was not as steep as might have been expected given the drastic changes to people's lives. It was also temporary: once lockdowns eased, emissions crept back up.

Change in global daily fossil fuel CO2 emissions by region, 2020

Per cent

Rest of the world

China

India

Europe

US

February   March   April   May
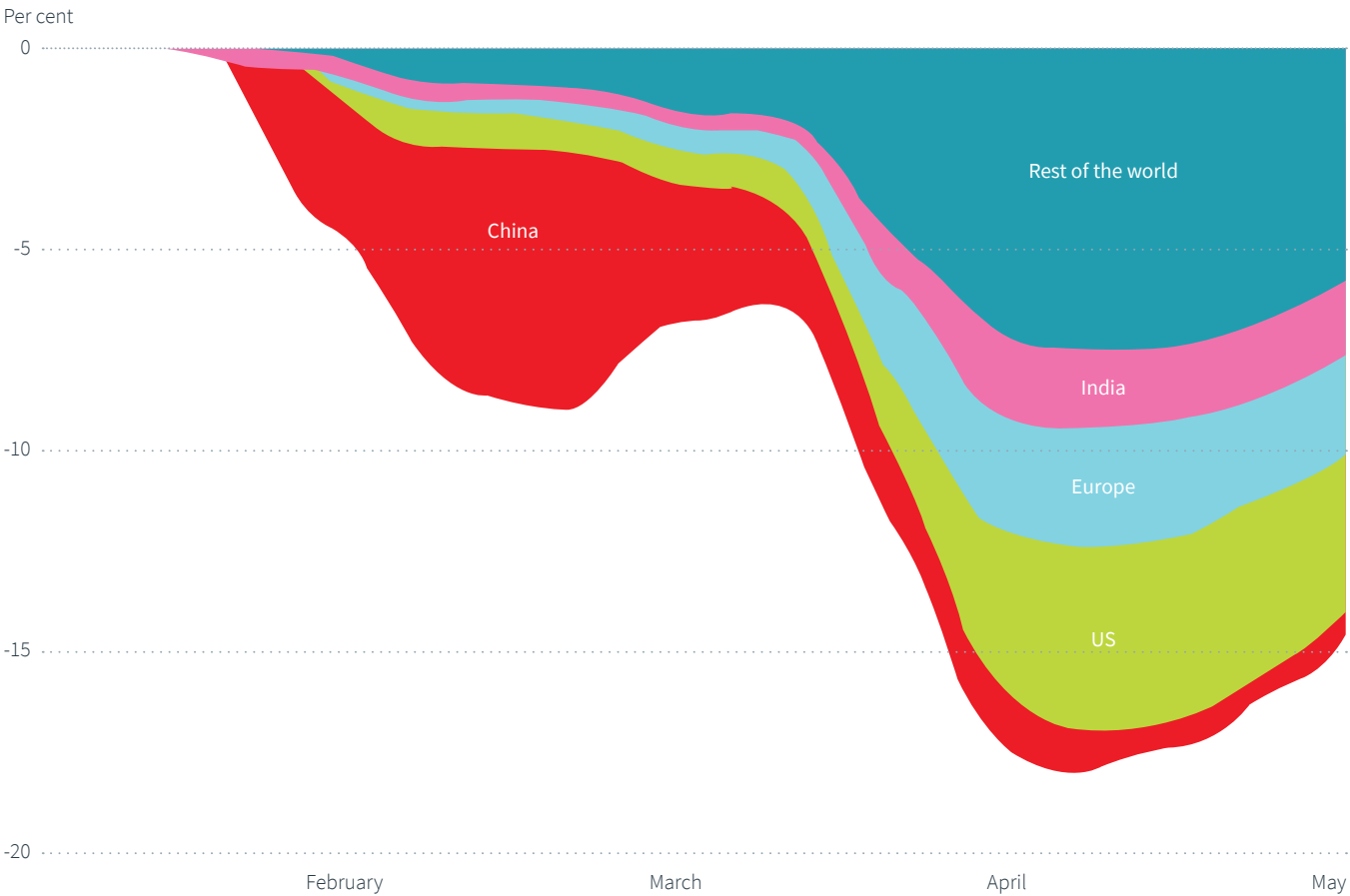
No structural changes have been made to energy systems, and fossil fuels remain deeply entrenched in the global economy. Decarbonisation will be a tough battle to win.

Change in global daily fossil fuel CO_2 emissions by sector, 2020

Per cent
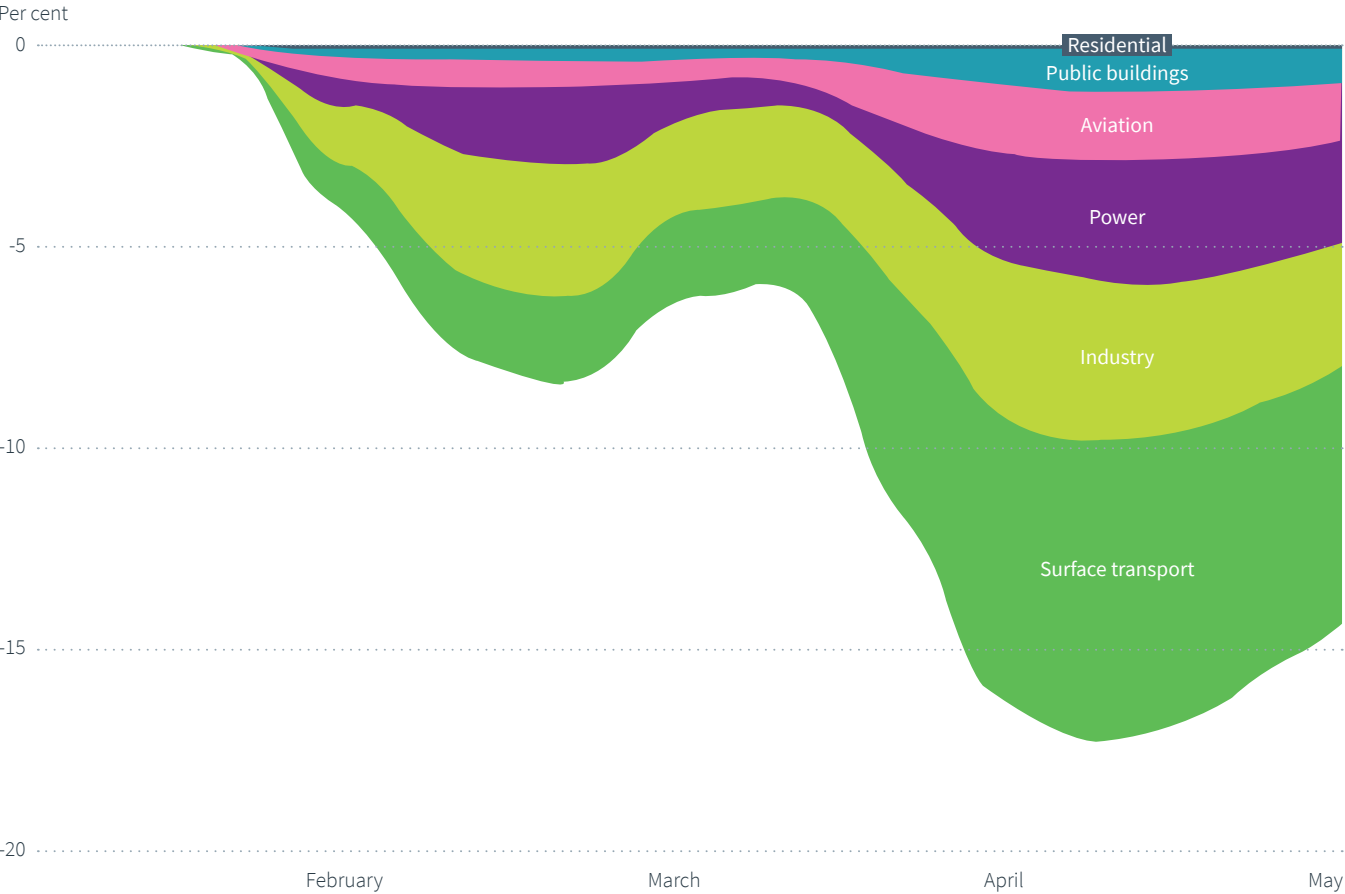
What a load of rubbish

Wealthier nations may be big on recycling, but they remain wasteful


Recycling Index

Germany
United Kingdom
France
US
Japan
Brazil
Russia

Over 2.1 billion tonnes of municipal solid waste are generated globally each year, 950 million tonnes of which are disposed of unsustainably. This gulf between what we produce and what we recycle creates huge challenges for governments, companies and populations.

Tougher regulation is an obvious option to address the issue. Companies that produce large volumes of waste may end up footing the bill if they do not find solutions to create a more circular economy.

Low income
Lower middle income
Upper middle income
High income

Low risk

High risk

China

India

5   6   7   8   9   10

Waste Generation Index

Weighing up life on Earth

Do we appreciate that we are just one small part of a complex biological system?

Microorganisms far outweigh human life. As populations expand into new habitats, they are forced to live in close proximity to new species. This sets the scene for zoonoses, where pathogens leap from non-humans to humans – like the journey thought to have been made by COVID-19.

Gigatonnes carbon
(basic element for life on Earth)

10
1
0.1
0.01

| 0.06 | 0.2 | 2 | 70 |
| Humans | Viruses | All animals | Bacteria |
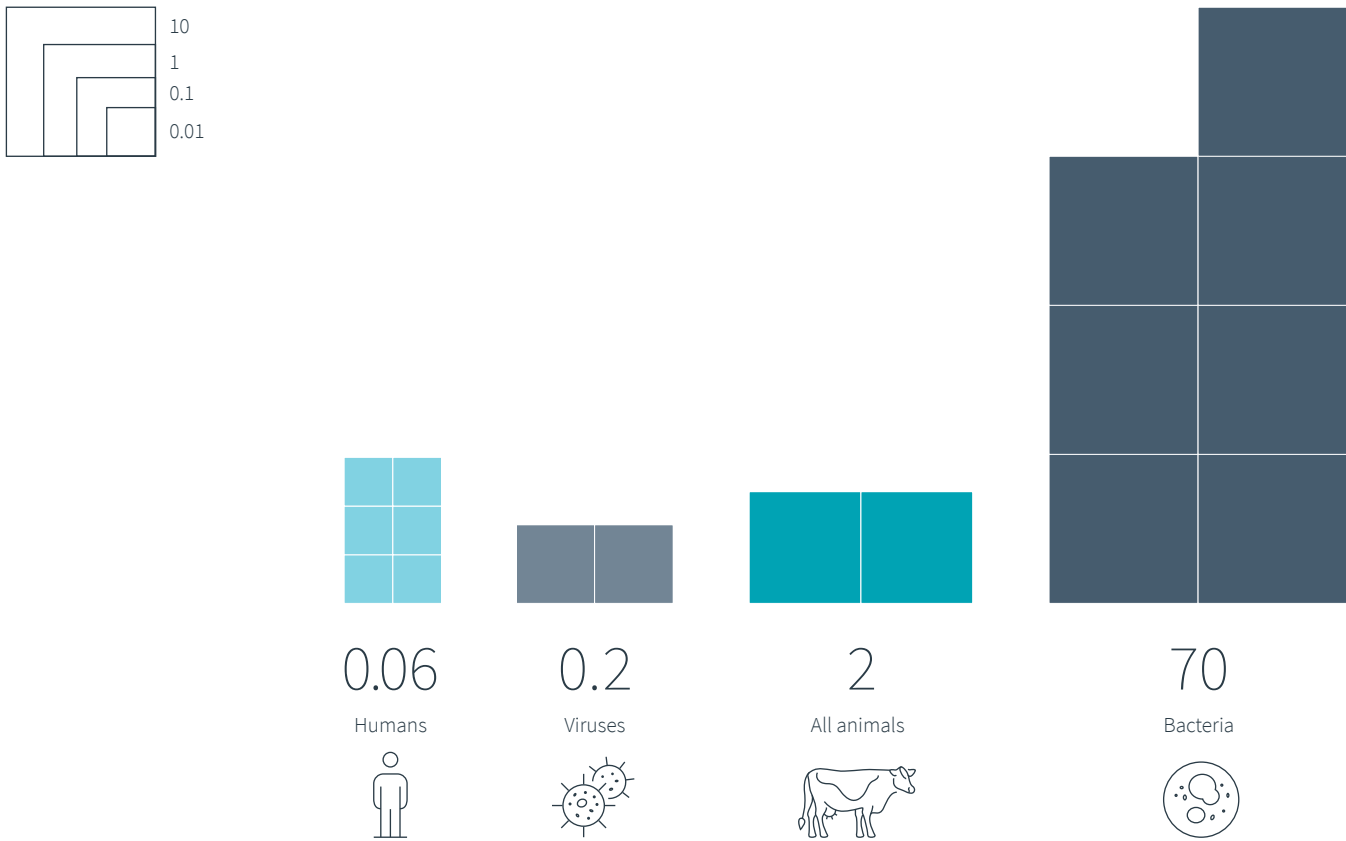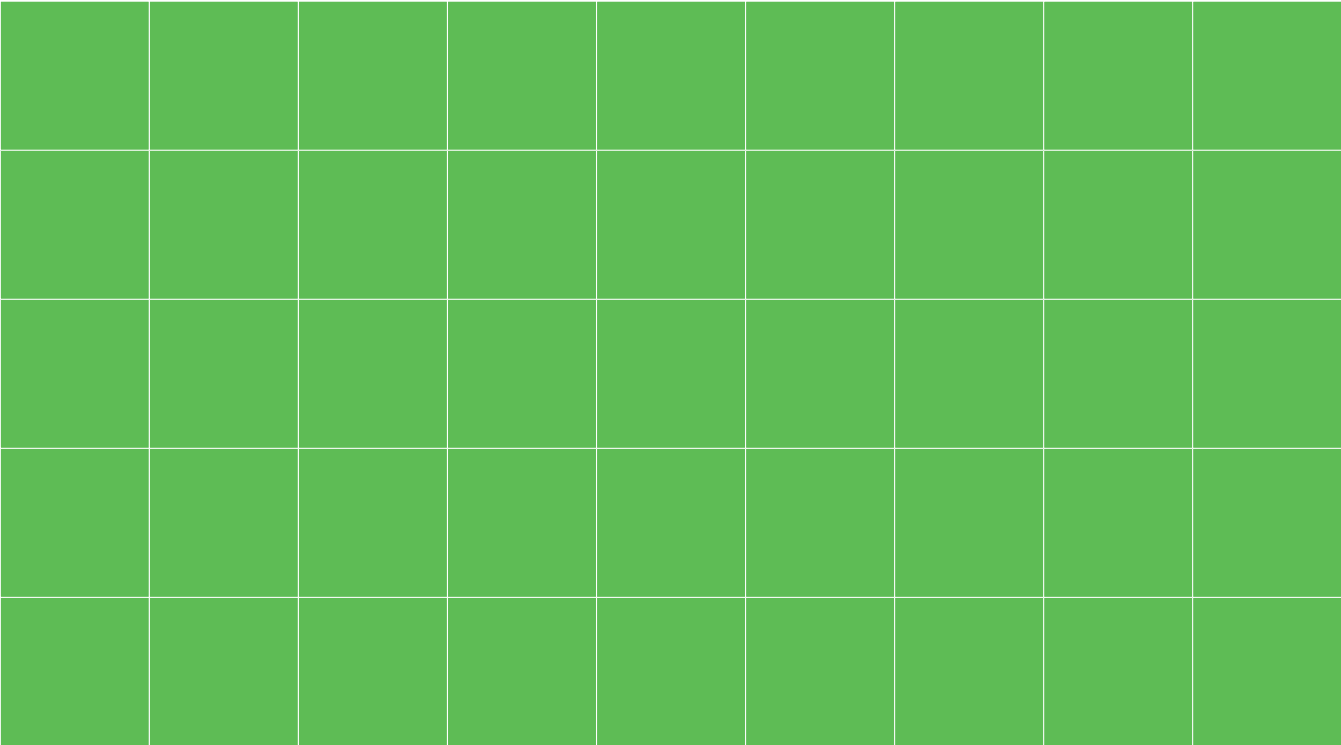
450

Plants

Going, going, gone: Sixth mass extinction

A study published in *Science Advances* suggests species may be declining up to 100 times faster than the background rate, the normal rate species are expected to disappear without human intervention.

In the sixth mass extinction, climate change, pollution and changing land use – among other human activities – are placing growing pressure on other species. But we do not fully understand the impacts, because many species are unknown, and their place in ecological food webs is also unknown. As life forms are linked, there are likely to be cascade and multiplier effects.

Percentage of species threatened in 2020, by category

18%
Reptiles

THREATENED

70% of 11,135 known species assessed

14%
Birds

THREATENED

99% of 11,147 known species assessed

41%
Amphibians

THREATENED

84% of 8,181 known species assessed

- Not threatened*
- Threatened*
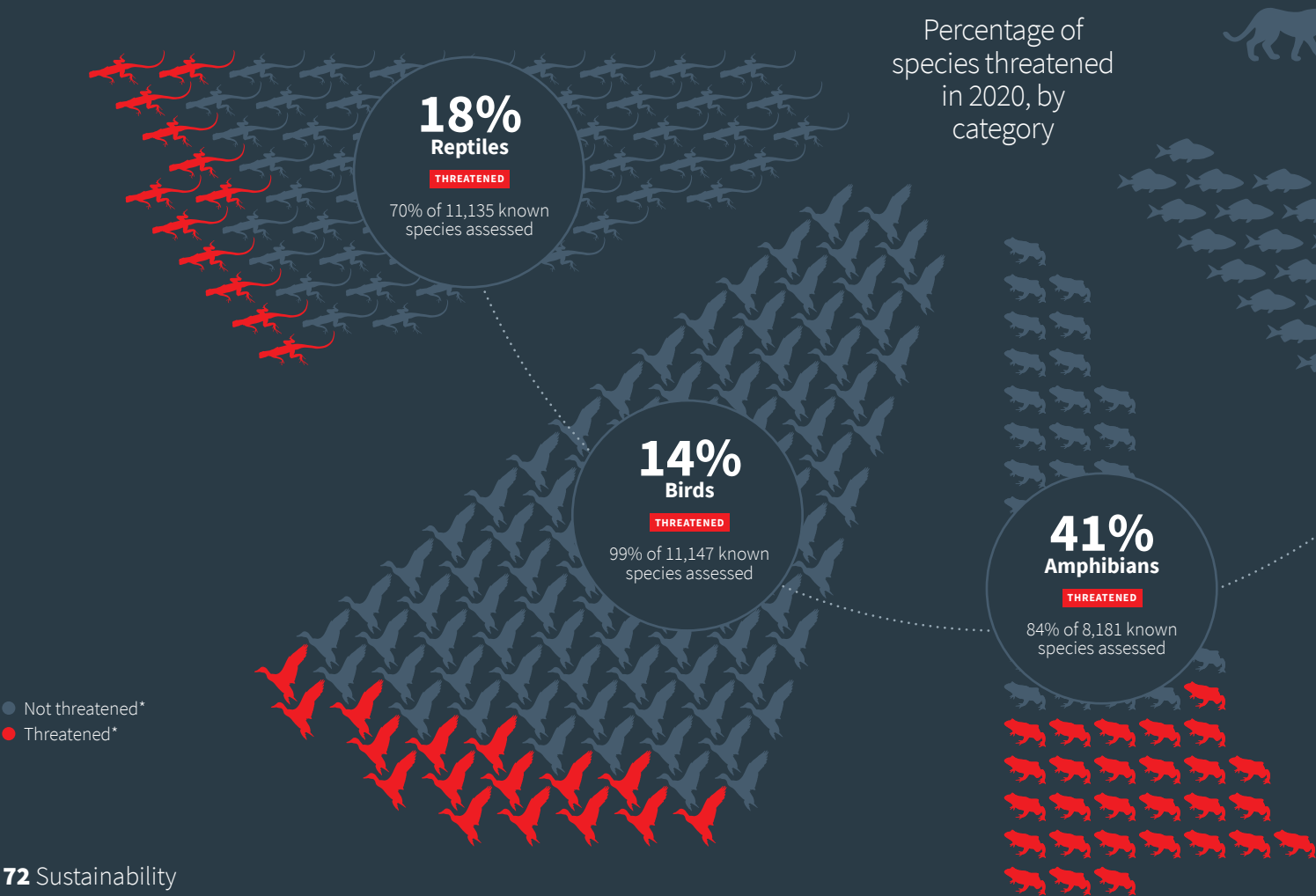
26%
Mammals
THREATENED
91% of 6,495 known species assessed

14%
Fish
THREATENED
59% of 35,519 known species assessed

Down to earth
Solar power really doesn't require much land

Surface area needed to power the world with solar in 2030

■ 496,805 square kilometres

Efforts to calculate just how much of the world's surface would need to be covered by solar panels to power transport, machinery and electrical appliances suggest it could be done by using a relatively small land area.

Of course, not all energy needs can be met by solar power; air transport is an obvious example. But efficiency improvements continue to be made. This illustration assumes panels with 20 per cent operating efficiency. Scientists at Oxford University recently developed a perovskite crystal covering for solar panelling that could boost efficiency by as much as a third. Such technological advances should reduce the amount of surface space required even further.

Amazon versus Amazon

Amazon market capitalisation (US$bn)

amazon

1,577

Jeff Bezos started the company we now know as Amazon a quarter of a century ago, naming it after the world's largest river that runs through nine countries in South America. As of September 30, 2020, that company is worth about three times the continent in which that river is located, based on the MSCI Emerging Markets Latin America Investable Market Index, which covers 99 per cent of the free float-adjusted market capitalisation of the continent's six largest economies.
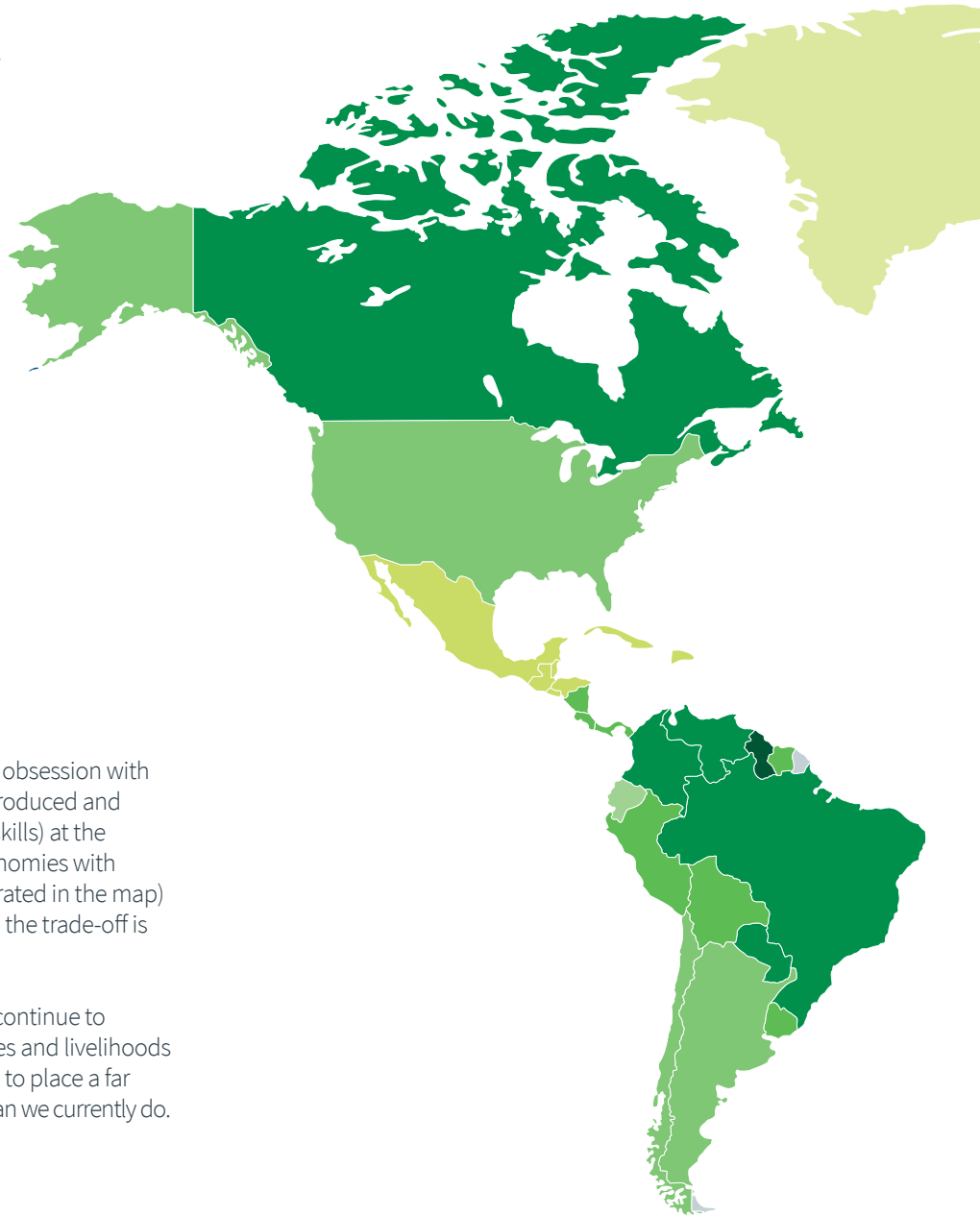
At least when it comes to how investors value assets, the worth of Amazon – the river – has far to go to catch up with its namesake.

MSCI EM Latin America IMI Index
market capitalisation (US$bn)

Brazil
337

Mexico
119

Chile
38

Peru
15

Columbia
12

Others
12
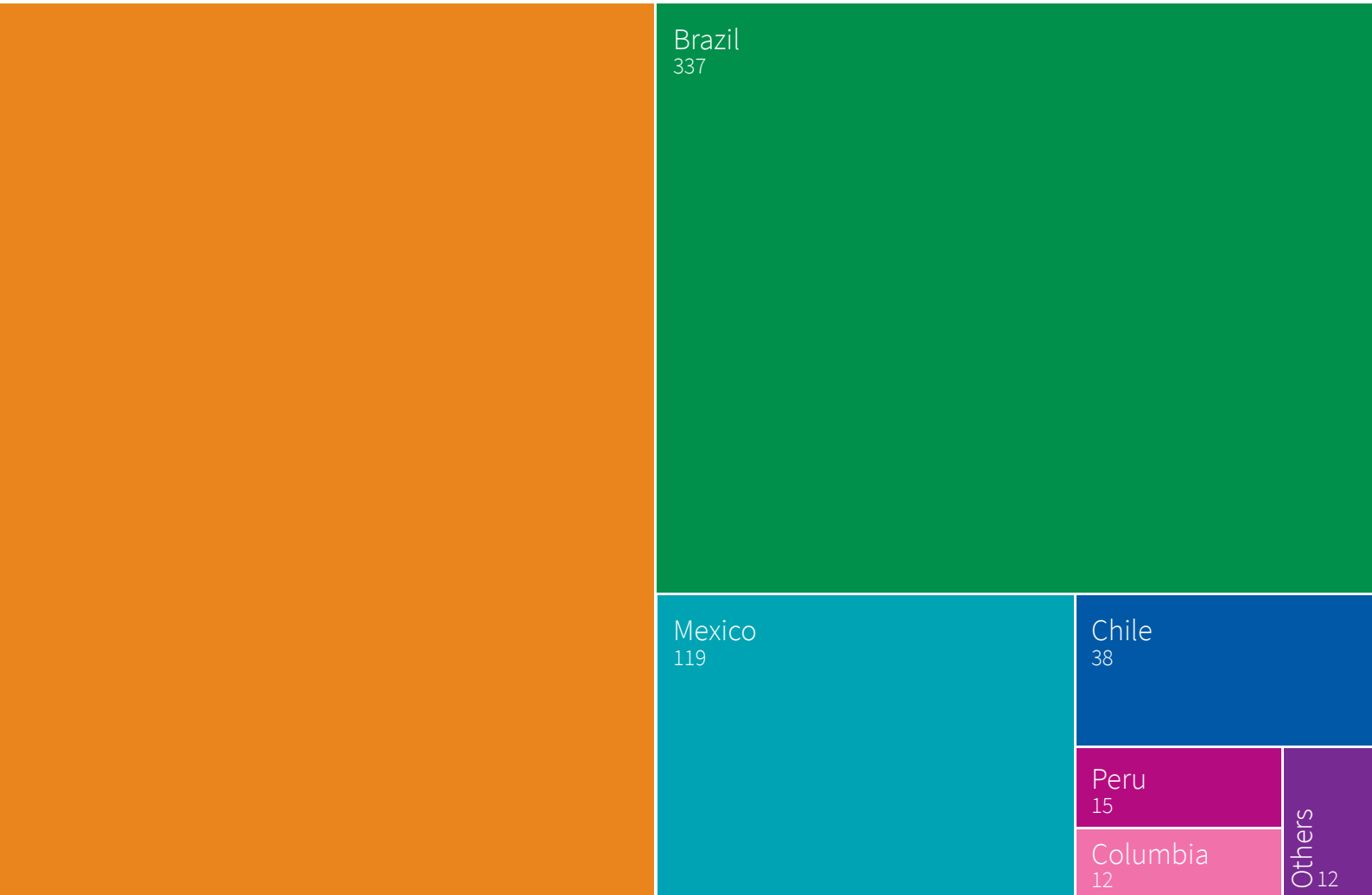
What's nature got to do with it?

Available natural capital, by country

Without nature, there would be no life. But the obsession with economic growth dictates we invest more in produced and human capital (accumulated knowledge and skills) at the expense of natural capital. For developing economies with relatively high levels of natural capital (as illustrated in the map) but low levels of produced and human capital, the trade-off is especially worrying.

If society fails to reflect nature's worth, we will continue to mismanage natural capital, threatening the lives and livelihoods of future generations. All this suggests it is time to place a far greater value and emphasis on natural capital than we currently do.

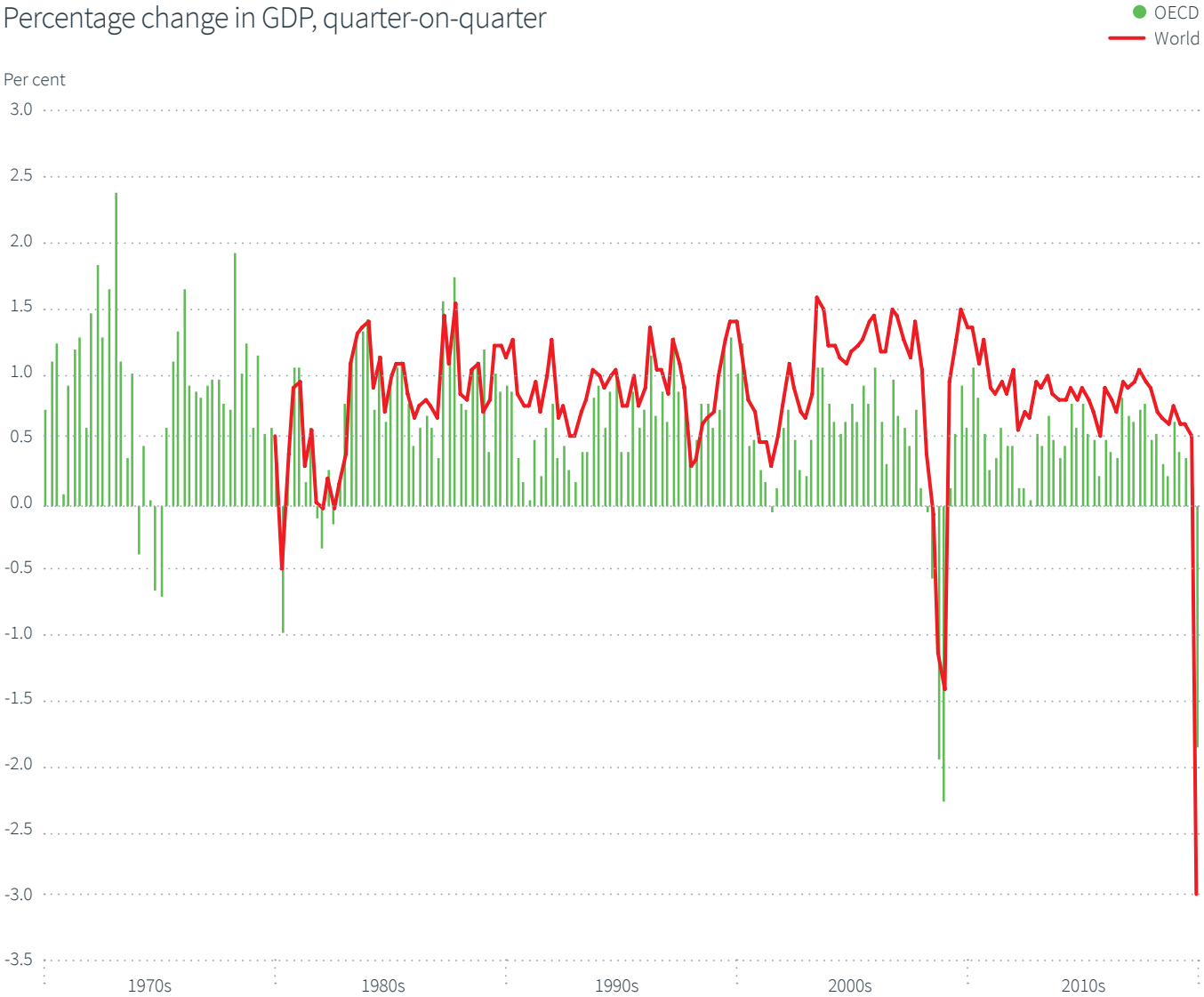Lower natural capital

Higher natural capital
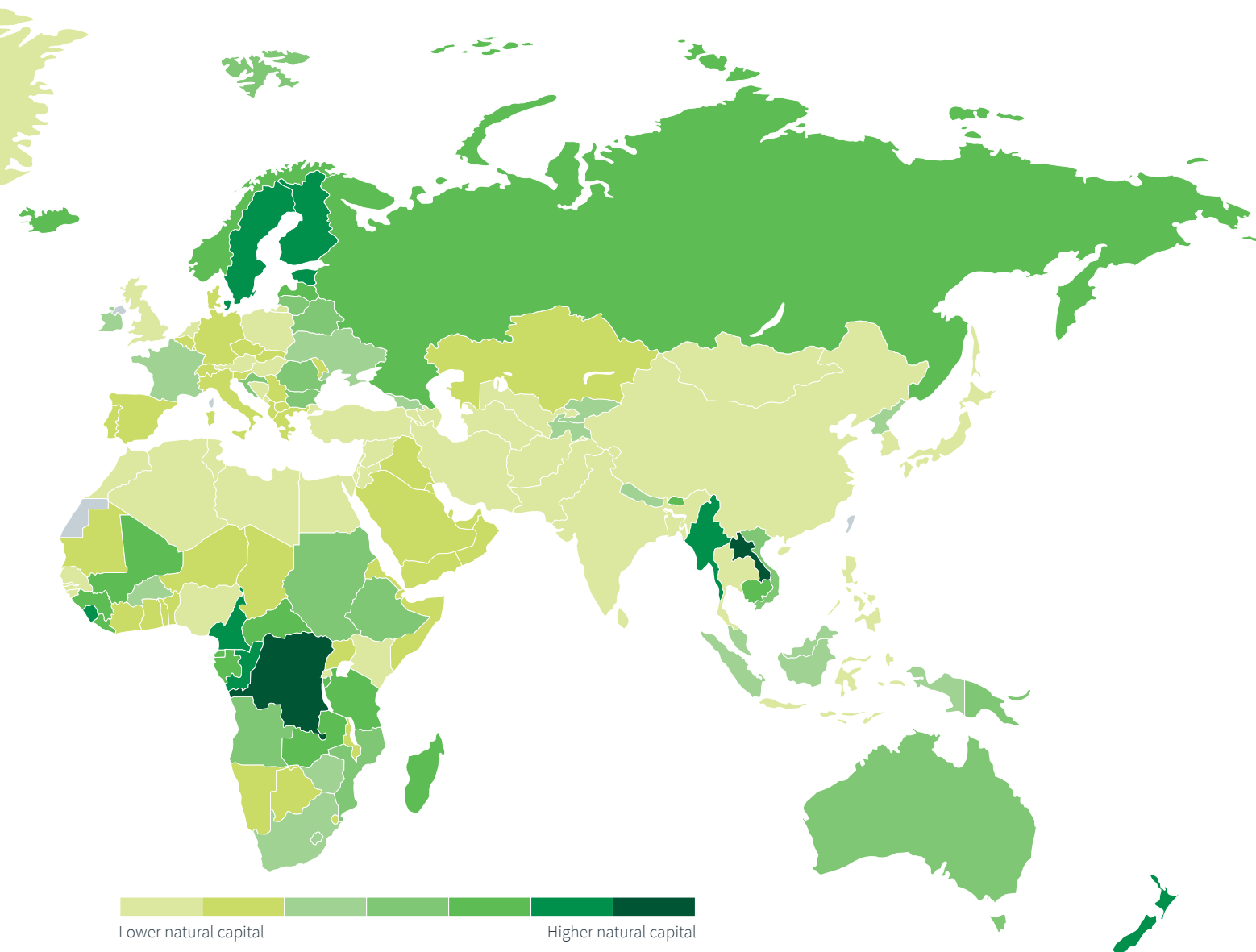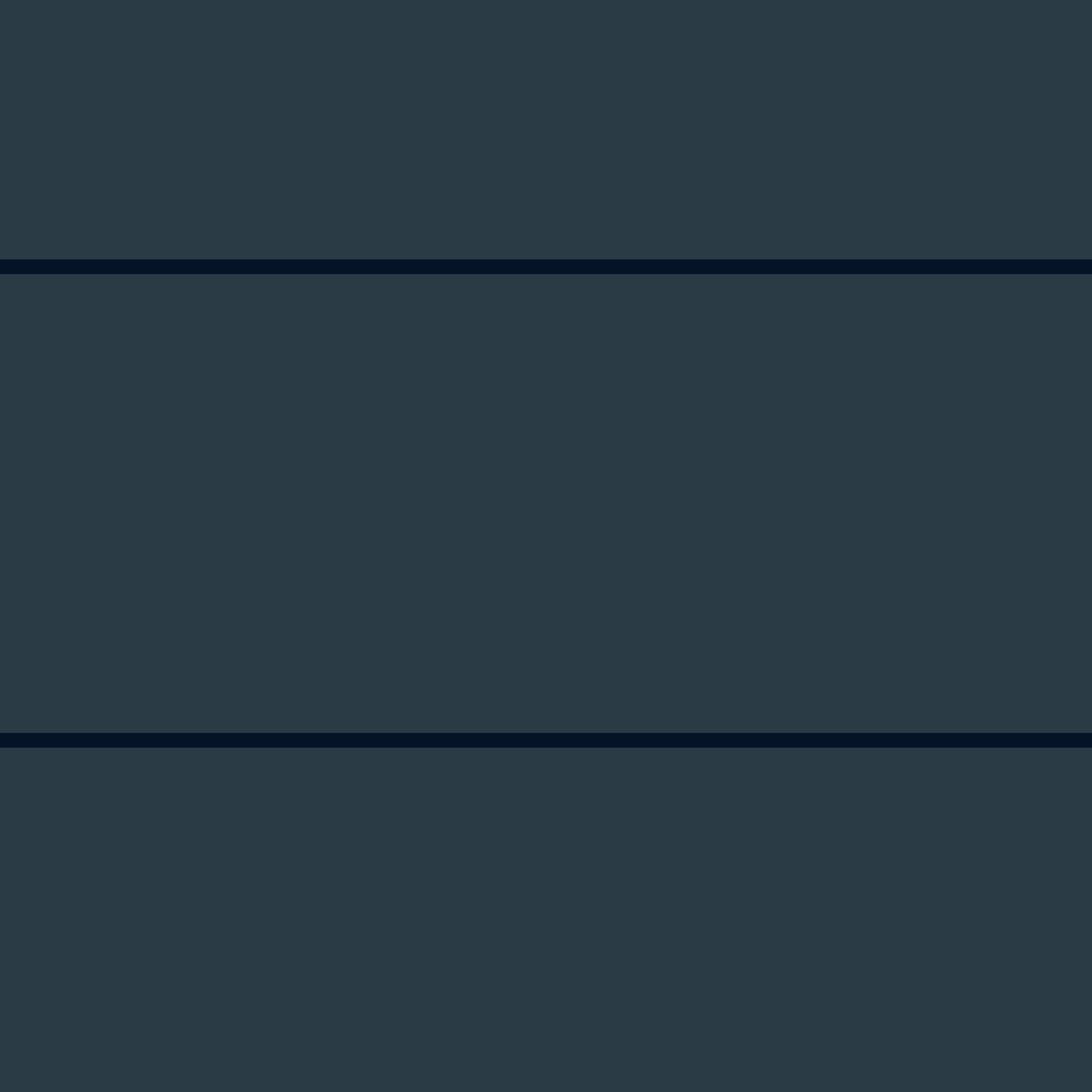
Markets and economies

Data visualisations highlighting the opportunities and risks in equities, bonds and alternative assets, as well as major global economic trends.

# Mixed signals: Economic cliff and the V-shaped equity market recovery

Percentage change in GDP, quarter-on-quarter

- ● OECD
- — World

Per cent

Global equity markets have staged a stunning recovery since March, far outstripping the pace of the rebound that followed the global financial crisis (GFC). The rally has been most pronounced in the US, where major indices have gone on to hit record highs, led by the Nasdaq Composite.

Markets are hopeful massive fiscal and monetary support from policymakers will help deliver a so-called V-shaped recovery, and that looking further ahead, economic growth will not be badly impaired as this support is withdrawn. Only time will tell if that view is too optimistic.
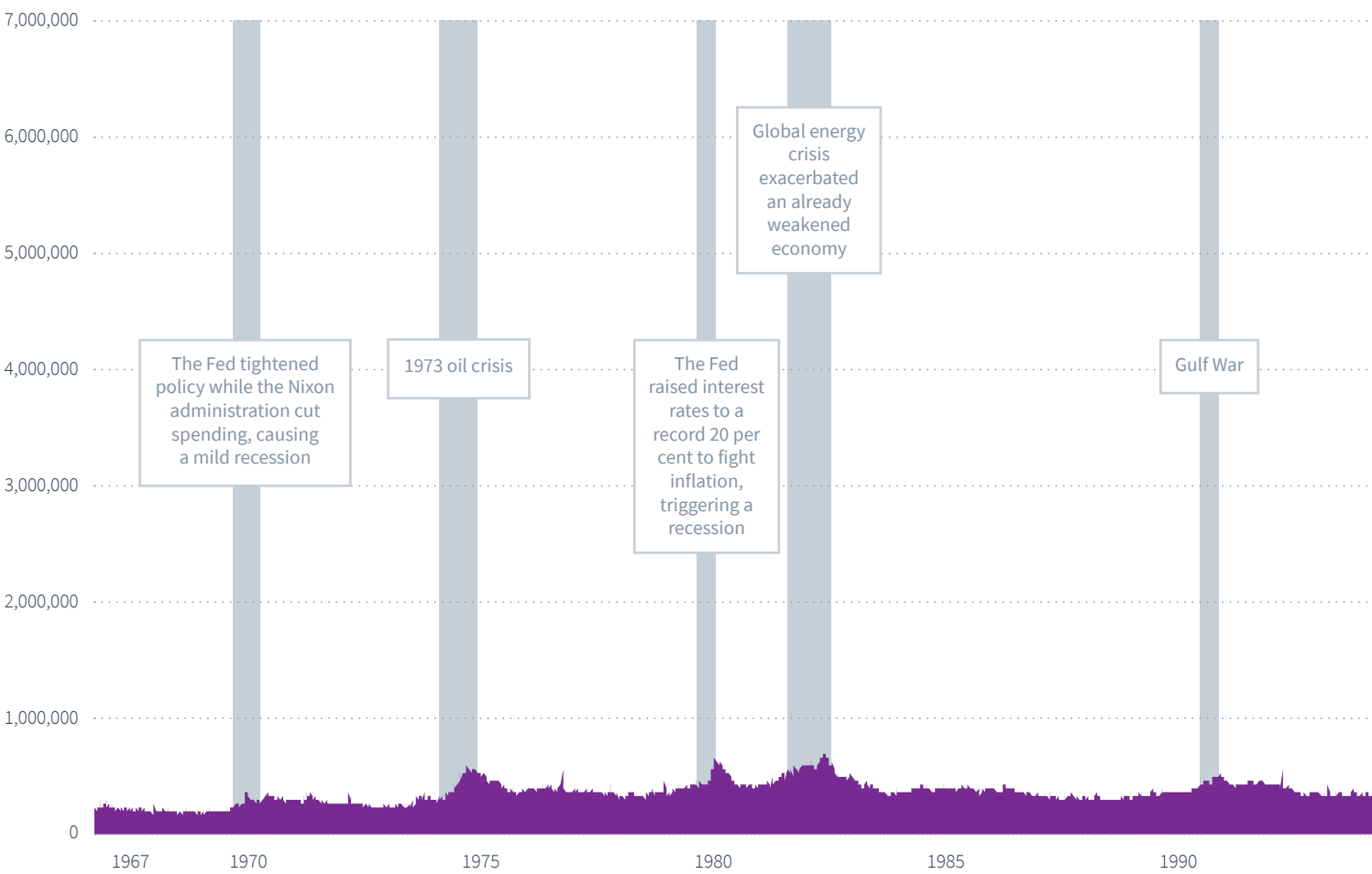
Performance of S&P 500, COVID-19 crisis versus global financial crisis

COVID-19
GFC

Per cent

Days before and after event*
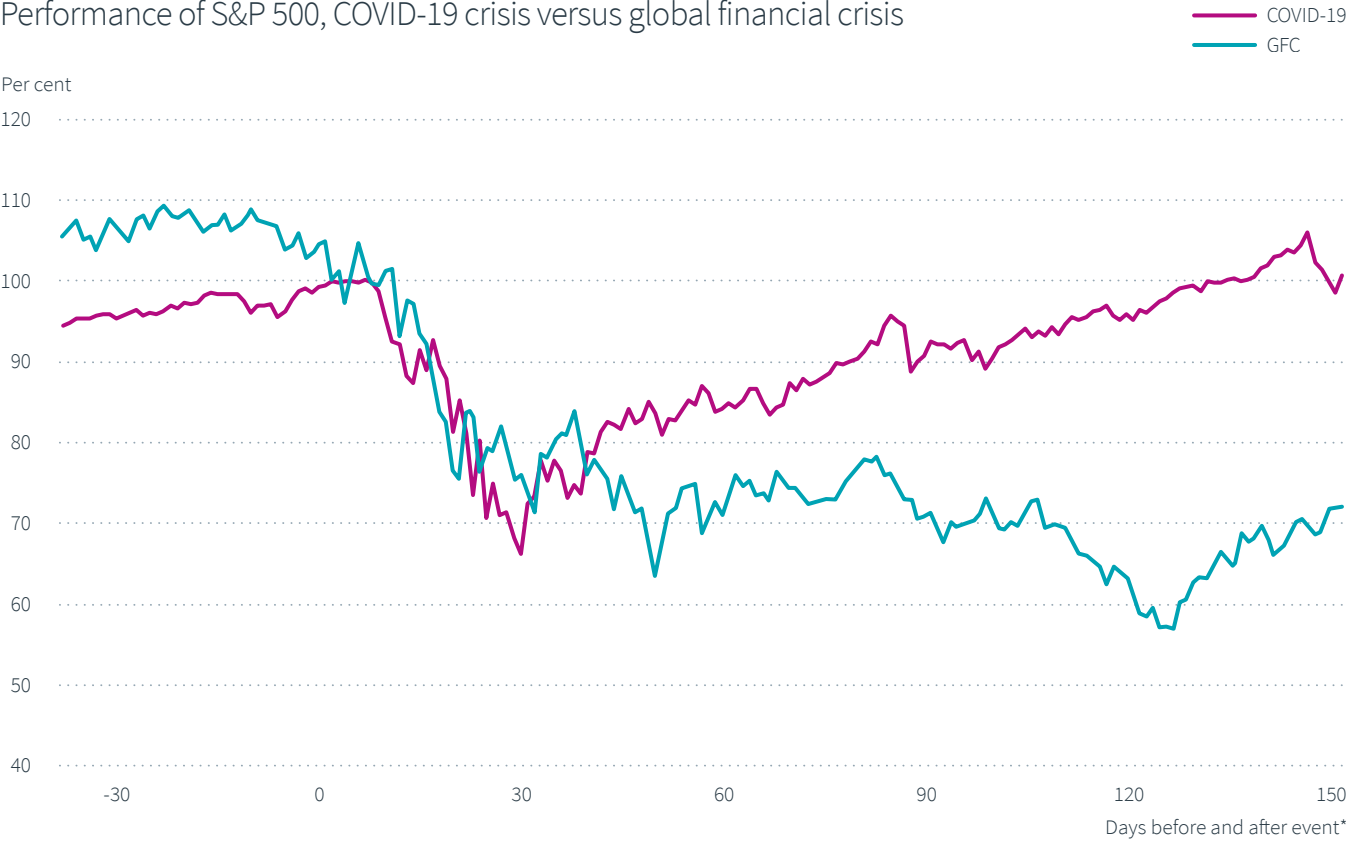
Labour's lost

Spike in US jobless claims highest since the Great Depression

In the week ending March 28, more than 6.6 million Americans filed for unemployment. Total non-farm payroll employment shrank in March and April by more than 22 million – more than erasing all the jobs created since the global financial crisis.

The Fed tightened policy while the Nixon administration cut spending, causing a mild recession

1973 oil crisis

The Fed raised interest rates to a record 20 per cent to fight inflation, triggering a recession

Global energy crisis exacerbated an already weakened economy

Gulf War

7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0

1967   1970   1975   1980   1985   1990

Although the economy has since recouped around half of those jobs, that still means about five-years' worth of new jobs had been wiped out. With the pace of hiring slowing as the country struggles to get the pandemic under control, it could be a long road to a US jobs recovery.

Week ending
March 28
6.648m

COVID-19
crisis

Week ending
March 21
3.307m

Dot-com
bubble burst

Global
financial crisis

US recessions

| 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |

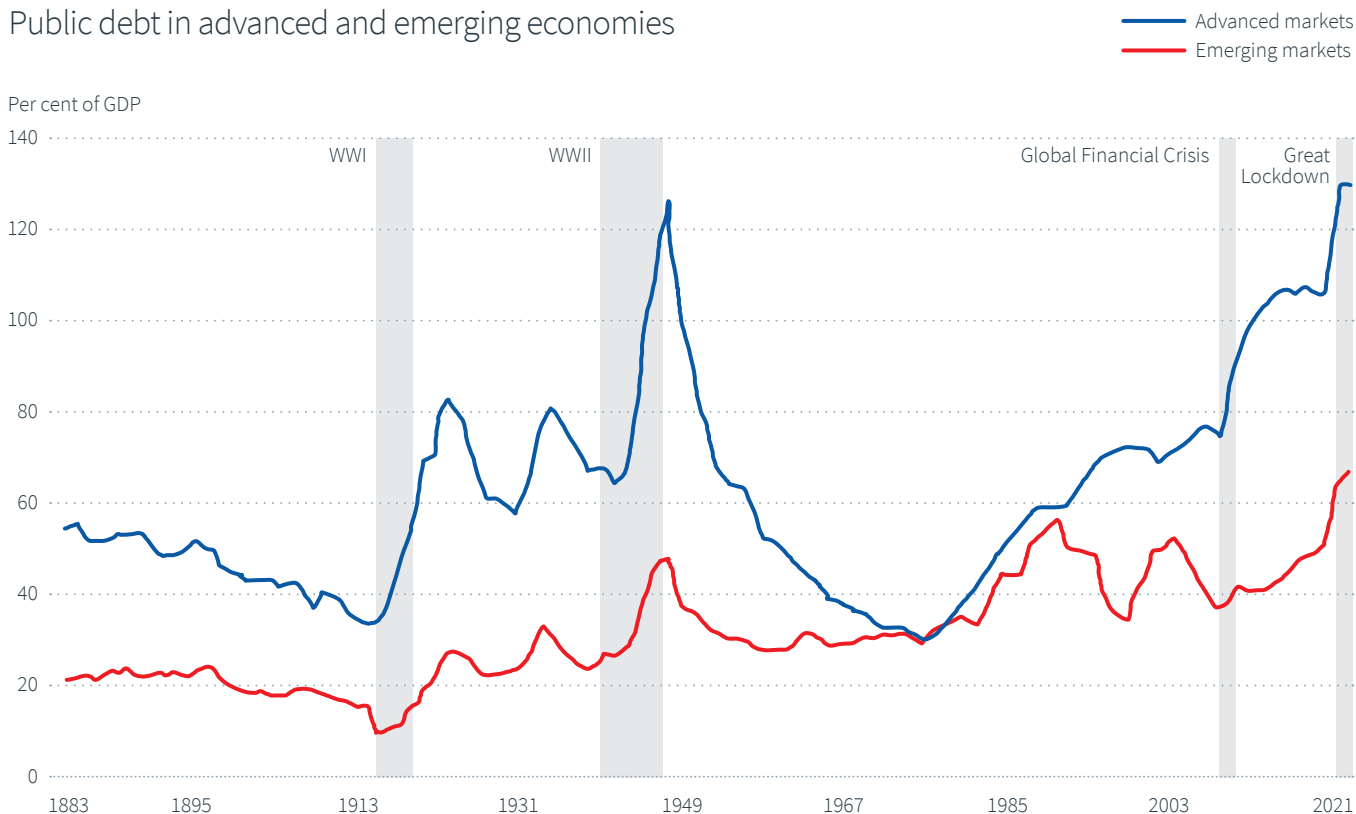Weekly US unemployment insurance claims
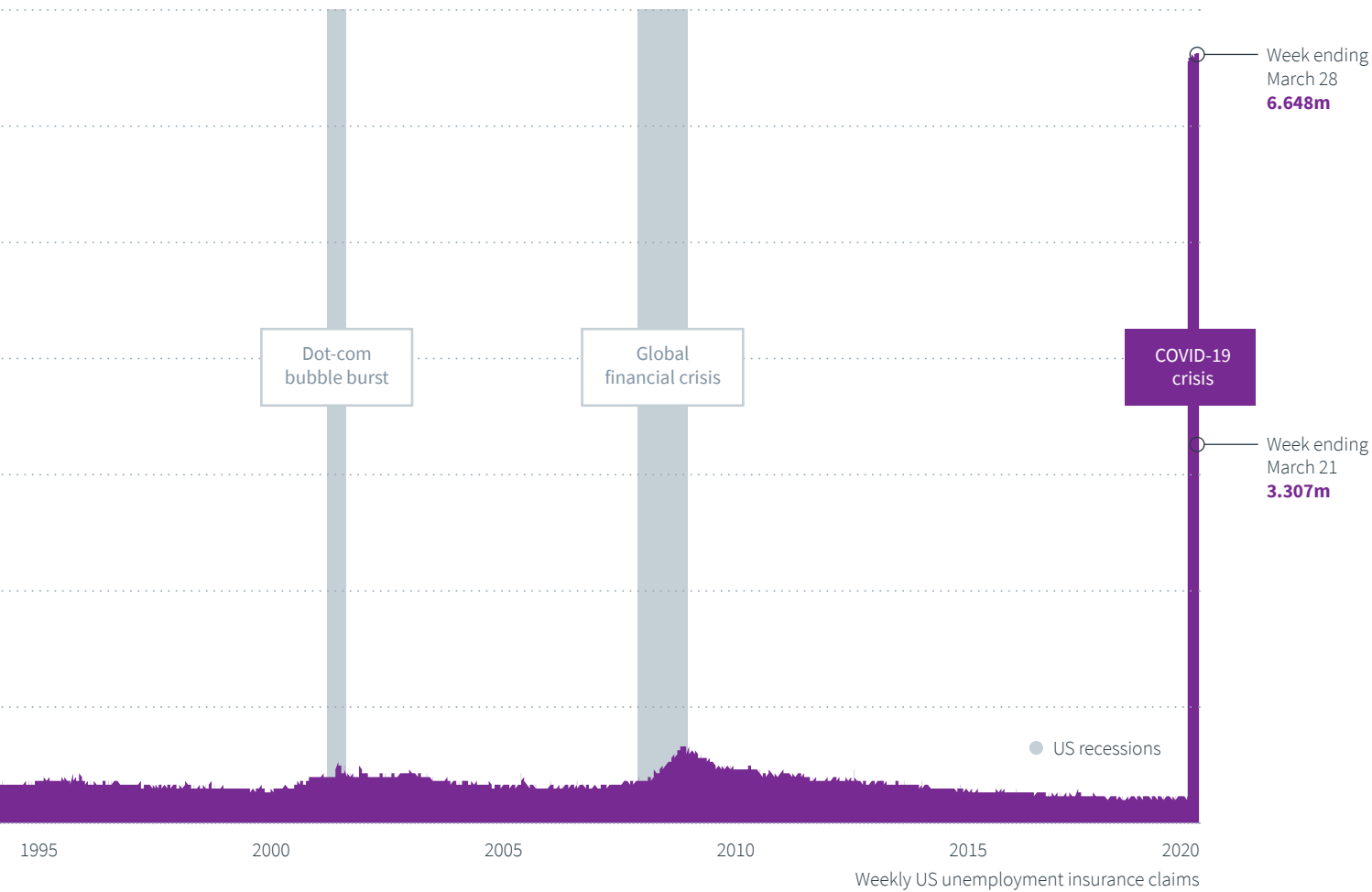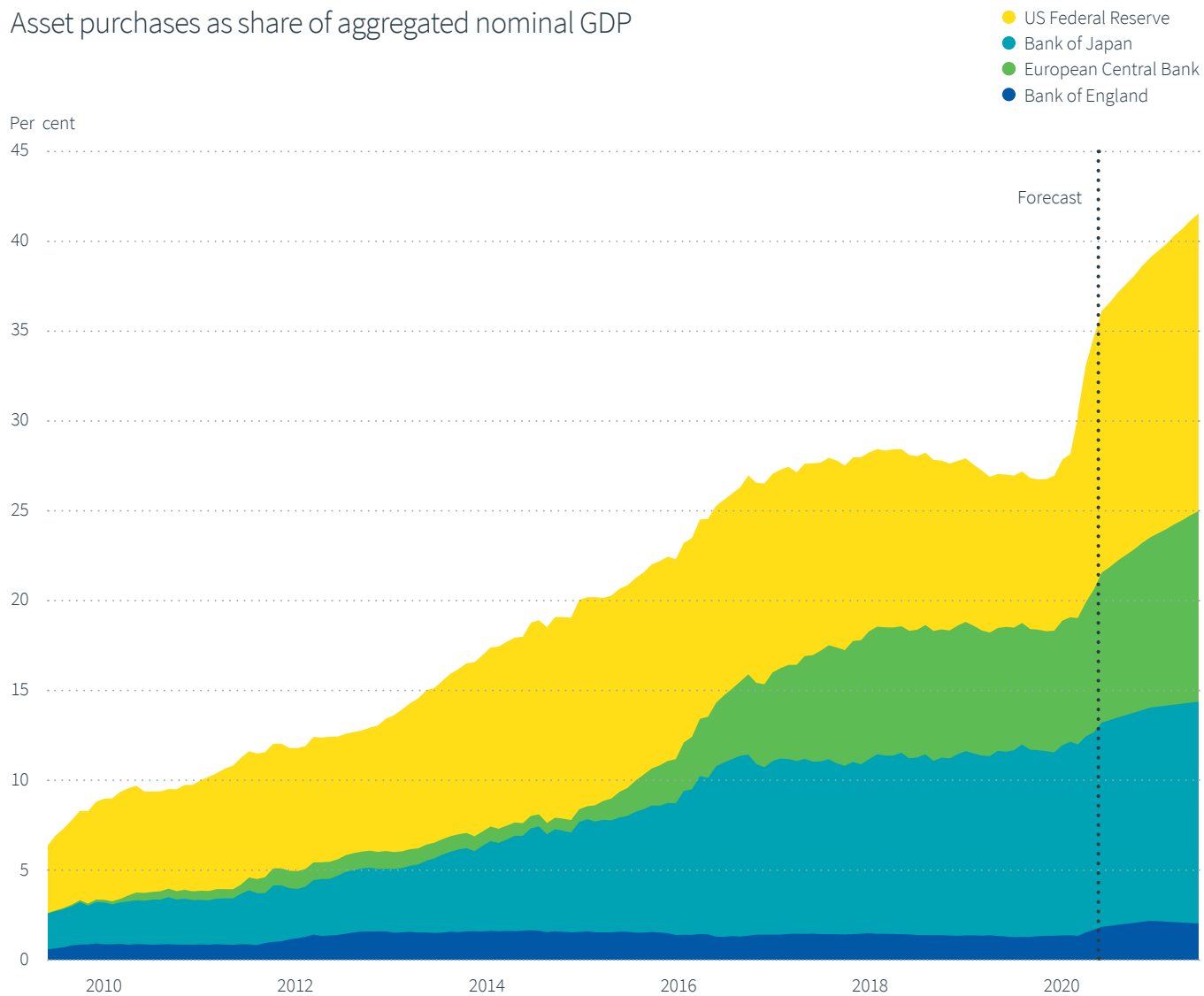
Nothing is certain but debt and taxes

Fiscal deficits have skyrocketed to record highs as governments around the world attempt to limit the damage caused by the pandemic. For now, huge government debt issuance is being absorbed by equally vast bond-buying programmes from central banks.

But is this a permanent solution? While tax rises may be part of the answer for some, the kind of austerity policies that followed the global financial crisis in a number of countries no longer appears politically acceptable. Investors face a difficult task trying to determine if, how, and when deficits will be brought back under control.

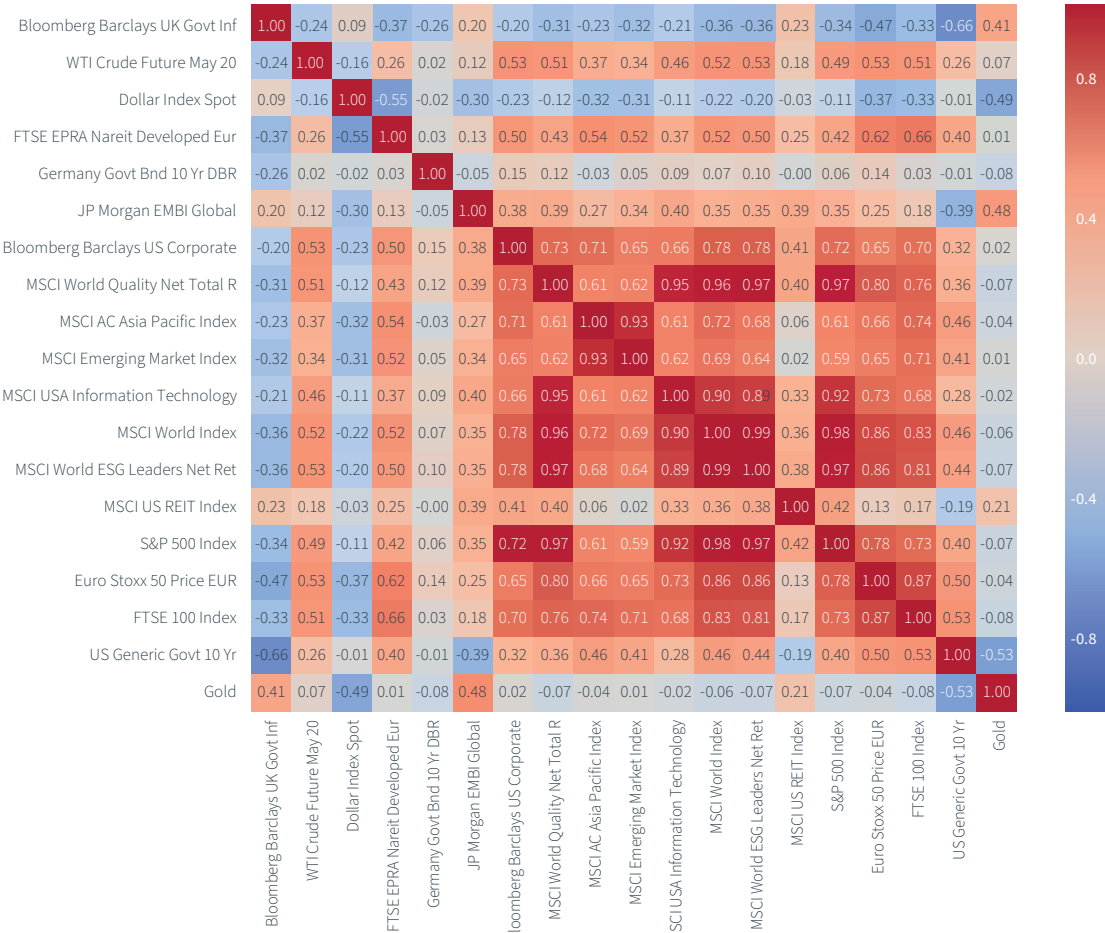## Public debt in advanced and emerging economies

Per cent of GDP

——— Advanced markets
——— Emerging markets

Asset purchases as share of aggregated nominal GDP

Legend:
- US Federal Reserve
- Bank of Japan
- European Central Bank
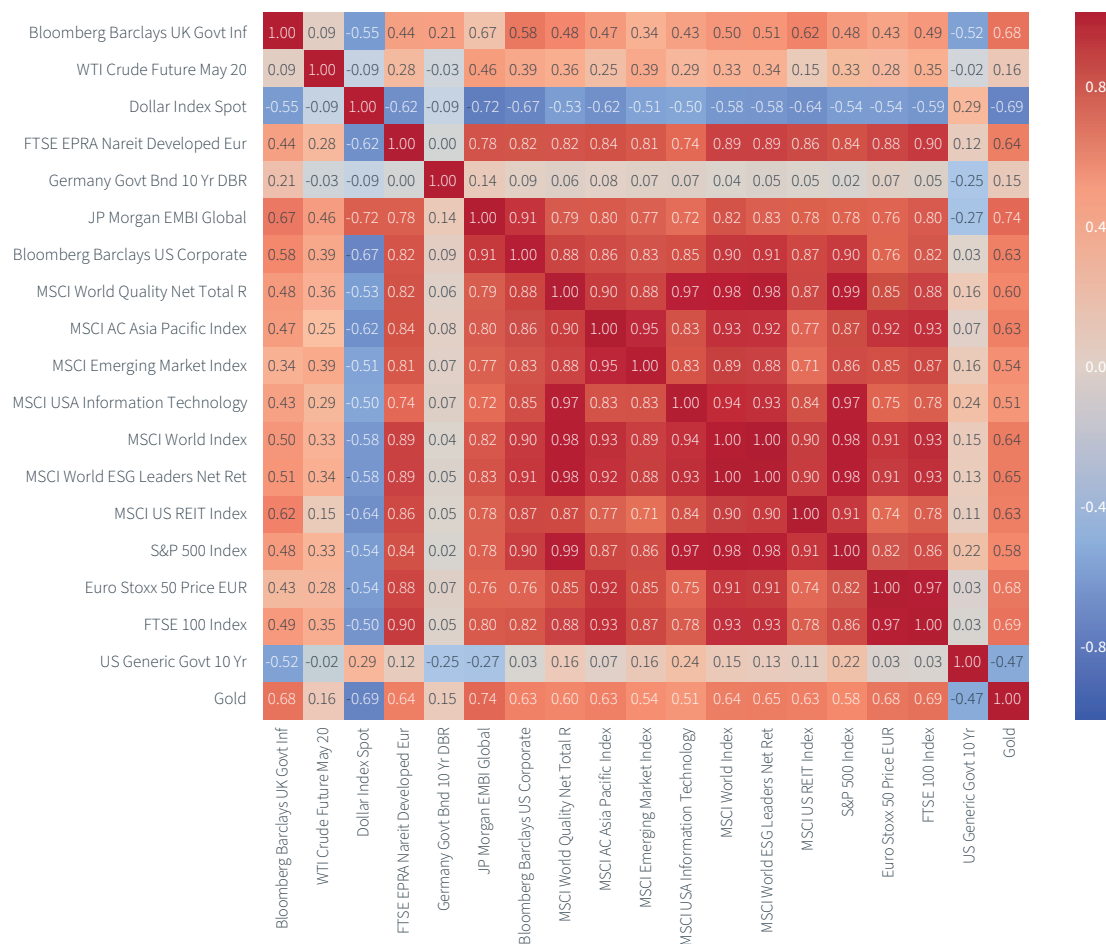- Bank of England

Per cent

Before and after: COVID-19's impact on correlations

All historical relationships can break down and must be constantly reassessed. In a 'normal' market environment, many assets behave differently from each other, providing a good level of diversification. This is in sharp contrast to the market stress created by COVID-19 when most assets started behaving in the same way, stripping portfolios of their protection. Only a few safe havens remained, including government bonds.

52-week correlations as of January 3, 2020

	Bloomberg Barclays UK Govt Inf	WTI Crude Future May 20	Dollar Index Spot	FTSE EPRA Nareit Developed Eur	Germany Govt Bnd 10 Yr DBR	JP Morgan EMBI Global	Bloomberg Barclays US Corporate	MSCI World Quality Net Total R	MSCI AC Asia Pacific Index	MSCI Emerging Market Index	MSCI USA Information Technology	MSCI World Index	MSCI World ESG Leaders Net Ret	MSCI US REIT Index	S&P 500 Index	Euro Stoxx 50 Price EUR	FTSE 100 Index	US Generic Govt 10 Yr	Gold
Bloomberg Barclays UK Govt Inf	1.00	-0.24	0.09	-0.37	-0.26	0.20	-0.20	-0.31	-0.23	-0.32	-0.21	-0.36	-0.36	0.23	-0.34	-0.47	-0.33	-0.66	0.41
WTI Crude Future May 20	-0.24	1.00	-0.16	0.26	0.02	0.12	0.53	0.51	0.37	0.34	0.46	0.52	0.53	0.18	0.49	0.53	0.51	0.26	0.07
Dollar Index Spot	0.09	-0.16	1.00	-0.55	-0.02	-0.30	-0.23	-0.12	-0.32	-0.31	-0.11	-0.22	-0.20	-0.03	-0.11	-0.37	-0.33	-0.01	-0.49
FTSE EPRA Nareit Developed Eur	-0.37	0.26	-0.55	1.00	0.03	0.13	0.50	0.43	0.54	0.52	0.37	0.52	0.50	0.25	0.42	0.62	0.66	0.40	0.01
Germany Govt Bnd 10 Yr DBR	-0.26	0.02	-0.02	0.03	1.00	-0.05	0.15	0.12	-0.03	0.05	0.09	0.07	0.10	-0.00	0.06	0.14	0.03	-0.01	-0.08
JP Morgan EMBI Global	0.20	0.12	-0.30	0.13	-0.05	1.00	0.38	0.39	0.27	0.34	0.40	0.35	0.35	0.39	0.35	0.25	0.18	-0.39	0.48
Bloomberg Barclays US Corporate	-0.20	0.53	-0.23	0.50	0.15	0.38	1.00	0.73	0.71	0.65	0.66	0.78	0.78	0.41	0.72	0.65	0.70	0.32	0.02
MSCI World Quality Net Total R	-0.31	0.51	-0.12	0.43	0.12	0.39	0.73	1.00	0.61	0.62	0.95	0.96	0.97	0.40	0.97	0.80	0.76	0.36	-0.07
MSCI AC Asia Pacific Index	-0.23	0.37	-0.32	0.54	-0.03	0.27	0.71	0.61	1.00	0.93	0.61	0.72	0.68	0.06	0.61	0.66	0.74	0.46	-0.04
MSCI Emerging Market Index	-0.32	0.34	-0.31	0.52	0.05	0.34	0.65	0.62	0.93	1.00	0.62	0.69	0.64	0.02	0.59	0.65	0.71	0.41	0.01
MSCI USA Information Technology	-0.21	0.46	-0.11	0.37	0.09	0.40	0.66	0.95	0.61	0.62	1.00	0.90	0.89	0.33	0.92	0.73	0.68	0.28	-0.02
MSCI World Index	-0.36	0.52	-0.22	0.52	0.07	0.35	0.78	0.96	0.72	0.69	0.90	1.00	0.99	0.36	0.98	0.86	0.83	0.46	-0.06
MSCI World ESG Leaders Net Ret	-0.36	0.53	-0.20	0.50	0.10	0.35	0.78	0.97	0.68	0.64	0.89	0.99	1.00	0.38	0.97	0.86	0.81	0.44	-0.07
MSCI US REIT Index	0.23	0.18	-0.03	0.25	-0.00	0.39	0.41	0.40	0.06	0.02	0.33	0.36	0.38	1.00	0.42	0.13	0.17	-0.19	0.21
S&P 500 Index	-0.34	0.49	-0.11	0.42	0.06	0.35	0.72	0.97	0.61	0.59	0.92	0.98	0.97	0.42	1.00	0.78	0.73	0.40	-0.07
Euro Stoxx 50 Price EUR	-0.47	0.53	-0.37	0.62	0.14	0.25	0.65	0.80	0.66	0.65	0.73	0.86	0.86	0.13	0.78	1.00	0.87	0.50	-0.04
FTSE 100 Index	-0.33	0.51	-0.33	0.66	0.03	0.18	0.70	0.76	0.74	0.71	0.68	0.83	0.81	0.17	0.73	0.87	1.00	0.53	-0.08
US Generic Govt 10 Yr	-0.66	0.26	-0.01	0.40	-0.01	-0.39	0.32	0.36	0.46	0.41	0.28	0.46	0.44	-0.19	0.40	0.50	0.53	1.00	-0.53
Gold	0.41	0.07	-0.49	0.01	-0.08	0.48	0.02	-0.07	-0.04	0.01	-0.02	-0.06	-0.07	0.21	-0.07	-0.04	-0.08	-0.53	1.00

52-week correlations as of April 15, 2020

	Bloomberg Barclays UK Govt Inf	WTI Crude Future May 20	Dollar Index Spot	FTSE EPRA Nareit Developed Eur	Germany Govt Bnd 10 Yr DBR	JP Morgan EMBI Global	Bloomberg Barclays US Corporate	MSCI World Quality Net Total R	MSCI AC Asia Pacific Index	MSCI Emerging Market Index	MSCI USA Information Technology	MSCI World Index	MSCI World ESG Leaders Net Ret	MSCI US REIT Index	S&P 500 Index	Euro Stoxx 50 Price EUR	FTSE 100 Index	US Generic Govt 10 Yr	Gold
Bloomberg Barclays UK Govt Inf	1.00	0.09	-0.55	0.44	0.21	0.67	0.58	0.48	0.47	0.34	0.43	0.50	0.51	0.62	0.48	0.43	0.49	-0.52	0.68
WTI Crude Future May 20	0.09	1.00	-0.09	0.28	-0.03	0.46	0.39	0.36	0.25	0.39	0.29	0.33	0.34	0.15	0.33	0.28	0.35	-0.02	0.16
Dollar Index Spot	-0.55	-0.09	1.00	-0.62	-0.09	-0.72	-0.67	-0.53	-0.62	-0.51	-0.50	-0.58	-0.58	-0.64	-0.54	-0.54	-0.59	0.29	-0.69
FTSE EPRA Nareit Developed Eur	0.44	0.28	-0.62	1.00	0.00	0.78	0.82	0.82	0.84	0.81	0.74	0.89	0.89	0.86	0.84	0.88	0.90	0.12	0.64
Germany Govt Bnd 10 Yr DBR	0.21	-0.03	-0.09	0.00	1.00	0.14	0.09	0.06	0.08	0.07	0.07	0.04	0.05	0.05	0.02	0.07	0.05	-0.25	0.15
JP Morgan EMBI Global	0.67	0.46	-0.72	0.78	0.14	1.00	0.91	0.79	0.80	0.77	0.72	0.82	0.83	0.78	0.78	0.76	0.80	-0.27	0.74
Bloomberg Barclays US Corporate	0.58	0.39	-0.67	0.82	0.09	0.91	1.00	0.88	0.86	0.83	0.85	0.90	0.91	0.87	0.90	0.76	0.82	0.03	0.63
MSCI World Quality Net Total R	0.48	0.36	-0.53	0.82	0.06	0.79	0.88	1.00	0.90	0.88	0.97	0.98	0.98	0.87	0.99	0.85	0.88	0.16	0.60
MSCI AC Asia Pacific Index	0.47	0.25	-0.62	0.84	0.08	0.80	0.86	0.90	1.00	0.95	0.83	0.93	0.92	0.77	0.87	0.92	0.93	0.07	0.63
MSCI Emerging Market Index	0.34	0.39	-0.51	0.81	0.07	0.77	0.83	0.88	0.95	1.00	0.83	0.89	0.88	0.71	0.86	0.85	0.87	0.16	0.54
MSCI USA Information Technology	0.43	0.29	-0.50	0.74	0.07	0.72	0.85	0.97	0.83	0.83	1.00	0.94	0.93	0.84	0.97	0.75	0.78	0.24	0.51
MSCI World Index	0.50	0.33	-0.58	0.89	0.04	0.82	0.90	0.98	0.93	0.89	0.94	1.00	1.00	0.90	0.98	0.91	0.93	0.15	0.64
MSCI World ESG Leaders Net Ret	0.51	0.34	-0.58	0.89	0.05	0.83	0.91	0.98	0.92	0.88	0.93	1.00	1.00	0.90	0.98	0.91	0.93	0.13	0.65
MSCI US REIT Index	0.62	0.15	-0.64	0.86	0.05	0.78	0.87	0.87	0.77	0.71	0.84	0.90	0.90	1.00	0.91	0.74	0.78	0.11	0.63
S&P 500 Index	0.48	0.33	-0.54	0.84	0.02	0.78	0.90	0.99	0.87	0.86	0.97	0.98	0.98	0.91	1.00	0.82	0.86	0.22	0.58
Euro Stoxx 50 Price EUR	0.43	0.28	-0.54	0.88	0.07	0.76	0.76	0.85	0.92	0.85	0.75	0.91	0.91	0.74	0.82	1.00	0.97	0.03	0.68
FTSE 100 Index	0.49	0.35	-0.50	0.90	0.05	0.80	0.82	0.88	0.93	0.87	0.78	0.93	0.93	0.78	0.86	0.97	1.00	0.03	0.69
US Generic Govt 10 Yr	-0.52	-0.02	0.29	0.12	-0.25	-0.27	0.03	0.16	0.07	0.16	0.24	0.15	0.13	0.11	0.22	0.03	0.03	1.00	-0.47
Gold	0.68	0.16	-0.69	0.64	0.15	0.74	0.63	0.60	0.63	0.54	0.51	0.64	0.65	0.63	0.58	0.68	0.69	-0.47	1.00

Infrastructure project evaluation

Significant new infrastructure investment is fundamental to the achievement of the Sustainable Development Goals (SDGs). Yet determining a project's potential contribution – positive and negative – is not a linear process.

Using the recent case study of a European utility company, our infrastructure investment team illustrate how the ESG elements of due diligence and decision making help assess a project's contribution.

Background: We were considering an investment in a company that builds, refurbishes and operates small-scale power plants supplying energy to local customers. The company aims to improve the energy efficiency of its plants.

Origination

The initial ESG analysis is positive:

- Environment: plant energy efficiency improvements
- Social: supplying energy to local businesses
- Governance: strong management track record and oversight on sustainability

Proceed

Due diligence

Technical due diligence:

- Still supplies a small amount of energy from highly polluting lignite
- Clear roadmap for decarbonisation
- Lignite exposure in decline

Legal due diligence:

- The plants are expected to become greener by 2025 in line with regulation

Enhanced value

ESG due diligence revealed minor exposure to lignite

Coal risk needs mitigation

Management of the asset

We added an ESG-specific covenant to the asset management agreement. It included the following:

- The company cannot build any new lignite or coal plants
- The company is restricted from buying other firms that build lignite or coal plants

Approval depends on the company agreeing obligations and reporting

Approval

Approval of the investment is *conditional* on the utility company agreeing the ESG covenant and reporting obligations

Reporting

We needed to make sure the company kept to its decarbonisation plan:

The company must report every year to Aviva Investors on progress

Progress must be proven

Result: The investment will contribute to **SDG 7** on affordable, clean energy, and to **SDG 13** on climate action

Real exposure: Balancing sources of portfolio diversification

Real assets can be used to achieve different investment outcomes. Understanding what drives risk and return is as important as measuring the factors themselves.

Our analysis highlights risk contributors in each equity asset class; power prices (for renewables), rental value growth and inflation are the three main drivers. This contrasts with fixed income, where the main risk driver is the level of defaults. In this respect, infrastructure and real estate may help diversify a fixed income portfolio.

Risk drivers of income in real assets

Legend:
- GDP-sensitive
- Inflation
- Idiosyncratic
- Power price
- Rental growth
- Property yields

Per cent

Categories (x-axis): UK renewables, UK real estate (all property), UK long lease, Euro long lease, UK income strip
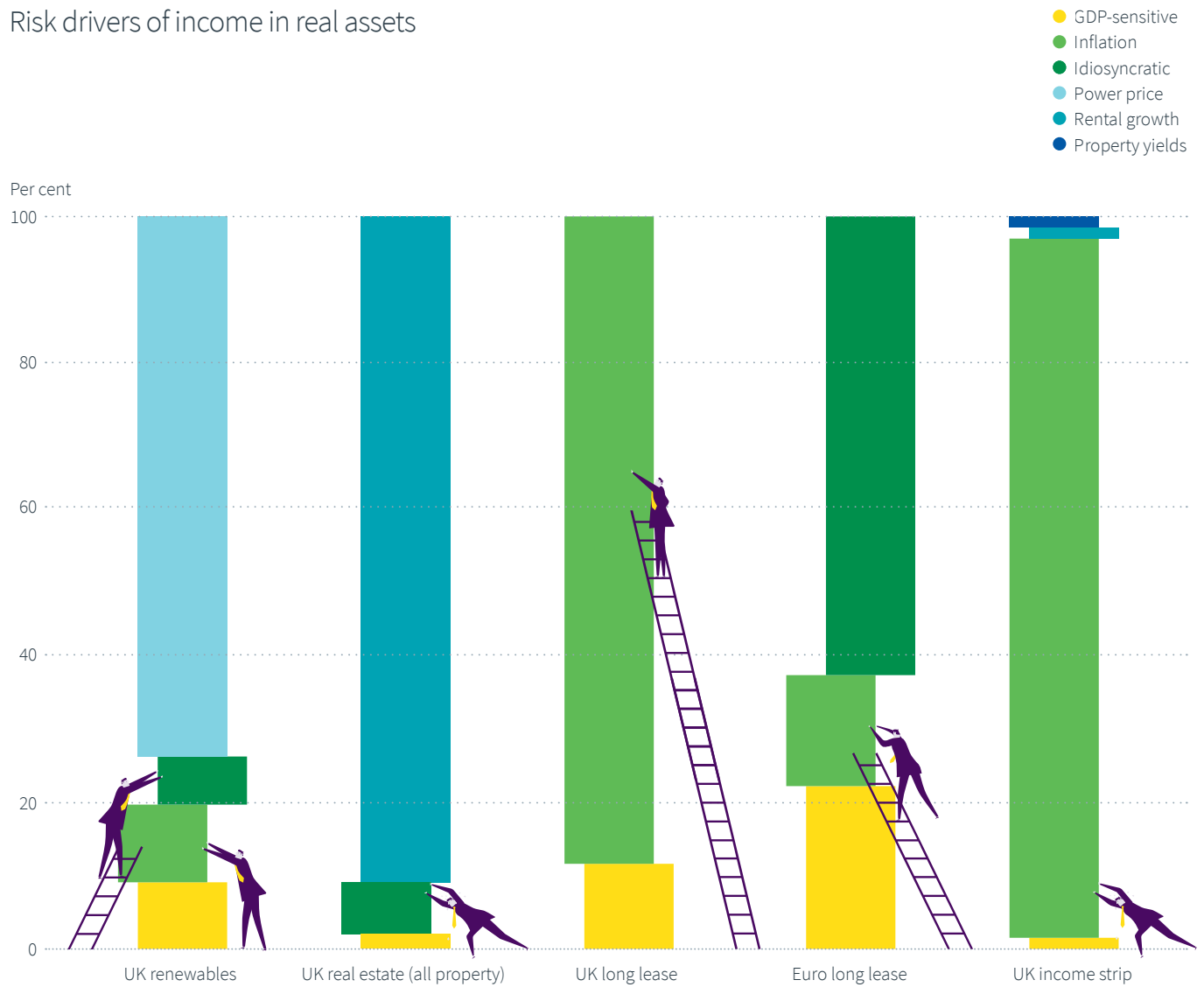
Crowding out
Big Tech just got bigger

Bigger companies have seized market share from smaller ones in recent years, especially in the technology sector, where digital platforms tend to favour incumbents and first movers.

As this bubble chart shows, the trend is most pronounced in China and the US, where huge platform companies now hold sway. These companies provide the public with convenient services – often for free – but some economists say that this level of market concentration is unhealthy, because it dampens competition and removes incentives for smaller firms to invest.

Market capitalisation of global platforms
as percentage of total, by region

NASPERS

Tencent

Alibaba

Microsoft

SAP

- Africa
- Asia
- Europe
- North America

Data as of September 30, 2020
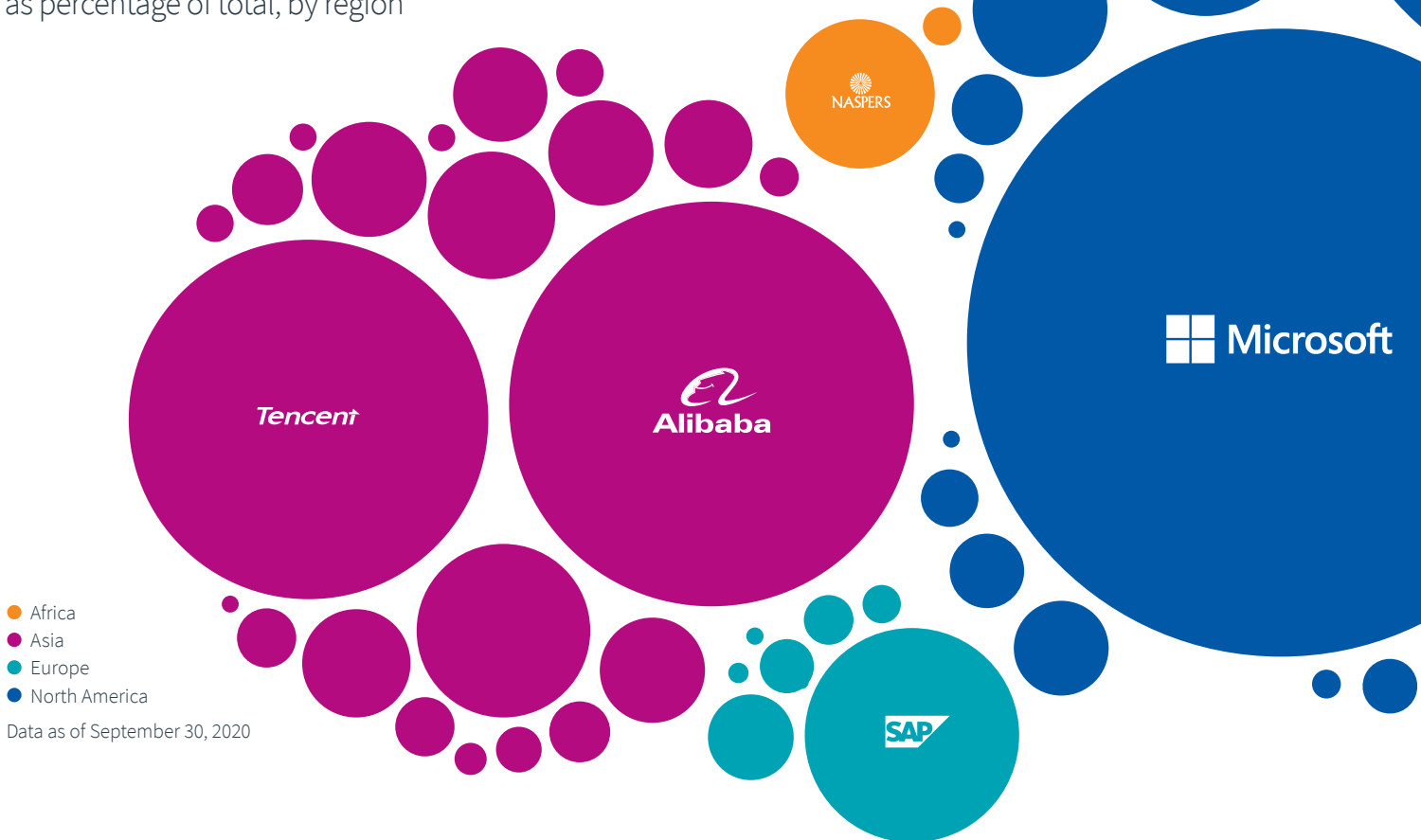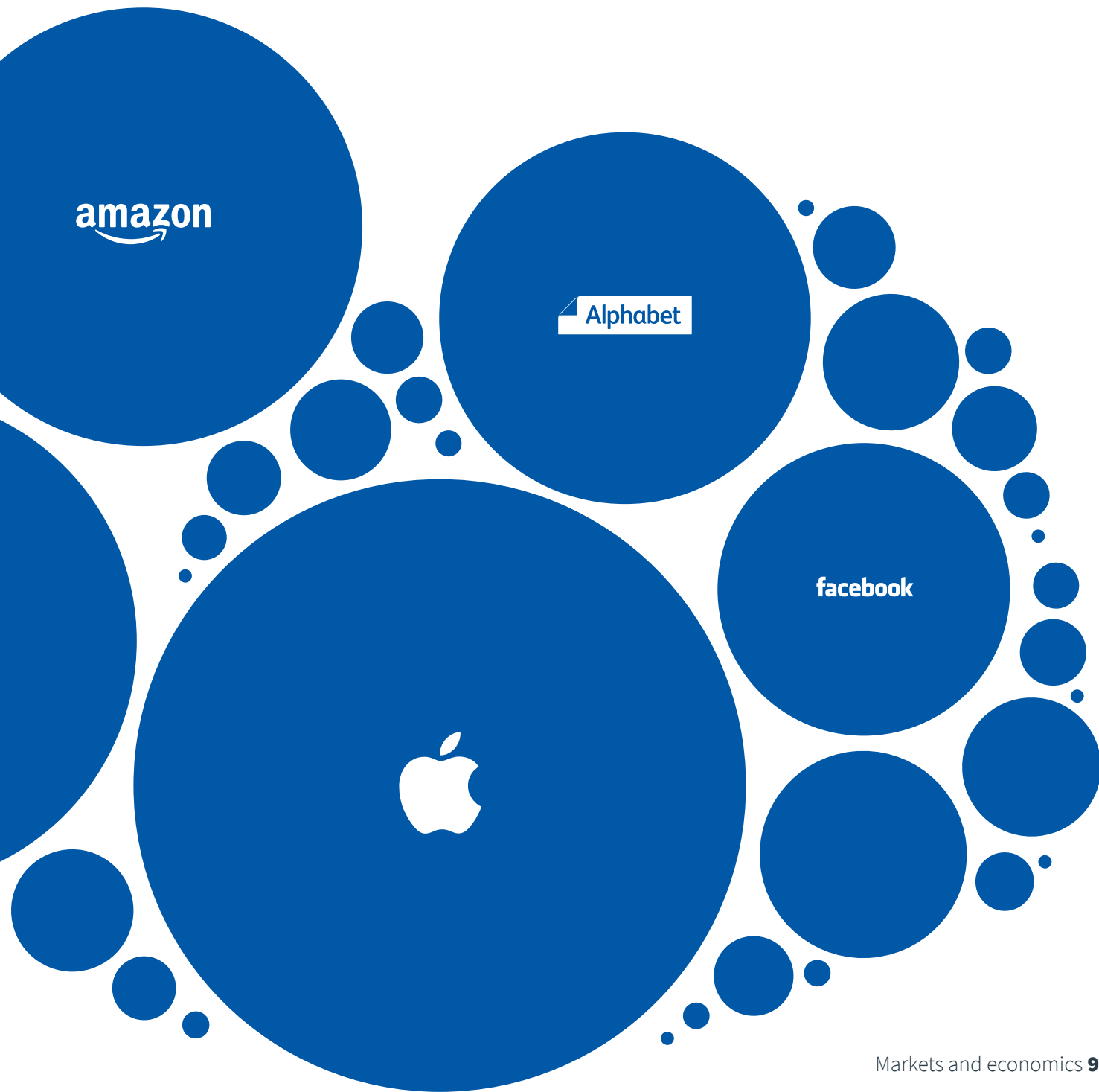
Constructive alignment
Illiquidity premia in private markets

Over the last decade, dwindling yields in fixed income markets have pushed investors to look elsewhere to boost returns, by allocating to riskier public assets or to less liquid private assets such as real estate, infrastructure and private corporate debt.

A key driver for the increase in allocations to private assets was the belief they could deliver illiquidity premia: higher expected returns than publicly traded assets of broadly similar quality. In the uncertainty brought by COVID-19, though, that premia came under intense pressure in the first half of 2020 as spreads widened. However, they quickly contracted again as unprecedented central bank and fiscal support worldwide boosted markets, with safer assets benefitting the most.

Illiquidity premium (basis points)

Legend:
- Illiquidity premia infrastructure debt
- Iliquidity premia private corporate debt
- Iliquidity premia real estate finance
- Infrastructure debt trendline
- Private corporate debt trendline
- Real estate finance trendline
- Real estate equity 3m illiquidity premia
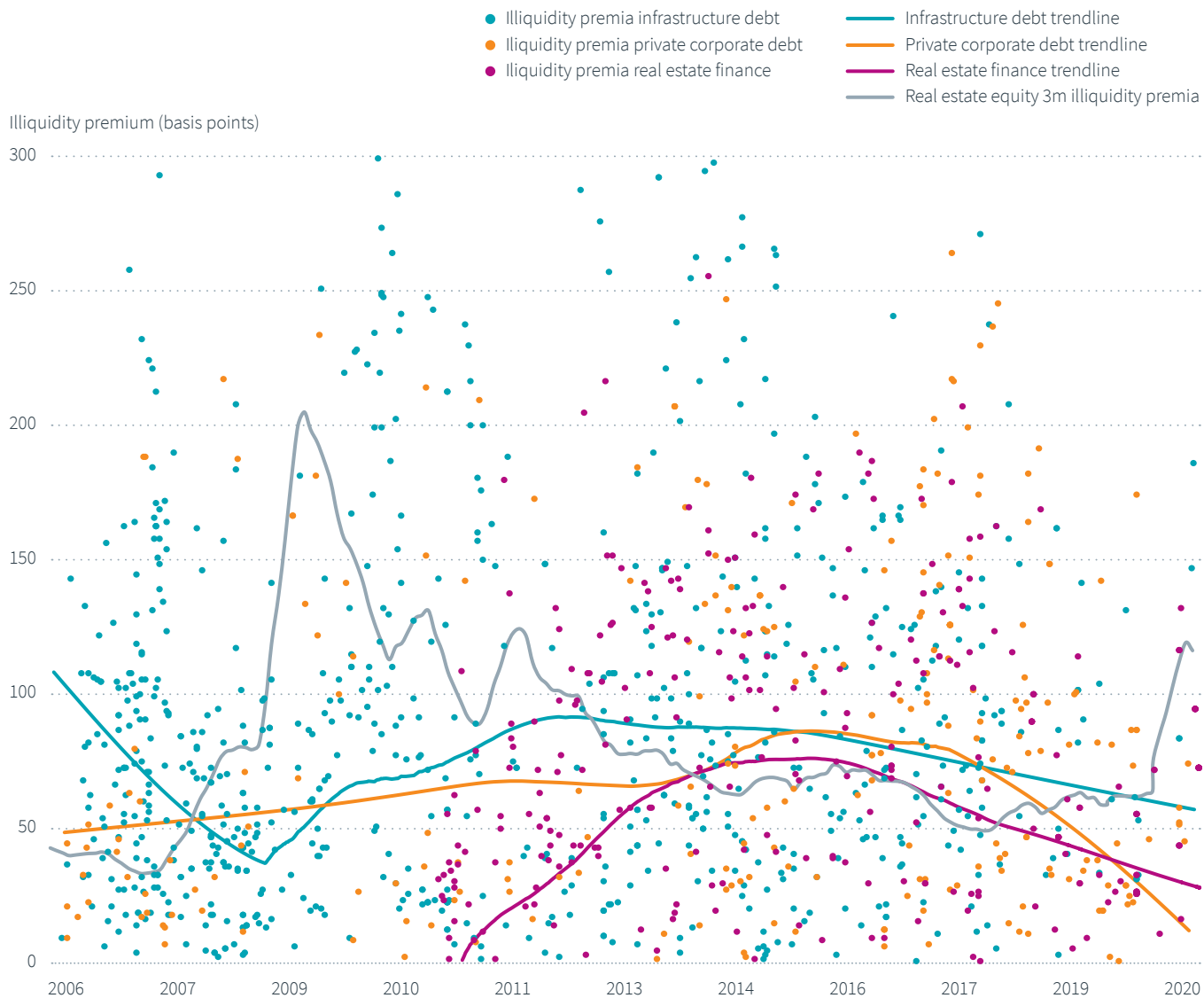
Then and now

Telling stories through data visualisation has shaped how we view the world through the ages. We pay homage to some pioneering work and provide a more modern interpretation.

W.E.B. Du Bois

Black employment history: Life after emancipation for African Americans

Relative number of African Americans
in businesses, by types (ca. 1900)

Estimated capital $8,784,637

General merchandise stores

Grocers

Bankers

Undertakers

Building contractors

Druggists

Publishers

Building and loan associations
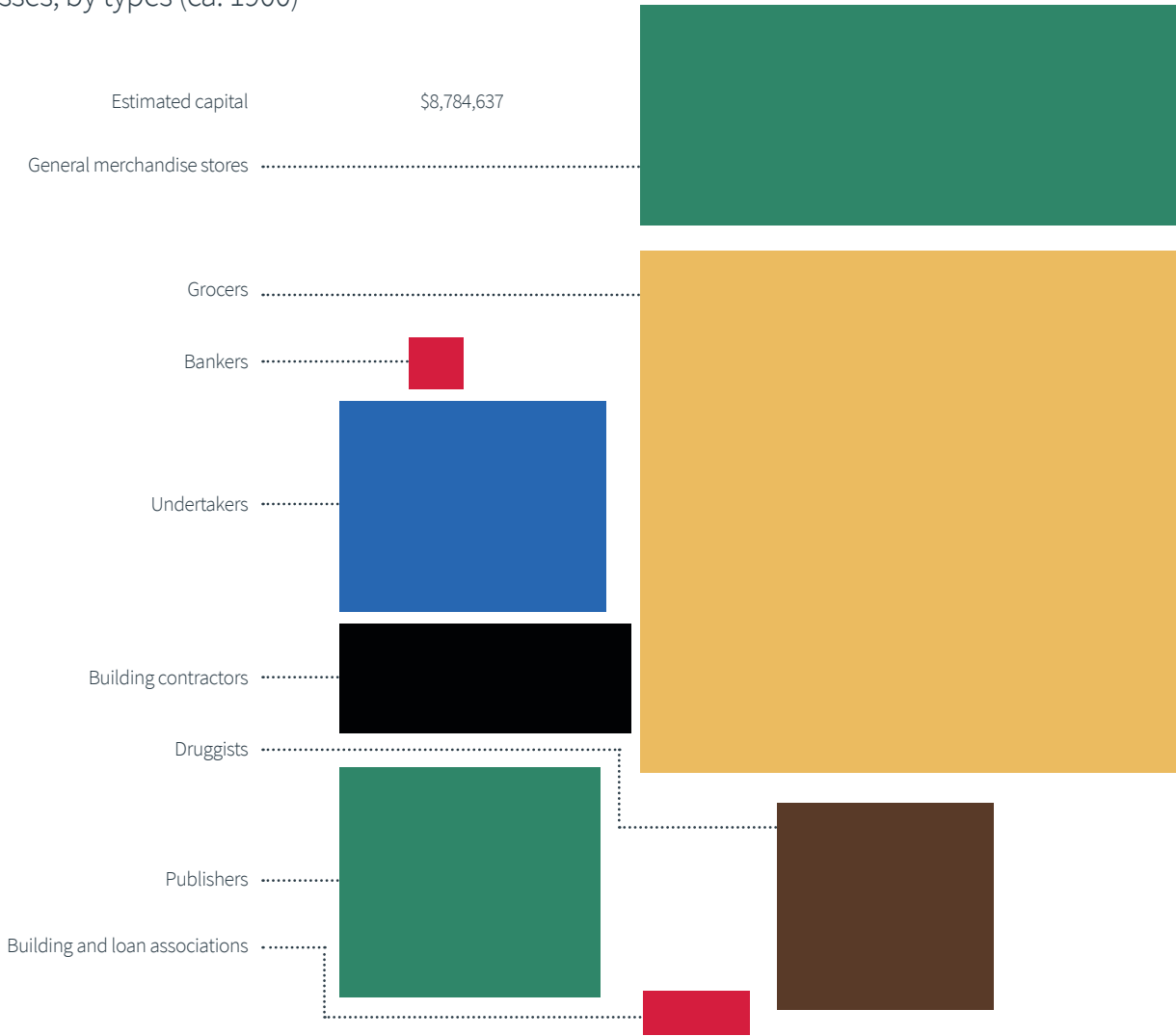
The Harvard-educated sociologist, historian and civil rights activist W. E. B. Du Bois first visualised the evolution of black life since emancipation through a series of charts, graphs and maps exhibited at the Paris Exposition Universelle in 1900.

At the time, Du Bois wrote that he was striving to present "life and development without apology or gloss". The chart to the left, for example, simply illustrates the types of black-owned businesses such as grocery stores, pharmacies and publishing companies. More recent US Census data indicate occupations among African Americans are more concentrated in service roles relative to whites. While about 30 per cent of black workers are employed as managers, professionals or related roles, this falls far short of the 40 per cent occupied by whites in the same category.

US labour force by occupation, race and ethnicity (per cent)

- ● Management, professional and related
- ● Service
- ● Sales and office
- ● Natural resources, construction and maintenance
- ● Production, transportation and material moving

White

| 11 | 10 | 23 | 16 | 40 |

Black or African American

| 15 | 6 | 24 | 25 | 30 |

Asian

| 10 | 3 | 20 | 16 | 51 |

Hispanic or Latino

| 16 | 16 | 21 | 25 | 22 |
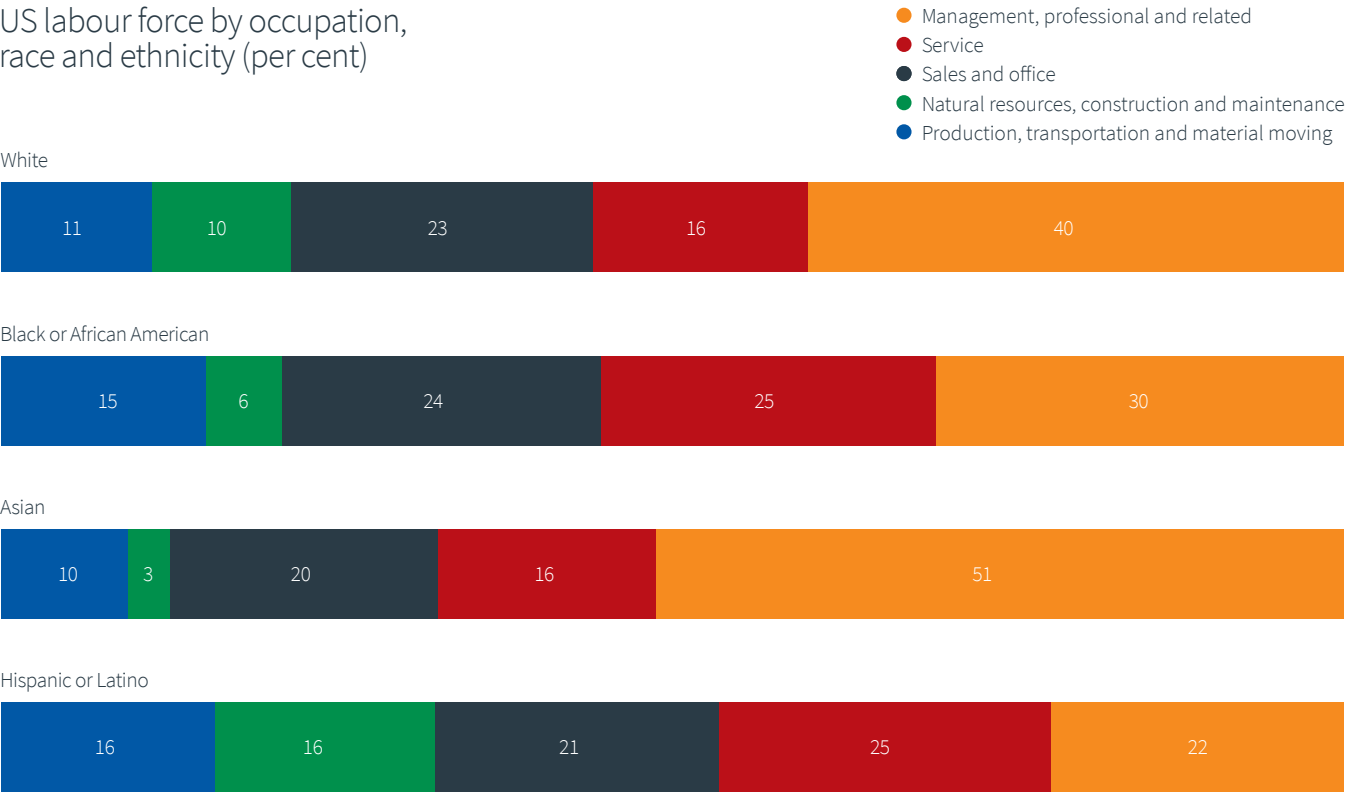
Florence Nightingale
Why you need to understand the causes of death to prevent it

The Lady with the Lamp is best known as the founder of modern nursing, but she was also a data visualisation pioneer who understood the power of statistics to persuade. In the graphic comparing the monthly rate and causes of death of the British army in 1855 and 1856 during the Crimean War, she demonstrated that the mortality rate significantly decreased when sanitary practices improved, helping to convince the government to raise hygiene standards in the military.

When the coronavirus pandemic spread across the globe earlier this year, US President Donald Trump tweeted that it's no worse than the seasonal flu. But, as a chart of US mortality and causes of death during the week commencing April 6 shows, COVID-19 is clearly not the flu. It is far more deadly, which explains why public officials imposed protective measures.

Causes of mortality during
the Crimean War, 1854-1856

**April 1855
to March 1856**

**April 1854
to March 1855**

- ● Deaths from contagious and mitigable infections/diseases
- ● Deaths from wounds
- ● Deaths from all other causes

Causes of death in
the US, April 6-12, 2020

COVID-19 killed more people
from April 6 to April 12 than
any other cause of death
except heart disease typically
does in a normal April week.

Heart disease
12,626

COVID-19
12,392

Cancer
11,437

Chronic lower
respiratory
disease
3,279

Accidents
2,911

Strokes, brain
aneurysms
2,764

Alzheimer's
2,184

Diabetes
1,586

Flu, pneumonia
1,227

Kidney disease
998

Suicide
876

Septicemia
806

Liver disease
779

High blood pressure
649

Parkinson's
572

Pneumonitis
399

Slave ship
Illustrating the state of forced labour

In this 'Brookes' slave ship diagram by the Plymouth Chapter of the Society for Effecting the Abolition of the Slave Trade, hundreds of enslaved men, women and children are shown packed into tiny spaces. They were often chained or shackled together, making movement more difficult, and the spread of disease, dehydration and malnutrition contributed to a high mortality rate during the journey. The image helped drum up support for the anti-slavery movement in the US and Europe.

Slavery remains widespread, with about 40 million people in either forced labour or forced marriages globally. Unlike the predominance of adult male captives during the transatlantic slave trade, however, modern slavery targets women more than men, even when excluding forced marriages.

Diagram of how slaves were stowed on board Brookes cargo ship, ca. 1789
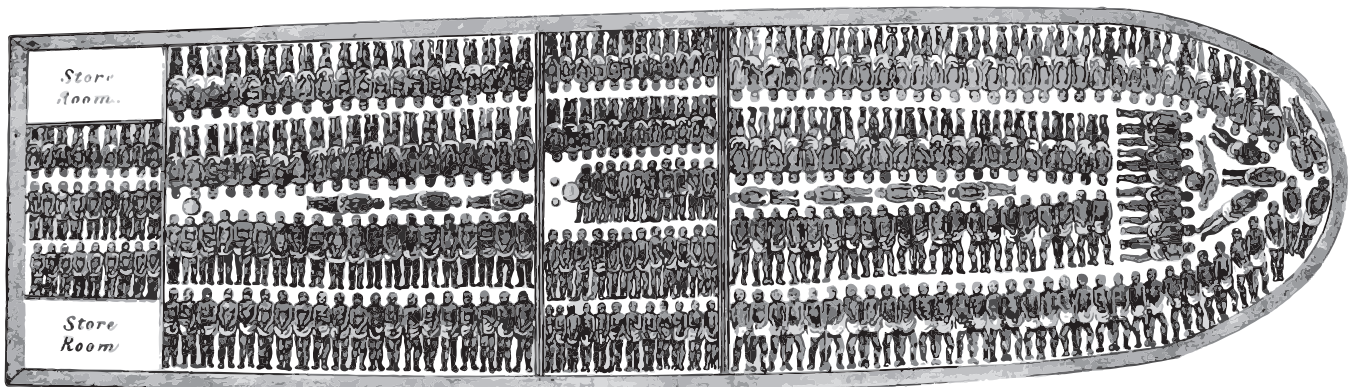
Modern slavery: Individuals in forced labour or forced marriages

Forced labour

Forced marriage

World total

Type

Exploitation   Sex   State-imposed

Women

Men

Adult

Children

Estimates for 2016
(number of individuals)

25 million

15 million

4 million

1 million

300,000
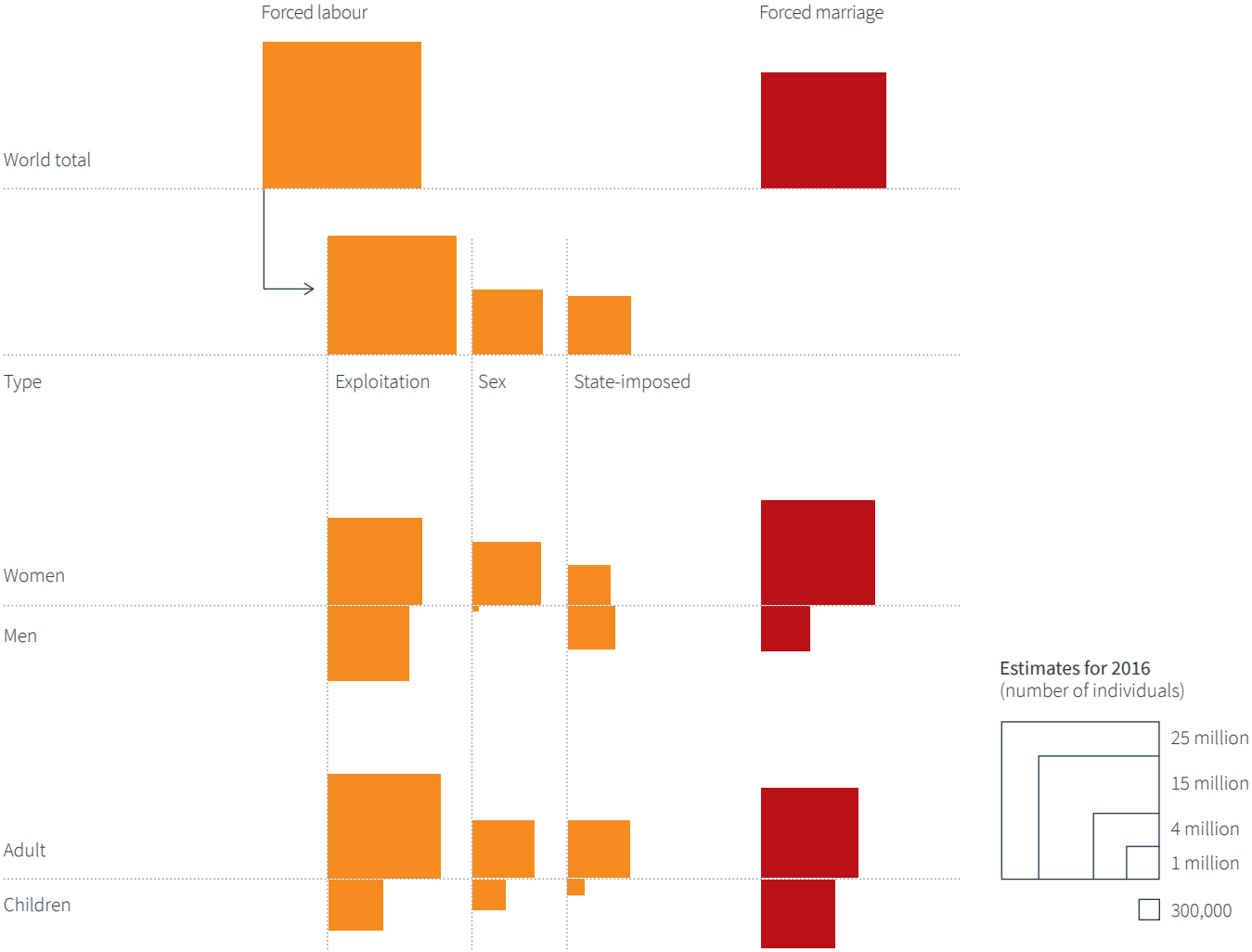
Big
data
is watching you

The pattern of ridges and furrows in our fingerprints begins to develop in the womb and is formed by the time we're born. No two are alike, not even among identical twins. Their individuality and immutability make them one of the most reliable methods of identification. Technology has paved the way to collect the digital traces we leave online to establish who we are, in a way that mimics the uniqueness of our physical fingerprints but on a far grander scale. Analysing visible content such as texts, emails and posts alongside the hidden metadata specific to our devices not only helps identify individuals, but also their preferences, personalities and ultimately behaviours, which physical fingerprints cannot do. This makes personal data as valuable to a retailer selling wares as a politician campaigning for votes or a criminal committing blackmail. As with any powerful tool, the potential for abuse is considerable. The other side of the coin is big data's central role in solving global problems. Its ability to mitigate climate risks, improve national security and personalise healthcare is well-documented. During the COVID-19 pandemic, online surveillance helped monitor the spread of the virus and manage the disease. Yet this involves individuals relinquishing privacy rights that history suggests may be difficult to regain long after the intended use for them disappears. If personal data is the new oil, as with any new market, effective regulations are required to create a level playing field. Tim Berners-Lee, inventor of the World Wide Web, has called for a 'Magna Carta for the web to address data security, data auditing and data use transparency. Otherwise, what was meant to connect the world may end up leaving a destructive divide in its wake.

Appendix
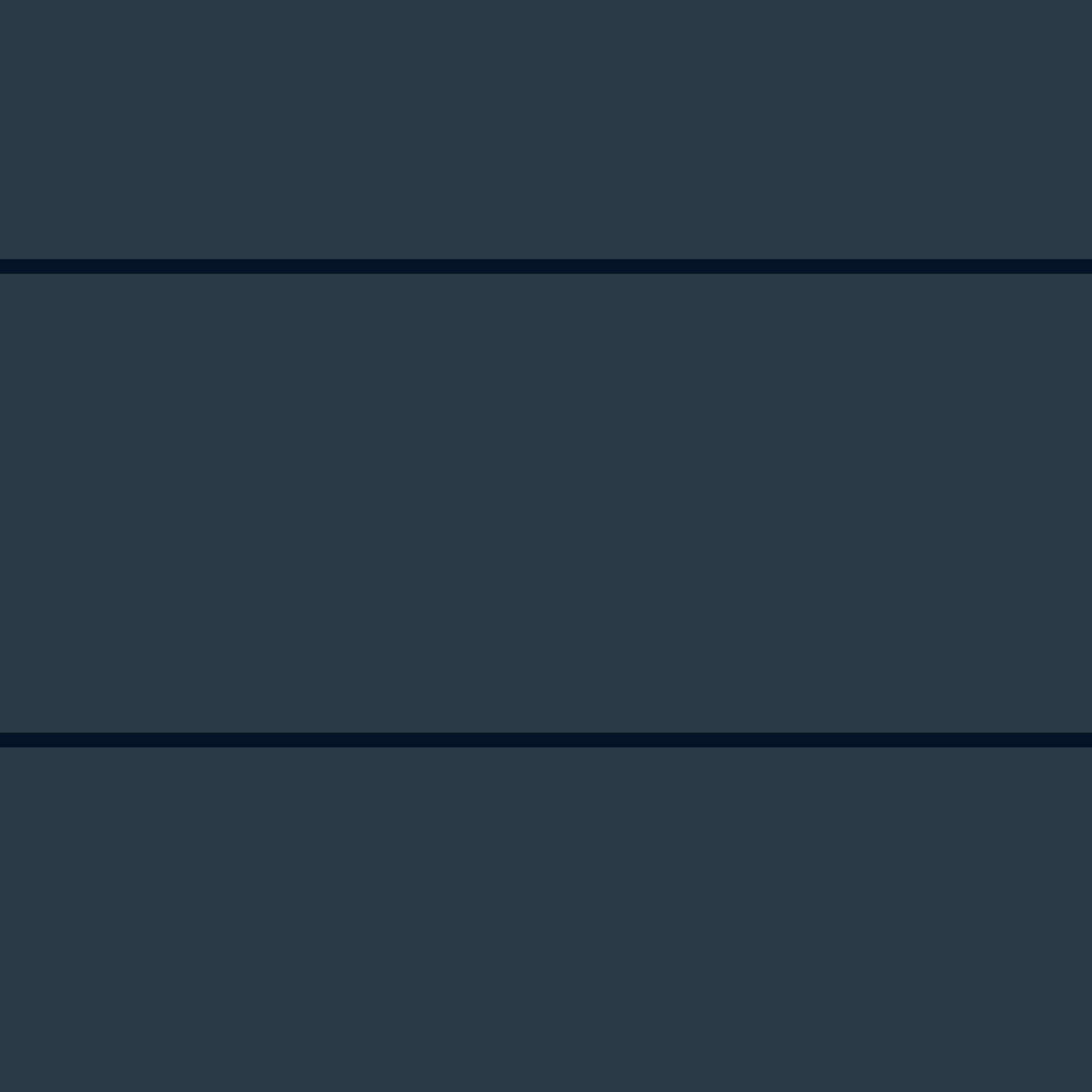
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100   **W.E.B. Du Bois** W. E. B. Du Bois, 'A series of statistical charts illustrating the condition of the descendants of former African slaves now in residence in the United States of America', ca. 1900.

101   **W.E.B. Du Bois** 'Labor force characteristics by race and ethnicity, 2015', US Bureau of Labor Statistics, September 2016.

102   **Florence Nightingale** 'Florence Nightingale: The pioneer statistician', Science Museum, December 10, 2018.

103   **Florence Nightingale** Dan Keating and Chiqui Esteban, 'Covid-19 is rapidly becoming America's leading cause of death', Washington Post, April 16, 2020.

104   **Slave ship** 'Diagram of the 'Brookes' slave ship', British Library, ca 1801.

105   **Slave ship** 'Modern slavery', Espace Mondial l'Atlas (World Atlas of Global Issues), 2018. Data based on International Labour Organization (ILO) and Walk Free Foundation, Global estimates of modern slavery: Forced labour and forced marriage, Geneva, 2017.

107   **Big data is watching you** Aviva Investors, 2020.

Important information

$= 0 + (+\infty) = +\infty;$

$2x + 1$

$\left(\dfrac{3}{3} + \dfrac{\frac{5}{x}}{\frac{7}{x}}\right)^{x+1}$

$\dfrac{n^2 + n - 1}{n^2 - 2n + 3} \cdot \dfrac{n^2 - 2n + 3}{n^2 - 2n + 3} = x \| $

$\lim\limits_{x \to \pi} \sin(x) = 0$

$\underline{n^2 - 2n + 3}$

$+\infty$

R_1

$R_2 > R_1$

ω_r

ω

$fsh(\omega)$

$\in \oint : \omega^n = z \}$

$\sum\limits_{\ell=1}^{n} C_{n+1}^{k}$

$\lim\left(1 + \dfrac{1}{\dfrac{3x+7}{2}}\right)^{\dfrac{3x+7}{-2}}$

$\left.\dfrac{\frac{x+1}{3x+7}}{-2}\right.$

$f(x) =$

$18 = 2x + 4x$

$x = 18/6 = 3$

$x + \dfrac{1}{x^2}\Big) =$

$\lim\limits_{x \to \pi} (x^2)$

$\sin x$

$\dfrac{AB}{CD} = \dfrac{2BC}{2AD}$

$18/9$

$\infty;$

$\dfrac{t}{\pi^2}$

$90°$

$(0,1)$

ctg

$in(x)) = 0$

$180°$ $45°$ $30°$

-1 $(1,0)$ 0

m

$\to 0$

$270°$

tg

$\dfrac{n^2 - 2n + 3}{0 \quad 3n + 4}$

$AB = 3 \cdot 2$

$\dfrac{n^2 + n - 1}{0 - 3n + 4}$

$lokal$ $max;$

$\left(\dfrac{3}{3} + \dfrac{\frac{5}{x}}{\frac{7}{x}}\right)^{x+1}$

$ctg : (-0, \pi) \ni x$

$f(x) = e^x$

$CD = 6$

$arctg : (-\infty, \infty)$

lim