

Research

Horizons

Pioneering research from the University of Cambridge



Issue 36

Spotlight

Work

Feature

Mapping the galaxy

Feature

Obesity: the complex truth



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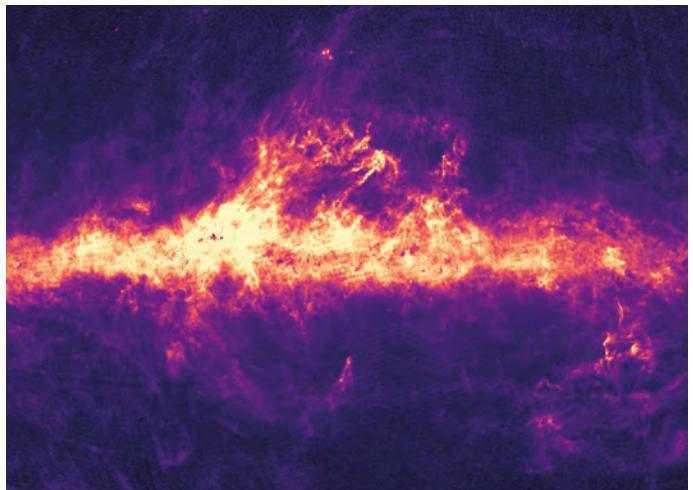
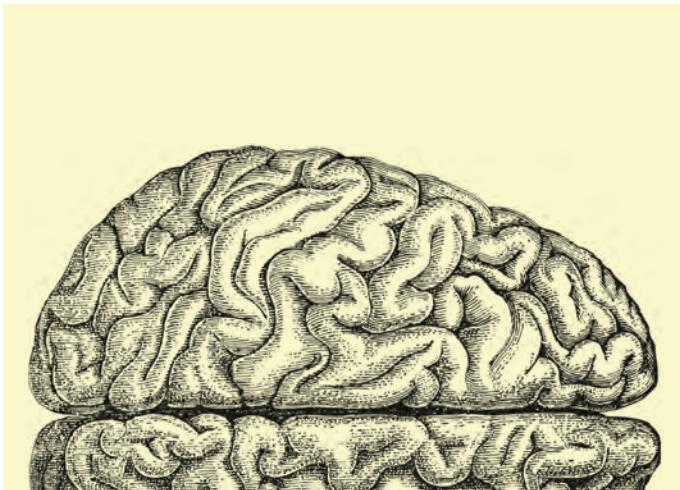
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Welcome

Work shapes people’s identity and the nation’s prosperity. ‘Good’ work gives citizens security, self-worth and respect, a route to social mobility and, for some, the chance to turn ideas into innovations. For a country, this contributes to a healthier population, increasing productivity, better living standards and the development of skills that drive economic growth.

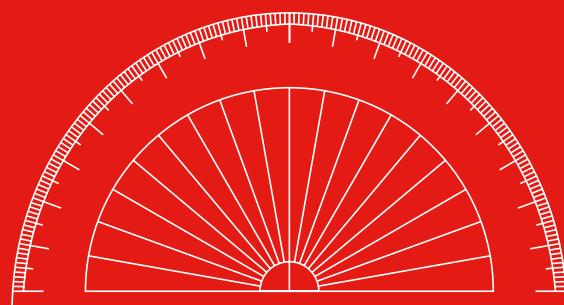
Good work sounds a simple enough concept to strive towards, but the world of work is continually being buffeted by political, societal and economic forces. New technologies, demographics, free markets, gender pay gaps, zero-hours contracts, ‘gig economies’: all of these are shaping and reshaping how we work, while the labour market continues to feel the impact of the global financial crisis and faces the uncertainties of Brexit. Given these complexities, how can we make the most of our ‘human capital’ for the success of individuals and the country? This question lies at the heart of the Spotlight section of this edition of *Research Horizons*.

Researchers in the University are working with policymakers and businesses to ask questions about productivity, wellbeing and gender parity. They are interrogating vast datasets – in one case, 44 years of labour laws spanning 117 nations, in another the educational achievements of three million schoolchildren per year – to understand, respectively, the balance between having a free economy and safeguarding workers’ rights, and the links between education and the labour market. Researchers are also looking to the future, to ask what impact will this new age of artificial intelligence and robotics have on our jobs.

Elsewhere in this varied edition, we learn how research at a newly opened Eating Behaviour Unit will help us to understand the food choices we make. We discover the latest news about the most detailed map of our galaxy ever created. And we meet a PhD student whose fieldwork on seals takes her to the island of Robinson Crusoe and the 80-year-old ‘King of Scuttle Flies’ who continues to discover new species.

We hope you enjoy these and other articles this issue.

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News



Institute to explore public policy in an age of disruption

The Bennett Institute for Public Policy will connect the world-leading work in technology and science at Cambridge with the economic and political dimensions of policymaking.

Led by inaugural Director Professor Michael Kenny and the Bennett Professor of Public Policy, economist Diane Coyle, the Institute will combine fundamental research with the search for new practical solutions to challenges such as the digital divide, resource scarcity and the need for more equitable growth.

“We live in an age of unprecedented disruption. More and more people are disenchanted with politics, and many feel that the rules of the economic game are rigged. At the same time, technological innovations and breakthroughs in scientific knowledge are gathering speed,” says Professor Kenny.

“Public policy thinking needs to engage much more deeply with the

challenges which these trends pose. It is time to set aside the ingrained assumption that there are technical fixes or ready-made solutions to our most intractable problems.”

The Bennett Institute, funded by a major gift from Cambridge alumnus and philanthropist Peter Bennett, will offer a unique combination of deep analysis, high-level training and effective policy engagement. Based at the Department of Politics and International Studies, it will be launching interdisciplinary research programmes on policy challenges in different parts of the world – from California to Calcutta, as well as in the city of Cambridge itself.

“The tensions between expertise and public participation are an unavoidable feature of our complex, technology-powered global world,” says Professor Coyle.

“Universities have a vital civic role to play in this context, ensuring that their accumulated expertise and new knowledge contribute to the development of solutions to significant policy challenges. There could not be a more important time to be launching this endeavour.”

www.bennettinstitute.cam.ac.uk

New AI supercomputer

The UK’s fastest academic supercomputer, funded with £10 million, will be based at the University of Cambridge.

As well as helping researchers to make the most of their data, the supercomputer will be made available to artificial intelligence (AI) technology companies from across the UK, in support of the government’s industrial strategy.

Capable of solving the largest scientific and industrial challenges at very high speeds, the supercomputer is supported by Cambridge’s Research Computing Service and funded by a £10 million partnership between the Engineering and Physical Sciences Research Council, the Science and Technology Facilities Council, and the University.

“AI projects involving Cambridge researchers are already under way,” says Dr Paul Calleja, Director of the University’s Research Computing Service. “In the life sciences we are working on medical imaging analysis and genomics, and in astronomy AI is being used as part of the Square Kilometre Array project and research to map exoplanets.”

Funding for the supercomputer is part of the UK government’s AI Sector Deal, which involves more than 50 leading technology companies and organisations. The deal is worth almost £1 billion, including almost £300 million of private sector investment into AI.

“AI provides limitless opportunities to develop new, efficient and accessible products and services which transform the way we live and work,” says Business and Energy Secretary Greg Clark. “Today’s new deal with industry will ensure we have the right investment, infrastructure and highly skilled workforce to establish the UK as a driving force in the development and commercial use of AI technologies.”

In addition to computing power, Calleja and his team will provide training, guidance and support to Cambridge researchers and the wider AI industry.

News in brief

More information at
www.cam.ac.uk/research

10.04.18

Cambridge joins Ceres Agritech Knowledge Exchange Partnership to boost multidisciplinary agritech research for sustainability and food security.

13.03.18

Max Planck Cambridge Centre for Ethics, Economy and Social Change launches to study the dynamics between ethics, religion and the economy.

WaterScope

A hand-held microscope printed from recycled plastic could help millions of people secure access to clean water.

A biologist, a physicist and an engineer walk into a bar... and start a social enterprise spin-out with a mission to help some of the 650 million people worldwide who struggle to find safe water supplies.

Cambridge researchers Dr Alexander Patto (the biologist), Dr Nalin Patel (the physicist) and PhD student Tianheng Zhao (the engineer) met one evening in 2015 at an event run by Cambridge i-Teams – an initiative that helps students and researchers to commercialise their ideas.

WaterScope, the not-for-profit organisation they founded (physicist Dr Richard Bowman also joining them), is using an open-source microscope designed by Bowman to make a water-testing kit that is smaller, lighter, cheaper and much faster than current technology. What's more, the microscope can potentially be 3D printed locally for education – even from old plastic drinking bottles.

"One in ten people don't have access to clean water and over 80% live in rural areas," explains Patto, who now works full time on WaterScope while the others continue their research. "Many rely on



Credit: WaterScope

external NGOs to test their water using a fiddly process that can take a couple of days before a result is known."

WaterScope visualises the bacteria at the water source with a microscope rather than having to take a sample back to the lab. The prototype connects to a battery-powered Raspberry Pi computer to give a faster digital read-out than conventional methods, meaning intervention can happen rapidly if contamination is detected.

The team's goal is for technicians to be able to upload and map out the tests, creating useful resources for people

planning water provision.

Already trialled at one of the world's largest refugee camps in Tanzania, the prototype will next be tested in Bangladesh in partnership with Oxfam.

"The kit can be used by anyone, anywhere, enabling permanent hubs for testing to be set up in schools and communities," adds Patto. "Our aim is to empower rural communities both to understand what contaminates their water and to test if it is safe to drink."

www.waterscope.org

Clapping with two hands

A new joint research Centre, sited in the Chinese city of Nanjing, will support research into smart cities and fully integrated urban environments.

The Cambridge University-Nanjing Centre of Technology and Innovation is the University's first overseas enterprise at this scale.

At the heart of the new Centre's activities will be research into technologies that support a modern 21st-century city

with integrated IT, healthcare and building management. Innovations emerging from the Centre will enable the development of smart cities in which sensors will enable sustainable lifestyles.

Funded by Nanjing Municipality for five years in the first instance, the agreement will allow Cambridge-based academics to engage with specific, long-term projects in Nanjing, in the Jiangsu Province, as well as fund positions in Nanjing and a professorship based in Cambridge. Any IP generated will be licensed for commercialisation by the University's innovation branch, Cambridge Enterprise.

Speaking before the official signing of the agreement, Cambridge's Vice-Chancellor Professor Stephen Toope said: "This is only the most recent example of our collaboration with Chinese partners – but it is by far the most ambitious to date.

"We see it as an essential part of Cambridge's contribution to society to tackle some of the great world problems. But we cannot do this on our own. There is a proverb: 'You cannot clap with just one hand'. To me this means that we can only accomplish great things by working together – which is what we will be doing with Nanjing."

22.02.18

CRUK funds Children's Brain Tumour Centre of Excellence based at the University of Cambridge and the Institute of Cancer Research, London.

31.01.18

Zero-gravity applications of graphene, such as cooling satellites, tested by researchers at the Cambridge Graphene Centre and the European Space Agency.

23.01.18

Cambridge to lead £11.9 million research project to extend battery life and accelerate the transition to electric vehicles and a low-carbon economy.

One island. One hundred thousand seals. And one graduate student so determined to study them that she crowdfunded her own fieldwork.

Fur seals dive in the pristine seas off the island of Robinson Crusoe and among them swims Constanza Toro-Valdivieso. Her research has brought her 7,500 miles to a remote archipelago located between the Chilean coast and Easter Island to study the Island's only endemic and native mammal: the Juan Fernández seal.

The seals live in one of the last great wild places of the ocean and almost nothing is known about them. Even their existence came as a surprise – thought to have been hunted to extinction, they were rediscovered only in the 1950s. Today, they number around 100,000 living in and around the islands, coming ashore in mating season.

Although the species is a 'comeback story', it is vulnerable once more – this time to ocean pollutants like microplastics and heavy metals. "It's these larger animals that will suffer first from poor ocean health. If the seals get sick, it could be the first sign you see before a catastrophe," says Toro-Valdivieso, a PhD student in Cambridge's Department of Veterinary Medicine. "Understanding and monitoring the species is made much harder by our poor knowledge of them."

She first read about the seals while studying for her veterinary degree in Chile: "I seem to remember googling 'diseases' and 'wildlife' and found them by chance," she says. Keen not to miss the short season the seals come on land, Toro-Valdivieso crowdfunded her first fieldtrip to Robinson Crusoe just before she started her PhD with Dr Barbara Blacklaws in Cambridge.

On the island, she studies the seals, swims with them, and collects their faeces for testing their health and immunity.

Meanwhile, following a proposal by the local Juan Fernández community and National Geographic's Pristine Seas initiative, the Chilean government has recently designated the area a marine park to safeguard its unique ecosystem.

"Research for me goes beyond the lab and the publications – I want to make a difference in the community," adds Toro-Valdivieso. "It would be amazing if I could manage to convince the Chilean government that monitoring these species is not only important for the seals' own conservation but also as an indication of what's happening in our oceans."



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Words
Louise Walsh





Crowdfunded to Crusoe

The long game: Turing's wager and the mathematical mind



Words

Louise Walsh

Andrew Thwaites knows that his hope of understanding the human brain mathematically is unlikely to be achieved in his lifetime. He's persevering because even the smallest of steps could prove enormously important to medicine.

In 1950, Alan Turing, a Cambridge graduate and the father of modern computing, made a cautious wager.

Turing regarded the mind as a fascinating computational phenomenon. He believed that the key to understanding something so complex lay in being able to describe it using the clearest, most unambiguous language there is – mathematics.

Turing's wager was about how long this might take: over a thousand years.

Mentioned in the famous paper in which he described the idea of an 'imitation game' for comparing human and artificial intelligence (see box), Turing's wager provides a reality check on the practical feasibility of brain mapping.

And yet, attempting to understand the mathematics of the mind – even if they can't beat the wager – is exactly what Dr Andrew Thwaites and colleagues from Cambridge's Department of Psychology and the MRC Cognition and Brain Sciences Unit have set out to do. Why? "Because there will be major gains along the way," explains Thwaites.

"Prosthetic limbs and hearing aids already use mathematical algorithms to mimic the equations of the brain and nervous system, and more detailed maps will make it much easier to replace lost function. Better maps also allow us to improve diagnosis and treatment of neurological disorders."

"A complete map could introduce a wide range of futuristic technologies – perhaps the ability to download memories as if they were photographs, to plug in instant multilingual translation or to augment intelligence."

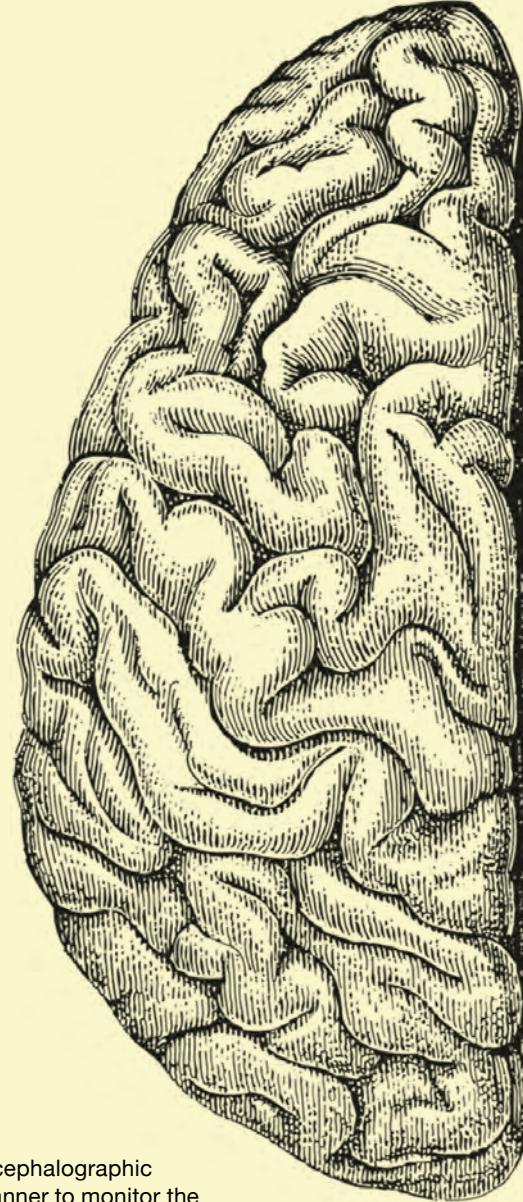
These revolutionary applications won't be here any time soon – a full mathematical description of the human brain (if it is even possible) being so far distant – but, says Thwaites, as the map grows, so will the number of potential applications.

The potential for such a map has been so alluring that in 2013 the European Commission invested €1 billion in the Human Brain Project to construct an accurate mathematical model of the brain – a decision that has courted much debate on the wisdom of funding something so inherently difficult.

Thwaites and colleagues know that they face a gigantic task – but they're making faster progress than they hoped possible. The product of their efforts is Kymata.

Built as part of a multidisciplinary collaboration between the Department and the MRC Unit, and powered by supercomputers, Kymata is a growing atlas of precise mathematical maps of the human brain. It feeds on equations and neural data, and it looks for matches. It's sometimes fussy, preferring one equation over another, and its appetite is insatiable.

The loudness of a sound, the brightness of a light, the sensation of a touch – each of these can be characterised as equations that take in sensory inputs and give out electrical outputs (brain activity) that can be measured. Thwaites uses an electro- and magneto-



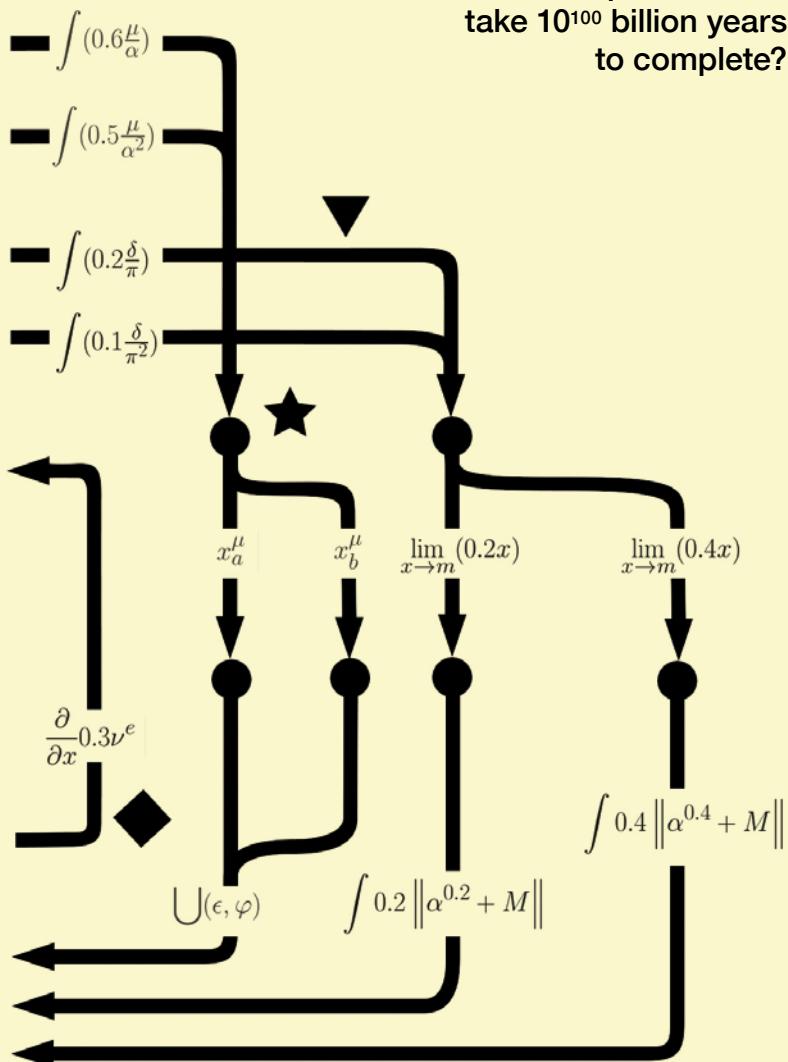
encephalographic scanner to monitor the location of firing neurons when, for instance, a sound is heard by volunteers.

What Kymata does is compare what an equation predicts will be the neurological behaviour with what actually happens in the brain – and searches for good matches at a rate of thousands of comparisons a second.

"It took seven years to match the first equation to what actually happens in the brain," says Thwaites. "In the three years since, we now have almost 100 matches."

Thwaites likens the process to trying to complete a jigsaw using a mixture of all of the jigsaw pieces in the world. "Each equation is a jigsaw piece, and Kymata is testing the fit of hundreds of thousands of pieces around the clock. When they fit they are added to the map. But the number of possible jigsaw pieces that Kymata needs to try is huge – most of them won't fit and some will fit better than others – and they all have to be checked."

By focusing first on sight, hearing and touch, the researchers have metaphorically



started with the easier ‘edges’ of the jigsaw – still vastly complicated but simpler than trying to piece together the ‘central pieces’ (equivalent to high-level functions of the brain like decision-making or personality).

Not that there isn’t an appetite to know more: “Kymata is open access and you’d be surprised how many people search for equations related to personality traits like charisma,” says Thwaites.

The equations that feed Kymata range in complexity from the relatively simple – those that were written in the 1930s and take little account of physiology or neuroscience – to equations like those of Thwaites’ colleague Professor Brian Moore, who has been perfecting the algorithms involved in auditory processing for decades. These latter equations are cutting edge, says Thwaites – they take into account the latest understanding of the brain and can run to hundreds or thousands of lines.

Thwaites will continue to test equations in Kymata, sourced from collaborations with researchers around the world and the public domain. Such is Kymata’s appetite, however, that one day the research community might not be able to produce equations fast enough, at which point artificial intelligence might be required to accelerate the community’s efforts.

“I think Turing would be delighted by our progress, but he was right to be cautious,” says Thwaites. “Even with the benefit of faster supercomputers, more powerful neuroimaging techniques and increasingly complex mathematical descriptions, obtaining a full map may never be finished in our lifetimes.

“My hope is that researchers will still be adding to Kymata’s map in a thousand years, with modern medicine all the while reaping the benefits of a growing mathematical model of the mind.”

Turing’s wager

Alan Turing’s paper ‘Computing Machinery and Intelligence’ was published in 1950 in *Mind*. It changed the face of computer science by introducing the concept ‘can machines think?’ Within this text was a separate, equally profound, philosophical argument where Turing set out the central difficulty of reverse engineering the brain.

“Turing noted that if the brain is a type of computer, then characterising the brain mathematically is equivalent to guessing the program running on a computer,” explains Dr Andrew Thwaites.

“But trying to guess the code of a program running on even a simple computer is very time-consuming. Someone trying to do so would likely have to test many thousands of programs before they chanced upon the one which correctly predicted the computer’s behaviour. Characterising the brain mathematically faces the same problem – multiplied exponentially.”

To emphasise the long timescales involved, Turing underscored the argument with a challenge, now known as Turing’s wager. “I have set up on the Manchester computer,” wrote Turing, “a small programme [...] whereby the machine supplied with one sixteen-figure number replies with another within two seconds.”

So confident was he that no-one would guess the program linking the two numbers, that he defied any reader to do it within a thousand years. The same logic, he claimed, holds true for the brain.

“Turing never gave an estimate of how long the brain itself might take to map,” says Thwaites. “But, following his reasoning, one can show that this figure could be well over 10^{100} billion years.”

Underlying Turing’s wager is a plea for realism, says Thwaites. “In searching for the mathematical basis of the mind, Turing reflected that there was only one truth we can be sure of: ‘We certainly know of no circumstances under which we could say we have searched enough.’”



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"THERE'S MORE TO LIFE THAN THE LITTLE BITS THAT YOU READ IN THE PAPER"

Muslims leaving prison talk about the layers of their lives



Words

Alex Buxton

The Lammy Review in 2017 drew attention to inequalities among black, Asian and minority ethnic people in the criminal justice system. It also flagged the over-representation of Muslims in prisons. Research by Dr Ryan Williams explores the sensitivities around this topic.

Dr Ryan Williams has become accustomed to uncomfortable moments. His research into the lived experiences of people in the criminal justice system (CJS) has taken him into high-security prisons to interview people convicted of serious crimes, and to East London to speak to recently released prisoners. All his interviewees were Muslim.

He describes this area of study as highly problematic: "I was working with people who often feel doubly marginalised – as individuals with a criminal record and seeking to rebuild their lives, and as Muslims living in British society and having to fight against stereotypes. You run the risk of bringing genuine harm to people by failing to reflect their complex life realities."

Williams is based at Cambridge's Centre of Islamic Studies. An interest in Islam and society took him into a domain usually studied by criminologists. His interviews explored the journeys, values and struggles of people caught up in the CJS. They took place in prisons (including segregation units), probation offices, cafés, mosques and 'chicken shops'.

In 2017, an independent review by the Rt Hon David Lammy put race equality in the spotlight by highlighting a rise in the proportion of BAME (black, Asian and minority ethnic) young offenders in custody: from 25% in 2006 to 41% in 2016. Lammy stated that his "review clearly shows BAME individuals still face bias – including overt discrimination – in parts of the justice system".

The same review drew attention to the over-representation of Muslims in the CJS. Between 2002 and 2016, the proportion of Muslims in the prison population doubled.

"The higher up the CJS you go, the greater the proportion of people identifying as Muslim," says Williams. "More than 40% of the prisoners in the high-security prison that I was working in were Muslim."

While the over-representation of Muslims in the CJS forms the backdrop to Williams' research, his work looks not at the causes of crime but at the experiences of offenders as they serve their sentences and reflect on their lives. "By asking questions around belonging and how people can lead a good life, we begin to

see what might help them in the future," he says.

Rapport with participants was key. He says: "In effect, they interviewed me to ensure that I wouldn't reinforce a 'one-dimensional' view of them as Muslims."

As one interviewee remarked: "There's more to life than the little bits that you read in the paper." The interviewee had observed other people taking an interest in Muslims in prison: "They're all asking the same questions" about discrimination and radicalisation, and "[I'm] just standing there thinking, like, 'is that all you want to know?'"

Through his interviews, Williams came to learn how difficult it is for people to put their finger on inequality and discrimination. It was often indirect, found in everyday examples like (says one interviewee) being refused a toilet roll by a member of staff but seeing a white prisoner acquire one with ease. For white Muslim converts, there was a sense that being a Muslim was incompatible with being British – they were seen as 'traitors' to their country, reinforcing the view that Islam is a 'foreign' religion.

For one interviewee, the rise of Islamophobia was both tragic and laughable. He observed: "It's really sad. People are scared of Muslims now and it makes me laugh because I think to myself, 'Hang on a minute, what are you scared of?'" He also pointed out: "Everybody knows a Muslim. You probably work with one. You might live next door to one. Your neighbour's cool. Your work colleague's cool."

Since 9/11, and more so in the wake of recent attacks in London, the term Muslim has become linked with negative associations.

"Muslim" is a badge applied to offenders in a way that masks other aspects of their identity – for example their roles as sons, brothers and fathers. For much of the popular media, it's a blunt term that hints heavily at terrorism," says Williams.

Through guided conversations, Williams encouraged his interviewees to talk about the things that meant most to them, sharing their feelings about family, community and society. He explains: "Broadly speaking, my work is about people's lives as a moral journey – one marked by mistakes and struggle – and how this connects to belonging and citizenship in an everyday sense."

The project was sparked by a conversation that Williams had four years ago with a Muslim offender of Pakistani heritage who'd been brought up in the UK. "He said that he felt so discriminated against that he felt he couldn't live here any longer. To me, that was shocking," says Williams.

"It made me wonder how the CJS might serve to help people feel like citizens and rebuild their lives. What if

we brought the end goal of citizenship into view, rather than focusing exclusively on risk to the public? How would this change how people see themselves and how others see them?"

Williams' interviews revealed that, for many, learning to be a good Muslim was also tied with being a better citizen, and each had their own way of going about this. "For one person, day-to-day practices of prayer kept them away from crime. For another, for whom crime was less of a struggle, practising zakat (charity) by providing aid to the Grenfell Tower survivors enabled him to fulfil a need to contribute to society," he says.

He interviewed 44 Muslim men, sometimes interviewing them more than once, and triangulated his data with conversations with prison and probation staff.

"My approach was experiential-based – qualitative rather than quantitative. I didn't have a set of boxes to fill in with numbers. I used one standard survey tool from research on desistance from crime, but I found it removed richness and detail from people's complex stories. Participants welcomed the chance to reflect more deeply on their lives."

An individual's faith journey, argues Williams, cannot be separated from the complex reality they find themselves in.

Faith is always interpreted and filtered through our experiences and can help to construe a positive view of what it means to live a life worth living. As one participant observed: "I want to actually do some things now, like goodness, like volunteering, helping people out, helping the vulnerable... God loves that."

Williams says that as a fellow human being he empathises with this improvised desire to find meaning in life by doing good in the world. He says: "The most profound thing to emerge from my conversations is that leading a good life is hard – and harder for some than for others."

In April 2018, Williams organised a workshop 'Supporting Muslim Service Users in Community and Probation Contexts' for frontline staff and volunteers. Probation officer Mohammed Mansour Nassirudeen, who attended the workshop, said: "We need Ryan and researchers like him to give us the bigger picture. I believe this would help bring about desired outcomes for service users from BAME backgrounds, which is long overdue."

Adds Williams: "My contribution is simply to get people to think about the issues in a different way, to facilitate discussion drawing on people's own strengths and expertise, and then see where it takes us."

The workshop 'Supporting Muslim Service Users in Community and Probation Contexts' was funded by the Arts and Humanities Impact Fund, and supported by the School of Arts and Humanities and the School of the Humanities and Social Sciences.



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Obesity is often characterised as nothing more than greed and lack of willpower. The truth is far more complex: our DNA, our brains and our environment conspire to encourage us to overindulge, say Cambridge researchers.

In August 2017, the *Daily Mail* carried a typically strident opinion piece from columnist Amanda Platell, entitled ‘Obesity a sickness? No, it’s just plain greed’.

Platell made it clear who she thought was to blame for our obesity epidemic. “It’s greed that makes you fat. Not ignorance about the dangers of junk food,” she wrote. “Fatties lack the willpower to stop eating. Reduce the burger size and the Billy Bunters after instant gratification will just order two, with extra chips.”

Professor Sadaf Farooqi disagrees with both Platell’s line of argument and her approach. “Blaming people for their obesity is never helpful,” she says. “It is a complex problem. It is not simply just about people choosing to eat too much or to not do enough exercise.”

Farooqi is one of the principal investigators at the Wellcome-Medical Research Council Institute of Metabolic Sciences (IMS), which sits at one end of Addenbrooke’s Hospital, at the heart of the Cambridge Biomedical Campus. The Institute, jointly led by Professors Sir Steve O’Rahilly and Nick Wareham, is dedicated to understanding what drives us to overeat and the impact that overconsumption has on our bodies.

A glance at the Institute’s website is enough to demonstrate the complexity to which Farooqi refers: its scientists study everything from how our gut tells our brain that we’re full and to stop eating, to how we’re preprogrammed in the womb to overeat, through to how the environment around us – the size of our crockery, the number of fast food outlets in our neighbourhood, and so on – conspires to make us overeat.

Farooqi’s own research has focused on the genetics of obesity. Her work with children who are severely obese due to

faults in their DNA has led to an understanding of the importance of the hormone leptin in regulating appetite (and hence body weight).

In fact, attitudes such as those voiced by Platell may come down to what psychologists refer to as the ‘fundamental attribution error’ – the assumption that behaviour is directed entirely by what goes on in our head.

“There’s a general notion that the brain is a puppet master which controls everything and that, as a consequence of rational, balanced, processes that go on in the brain, we make our decisions and we carry out our actions,” says Professor

whatever they like but never gain weight. What is it about their DNA and their bodies that stops them piling on the pounds?

“We think there are genes, but also hormones, that might protect some people from gaining too much weight,” she says. One way to test this is to bring healthy thin people into the facility and feed them a high-fat diet to see what happens. “You need a facility where you can keep people in a comfortable environment for ten days, and where you can control everything about that environment so that you can make really precise measurements.”

And when she says “control everything about that environment” that is exactly what she means. “What we eat, when we eat, how many calories we burn – it’s all controlled by many things in our environment. In our facility, we can control light, the temperature of the rooms, what time people eat, the kinds of food they’re given...”

The testing areas are also built to support people who are severely obese, so that they can have a comfortable environment. “It’s quite noticeable now that when we bring people in they’re immediately at ease because they’re not having to worry how they’ll manage,” she says.

The facility includes an Eating Behaviour Unit, which has a modern, stylish lounge and dining room that would not look out of place in an Ikea catalogue. It’s here, says Farooqi, that some of the most interesting work will take place. Study participants may take part in conventional, computer-based tests of cognition, for example, but when the study is ‘over’ they are invited to help

“Blaming people for their obesity is never helpful”

Paul Fletcher from the Department of Psychiatry. “But the reality is the brain is a slave to the environment and to what’s going on in the body. It’s this three-way interaction, between the body, the brain and the world, that’s shaping our behaviour.”

The IMS’s new Translational Research Facility, recently opened with funding from Wellcome, will be uniquely placed to better understand how these three elements influence our diet. Fletcher is one of the collaborators in the Facility, which is led by Farooqi.

“The new facility allows us to do more research in a state-of-the-art environment and to open our minds – to do the kinds of research that we couldn’t do before,” she says.

One of the first studies that will take place here, interestingly, is not one of obese people, but rather of healthy thin people who seem to be able to eat

A WEIGHTY PROBLEM

themselves to an all-you-can-eat buffet; in fact, this buffet is itself part of the study, allowing the researchers to observe how people behave and why they make particular food choices, for example.

In 2016, Farooqi published research that demonstrated how complex and unconscious these choices can be. Participants were allowed to help themselves to an all-you-can-eat buffet of the UK's favourite curry, chicken korma. There were three options, manipulated to look and taste the same, but in which the fat content varied from 20% to 60% of the total number calories. Participants with a particular genetic defect ate twice as much of the high-fat korma compared with their lean counterparts.

More often, though, it is external factors that influence our food choices. "We are sensitive to very many cues in our environment, often without awareness, which lead us to eat more than we think we have eaten," explains Professor Dame Theresa Marteau, one of Farooqi's collaborators at the Translational Research Facility.

Several of Marteau's studies have focused on size: the size of our portions, plates, wine glasses, and so on. Her team led a Cochrane Review – the 'gold standard' of meta-analyses, which review all the available evidence – and found that

eliminating larger-sized portions from our diets could reduce the number of calories consumed by up to 16% among UK adults or 29% among US adults.

Marteau describes the work that she will be carrying out at the Facility as "virgin territory". The idea is to do real-world studies – in bars, cafeterias and supermarkets – and then return to the Eating Behaviour Unit to analyse what they find and optimise interventions, and then test them back in the outside world.

"The answer at one level is simple: change our environment and you change our behaviour. But then there's a question of how much evidence is needed to give certainty to the policymaker and for the courts to do battle with the industries that stand to lose by changing these cues in our environment."

Platell at the *Daily Mail* believes she knows the solution to the obesity problem: all it will require is "common sense and strength of character". The overwhelming evidence from Cambridge's researchers suggests that this is very unlikely to be the case.



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Words
Craig Brierley

GALAXY QUEST

Cambridge researchers are at the forefront of a pan-European project that is building the biggest, most detailed map of our galaxy ever created.

April 25th 2018 was a big day for astronomers, astrophysicists and backyard stargazers. A torrent of data, containing information about more than one billion stars in the Milky Way, was made freely available to anyone, anywhere with an internet connection.

The data were sent from a high-precision imaging satellite orbiting the Earth at a distance of 1.5 million kilometres, and contained information about the stars that blaze above our heads: how far away, how old, how bright, how fast, how big. When the data release arrived, amateur and professional astronomers worldwide immediately began combing through it to find the treasures within.

The satellite, called Gaia, has been surveying the sky since it was launched in 2013, and will observe each of more than one billion stars – roughly 1% of the total stellar content of our galaxy – about a hundred times during its planned five-year mission, and during its likely five-year extension.

Gaia's mission, funded by the European Space Agency and involving researchers and industrial partners from across Europe, is to build the largest, most precise three-dimensional map of our galaxy ever created. The map will be a crucial tool for the study of the origin and evolution of the Milky Way.

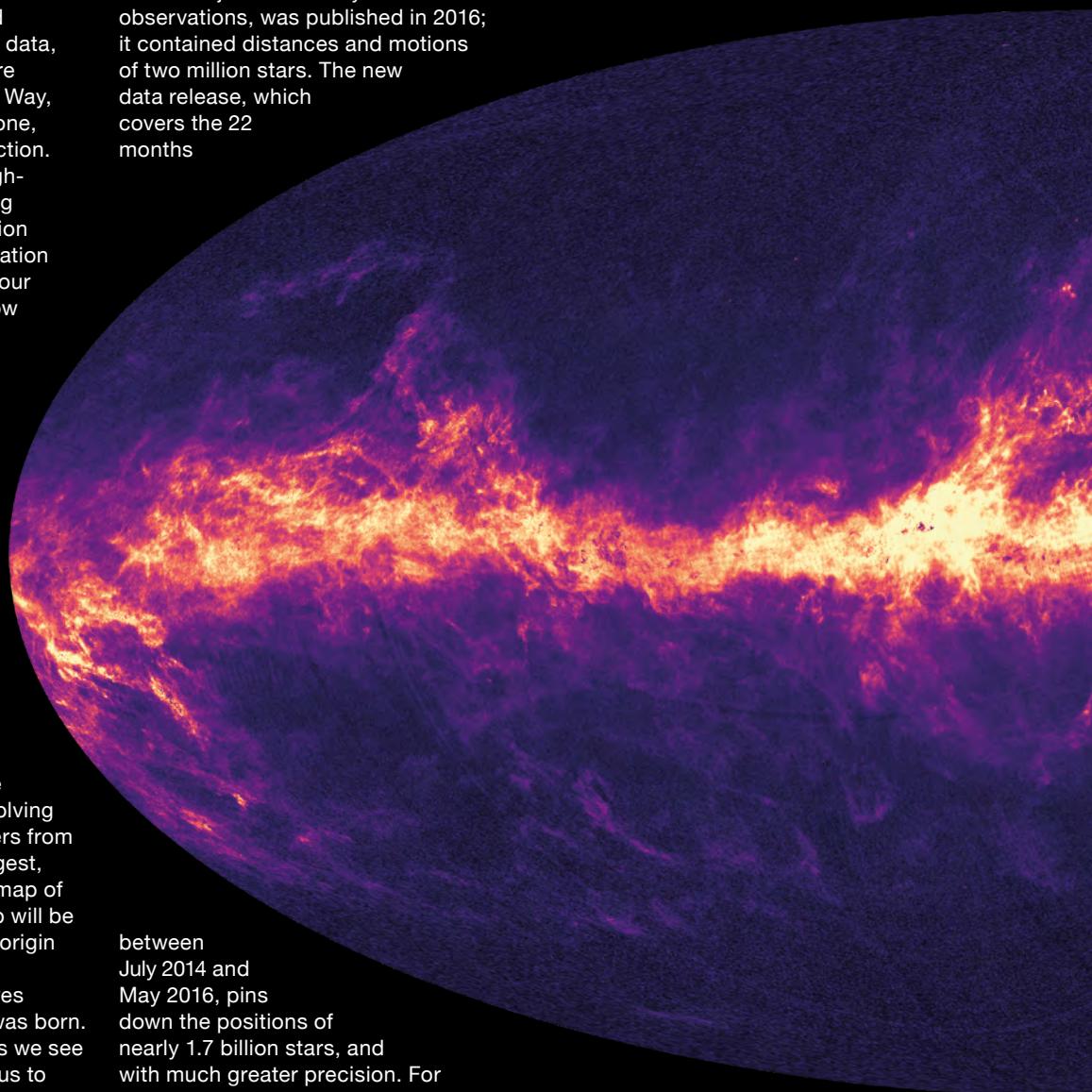
Every celestial object preserves something of the era in which it was born. So, as well as mapping the sky as we see it today, the Gaia mission allows us to look back billions of years into the past – making possible what some have called a 'time-lapse video' of the birth and life

of our galaxy. Gaia will also detect new asteroids in our solar system, discover planets around other stars, and provide new and improved tests of Einstein's theory of general relativity.

The first data release from Gaia, based on just over one year of observations, was published in 2016; it contained distances and motions of two million stars. The new data release, which covers the 22 months

astronomers can directly estimate distances to individual stars.

The comprehensive dataset includes brightness information of all surveyed stars and colour measurements of nearly all, plus information on how the



between July 2014 and May 2016, pins down the positions of nearly 1.7 billion stars, and with much greater precision. For some of the brightest stars in the survey, the level of precision equates to Earth-bound observers being able to spot a Euro coin lying on the surface of the Moon.

With these accurate measurements it is possible to separate the parallax of stars – an apparent shift on the sky caused by Earth's yearly orbit around the Sun – from their true movements through the galaxy. The new catalogue lists the parallax and velocity across the sky for more than 1.3 billion stars. From these accurate parallax measurements

brightness and colour of half a million stars change over time. It also contains the velocities along the line of sight of a subset of seven million stars, the surface temperatures of about 100 million and the effect of interstellar dust on 87 million.

Gaia also observes objects in our solar system: the second data release contains the positions of more than 14,000 known asteroids, which allows precise determination of their orbits.

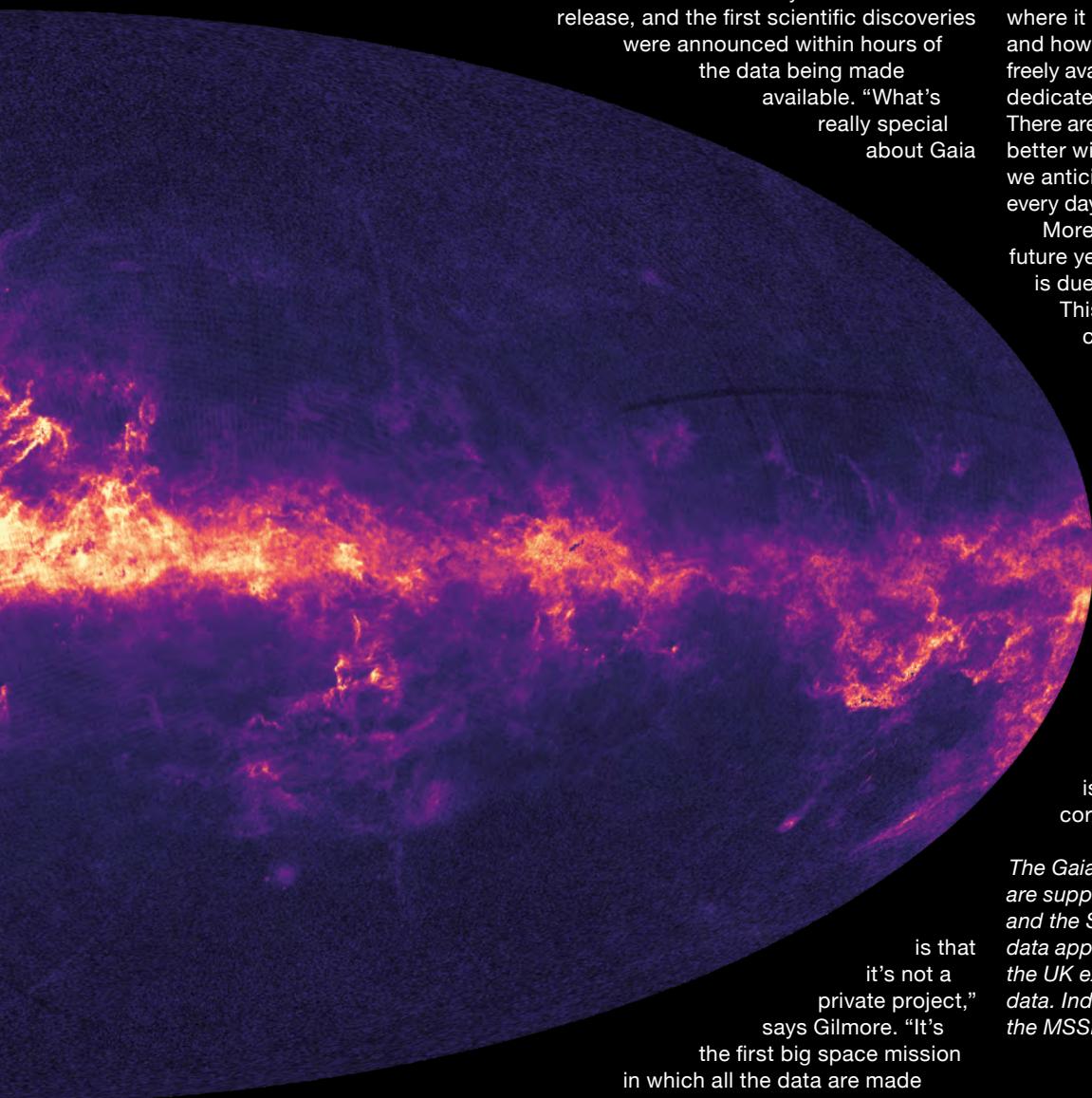
"Today is a magnificent harvest, but cornucopia awaits"



Image

Gaia's all-sky view of the interstellar dust that fills the Milky Way

This unique mission is reliant on the work of Cambridge researchers who collect the vast quantities of data transmitted by Gaia to a data-processing centre at the University, overseen by a team at the Institute



of
Astronomy. The tidal wave of Gaia data will keep astronomers busy for decades.

"There is hardly a branch of astrophysics which will not be revolutionised by Gaia data," says Professor Gerry Gilmore, who leads the Cambridge team and is the UK's principal investigator for Gaia. "For the first time, we've got measurements on more than a billion stars, which is a thousand times more than we've ever had before. It's a spectacular step."

In addition to the work taking place at Cambridge, teams from Edinburgh, the Mullard Space Science Laboratory (MSSL) at University College London, Leicester, Bristol and the Science and Technology Facilities Council (STFC) Rutherford Appleton Laboratory are all contributing to the processing of the vast amounts of data from Gaia, in collaboration with industrial and academic partners from across Europe.

Hundreds of research teams from all over the world anxiously awaited the data release, and the first scientific discoveries were announced within hours of the data being made available. "What's really special about Gaia

is that it's not a private project," says Gilmore. "It's the first big space mission in which all the data are made freely available to anyone, anywhere."

With the additional information contained in the 2018 data release, Gaia's galactic map has come into sharper focus. "By measuring the properties of stars, it tells you almost everything about how stars evolve, and how the Milky Way evolves as well," says Gilmore.

The team in Cambridge is led by Dr Floor van Leeuwen, Dr Dafydd Wyn Evans and Dr Francesca De Angeli. In addition to processing the information contained within the major data releases, the team

also checks the daily photometric data for unexpected large outliers. These lead to the regular publication of photometric science alerts ready for immediate follow-up observations from the ground.

"The combination of all these unprecedented measures provides the information for astronomers to take the next big steps in mapping the formation history and evolution of stars and our Milky Way galaxy," says Gilmore.

"The global community will advance our understanding of what we see, where it came from, what it is made of and how it is changing. All this is made freely available to everyone, based on the dedicated efforts of hundreds of people. There are so many exciting things to do better with the exquisite Gaia data that we anticipate new publications appearing every day after this release."

More data releases will be issued in future years, and the final Gaia catalogue is due to be published in the 2020s.

This will be the definitive stellar catalogue for the foreseeable future, playing a central role in a wide range of fields in astronomy.

"This vast step into a new window on the universe is a revolution in our knowledge of the contents, motions and properties of our local universe," adds Gilmore. "We look forward to the international astronomical community building on this European project, with its major UK contributions, to interpret these data. Today is a magnificent harvest, but cornucopia awaits."

The Gaia data-processing teams in the UK are supported by the UK Space Agency and the STFC, which helped set up the data applications centre and is supporting the UK exploitation of Gaia's scientific data. Industrial partners include Airbus, the MSSL and e2v Technologies.



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Words

Sarah Collins

THE ‘BRAIN’ THAT’S HELPING REDUCE CARBON EMISSIONS

From their base halfway across the globe in Singapore, Cambridge researchers are working with colleagues from around the world to reduce carbon emissions in industry.

For a chemical engineer, Jurong Island is a kind of paradise. The artificial island, built upon seven smaller islands off the Singapore mainland in the 1980s and 1990s, is now home to nearly 100 global petroleum, petrochemical and speciality chemical companies, indicating Singapore’s status as a global crossroads.

All those plants and factories produce a lot of carbon emissions – in fact more than half of global emissions come from industries like those based on the Island. With so many companies in such a small space, Jurong is an ideal laboratory for looking at ways to reduce emissions and improve sustainability. Little wonder that it has become the centre of Singapore’s efforts to cut its emissions intensity by 36% (compared with 2005 levels) by 2030.

“Because Singapore is a city-state, you’re never too far from the people who have the power to enact policy change,” says Professor Markus Kraft. “In Singapore, it’s easier to see the impact that certain changes can have on the carbon footprint of the whole country – it’s an ideal test bed for researchers. We can then use our results from Singapore as an example to roll out to other cities and other countries.”

Kraft is Director of the Cambridge Centre for Advanced Research and Education in Singapore (CARES), a wholly owned subsidiary of the University based at Singapore’s Campus for Research Excellence and Technological Enterprise (CREATE), which was established in 2007 with funding from Singapore’s National Research Foundation to encourage collaboration between universities and industry.

The team in Singapore is made up of researchers from Cambridge, local universities and other institutions. Its unique setting, combined with a diverse membership that ranges from PhD

students to professors, has enabled CARES, which was established in 2013, to be involved in several research and industry collaborations. The most recent, with fellow CREATE partners, the University of California, Berkeley, the National University of Singapore and the Nanyang Technological University, will develop new ways to transform industrial CO₂ emissions into compounds that are useful in the chemical industry supply chain.

The overall goal of the researchers based at CARES is to reduce industrial carbon emissions and improve sustainability through the development of cleaner fuels, carbon capture and efficiency improvements in industrial processes.

Research to assess and reduce the carbon footprint of an eco-industrial park like Jurong Island is happening under CARES’ first research programme (the Cambridge Centre for Carbon Reduction in Chemical Technology). The work has been split into complementary areas that include making chemical processes and reactions more efficient, creating cleaner fuel blends and reducing energy consumption within electrical and chemical supply systems.

Their flagship project is the J-Park Simulator, an AI-driven engine that combines mathematical modelling with the ‘Internet of Things’ to help reduce carbon

"We've estimated that this could save approximately 0.8 million tonnes per year of CO₂ for Singapore"

policy to implement," says Kraft. "To reach an optimum symbiotic relationship among industries and other networks, all resources need to be taken into account simultaneously."

In its first phase, the CARES team investigated technologies with the potential to save more than eight million tonnes of CO₂ emissions per year from Singapore – approximately 18% of Singapore's 2012 emissions. In its second phase, the team want to take its ideas forward and closer to real-world application.

"One of the ideas we developed in Phase One was to blend biodiesel with diesel fuel for road transport," says Kraft. "We've estimated that this could save approximately 0.8 million tonnes per year of CO₂ for Singapore. What we plan to look at in Phase Two is whether we can do something similar for marine shipping traffic. We have estimated that this has the potential to save approximately an additional 0.5 million tonnes per year of CO₂ in Singapore, but it also has the potential to be adopted worldwide. This could have a much broader global impact, far beyond just shipping in the Singapore Strait."

In CARES' second phase, the J-Park Simulator will be extended and expanded, and the team is exploring the possibility of connecting it to a real-world smart grid. Kraft and his team are also busy building relationships with government and policymakers in Singapore to implement their research and help reduce Singapore's carbon footprint.

"I'm grateful that we can work in Singapore with so many colleagues from around the world," says Kraft. "Our work here has also had a positive impact in Cambridge – not just because of the funding, but also because of the international exchange of ideas and talent. It's an ideal platform for collaboration."



Professor Markus Kraft

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emissions, as Kraft describes: "In the future, we may be able to access whole networks of machines, and the machines will talk to each other.

"There are models behind industrial processes, but to build them you need a semantic representation of everything you might find in an industrial plant. You also need mathematical models that contain knowledge about any given physical entity. These entities can broadcast data into the model – it's a bit like the nerves in your hand sending a signal to your brain. The J-Park Simulator is essentially that brain."

The J-Park Simulator aims to provide a virtual representation of multiple domains in real time. It could have the ability to represent every plant on Jurong Island, and every piece of equipment in each of those plants from data that is constantly fed into it.

"Each piece of data is like a single brick – when you have enough bricks, you can start to build walls and houses; the idea of the Simulator is to allow you to design plants in ways that you couldn't before because now we can make better use of mathematical optimisation," says Kraft, who is a Fellow of Churchill College.

The Simulator attempts to represent the highly interconnected nature of Jurong Island, and could be a powerful tool to demonstrate the effects of certain policies. For example, if a single power plant was able to reduce its carbon emissions by 10% through optimising its processes, the J-Park Simulator could show the effect of that reduction across multiple domains – it could allow the impact of different 'what-if' scenarios to be modelled in real time.

"We are developing the Simulator with the aim of helping us to understand cross-domain connectivity and to create alternative scenarios for us to study which



Words
Sarah Collins

Things

“Natural history museums can save the world”

The Museum of Zoology has reopened after a £4.1 million redevelopment that involved moving more than two million specimens – from ladybirds the size of pinheads to a 70-foot-long fin whale.

A unique opportunity to ‘reimagine’ collections that span 400 million years, the Museum’s redesign was also a chance to re-evaluate its role in championing conservation and igniting a passion for biodiversity in the next generation of zoologists.

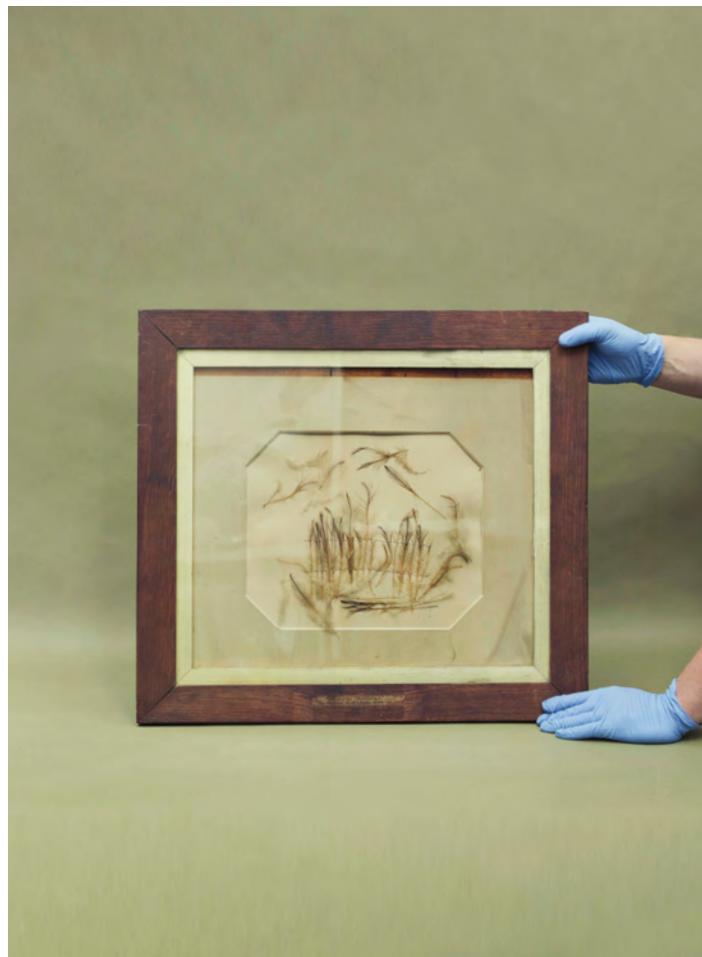
“We want to encourage dialogue with the wider public about the need to preserve and increase biodiversity,” explains Heather Lane, the Museum’s Project Manager. “So we’ve redisplayed our collections to tell these stories of conservation, habitats, ecology and biodiversity.”

Housed in the David Attenborough Building along with the Cambridge Conservation Initiative, the Museum is also contributing to biodiversity research worldwide. The specimens have been carefully organised and conserved ready to be used by the global research community, and a computerised tomography scanner – one of only a handful in the UK – is available to create three-dimensional reconstructions of the inside of any animal.

“I truly believe that natural history museums can save the world,” says Dr Jason Head, Lecturer and Curator of Vertebrate Palaeontology. “The collections are providing new data that will inform research on future conservation strategies in the face of climate change. And we have the primary data – the specimens – which will be needed for working out how to maximise biodiversity in the future.”

Redevelopment of the Museum received funding from National Lottery players via the Heritage Lottery Fund.

www.museum.zoo.cam.ac.uk



Words
Charis Goodyear



Mend the gap

Solving the UK's productivity puzzle



Words

Stuart Roberts

When it comes to the output, education and wellbeing of the Great British workforce, our towns, cities and regions exist on a dramatically unequal footing. A new, wide-ranging research network hopes to find answers to a decades-old problem – the UK's productivity gap.

The UK is the world's sixth largest economy. But would it surprise you to learn that outside of London, the South East and a handful of major cities, many areas of the UK are just as poor as swathes of Eastern Europe?

The disparity between different regions of the UK is stark, and not only in terms of living standards and educational attainment – but, crucially, also in the productivity of its workforce.

The productivity gap is one of the most serious and vexing economic problems facing the government of the day, and Brexit is adding uncertainty to the mix (see box).

Close the productivity gap between the most and least successful regions of the UK, and the GDP of UK PLC will invariably rise. Allow it to remain at current, stagnant levels – or, even worse, let the gap widen – and it's not only our place in the world rankings that suffers, but also the UK's economy, infrastructure, educational standards and health, as well as other indicators of social cohesion, such as child poverty and rising crime rates.

Put simply, productivity fires the engine of our economy – and we all need to mind the gap.

The UK's 'productivity puzzle' is what concerns Dr Maria Abreu from the Department of Land Economy. She's working with colleagues from universities around the UK as part of the Productivity Insights Network funded by the Economic and Social Research Council (ESRC) and led by the University of Sheffield. The group of economists, geographers, management experts and other scientists are taking a place-based approach to a problem HM government is desperate to solve.

Last year, the government published a 256-page Industrial Strategy that placed the productivity gap at its centre and is looking to the Network to provide policy recommendations, explains Abreu.

"There's a narrative that the UK is a very rich country, but many regions of the UK outside the capital are poor," she says. "We have a few of the richest regions in Europe and some of the poorest. It's a delusion to say we're rich."

"All the growth in the economy is centred on London, the South East and a few other cities. But growth is low or negative in the rest of the UK, and overall that means there is nearly no growth whatsoever. We are standing still."

Compared with other OECD countries, the UK has had low productivity performance since the 1970s.

The gap with other countries closed significantly during the Labour governments of the late 1990s and 2000s: GDP per hour worked grew at an average rate of 2.1% until 2007 when the global financial crisis began.

Since then, however, productivity growth has been negative (-1.1% per year for 2007–9) or very low (0.4% per year

from 2009–13), and the gap with other OECD countries has increased again despite employment rates remaining relatively strong, leading to the so-called productivity puzzle.

The three-year ESRC project is divided into distinct themes, and Abreu is leading on researching how the skills of the UK labour force, developed from preschool to life-long adult learning, go hand in hand with the rise (or fall) of productivity – and how place is a crucial, determining factor in all of this.

Figures from the Office for National Statistics showed that labour productivity in 2016 was significantly above the UK average in London (+33%) and the South East (+6%), but below average in all other regions and nations, and particularly low in the North East (-11%), the West Midlands (-13%), Yorkshire (-15%), and Wales and Northern Ireland (-17%).

"My group is looking at education and teaching standards, and what might be causing the regional disparities," says Abreu. "We are also looking at graduate migration because we have some excellent northern universities, but those regions lose a lot of people after graduation."

"London and its surrounding areas are very successful in attracting graduates



Many areas of the UK are just as poor as swathes of Eastern Europe

and highly skilled workers from around the UK, as well as migrant workers from abroad.

"The capital's productivity is enormous, but this means it is decoupling from the rest of the economy. We can link this directly to globalisation in the 1980s and the offshoring of certain industries. Most of the new jobs have been in hi-tech industries concentrated in only a few places."

Abreu suggests the dismantling of the Regional Development Agencies and the move to LEPs (Learning Enterprise Zones) from 2010 has come at a huge cost to large areas of the UK that are no longer covered by a consistent development strategy.

She passionately believes that increasing education standards across the country is vital if the UK is ever to

close its productivity gap. She also argues for proper development strategies for all regions of the UK – as well as investment in education.

The extent to which parents are engaged with their children's schooling also displays strong regional variations. Areas that are better off attract better teachers. The benefits and drawbacks of this regionalism become self-perpetuating and that affects everyone.

"These disparities in productivity, education and living standards affect us all," says Abreu. "It matters if you have one region that far outpaces everywhere else. Regions get left behind, become very socially and politically unstable, and low productivity translates into low wages and deprivation. Families do badly at school and this entrenches poverty and poor social mobility, which impacts the rest of the country."



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Migrant workers and domestic labour

A study by the Department for Business, Innovation and Skills in 2015 found that migrant workers brought benefits to UK employers that led to productivity boosts. What happens after Brexit?

Professor Catherine Barnard from the Faculty of Law believes that too much of the Brexit debate has been taken up with the discussion of trade – manufacturing amounts to only 15% of the economy – rather than the impact of the migrant workforce.

"We know there are sectors that are highly dependent on EU labour such as agriculture, which is often low-paid, seasonal work where the incentive to UK workers is not that great," says Barnard. "We also know that 10% of the NHS, especially in London, is made up of migrant workers. At Cambridge University, it's 27% at postdoctoral level."

Barnard, working with Dr Amy Ludlow and Sarah Fraser-Butlin, has been looking at the issue of immigration and the labour force, funded by the ESRC. They have focused on the East of England, visiting schools in Spalding as well as attending town hall meetings in Holt and Sheringham. Barnard says: "You get a very different view of the world. When I have given evidence to parliament, I can talk about these towns and their experiences of Eastern European migration – which are very different to the experiences of a town like Cambridge.

"The reason people can't get a hospital appointment or a school place is partly to do with migration, but it's also because of the underfunding of public services. Local councils have lost 40% of their funding from central government since 2010."

Barnard's research has also looked at the perception that EU migrants were undercutting British workers or acting as 'benefits tourists'. Through interviews and focus groups, her team built an evidential base for migrants' experiences of, and attitudes towards, Britain's employment and social security systems. "There is actually very little evidence of the widespread abuse of the benefit system by migrants to this country," she says.

"So the question going forward is what will our migration policy look like to sustain areas of the labour force currently filled by migrants? That's a question the government doesn't seem able to answer at the moment."

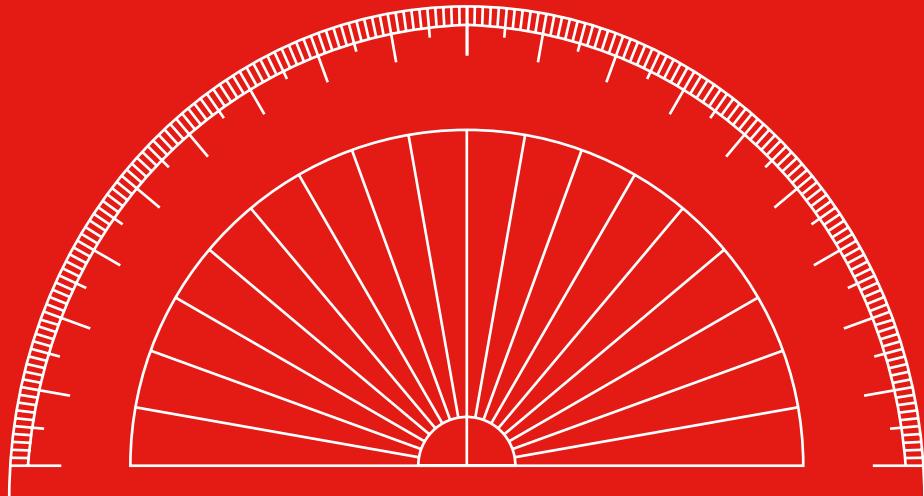


THE FIFTY



Words

Louise Walsh



Almost half of young people in the UK now go to university. Who gets in – and what and where they study – affects a person's place in society and their future earnings, as well as the skills available to the job market. Can big data help the 'fifty percenters' make one of the most important decisions of their lives – and advance the success of the UK's graduate economy?

At the start of the 1970s there were 600,000 university students. Now there are 2.5 million. In 2017, the participation of young people in higher education reached 49% – the highest level since the introduction of tuition fees.

University offers the promise of life-changing opportunities and teaching that develops knowledge and skills. Individuals, society and the economy are all winners in the game of higher education.

On the other hand, students will face an average debt of £50,000, a rising drop-out rate in some institutions and an uncertain future job market.

Arguably it is the best of times and the worst of times to be a student.

And now experts are predicting that 300,000 new university places will be needed by 2030 to keep up with demand.

"Needed is an interesting word in this context," reflects Professor Anna Vignoles

from Cambridge's Faculty of Education. "It indicates an assumption that is built into our society that everybody should try to go to university. If this is the case then it becomes absolutely vital that prospective students understand what this means in terms of their future employability."

Education plus the jobs it leads to are major factors in improving social mobility and the growth of an economy. And while Vignoles doesn't claim to have answers to how this works best, what she and her colleagues do have is access to the largest UK education dataset ever to link education with earnings – and a set of complex questions to ask of it.

The data has been collected as part of the Department of Education's Longitudinal Education Outcomes (LEO). It's actually two datasets: the educational performance of three million primary-school-aged children per year, followed through their secondary and further education to university, including the subject and university they choose; and their subsequent tax records data up to ten years after graduating.

Vignoles and colleagues in Cambridge and the Institute of Fiscal Studies are the first to be given access to such types of data, which they've been working on since 2013. Some of their results have been published, and many more are to follow.

"The top-line result is that graduate-level skill is valued in the labour market

and that, for most graduates, higher education leads to much better earnings than those earned by non-graduates," says Vignoles. "Tony Blair pledged in 2001 as Prime Minister to increase the proportion of young people progressing to university to 50%. It's clear that the UK is now well on its way to this milestone and to achieving the ambition of becoming a graduate economy."

But when the team looked in detail at how graduate earnings vary by institution, degree subject and parental income, they were struck by the sheer scale of the variation.

For instance, their initial study, published in 2016, showed that more than 10% of male graduates from the London School of Economics, Oxford and Cambridge were earning in excess of £100,000 a year ten years after graduation, whereas the median earnings of graduates from some institutions were less than the median earnings of non-graduates ten years on.

Medical students were the highest earners ten years after graduating, followed by economics graduates. Those studying the creative arts had the lowest earnings, but there were major differences depending on the institution attended.

Some of these earnings differences are attributable to differences in entry requirements and levels of prior

achievement at A-level. The point that Vignoles makes is that it's important for young people to be aware of these differences when they make their choices.

"Of course factors beyond graduate earnings, such as the student's interest in a subject, will and should drive student choice, and we should value subjects irrespective of whether they have high earnings," says Vignoles. "However, it is also important that we don't hide this information from students in the hope that they won't notice the lack of jobs or earning power when they leave."

The team's analysis of LEO doesn't just give a full picture of what our education system is doing as a whole but also what it's doing for those from disadvantaged backgrounds.

"It's partly through analysis of these data that we show that a massive socio-economic gap in achievement at the point of entry into the school system actually worsens through primary and early secondary school. It is these early gaps in achievement that are largely responsible for fewer young people from poorer households going to university."

But the inequality doesn't end there. "What you really want to know is what about the students from poorer backgrounds who have managed to achieve in the system? We shouldn't expect any difference between their

success in the labour market and that of their advantaged peers – if education is the route to social mobility then they've done their bit."

In fact they found that students from richer backgrounds still did better in the labour market than other students. "Even students who studied the same subject at the same university earn on average 10% less than more affluent peers if they come from poorer backgrounds," she says.

"Why is there this second socio-economic gap? Is it around 'social capital' networks that they don't have? Or types of postgraduate study they can't afford? It's really important for us to know what we're dealing with so that we can get to the root causes."

The team's findings are also relevant to discussions around the demand for skills that will advance the success of the UK's economy and the level at which the state subsidises higher education. "How these relate to higher education are controversial issues," says Vignoles, "It's important that the intrinsic value of going to university is not lost in discussions that focus on the economics of human capital investment."

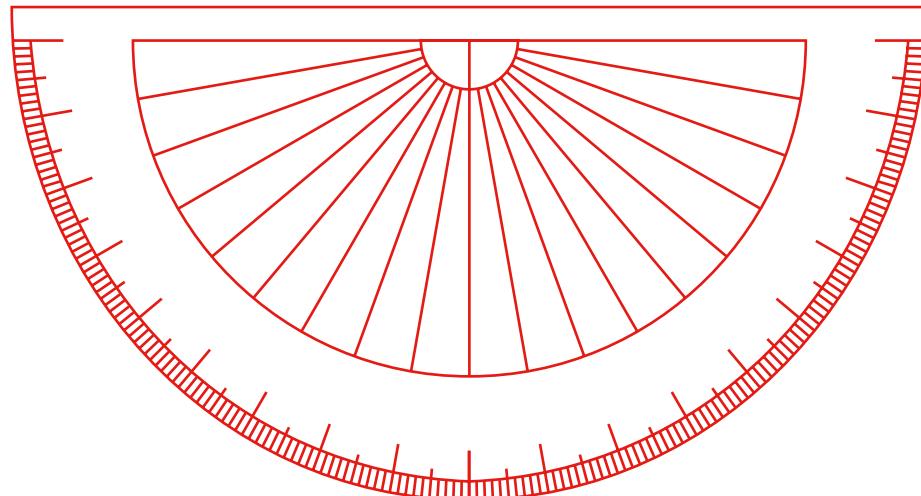
Yet, according to the 2017 CBI/Pearson Education and Skills Survey, 61% of businesses said that they fear a shortage of people with the necessary skills to fill their predicted increase in high-skilled roles over the coming years.

Meanwhile, the government underwrites student loans; graduates pay 9% of their earnings above an income threshold of £25,000. "For around three quarters of graduates, it's unlikely they will have paid off the loan by the end of their working lives," says Vignoles.

"This income contingency is crucially important – we can't give students mortgage-sized debts and ask them to take the risk of not being able to repay them. The state has to subsidise students. But, as a consequence, the state will be subsidising some subjects that attract lower earnings more than others. And subsidy for higher education may mean less resource for further education or apprenticeships. We need a public debate on this."

"We might argue the government should be investing more in education across the piece because we want a highly skilled future, but some hard choices need to be made about where to invest. That's where big data approaches can inform a wider debate – helping us to dig deep below the surface of these complex issues."

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"Education... some hard choices need to be made about where to invest"

PERCENTERS



Words
Fred Lewsey

THE BOSS OF ME

While self-employment may not be the labour market remedy some want to believe, new research is revealing its global prevalence and intergenerational roots.

There is a recurring political reverie familiar to many nations: that the right policies can conjure an entrepreneurial class of the self-employed who will pull the economy up by the bootstraps of their start-ups.

When he was UK Prime Minister, David Cameron described admiring the “bravery of those who turn their back on the security of a regular wage” more than almost anything else. This was swiftly followed by the obligatory reference to creating the “next Google or Facebook”.

Of course, the overwhelming majority of self-employed people do not “wind up a billionaire” as Cameron put it. They are the window cleaners and web designers. The hairdressers and home-school tutors. And in the UK their number has grown in recent years to almost five million people – over 15% of the workforce.

Dr Brendan Burchell, an expert on work and wellbeing from the University’s Department of Sociology, and a Fellow of Magdalene College, talks of a disjunction between the perceived desirability of self-employment and the lived reality for millions.

“There’s long been this idea that policy mechanisms promoting self-

employment have the potential to significantly reduce youth unemployment,” says Burchell, who has conducted research on everything from gender pay gaps to zero-hours contracts.

“However, while we’ve got quite good at turning unemployed people into employees, schemes to encourage self-employment – often couched in glamorous language of entrepreneurship and fronted by self-made millionaires – rarely seem to actually work.”

Burchell points out that self-employment is often politically convenient: it shifts the onus from governments to individuals, and can help with the ‘statistical impression’ of unemployment. Plus, there are always a tiny number of stellar success stories.

“Media and politicians cherry-pick aspirational accounts of self-employed people building businesses and making fortunes. Yet the available evidence from a number of economic contexts suggests that, particularly for young people, self-employment is often a highly vulnerable labour market status in terms of the levels of pay and job security it offers.”

In 2015, Burchell was commissioned by the International Labour Organization (ILO) to conduct research into patterns of self-employment in young people.

Together with his Cambridge colleague Dr Adam Coutts, Burchell dug into huge datasets on the labour market experiences of 15–24-year-olds the world over – from Asia to developing nations in sub-Saharan Africa.

They found that rates of self-employment ebb and flow over the

decades. In the EU, rates have been hovering around 10–15% of the workforce in most countries in the past couple of decades. But, in some of the least developed nations, up to 70% of the labour market consists of self-employed people. In many rural areas, “pretty much everyone” is self-employed says Burchell.

“Self-employment in the developing world isn’t the bold decision it’s framed as in Western economies – for many people there simply isn’t any other choice. Formal sector jobs are scarce and almost all are located in cities, so everyone else sells tasks or finite stock as individuals, with limited success.

“These are not scalable businesses that will, for example, help get Africa on the digital economy bandwagon. But many governments continue to take cues from the West, and push the idea of self-employment as a route to economic success.”

Big data approaches to analysing self-employment can be problematic, says Burchell. Wages are irregular and not always declared, and many individuals flit between the reported and ‘shadow’ economies in both high- and low-income countries.

He describes the project as having “the advantages but also frustrations of someone else’s datasets”, and a lot of time spent staring at spreadsheets. “I began itching to get out there and do my own, more ethnographic, data collection – to get people’s stories about their own businesses. So I began travelling around asking questions.”

As well as interviewing and observing in the UK, Burchell has spent time in South Africa, the US state of Nevada, and

“They are the window cleaners and web designers. The hairdressers and home-school tutors”

has just come back from Ghana, where his former PhD student is now researching informal employment and work-life balance.

One of the more intriguing patterns he has begun to notice in both the observational research and the big data analyses is that self-employment often tends to be a family affair.

While the traditional approach of passing a small business between generations (“Smith and son butchers, etc.”) may be in decline, Burchell is finding that self-employment still has a significant yet underreported dynastic dimension.

“The majority of self-employed people have parents or siblings who are also self-employed – they are rooted in families where self-employment is the default, and getting a qualification to become a professional worker is quite a foreign notion.

“People from such families are perhaps more likely to grow up around discussion of profit margins and self-reliance, and feel more confident with these ideas as a result,” suggests Burchell.

“For those with a family background in it, self-employment does appear to be less risky. In fact, many self-employed people describe receiving regular help, both on and off the books, from family members.”

Burchell found many examples of this during recent research trips to South

Africa – particularly for self-employed women. The sisters who operate a hair-braiding business with help from their mother. Or Joy, who runs a childcare centre developed by her aunt in premises built by her father, a self-employed construction worker.

Sometimes family members support each other’s businesses, such as Patience and her mother, who work separately as self-employed seamstresses but have pitches three metres apart and swap offcuts. “The more I look, the more I think family is fundamental to understanding why some people are successfully self-employed,” says Burchell.

For many of those lucky enough to have the choice, the insecurities of self-employment are the stuff of nightmares. People tend to crave stability when making big life decisions such as having children, says Burchell.

Other benefits to being an employee include access to training and apprenticeships, meaning that – for all the entrepreneurial talk – the risks of stagnating are perhaps even greater for the self-employed.

Nevertheless, the ILO data and Burchell’s own interviews show that self-employed people are either as satisfied or, in many parts of the world (including the UK), even more satisfied with working life than their formally employed counterparts.

“The perception of autonomy, perhaps of freedom from the tyranny of

a micromanaging boss, comes up when talking to self-employed people. Also, while often working longer hours than employees, many self-employed people value the flexibility they feel their work affords them.”

Burchell argues that, up until relatively recently in the broad sweep of history, people were rewarded per task, instead of an allotted amount of hours now familiar through nine-to-five work. “There is a pride that comes with the interaction, task completion and immediate feedback that is inherent in many classic forms of self-employed work.

“Taxi drivers like chatting to passengers and dropping them off safely. Hairdressers like making customers feel better than they did when they walked in. Maintaining a sense of achievement is vital for people’s wellbeing.”

Burchell is now embarking on a large research project to explore how labour markets might change if machine learning and robots take over many of the jobs being done by people.

“As automation starts taking effect, we need to make sure that human labour is valued for the benefits it provides each of us in terms of structure and goals. What is the minimum amount of work people need to feel valued? We may see a wider return to the more task-oriented work currently familiar to many self-employed people.”



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LEGISLATING LABOUR IN THE LONG RUN

Researchers have built the single largest dataset of employment laws – spanning more than 100 countries across much of post-war history – to look at how worker rights affect economies over decades.

There's a familiar story that goes something like this: the post-war consensus was one of heavy regulation, dominant trade unions and the same job for life; then, in the 1980s, free market

forces were unleashed, and regulation came to be viewed as a 'market distortion' that stifled productivity. By the start of the 1990s, deregulation was a cornerstone of the emergent 'Washington Consensus', and worker protection and unions were in steep decline. Legal reforms to 'free up' the labour market were declared a route to prosperity by international bodies such as the OECD and World Bank.

Now, a decade on from a global economic crash, and the mood music

may again be changing. Issues of inequality and migrant labour are destabilising politics, while all-conquering technology companies are driving new and more flexible – as well as precarious – ways of working.

Last year, for the first time in a generation, both major UK parties went into an election with manifestos that argued free market forces alone were not sufficient to achieve the desired levels of productivity and social cohesion.

From time limits on working to minimum wages, from dismissal rights for workers to legal support for strikes, the extent to which labour regulations engender flourishing or sclerotic economies is a major policy question that is now firmly back on the table.

Helpfully, a research project compiling the largest ever dataset of employment regulations from countries representing over 95% of world GDP (117 nations) tracked across a 44-year period (from 1970 to 2013) is now beginning to publish findings. The team has made the data open access for other researchers to use.

Ten years (with various intermissions) in the making, the project involved around 20 legal, economic and statistical researchers – from senior academics to PhD students and postdocs – pulling together numerous data sources before refining the analysis with sophisticated regression models based on equations created by Cambridge economists in the 1990s.

One constant, however, has been Simon Deakin, Director of the Centre for Business Research, Professor of Law at the Faculty of Law and Co-Chair of the University's Public Policy Strategic Research Initiative.

"What we've ended up with is a vast dynamic dataset – a concrete product with implications for big policy debates, not least whether legislating to strengthen worker rights helps or hinders different types of economies," says Deakin.

"Complex data of this nature may well prove helpful when exploring crucial issues for the future of society, such as how to combine social justice with economic growth. It's really a question of the kind of global society we want."

The datasets tell a story that contrasts to some extent with the familiar political story that most of us recognise.

It goes something like this: despite the massive deregulation that accompanied economic liberalisation in the 1980s – spreading through former Soviet territories as well as into the global South during the 1990s – employment protection laws became gradually stronger over time pretty much everywhere.

"Even during the Thatcher years – while trade union laws were certainly dismantled – we don't see significant weakening in individual protection laws governing areas such as termination of employment, for example," says Deakin.

Moreover, after controlling for all other effects, the data suggest that this increase in employment protection that most countries and regions experienced during much of post-war history appeared to have no negative impact on their economies.

In fact, the team found small but positive correlations between stronger

protective legislation and beneficial social and economic outcomes. This was seen in overall levels of employment, in increased labour productivity and in the amount of national income going to workforce wages rather than to capital profit.

Some of these positives may be the result of a "virtuous circle" in the long run, argues Deakin. Employment regulations can create short-term shocks: labour costs go up, leading to recruitment freezes or even lay-offs.

In the medium term, however, firms invest in new technologies and in training workers to use them. This improves morale, job security and productivity, while workers and their employers co-invest in learning and sharing knowledge – it's called a "capital deepening" effect. "Innovation is connected to the way we regulate the labour market," Deakin suggests.

He offers some important caveats. The positive coefficients seen in the data are small, conclusions can't be drawn about any single nation and empirically it's not straightforward to infer causation from correlation. "This is the first time anyone's done this for so many countries

became entangled in the Eurozone's austerity drive, particularly in "debtors nations" such as Greece and Portugal.

"A reactionary resurgence of Washington-Consensus-style thinking post-crash resulted in minor rolling back of employment protections in Europe, but this approach is short-termist and I doubt there's any real economic evidence for its effectiveness," he says.

While liberalising legislation is often combined with new worker protections, as seen in Italy's Jobs Act of 2014 or Germany's controversial Hartz IV in the mid-2000s, reforms such as these loosened rules around 'nonstandard' employment: fixed-term and temporary work.

The rise of this type of work – along with new notions of self-employment through digital platforms – make up the so-called gig economy of often-piecemeal and insecure employment.

How labour relations in this economy are regulated may prove to be a crucible for policymaking in many countries in the future. Deakin sees potential similarities within the dataset and beyond.

"The gig economy is an issue that's exploded in recent years, but our data show similar debates around labour law when part-time and agency work dramatically expanded 30 years ago and people needed better protection."

"You could even argue similarities to the late 18th century with factory expansion. At various points in history, labour law comes under pressure from technological innovation, an oversupply of labour or a loss of collective power. Traditional forms of regulation start to look worn."

"But the law evolves. We're starting to see this with the designation of Uber drivers as 'limb b' workers: dependent to some extent on an employer, with accompanying rights." There are parallels between 'limb b' and the introduction of part-time and temporary work in the 1980s, argues Deakin – "but the law caught up then and will do so again".

"The law, society and technology often evolve out of sync. Sometimes the law actually triggers advancement, such as the commercialisation of intellectual property rights contributing to innovation in IT and pharmaceuticals. You need to take a broad historical perspective to gauge these interactions, which is exactly what our research allows."

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 **Words**
Fred Lewsey

"Labour rights are fighting a constant headwind across the decades"

over such a long period; much more work is needed to extend the analysis, including studies of individual countries."

In addition, the bigger picture remains one of widening inequality and shrinking labour share – as illustrated by another time-series dataset the researchers have been working on: the shifting legal protections of shareholders.

"Labour rights are fighting a constant headwind across the decades," says Deakin. "Worker protections gradually get a bit stronger over time, while shareholder rights start to rocket from the early 1990s – across the West but also in China and Russia."

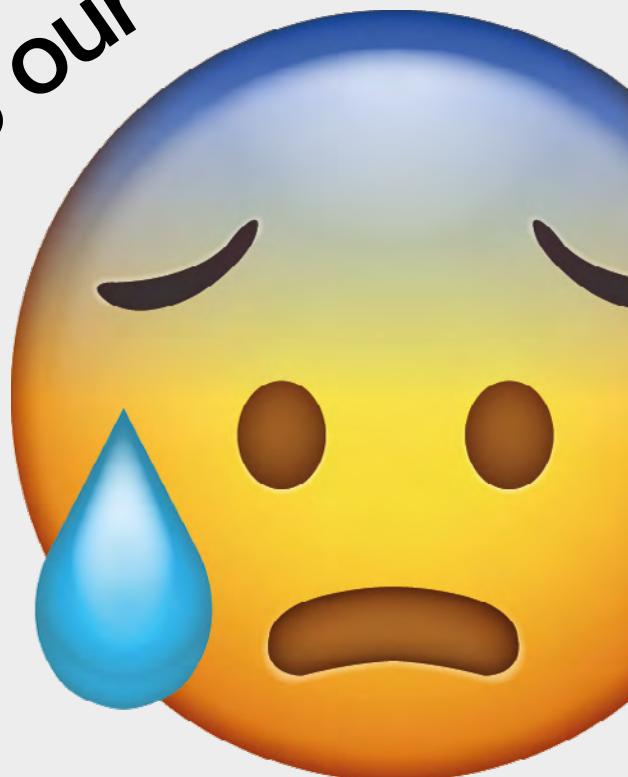
"When you put these datasets together you can see labour weakening significantly compared with capital. However, we can say that the labour share would have gone down even further were it not for the strengthening in employment protection law."

The only dip of real note in the otherwise steady uptick of global employment regulation is found in Europe following the 2008 crash. The data show that labour protection laws

For better, for worse.



how emotions shape our work life



Jochen Menges, an expert in organisational behaviour, thinks that emotions matter profoundly for employee performance and behaviour. His studies bring nuance to our understanding of how employees wish to feel at work.

Happiness at work sounds like it can only be a good thing, but add the word compulsory in front and it becomes a rather chilling concept.

It is important for people to feel happy rather than miserable in their work – research shows that contented employees deliver better results after all.

But some businesses regard happiness initiatives as a ‘salve’ that can be applied across an organisation to increase employee wellbeing, as Dr Jochen Menges from Cambridge Judge Business School explains.

“The very fact that many organisations now ‘invest in happiness’ means they

understand that emotions matter. But what they typically do – offering benefits like chill-out zones, free food, yoga classes – is rather blunt and does not account for the complexity of people’s emotional life.”

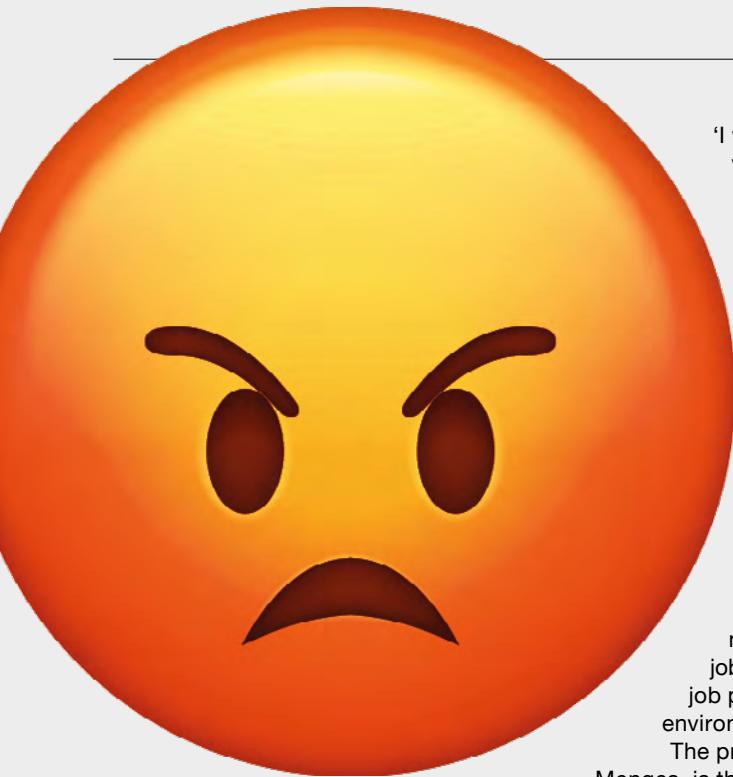
Working with the Yale Center for Emotional Intelligence and the Faas Foundation, Menges is diving deeper into our understanding of emotions at work. The ‘Emotion Revolution in the Workplace’ project has asked over 10,000 employees from a mix of occupations, levels, ages, genders and ethnicities in the USA not just how they feel, but also how they wish to feel at work.

The results show that while some report feeling happy, many say they are stressed, tired and frustrated at work. When it comes to how people wish to feel, the study finds that most want to be appreciated, excited and happy. “There is a considerable gap between how people feel at work and how they would

like to feel,” Menges explains. “Now the challenge is to find ways to close that gap.”

Although the analyses of this new dataset are still ongoing, Menges’ previous work gives some hints. He suggests that happiness may not primarily be about perks. “The work itself, colleagues and supervisors, and the organisational structure and culture play major roles in whether or not employees are happy.”

In one study, Menges found that people experience more positive emotions in organisations that are in close touch with customers.



"These organisations tend to be more decentralised – decisions can be taken at lower levels – and they pay more attention to employees' emotional abilities in recruiting and promotion processes. Those two factors in turn are linked to how positive the employees across an organisation feel."

It's not all about being positive, however.

Although most research suggests that any pleasant emotion has beneficial effects on performance, creativity and commitment, Menges and his colleagues found in a recent study that some positive emotions – pride, for example – can be a problem.

"If employees do not identify with their organisation, then pride increases their intention to leave. They think 'I am better than this place,' and look for new opportunities." By contrast, if employees identified with their organisation and experienced events that made them feel angry, they were less likely to quit. "They want to stick it out and improve the situation."

So any emotions can be a good thing, Menges suggests, even if they are unpleasant. "If managers suppress employees' emotions, they over time create an environment of indifference. Employees just get on with work, but they are not as committed and invested anymore. A bit of emotion, a bit of up and down – that's what makes work meaningful."

Menges also challenges the idea that employees should pursue 'happiness'. "I think people differ in how they wish to feel at work. Although many of us simply say

'I want to be happy at work', what we actually mean by 'happy' can differ greatly."

Menges tries to understand how people differ in the feelings they look for at work, and whether those differences affect people's choice of employer and engagement at work.

For example, someone wanting to feel safe is likely to look for a stable, predictable job, whereas someone looking for excitement might not care much about job security as long as the job provides a stimulating environment.

The problem, according to Menges, is that most of us are not that specific when it comes to how we want to feel. "We lack the emotional vocabulary to pinpoint our desired emotions, so we just use 'happy'. If we had better search terms, perhaps the search for happiness

speed of activities, raised performance goals, shortened innovation cycles. They were trying to get more done with fewer people at a faster pace."

But when performance went up, too often companies tried to make this pace the new normal. The result was that employees' energy began to drain.

These companies were in the 'Acceleration Trap' – a term he and a colleague coined in an article published in *The Harvard Business Review*. A sobering 60% of surveyed employees in companies that were in this trap said that they lacked sufficient resources to get their work done, compared with 2% in companies that were not trapped.

"Managers in accelerated companies realised that something was amiss, but they took the wrong cure. Rather than giving employees some relief, they increased pressure. Ironically, their calls for high performance led to lower performance," Menges says.

"The Acceleration Trap is still a common problem. Any uncertainty, such as Brexit, can generate the conditions where companies overload and under-resource employees, and where organisational fatigue and burnout can result."

The good news is that it is possible to escape the trap. Menges looked at how leaders recognised the trap and moved their company in different directions – such as halting less-important work, being clear about strategy and changing the culture.

"When it comes to how people feel in a business, many point to the leader. And it is right that leaders play a key role in setting the mood of a place," Menges explains. In particular, leaders with emotional intelligence – the ability to recognise emotions in oneself and others, and to regulate emotions in ways that help reach rather than hinder goals – are in a good position to steer their team's and organisation's collective emotions in the right direction.

"But I think we need to also look at how the organisation as a system is set up," he says. Menges believes that some places are organised in a more emotionally effective way than others. "If companies figure out how they can institutionalise emotionally intelligent systems, they would be much better off than investing in 'happiness initiatives'."



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Words
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"A bit of emotion, a bit of up and down – that's what makes work meaningful"

would not be that fuzzy and difficult."

He suggests that organisations have a considerable influence on employees' emotions and that employees within an organisation tend to feel alike. "Emotions are a very intimate and personal experience, and yet how we feel often depends largely on how people around us feel."

"In some places, people are enthusiastic, excited and inspired for a better future; in others, they are satisfied, calm, relaxed, easy-going. Both are positive but have very different energy levels, and that is linked to different outcomes."

"In other places, there is aggression, stress and anxiety – or frustration, resignation and apathy. Again, both negative, but with different energy levels and outcomes."

Places with high positive energy are at risk of losing it. Menges saw this at first hand when he studied the impact of the economic crisis of 2008–2009. "Companies were working at a frenetic pace – they increased the number and

THE STRESSES AND STRAINS OF WORK AND UNEMPLOYMENT

A stressful workplace can damage your health. But so too can being out of work. Cambridge researchers are trying to understand why both situations can be detrimental to our health and wellbeing – and help employers and government provide solutions.

When I ask Dr Adam Coutts what we know about the impact of unemployment on health, his response is blunt and to the point: “It’s very bad.”

There’s a pause before he goes on to say that we’ve known for more than half a century that unemployment is bad for mental health and wellbeing, and that this has a knock-on effect on our physical health. Where there is debate, though, is over why it is so bad.

Studies suggest that work provides what he describes as “psychological vitamins or functions”, such as structure, routine, a sense of identity and the opportunity to meet people and socialise. “It’s not all about a wage,” he says.

Coutts has been on research placement from the Department of Sociology to the UK government’s Department for Work and Pensions (DWP) and the Department of Health and Social Care (DHSC) Work and Health Unit since June 2016. There, he has been looking to better understand the link between unemployment and mental health, particularly in

the context of today’s Britain, and how policy can intervene to help.

He is studying an intervention that aims to get people back to work and to support their mental health needs. The programme is adapted from one developed by the Institute of Social Research at the University of Michigan and now being trialled by the DWP. Participants take part in a voluntary five-day course, during which they receive help with CV writing, social support, interview techniques and how to search for a job, including how to see the process from the viewpoint of an employer.

Coutts has been conducting an ethnographic study across five areas of England since the trial started in January 2017 to complement a large-scale randomised control trial evaluation. He has what he describes as “a ringside seat” of the policy process and has seen how the intervention has been designed, implemented and evaluated: a privileged point of access for any academic researcher. He observes course participants and facilitators, and staff at job centres – “everyone from the unemployed to senior civil servants” – to see how these policies actually work on the ground.

“We know these types of interventions have an effect on job search behaviours and a person’s health, but we don’t really know why and who is most responsive.

I’m trying to tell a story of what it’s like to go through these programmes, be unemployed and cope with mental health issues in Britain today.”

If the evidence from previous trials in the USA is anything to go by, then the benefits from such an intervention would reach beyond the individual: as well as helping people get back to work, improving their mental health and wellbeing could save money for the NHS, as a result of less reliance on GP or mental health services.

But mental health issues are not just associated with unemployment. There is a growing recognition of the link between employment and our health and wellbeing, too. A recent



report for government, entitled 'Thriving at Work', included some startling statistics for the UK: 15% of workers have a mental health condition and 300,000 people with long-term mental health problems lose their jobs each year. Mental health costs employers over £33 billion per year, the state over £24 billion and the whole economy over £73 billion.

"Employers need to understand that stress and anxiety, and mental ill health, is a large problem in terms of people not being at work, or being at work and not performing well," says Professor Dame Carol Black, Principal of Newnham College, and author of several influential reports for government about work and health.

Black believes that training at line management level to identify and support workers with mental health issues is essential to tackling this problem; without this, measures to create healthier workplaces will amount to little more than papering over the cracks, Black says.

However, she has seen enough examples of good practice in companies such as BT, Unilever and Anglian Water to be optimistic that we can tackle this problem. "What you see are pockets of good practice, but I think we need a campaign to really get it out there and say we know this is what we all should be doing – it isn't that difficult to do."

Business leaders are beginning to pay attention. In an article earlier this year following the annual meeting of the World Economic Forum, Clifton Leaf, Editor-in-Chief at the influential business magazine *Fortune*, chose as number one of '7 Takeaways From Davos': 'The mental health disorder time bomb is upon us'.

One of the problems, however, is the lack of concrete evidence about what works. "People often ask 'where's the Cochrane-type evidence?'" says Black, referring to the 'gold standard' of evidence reviews in research. "It's not easy to collect data in the workplace, but we would only have better evidence if more organisations collected data and were willing to share it."

Dr Tine Van Bortel from the Cambridge Institute of Public Health is helping to

WORK LOOK

"Employers need to understand that stress and anxiety, and mental ill health, is a large problem in terms of people not being at work, or being at work and not performing well"

build this evidence base. In fact, she was namechecked in Leaf's article after he attended a mental health event at Davos that she co-presented with the international care consortium Kaiser Permanente.

As part of her mandate with the World Economic Forum Global Agenda Council on Mental Health, Van Bortel has been leading a study looking at policies used by major corporations aimed at improving the health and wellbeing of their workforce.

"A lot of these corporations say that a combination of integrated and targeted approaches are really important," she says.

An integrated approach might consist of providing access to a gym.

Targeted interventions might include a willingness to make 'reasonable adjustments' such as moving an employee to less strenuous work or allowing them to work part time.

While Van Bortel believes employers should take responsibility for ensuring the health and wellbeing of their employees, she is a passionate believer that government can – and should – think about our mental health.

"I firmly believe that government should ensure our workplaces are healthy and that we're not being confronted with some of the stressful, unjust and – quite frankly – inhumane situations that we're currently seeing."

"Think about zero-hours contracts, or people having to work three jobs to make ends meet, or wage discrepancies and other structural inequalities. This puts a lot of stress on persons, families and ultimately society, and can reflect on work and productivity. More can and should be done. After all, healthy and all-inclusive workforces make excellent business sense."

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 **Words**
Craig Brierley

9000 LISTS 300 YEARS

How do education and economic growth add up?



Words

Louise Walsh

The handwritten inventories had lain largely untouched for centuries. Sand used to dry the ink still lay between the pages. Written neatly inside were thousands of lists that might hold the key to an enduring puzzle in economics – does education fuel economic growth?

In 1752, Juliana Schweickherdt, a 50-year-old spinster living in the small Black Forest community of Wildberg, was reprimanded by the local weavers' guild for "weaving cloth and combing wool, counter to the guild ordinance".

When Juliana continued taking jobs reserved for male guild members she was summoned before the guild court and fined the equivalent of one third of a maid servant's annual wages. The entire affair was then recorded neatly in a ledger.

It was a small act of defiance by today's standards, but it reflects a time when laws in Germany, and elsewhere,

regulated people's access to labour markets. The dominance of guilds not only prevented people from using their skills, as in Juliana's case, but also held back even the simplest of industrial innovations.

What makes this detail of Juliana's life so interesting is that it is one among a vast number of observations in a huge database on the lives of southwest German villagers between 1600 and 1900. Built by a team led by Professor Sheilagh Ogilvie in the Faculty of Economics, the database includes court records, guild ledgers, parish registers, village censuses, tax lists and – the most recent addition – 9,000 handwritten inventories listing over a million personal possessions belonging to ordinary women and men across three centuries.

Ogilvie, who discovered the inventories in the archives of two German communities 30 years ago, believes they may hold the answer to a conundrum that has long puzzled economists: the lack of evidence for a causal link between education and a country's growth and development.

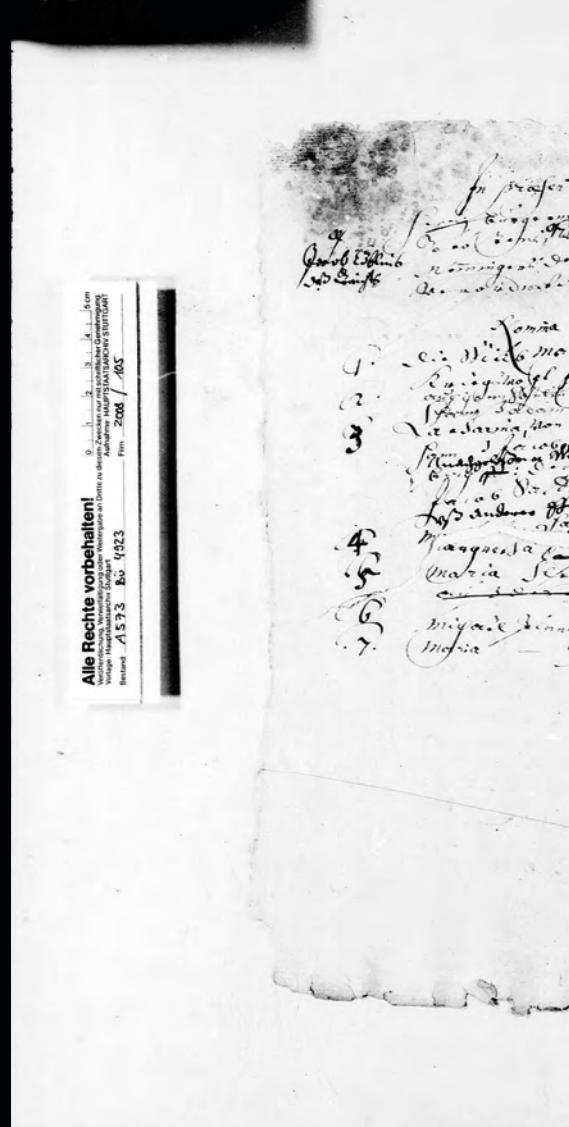
"It might sound as if this is a no-brainer," explains Ogilvie. "Education helps us to work more productively, invent better technology, earn more, have fewer children and invest more in them – surely it must be critical for economic growth? But, if you look back through history, there's no evidence that having a high literacy rate made a country industrialise earlier."

She explains that between 1600 and 1900, England had only mediocre literacy rates by European standards, yet its economy grew fast and it was the first country to industrialise. Germany and Scandinavia had excellent literacy rates, but their economies grew slowly and they industrialised late.

"Modern cross-country analyses have also struggled to find evidence that education causes economic growth, even though there is plenty of evidence that growth increases education," she adds.

The inventories Ogilvie is analysing listed the belongings of women and men at marriage, remarriage and death. From badger skins to Bibles, dung barrows to dried apple slices, sewing machines to scarlet bodices – the villagers' entire worldly goods were listed. Inventories of agricultural equipment and craft tools revealed economic activities; ownership of books and education-

0 1 5 6



related objects like pens and slates suggested how people learned.

In addition, tax lists recorded the value of farms, workshops, assets and debts; signatures and people's estimates of their age indicated literacy and numeracy levels; and court records revealed obstacles that stifled industry, like Juliana and her wool-combing.

"Previous studies usually had just one proxy for linking education with economic growth – the presence of schools and printing presses, perhaps, or school enrolment, or the ability to sign names. This database gives us multiple indicators for the same individuals," she explains. "I began to realise that, for the first time ever, it was possible to link literacy, numeracy, wealth, industriousness, innovative behaviour and participation in the cash economy and credit markets – for individual women and men, rich and poor, over the very long term."

Since 2009, Ogilvie and her team have been building the vast database

**"It might sound
as if this is a
no-brainer"**



of material possessions on top of their full demographic reconstruction of the people who lived in these two communities. "We can follow the same people – and their descendants – across 300 years of educational and economic change," she says.

Individual lives have unfolded before their eyes. Stories like that of the man who wanted to grow a new crop – turnips – but was forbidden by the village council because it meant driving his cart to the fields at a different time, threatening others' crops in the communal rotation system.

Or the young weaver's wife Magdalena Schöttlin fined 11 days' wages for wearing an "excessively large neckerchief ... above her station". Or the 24-year-olds Ana Regina and Magdalena Riethmüllerin who were chastised in 1707 for reading books instead of listening to the pastor's sermon. "This tells us that they were continuing to develop their reading skills at least a decade after leaving school," explains Ogilvie.



Image

One of the lists that is being used to reconstruct 300 years of economic history

It would be easy to focus on these stories – the aspirations and tragedies, the societal norms and individual rebellions, the possessions precious and prosaic – but, says Ogilvie, now that the data-gathering phase of the project is complete, "it's time to ask the big questions".

One way to look at whether education causes economic growth is to "hold wealth constant" and follow the lives of people of a certain level, rich or poor, she explains. "Do we find education positively linked to the cultivation of new crops, or to the adoption of industrial innovations like knitting frames or sewing machines? Or to the acquisition of 'contemporary' goods such as cottons or coffee cups? Or to female labour force participation or involvement in the credit market?"

The team will also ask whether more highly educated women had fewer children – enabling them to invest more in those they had – as well as what aspect of education helped people engage more with productive and innovative activities. Was it, for instance, literacy, numeracy, book ownership, years of schooling? Was there a threshold level – a tipping point – that needed to be reached to affect economic performance?

Ogilvie hopes to start finding answers to these questions over the next two years. One thing is already clear, she says: the relationship between education and economic growth is far from straightforward.

"German-speaking central Europe is an excellent laboratory for testing theories of economic growth," she explains. "We know that literacy rates and book ownership were high and yet the region remained poor. We also know that local guilds and merchant associations were powerful and resisted changes that threatened their monopolies. Entrenched village oligarchies opposed disruptive innovations and blocked labour migration."

"Early findings suggest that the potential benefits of education for the economy can be held back by other barriers, and this has implications for today," she says. "Huge amounts are spent improving education in developing countries but this spending can fail to deliver economic growth if restrictions block people – especially women and the poor – from using their education in economically productive ways. If economic institutions are poorly set up, for instance, education can't lead to growth."

Ogilvie also hopes to dig deeper into which aspects of education matter. "We feel intuitively that the answer to the famous question posed by Tolstoy – 'Can there be two opinions on the advantage of education?' – is the one that Tolstoy gives: 'If it's a good thing for you, it's a good thing for everyone'.

"But while some types of schooling just benefit the providers or the authorities, other types make kids happier, increase their productivity, maximise impact on people's wellbeing and benefit the wider society."

Ogilvie believes the data will contain answers, and says: "I look at what we've amassed and I realise that I'm going to be working on these inventories for the rest of my life... I can think of much worse fates."

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Making the numbers count

Researchers call for gender equality and career support for women in the workplace, and an end to “the doom and gloom narrative” over their limited numbers.

Glass ceilings, glass cliffs, glass escalators... much has been written about the metaphorical glass barrier that stands invisibly yet solidly between women and high-level success across the economy.

It's a description that exasperates Professor Sucheta Nadkarni from Cambridge Judge Business School. “The challenges faced by women in business are well documented and fiercely debated, and there's a tendency for most of this talk to be negative. I

call this the doom and gloom narrative – it's about the barriers that women face and why women fail. Let's change the conversation about gender equality to focus on the factors that help women to succeed.”

Nadkarni is the lead academic on a major global research project that reported in the *European Business Review* last year on the factors that help women to succeed in corporate environments. The project gathered data from 1,071 companies in 42 countries, covering 56 industries. The information spanned a ten-year period, during which the average percentage of women on executive teams in sampled firms rose from 7.6% to just 11.7%.

The study highlighted the many benefits that women in senior roles bring to companies. “It's not just that hiring more women into senior positions is the right thing to do for gender equality, it's also the smart thing to do from a business perspective,” says Nadkarni.



Words
Eleanor Dodd



“We found that bringing more women to top roles can make a business function better, attract new customers and improve the bottom line. Women bring in diverse capabilities, diverse knowledge and new ways of thinking, which organisations need.”

With revelations about the gender pay gap making current headlines – three quarters of the 10,000 firms that have provided information pay men more than women – the inequality problems women continue to face in the labour market are gaining increasing attention.

However, Nadkarni is keen to focus on the future. “The question we need to ask now is: what can we do about this situation of unequal pay and unequal

representation, and how can we create a more optimistic, promising picture for our students and for the women who are just starting to rise up?"

Her study considered the economic, political, legislative and cultural forces that determine the number of women in the boardroom in different countries. The findings showed that the strongest drivers are 'female economic power' and a requirement for gender diversity in a country's corporate governance code. Maternity provisions and female politicians providing a championing voice for women are also important factors.

Female economic power was measured by the expected years of schooling for women, and the percentage of women in the labour force. The results suggest that as women become more highly educated, and gain increasing levels of employment, they play a greater role in the marketplace. This then provides a powerful incentive for companies to hire more women onto the board, to reflect the market they cater for.

Corporate governance codes are a set of best practice recommendations, including gender diversity requirements. In the past decade, codes have been created in 64 countries. Among countries sampled in Nadkarni's study, Colombia had the highest percentage of women in executive teams, at 28.5%, and Japan ranked bottom with 0.57%.

These codes, says Nadkarni, are one example of a 'soft' measure that has been shown to be effective in helping women to gain top roles in executive teams or on management boards. In comparison, 'hard' targets – such as the mandatory quotas enforced on companies by several countries to give a percentage of seats on the board to women – do little to support gender diversity, and can also have a negative effect on company cohesion.

"Although quotas can help to improve the representation of women on corporate boards, they do little to help women stay in senior positions long enough to make a real impact, and can have both positive and negative effects on turnover rates,"

says Nadkarni. "They can also create a hostile environment, by conveying a sense of 'preferential treatment' rather than recognition of hard work, skills and capabilities."

The research also uncovered some of the loopholes that companies exploit to meet quota requirements. For example, in countries where family businesses are common, quotas are sometimes fulfilled by appointing female relatives to the board. In one case, an 86-year-old, the daughter of the founder of a company in Turkey, had been on the board since 1964.

Dr Jude Browne, the Jessica and Peter Frankopan Director of the University of Cambridge Centre for Gender Studies, has constructed a different approach to addressing gender equality that focuses on encouraging diversity at all levels of an organisation rather than simply quota requirements for senior roles.

Browne suggests that "each organisation with significant pay gaps and other segregation patterns needs to begin by building a detailed picture of what it thinks its data *ought* to look like and, crucially, publish its goals.

"Too many organisations simply collect data, compile aggregate figures that don't tell us that much and then look to other organisations to see how they compare. Given that a great many are failing to pick up real pace in addressing these patterns, the 'comparison with competitors approach' tends to generate a complacent comfort zone around what ought to be, in many cases, unacceptable."

As Browne set out at the European Commission recently, the 'Critical Mass Marker' approach focuses on skilled women who are not advancing to the next level as quickly as one might expect – that is, where critical mass is not having the desired flow effect.

The approach requires an organisation to undertake a detailed analysis of its workforce and mark out goals that proportionately relate each level to the

next, taking critical mass failures into particular account. Organisations would then be required to analyse and explain their continued segregation patterns against their published goals. This might include analysing the different career profiles that various intersectional groups tend to have and the impact of dependant-related responsibilities, reassessing the benchmark criteria for promotion, and comparing those who have worked within the organisation for long periods to newcomers with very different workloads.

"The Critical Mass Marker approach is not going to solve all the segregation problems that organisations tend to have," she adds. "But it puts a greater onus on them to ensure those equipped with the relevant talents are able to move up and across institutional structures in a more effective and proportionate way than blanket quotas aimed solely at the top layers of management where we often only see the same few women."

Nadkarni is also keen to see more women supported at every level, and would like to see action to increase the number of women in executive teams, not just on corporate boards.

"Corporate boards are important, but they only play an indirect role in influencing company strategies and performance, because they mainly have an advisory capacity," she says. "The decisions are made by the executive team. So, if we want companies to benefit, if we want women to really make an impact, then it's the executive teams that matter.

"In this context, a quote that comes to mind is it's not about 'counting the numbers', it's about 'making the numbers count'. In other words, it's not merely the quantity of women in top positions that matters, but also whether policies are in place at various levels – company, government and corporate governance codes – to ensure that women can make a true impact in such roles.

"Hopefully in the future we will watch the doom and gloom ebb away as the true benefits of gender equality become crystal clear to everyone."

"Hiring more women into senior positions is the right thing to do for gender equality, it's also the smart thing to do from a business perspective"



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Humans need not apply



Words

Louise Walsh

Will automation, AI and robotics mean a jobless future, or will their productivity free us to innovate and explore? Is the impact of new technologies to be feared, or a chance to rethink the structure of our working lives and ensure a fairer future for all?

human farmer



**automated picker
self-driving tractor
drone sprayer**

On googling ‘will a robot take my job?’ I find myself on a BBC webpage that invites me to discover the likelihood that my work will be automated in the next 20 years. I type in ‘editor’. “It’s quite unlikely, 8%” comes back. Quite reassuring – but, coming from a farming family, it’s a sobering moment when I type in ‘farmer’: “It’s fairly likely, 76%”.

The results may well be out of date – such is the swiftness of change in labour market predictions – but the fact that the webpage even exists says something

about the focus of many of today’s conversations around the future of work.

Many of the discussions are driven by stark numbers. According to a scenario suggested recently by consultancy McKinsey, 75–375 million workers (3–14% of the global workforce) will need to switch occupational categories by 2030, and all workers will need to adapt “as their occupations evolve alongside increasingly capable machines”.

Just recently, online retailer Shop Direct announced the closure of warehouses and a move to automation, putting nearly 2,000 jobs at risk. Automation – or ‘embodied’

artificial intelligence (AI) – is one aspect of the disruptive effects of technology on the labour market. ‘Disembodied AI’, like the algorithms running in our smartphones, is another.

Dr Stella Pachidi from Cambridge Judge Business School believes that some of the most fundamental changes in work are happening as a result of ‘algorithmication’ of jobs that are dependent on information rather than production – the so-called knowledge economy.

Algorithms are capable of learning from data to undertake tasks that previously

needed human judgement, such as reading legal contracts, analysing medical scans and gathering market intelligence.

"In many cases, they can outperform humans," says Pachidi. "Organisations are attracted to using algorithms because they want to make choices based on what they consider is 'perfect information', as well as to reduce costs and enhance productivity."

But these enhancements are not without consequences, says Pachidi, who has recently started to look at the impact of AI on the legal profession.

"If routine cognitive tasks are taken over by AI, how do professions develop their future experts?" she asks. "Expertise and the authority it gives you is distributed in the workplace. One way of learning about a job is 'legitimate peripheral participation' – a novice stands next to experts and learns by observation. If this isn't happening, then you need to find new ways to learn."

Another issue is the extent to which the technology influences or even controls the workforce. For over two years, Pachidi was embedded in a telecommunications company. There she observed "small battles" playing out that could have vast consequences for the future of the company.

"The way telecoms salespeople work is through personal and frequent contact with clients, using the benefit of experience to assess a situation and reach a decision. However, the company had started using a data analytics algorithm that defined when account managers should contact certain customers about which kinds of campaigns and what to offer them."

The algorithm – usually built by external designers – often becomes the curator of knowledge, she explains. "In cases like this, a myopic view begins to creep into working practices whereby workers learn through the 'algorithm's eyes' and become dependent on its instructions. Alternative explorations – the so-called technology of foolishness where innovation comes out of experimentation and intuition – is effectively discouraged."

Pachidi and colleagues have even observed the development of strategies to 'game' the algorithm. "Decisions made by algorithms can structure and control the work of employees. We are seeing cases where workers feed the algorithm with false data to reach their targets."

It's scenarios like these that many researchers in Cambridge and beyond are working to avoid by increasing the trustworthiness and transparency of AI technologies (see issue 35 of *Research Horizons*), so that organisations and individuals understand how AI decisions are made.

In the meantime, says Pachidi, in our race to reap the undoubted benefits of new technology, it's important to avoid taking a laissez-faire approach to algorithmication: "We need to make sure we fully understand the dilemmas that this new world raises regarding expertise, occupational boundaries and control."

While Pachidi sees changes ahead in the nature of work, economist Professor Hamish Low believes that the future of work will involve major transitions across the whole life course for everyone: "The traditional trajectory of full-time education followed by full-time work followed by a pensioned retirement is a thing of the past."

"Disruptive technologies, the rise of the ad hoc 'gig economy', living longer and the fragile economics of pension provision will mean a multistage employment life: one where retraining happens across the life course, and where multiple jobs and no job happen by choice at different stages."

His research examines the role of risk and the welfare system in relation to work

of unemployment. "History is clear that change can mean redundancies – after World War II, 42% of UK jobs were redundant, but social policy maintained full employment. Yes, technology can displace people. But social policies can tackle this through retraining and redeployment."

He adds: "The big problem won't be unemployment it will be *underemployment* – people who want to work but can't because they have zero-hours contracts. If there is going to be change to jobs as a result of AI and robotics then I'd like to see governments seizing the opportunity to improve policy to enforce good job security. We can 'reprogramme' the law to prepare for a fairer future of work and leisure."

This might mean revitalising fiscal and monetary policies such as a universal social security and taxing the owners of robots.

McGaughey's findings are a call to arms to leaders of organisations, governments and banks to pre-empt the coming changes with bold new policies that ensure full employment, fair incomes and a thriving economic democracy.

"The promises of these new technologies are astounding. They deliver humankind the capacity to live in a way that nobody could have once imagined," he adds. "Just as the industrial revolution brought people past subsistence agriculture, and the corporate revolution enabled mass production, a third revolution has been pronounced. But it will not only be one of technology. The next revolution will be social."

"If routine cognitive tasks are taken over by AI, how do professions develop their future experts?"

at these various life stages. "When we are talking about the future of work," he says, "we should have in mind these new frameworks for what people's lives will look like, and prepare new generations for a different perspective on employment."

On the subject of future job loss, he believes the rhetoric is based on a fallacy: "It assumes that the number of jobs is fixed. If in 30 years, half of 100 jobs are being carried out by robots that doesn't mean we are left with just 50 jobs for humans. The number of jobs will increase: we would expect there to be 150 jobs."

Dr Ewan McGaughey, at Cambridge's Centre for Business Research and King's College London, agrees that "apocalyptic" views about the future of work are misguided. "It's the laws that restrict the supply of capital to the job market, not the advent of new technologies that causes unemployment."

His recently published research answers the question of whether automation, AI and robotics will mean a 'jobless future' by looking at the causes

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The ‘King of Scuttle Flies’ who continues to discover new species

“Scuttle flies are fiendishly clever”



Credit: Nick Saffell

Henry Disney admits that the task of classifying hundreds of species of scuttle fly has sometimes seemed like a crazy undertaking, especially with his deteriorating eyesight.

The insect specimens I work on are tiny. Because of my poor vision, I rely on a whole range of devices to magnify things.

I think I'm the only person willing to look at any phorids, or scuttle flies, from anywhere in the world. At the moment I've got a queue of specimens waiting for me to identify them my lab at the Zoology Department. Identification relies on fine details including making a series of accurate measurements. I'm told that I'm known as the 'King of Scuttle Flies'.

Estimates suggest that 80% of species have yet to be described. Of around 250 genera of scuttle flies, more than half the species belong to the giant genus *Megaselia*, which has been called the most challenging genus in the animal kingdom. At times, the task of classifying them has seemed a crazy undertaking. It can be a question of looking at tiny variations in male genitalia.

I'm sometimes asked: “what's the point of studying flies?” My answer is that they tell us a huge amount about evolution, specialisation and the world we live in. As a result of globalisation – the movement of people and goods across the world – insects are flourishing in new habitats. Several species breed in corpses, including the infamous coffin fly. Over the years, I've worked with forensic scientists to pinpoint the probable time of death of the victim by using the life cycles of phorid flies as a guide.

I studied Natural Sciences at Cambridge. I went on to work at Flatford Mill Field Centre in Suffolk, and as a medical entomologist in British Honduras (now Belize) and Cameroon. For 14 years, I ran the Field Centre at Malham Tarn in Yorkshire. In 1984, I came back to Cambridge to concentrate on research into Phoridae.

When my wife died in 2012, I was faced with a choice. I'd never expected to outlive her and I considered that I'd already had nine lives, almost dying twice from cerebral malaria. I thought that I could either stay at home and mope or carry on with the work I loved. I opted for the latter.

That same year I had another big blow. I'd lost much of the sight in my left eye over 30 years earlier. In December 2012, I developed a serious problem in my other eye. It happened in the space of a single day. I was at a memorial service in a Cambridge church when a kind of horizon appeared in my good eye.

The experts think the problem arose from a sarcoidosis. I'm on a combination of medications including steroids. Usually with steroids you put on weight but I haven't. That's probably because I walk about 20 miles a week, from home to my lab. I carry a hazel stick that I cut from the hedge at the bottom of my garden and painted white. Like me, it's a bit wonky.

The badge I wear around my neck makes my life much easier. It warns people that I can't see well and saves all sorts of confusion in shops, for example. On the reverse is a message that explains that I'm blind in one eye and purblind in the other but people kept asking me what purblind meant.

Friends and colleagues help me keep abreast of imaging technology. A combination of hardware and software

enables me to keep working in my lab. Cambridge University's Disability Resource Centre has been very helpful. My grandchildren too are brilliant at teaching me how to use the latest gadgets.

I was born just before the Second World War. My father was based in Sudan where he was an administrator. In 1942, my mother went with him to help with a relocation and was stranded there. I didn't see my parents until four years later when I was almost seven.

In our parents' absence our Aunt Sheila was officially our guardian. We spent holidays with her at Burnham Overy Staithes in north Norfolk, where she had rooms above a boathouse. One of her rules was that we should bring back free fuel and food every day. This meant searching the marsh and creeks for sea coal and whelks.

I've always loved field work. I met my wife when we were both working at Flatford Mill Field Centre. During my time at Malham Tarn Field Centre, I started and, with my colleague Dr Sarah Corbet, co-edited the *Naturalists' Handbooks* series as practical guidebooks for others working in the field.

Scuttle flies are fiendishly clever. Many are parasitoids. They enter the host's rear end and move forward consuming the non-vital organs before entering the ant's head capsule where they pupate.

My 600th paper is currently in press. One is co-authored with a Danish schoolmaster. We've identified 14 new species of phorids.

For years, friends and colleagues told me I should write about my life. I resisted because I felt that autobiography was often more fictitious than fiction. I eventually caved in and *Regaining Life's Winding Trail* was published in 2017.

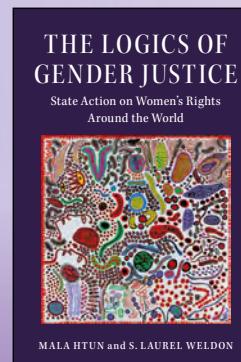
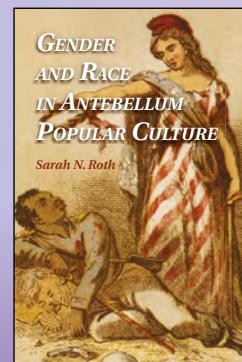
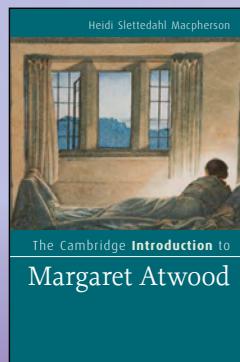
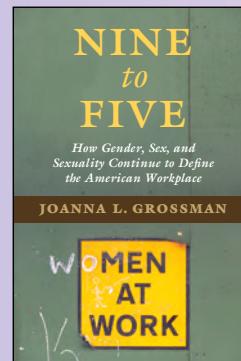
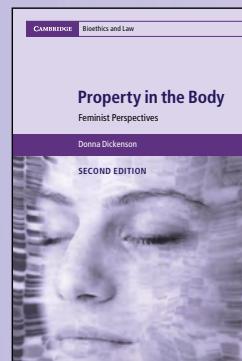
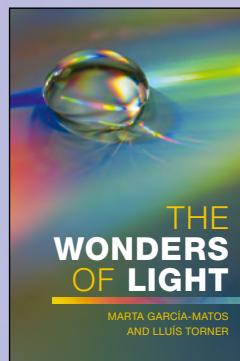
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 Interview
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GENDER EQUALITY

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**The productivity gap is
one of the most serious
and vexing economic
problems facing the
government of the day
(p. 20)**

Credit: T-Rex & Flower
Correction: the cover image of
issue 35 was a photograph of a
sculpture by Rona Pondick