

Globalization has made people in one country utterly dependent on markets in others, and automation might unravel large parts of this global trade network with disastrous consequences for the weakest links. AI might generate immense wealth in hi-tech hubs such as Silicon Valley and Bangalore, while devastating the economies of underdeveloped countries that rely on cheap labour, such as Honduras and Bangladesh.

US voters might conceivably agree that taxes paid by tech giants Amazon and Google for their US business should be used to give stipends to unemployed coalminers in Pennsylvania or jobless taxi-drivers in New York. But they are unlikely to send their taxes to Honduras. We are still far from having any feasible models for a post-work economy, society or political system, and we don't have much time to formulate them.

In the nineteenth century, the Industrial Revolution created new conditions and problems that none of the existing social, economic and political models could cope with. Consequently, humankind had to develop completely new models — liberal democracies, communist dictatorships and fascist regimes. It took more than a century of terrible wars and revolutions to experiment with these, separate the wheat from the chaff and implement the best solutions.

The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels. Given the immense destructive power of our modern civilization, we cannot afford more failed models, world wars and bloody revolutions. We have to do better this time. ■

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Workers protest in London in February.

The second Renaissance

Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.

The Renaissance that began in Europe in the mid-1400s and ended in the early 1500s brought a radical transformation of the sciences, the humanities and politics. Building on the invention of the printing press and cheap paper, information was democratized, there was a hunger for literacy and the Catholic Church's near-monopoly on knowledge was challenged. The resulting breakthroughs took Europe from being one of the more backward regions of the world to being the most advanced by far, within just 80 years.

But it ended in tears. Extremists, pointing

to growing inequalities and the corruption of the elite, called for a return to spiritual values. In Italy, thousands of artworks and books were burned, branded as irreverent. Across Europe, rising intolerance of scientists, intellectuals, foreigners and ethnic minorities became the norm, with religious wars and inquisitions playing out over the following centuries.

In my view, many parts of the world are now in the middle of a second Renaissance. This one is seeing even faster change than the last, and across the entire globe. History tells us that it will be disruptive. It will bring immense benefits and it will be highly destabilizing. We should expect more extremism and the rise of potentially catastrophic risks.

Innovation today is happening faster than ever, driven by the unlocking of individual



► and collective abilities in a booming population. On average, literacy levels, life expectancy and incomes have soared. Flows of goods, services, money, people and, most importantly, ideas across national borders — globalization — has unleashed unprecedented progress and a scientific and broader renaissance. They have also brought growing interdependence and new risks^{1,2}.

The Internet helps to harness the global capacity for connectivity and innovation, but also brings us malware, cybercrime and the sacrifice of privacy. Airports are crucial to international integration of science and commerce, but they can also be super-spreaders of pandemics — just as explorers to the new world brought with them fatal diseases. Financial hubs create fresh opportunities for economies to prosper, but they simultaneously allow a financial crisis in one country to destroy jobs and pensions in distant parts of the world³.

The tension between individual success and collective collapse is growing. As more people escape poverty and climb the energy curve, climate change and biodiversity loss accelerate. As more people benefit from better nutrition, ocean fisheries are at risk of collapse and forests are destroyed for cattle. Improvements in global health could soon be threatened by rapidly rising antibiotic resistance.

Accelerating technological change will provide solutions for many challenges, from cancer to cleaner sources of energy. But our politics and our institutions are locked in past models that are increasingly unfit for purpose. Deep ethical issues arising from genomics research and the potential dangers of biological pathogens are not being adequately addressed. Improvements in computing and artificial intelligence will kill off many jobs. Breakthroughs in nanotechnology and materials science, augmented and virtual reality, 3D printing and other applications will also radically disrupt society. All are barely understood by politicians and most citizens.

GROWING GAP

Inequality is rising in almost all countries that are experiencing rapid change. The faster the pace of change, the more rapidly people are being left behind. The share of wealth enjoyed by the top 1% of citizens in the advanced economies has risen from an average of 17% in the late 1980s to more than 23% today (it is 39% in the United States). Countries starting from a more equal distribution of wealth, such as China and the nations of the former Soviet Union, have seen the most rapid rise in inequality⁴.

Far from levelling the playing field and making the world more ‘flat’, as is alleged, globalization is making it more mountainous. Place matters more than ever. Cities hold a growing share of wealth and job



A robot sweeps food towards two dairy cows at an ‘automated farm’ exhibit at a food and agriculture fair.

opportunities, but it is increasingly difficult to afford to live in them. In dynamic ones, such as London, San Francisco, Paris, Berlin, Shanghai and Mumbai, house prices relative to average incomes are at an all-time high.

Technological change is already a key contributor to the growing inequality⁵. This is likely to be exacerbated as machine intelligence and automation take over a growing share of routine tasks in manufacturing and services, including retail, administration and call centres. Over the next 20 years, up to half of US jobs, one-third of jobs in the United Kingdom and the European Union and two-thirds of jobs in China and Mexico may be replaced by computers and robotics⁶.

The future will bring new jobs, but their number will be small relative to those lost. And the quality of many of these new jobs will be inferior, in terms of the conditions of work and pay. Although it is tempting to imagine a world in which machines do dangerous and routine jobs, leaving more creative, stimulating and well-paid jobs for humans, this may not come to pass. The pace and scale of technological disruption, which far exceeds that of any previous industrial revolution, raises doubts about our capacity to keep up. We may not be able to redistribute enough funds from the wealthy, or come up with sufficiently creative changes to our systems of work and social safety, to prevent a further rise in inequality^{6,7}. Although this is a major issue for advanced economies, it is even more so for developing countries, because automation may remove

key rungs of semi-skilled tasks from the development ladder.

Growing interdependence and complexity also mean that our politicians are increasingly unable to protect or shape our futures. Rather than pursue more cooperative politics, which enhance the benefits of connectivity and mitigate the risks, politicians increasingly blame foreigners and immigrants for the ills. This is profoundly misguided. Immigrants contribute disproportionately to the dynamism of our societies, as can be seen in the talent pool of leading universities, Silicon Valley

“We should nurture a greater respect and pay for creative, caring and home-based activities.”

firms, Nobel prize-winners and patent holders⁸. Those living in the fast-changing cosmopolitan cities of the world are embracing globalization and change: most Londoners did not support Britain’s decision to exit from the European Union; people living in dynamic cities tended not to support US President Trump. The populist call for protectionism is driven by those in the United States who fear being left behind. This is not an irrational fear: as is evident from inequality, unemployment and health data, some people are being left behind. There is a correlation, for example, between those who voted for Trump and those whose jobs are vulnerable to having



machines take over their jobs⁹.

Alongside their anxieties about being left behind by globalization comes a deep mistrust of the 'experts' in charge of the global systems, and a rejection of evidence. Paradoxically, although we know more than ever, rising complexity and speed of change mean that experts are likely to be wrong more often. The financial system, for example, is home to numerous highly qualified experts, housed in a formidable array of powerful institutions, who are handsomely paid to secure economic stability. Yet, as the 2008 financial crisis demonstrated, they have proved dismally unequal to the task. Similarly, experts in the European Commission seem to have failed to control reporting of emissions from leading car manufacturers. Little wonder that trust in authority has been severely eroded. When the evidence threatens entrenched elites, scepticism regarding expertise becomes particularly poisonous. Trump's dismissal of the science of climate change is an egregious example of this trend.

The flourishing of science was contested in the original Renaissance, too. Printing presses provided the means for experts and intellectuals to share knowledge, but also allowed fake news to flourish. In Medici Florence, fundamentalist Italian preacher Girolamo Savonarola circumvented the authority of popes and princes with the mass production of one-page pamphlets — the equivalent of today's tweets. Both Savonarola and the clergy denied that Earth went around

the Sun, and that the heart was a pump.

Although history does not repeat itself, it does rhyme. In the United Kingdom, campaigners successfully used social media to convince people to support Brexit even when it was against their interests, as in the case of farmers who receive subsidies from the European Union. In the United States, social media that propagated fears rather than facts played a key part in shaping the outcome of the 2016 presidential election¹⁰.

RAPID RESPONSE

As societies change more rapidly, flexibility becomes more important. For individuals, it becomes more necessary to move to where the jobs are and to reskill. For governments, it is crucial to renew infrastructure and social safety nets. Regulatory frameworks also need to evolve rapidly, to address a widening range of risks — from the genetic enhancement of humans to geoengineering.

Unfortunately, at a time when the need to renew and invest in the future is rising, the ability of governments to keep pace with change is being undermined. The use of off-shore tax havens — notably by companies at the frontier of technological change — as well as competition by governments to attract increasingly mobile individuals and companies by reducing taxes, together with austerity policies, have reduced the capacity of governments to invest in health, education, infrastructure, social security, research and other expenditures¹¹. Lower investment leads to lower growth and political gridlock, as politicians fight over the allocation of fixed or diminishing resources.

Stronger safety nets are necessary to prevent poor and vulnerable individuals and families from being undermined by technological and other changes. If not, social cohesion will be eroded, fanning the flames of populist push-back against change and all things foreign.

Some Silicon Valley billionaires, fearing revolt against the growing wage gap, along with some social activists, have called for the introduction of a Universal Basic Income (UBI) for people working and not. But a UBI is not a panacea. The Organisation for Economic Co-operation and Development has shown that the policy could, perversely, increase inequality and poverty. And, because jobs are so important to our status and self-worth, having money alone does not protect against the increases in morbidity, criminal activity, opioid and alcohol abuse that have been associated with unemployment¹².

Instead, we need a broader change in attitudes towards work. We need to remove the stigmas associated with part-time employment, retirement and volunteer work. We should nurture a greater respect and pay for creative, caring and home-based activities.

There are reasons for optimism. There are more scientists alive today than all those who previously lived; citizen science adds millions more. As well as more minds at work, there are more-diverse collaborations, thanks to greater gender equality and the participation of more nations and peoples. The probability of unlocking mysteries and finding solutions to great challenges is rising, as is the global dissemination of the benefits. Cross-border collaborative projects, from the CERN particle-physics laboratory near Geneva, Switzerland, to the Human Genome Project, highlight the benefits of cooperative activity, in stark contrast to isolationist politics.

Now, more than ever, scientists must engage and communicate, to ensure that science is not overrun by politics. Renaissance moments are associated with an intensifying battle of ideas. Scientists need to engage in this struggle over the development and application of their expertise and inventions.

In the first Renaissance, extremists won; reason and evidence did not prevail. In our second Renaissance, knowledge and enquiry must find a way to conquer prejudice and ignorance. Scientists know that they can never progress through isolationism or ignorance. Nor can our societies. ■

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