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# IfM | REVIEW

UNIVERSITY OF CAMBRIDGE
Department of Engineering

IfM MANAGEMENT TECHNOLOGY POLICY

IfM | REVIEW

## INSTITUTE FOR MANUFACTURING (IfM)

The IfM is part of the University of Cambridge's Department of Engineering. We are a dynamic body of researchers, educators, practitioners, professionals and technical experts contributing to world-leading research and education. With a focus on manufacturing industries, the IfM creates, develops and deploys new insights into technology, management and policy.

## IfM ENGAGE

IfM Engage is an embedded knowledge transfer company within the Institute for Manufacturing (IfM). We combine research excellence and industry expertise to conduct bespoke strategic consultancy, talent and leadership development and company membership programmes. Our profits are gifted to the University of Cambridge to fund future research.

## COVER IMAGE

Credit: Amy Reinecke / Institute for Manufacturing

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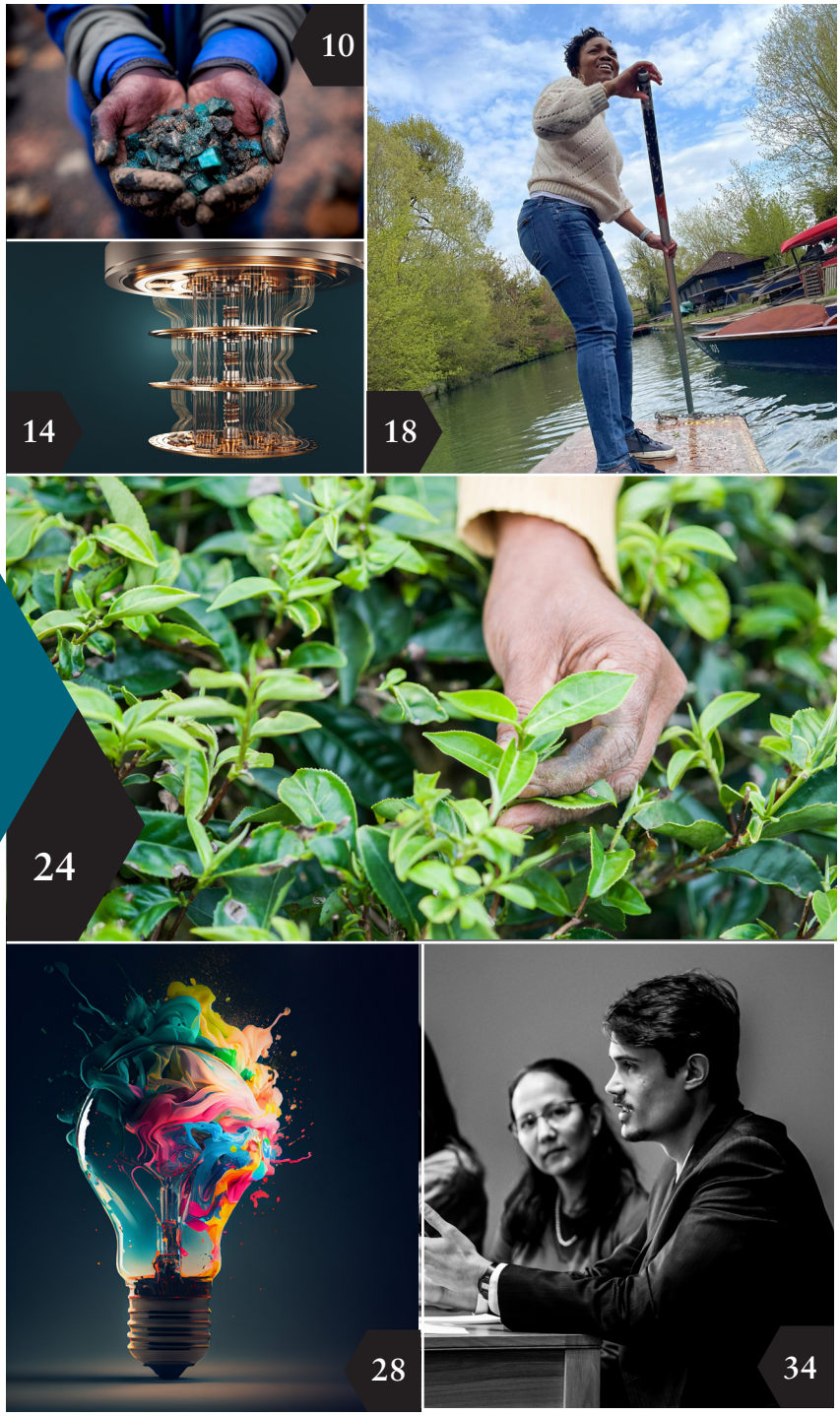



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# WELCOME TO ISSUE 15

Welcome to Issue 15 of the *IfM Review*. I'm delighted to share some of the latest exciting work from across the Institute for Manufacturing, spanning our technology, management and policy activities.

In this issue, we explore the fascinating uses of future technology. Michael de Volder from the Nanomanufacturing Group explains how his team is working to eliminate cobalt from electric vehicle batteries because of concerns about ethics and the environment, offering a glimpse into a more sustainable era for electric mobility. We also hear about the latest work from the Fluids in Advanced Manufacturing Group as they expand their capabilities in their efforts to tackle hard-to-treat cancers.

This issue also highlights our continued involvement in the Women in Manufacturing initiative and our role in organising its first conference. Unfortunately, the gender imbalance in the manufacturing sector is stark: although women comprise nearly half of the UK's workforce, they only represent 26% of the manufacturing industry. So, I am delighted by our efforts to support a more inclusive manufacturing landscape by providing networking opportunities and thought leadership.

In our news section, you can find recent updates, including our participation in the World Economic Forum meeting in Davos and some of our latest report launches. I am particularly pleased to highlight that Professor Bill O'Neill has been elected as a Fellow of the Royal Academy of Engineering, which is a well-deserved recognition of his achievements.

In other articles, we get insights on how AI can enhance processes, as Sebastian Pattinson shares his thoughts on effectively using AI-controlled systems. Chander Velu delves into the challenges and hurdles that businesses, researchers and governments need to overcome as they explore the potential of quantum computing. And we hear from entrepreneur Griselda Togobo, an ISMM alumna, as she talks about how her time at the University of Cambridge gave her the courage to take risks and embrace failure.

There are also stories from our knowledge-transfer company, IfM Engage. We learn how Domino Printing Sciences keep up with the fast pace of changes in the business environment; and how a tea producer in Kenya has been able to make sustainability relevant to their local workforce by introducing straightforward energy-saving solutions.

From our Policy Links team, we hear how their research on adopting digital tech in the manufacturing sector contributed to a UK government funding boost of £147 million to support investments in digital manufacturing research. Jennifer Castañeda-Navarrete tells us about her work in helping policy-makers make decisions that benefit both the local community and industry while considering the global perspective.

Now, more than ever, we need to do all we can to support activities that lead to a more resilient, sustainable and equitable world. Whether by developing the latest technologies, teaching and inspiring the next generation of leaders or encouraging a more inclusive manufacturing sector, all of us at the IfM are energised by the possibility of helping to manufacture a better world.

**Tim Minshall**
Dr John C Taylor Professor of Innovation and Head of the Institute for Manufacturing

# NEWS


## IFM WELCOMES GLOBAL DELEGATES TO DIGITAL TRANSFORMATION SUMMER SCHOOL

In July 2023 the IfM hosted the EINST4INE summer school, bringing together leading academics, young scholars and industry professionals for a week-long event focused on digital innovation.

The aim of the summer school – organised by the IfM's Decision-Making for Emerging Technologies group as part of the EU EINST4INE project – is to foster knowledge transfer, collaboration and skills development in the field of industrial digital transformation.

Throughout the week, participants engaged in various activities designed to expose researchers to different practical methods that could be used in the study and management of digital transformation. The week also included research workshops to help EINST4INE researchers enhance the impact of their projects and a day of industry engagement with the IfM's Strategic Technology & Innovation Management (STIM) Consortium.

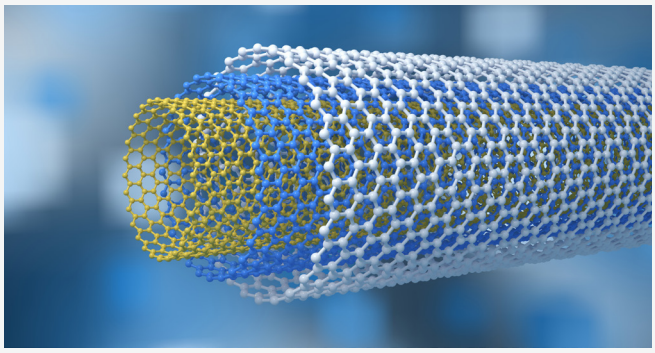
EINST4INE is a consortium funded by the EU as part of the Marie Sklodowska-Curie Innovative Training Networks (ITN) scheme. The consortium comprises universities, research organisations and industry partners from around the world and strives to develop new concepts, approaches and young talent to support the ongoing digital transformation.

Summer school delegate Vivian Marcelino from RMIT University said: "The EINST4INE summer school at the IfM has been a fantastic opportunity to discover some of the latest thinking on innovation management and digital transformation and build connections with peers and industry partners from across the globe. I am leaving the IfM with a stronger toolkit that will support me not only in my PhD but also in my future industry career."

## REPORT EXPLORES THE INTEGRATION OF SOCIAL AND DIGITAL DECISION-MAKING PROCESSES

As decision-making increasingly moves into the digital realm, the boundary between digital and physical decision-making is constantly evolving. The IfM's Decision-Making for Emerging Technologies group has produced a report that explores the integration of human and digital decision-making processes.

The report, "(Best) Practices in the Integration of Social and Digital Decision-Making Approaches Across Industries", was conducted as part of the EINST4INE project, which is sponsored by the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 956745.



## £1 MILLION EPSRC FUNDING PAVES THE WAY FOR ADVANCED CARBON NANOTUBE PROCESSING

A team of researchers from the IfM's Nanomanufacturing Group and University College London have been granted £1 million by the Engineering and Physical Sciences Research Council (EPSRC) to advance carbon nanotube processing.

The project is part of a £4 million investment by the EPSRC into "adventurous manufacturing" to foster highly transformative research that could disrupt the future of manufacturing.

The 3-year project, which began in 2023, will explore how carbon nanotube structures can be effectively processed and integrated into scalable manufacturing processes. It brings together various aspects of carbon nanotube processing developed at the IfM over the past 10 years, building on the pioneering work of Professor Michael de Volder and PhD researchers Sammy Mahdi and Maxime Burgonse.

"The ultimate goal", says Professor Michael de Volder, "is to bring high-end products utilising carbon nanotubes closer to the market, paving the way for enhanced technological advancements and applications."

## PROFESSOR BILL O'NEILL ELECTED FELLOW OF THE ROYAL ACADEMY OF ENGINEERING

Professor Bill O'Neill in the Centre for Industrial Photonics was elected Fellow of the Royal Academy of Engineering (FREng) on 19 September 2023. Bill received this honour in recognition of his outstanding contributions to the field of high-power lasers and their use in materials processing.

## BREAKING BARRIERS: UNIDO REPORT EXPLORES GENDER AND DIGITAL TRANSFORMATION

A United Nations Industrial Development Organization (UNIDO) report, in collaboration with the IfM's Cambridge Industrial Innovation Policy and the Western Norway Research Institute, was launched at a UN High-Level Political Forum side event on Sustainable Development in New York in July 2023.

The report, "Gender, digital transformation and artificial intelligence", provides a framework to address gender bias and stereotypes that hinder the participation of women as users, learners and developers of digital technologies. Based on a review of more than 150 initiatives across 5 geographical regions, it offers recommendations on the priorities and entry points to advance gender equality and female empowerment in the context of digital transformation.

Lead author, Dr Jennifer Castañeda-Navarrete, of Cambridge Industrial Innovation Policy, said: "I hope this report inspires organisations across different sectors to take action and ensure a gender-inclusive digital transformation where both men and women contribute and benefit equally from the opportunities presented by digital technologies, such as artificial intelligence."

## WOMEN IN MANUFACTURING: CHANGING PERCEPTIONS CONFERENCE

The inaugural Women in Manufacturing conference, organised jointly by the IfM and Innovate UK's Made Smarter Innovation programme, was held at the Manufacturing Technology Centre in Coventry last October. The aim of the Changing Perceptions conference was to challenge gender stereotypes and foster diversity in the industry by providing enlightening talks, collaborative workshops and valuable networking opportunities.

With more than 160 delegates from diverse manufacturing backgrounds, the event demonstrated the widespread support for gender equality within the sector. Attendees represented a broad spectrum of experience levels, from eager apprentices embarking on their journey to seasoned industry leaders who have significantly shaped their fields.

The Women in Manufacturing initiative, established in 2022, is led by a dedicated network of academics, practitioners and industry professionals. Its mission encompasses networking opportunities, peer support, thought leadership, industry expertise and policy advocacy to create a more inclusive manufacturing landscape.

"The Women in Manufacturing conference was not only a testament to the growing momentum for inclusivity in the manufacturing sector but also a testament to the power of thought leadership and meaningful engagement in driving industry change," said the IfM's Jennifer Castañeda-Navarrete. "The event is a pivotal moment in the journey towards a more diverse and representative manufacturing industry. Its positive impact has set the stage for an even more promising future in the field."

## IFM ENGAGE AND ATOS: CELEBRATING 10 YEARS OF EXCELLENCE IN PROFESSIONAL DEVELOPMENT

Last year (2023) marked the 10th anniversary of the collaboration between IfM Engage, the multinational IT company Atos and Paderborn University in delivering executive education programmes to outstanding Atos employees.

Since 2013, more than 600 people have attended the GOLD for Technology Leaders programme. Every year, students come from around the world to study in Cambridge and Paderborn to participate in a unique and enriching educational experience.

Dr Judith Shawcross, Head of the IfM Engage Executive and Professional Development team, said: "The programme has evolved over 10 years as Atos has grown and the digital technology landscape has changed. The Institute for Manufacturing and Paderborn University have forged a strong collaboration with Atos on this fascinating journey, delivering an excellent programme aligned with both organisational priorities and participants' needs."

Kat Hopkins, Vice President of Atos and Group Head of Talent, Career and Learning at Atos International, said: "Through a decade of dedicated learning and partnership, the programme has been a catalyst for transformation within our organisation, shaping leaders who continue to make a lasting impact."

## SHOESTRING INTRODUCES STARTER SOLUTIONS

The Shoestring Digital Manufacturing initiative has taken its first steps into commercialisation with a suite of starter solutions, helping more companies to tackle digital transformation.

Shoestring Digital Manufacturing offers tools to help companies learn how to automate the monitoring of their manufacturing processes, from temperature control and process monitoring to waste management – ultimately helping them to digitalise for profitability and sustainability.

Companies can now purchase a training package that incorporates a starter solution chosen from a range of ready-made starter solutions designed to meet their digitalisation needs. Enthusiasm for the programme sparked the early launch of the membership package, which gives member companies annual access to three training packages, as well as all the starter solution guides and an online support forum.

## POLICY EVIDENCE UNIT FOR UNIVERSITY COMMERCIALISATION AND INNOVATION EXPANDS

Since October 2023, the Policy Evidence Unit for University Commercialisation and Innovation (UCI) at the IfM has grown – from three to seven members – and is now ready to take on larger projects. Their goal is to strengthen the ability of academia to drive innovation and economic growth.

Building on a platform developed with Dr Eoin O'Sullivan at the IfM's Centre for Science, Technology and Innovation Policy (CSTI), UCI was established in 2020 with funding from the Research England Development Fund to support a three-person team. Led by Tomas Coates Ulrichsen, and with Zoi Roupakia and Len Kelleher in Research Associate roles, the UCI team set out to help government departments, funding agencies and university leaders support the transfer of academic research into commercially viable and innovative applications generating economic and societal impacts. This remains UCI's mission, and, since its inception, Tomas, Zoi and Len have studied the impact of COVID-19 on universities and their innovation missions, the role of universities in innovation systems and improving university data on spinouts. UCI is now expanding its portfolio of work. This includes collaborating with UKRI Research England to create a new national capability to improve insights and evidence on how universities contribute to the economy and society. Through their work, Tomas and the team will help to lay important foundations for this new capability, with their initial work seeking to strengthen the university spinout ecosystems, support UK industrial competitiveness through research and innovation, and build a better metrics system for measuring and demonstrating progress in knowledge exchange.

## RETHINKING MANUFACTURING AT MANUFACTURING LEADERS' SUMMIT

The IfM partnered with The Manufacturer for its 2023 Manufacturing Leaders' Summit in Liverpool in November. Each year, the event offers a valuable opportunity to connect with prominent industrialists and showcase the work taking place at the IfM.

As part of this partnership, Professor Tim Minshall, Head of the Institute for Manufacturing, delivered a keynote to more than 200 delegates on "Rethinking Manufacturing: Changing the Perspective on Manufacturing's Role in the UK Economy", offering critical insights into the sector's value.

IfM Engage also hosted an exclusive innovation-focused breakfast briefing at the event, attended by 40 senior innovation and technology leaders.


## JAG SRAI DISCUSSES ADVANCING SUPPLY CHAIN RESILIENCE AT WEF GLOBAL FUTURE COUNCILS MEETING

In a session at the World Economic Forum (WEF) Annual Meeting of the Global Future Councils in October 2023, Dr Jagjit Singh Srai, Director of Research in the Department of Engineering, and Head, Centre for International Manufacturing, IfM, discussed the significant impact of the COVID-19 pandemic on global trade.

Dr Srai was joined by experts Mona Haddad, the Global Director for Trade, Investment and Competitiveness at the World Bank, Sarah Thorn, Senior Director of Global Government Affairs at Walmart Inc., and Lynn Kuok, a Shangri-La Dialogue Senior Fellow specialising in Asia-Pacific Security at the International Institute for Strategic Studies (Asia) Ltd.

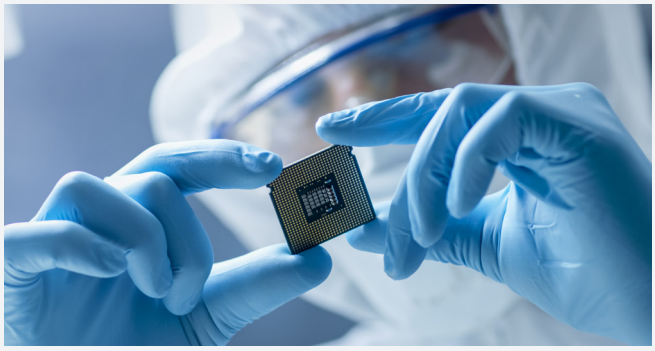
The gathering in Dubai also marked the beginning of a new term and team for the WEF Global Future Council on Advanced Manufacturing Value Chains. As Co-Chairs, Dr Srai and Priya Balasubramaniam, VP Operations, Apple, will bring their expertise and leadership to guide the council's efforts over the coming year through to Davos 2025.

## IFM ENGAGE HELPS TO BUILD A GREENER FUTURE IN EUROPEAN CITIES

Over the last 4.5 years, industrial experts from IfM Engage, the IfM's knowledge transfer arm, have worked with an international group of collaborators to help four European municipalities undertake sustainability and energy transition projects through the ACCESS initiative.

Enabled by the project, local authorities in Amersfoort (the Netherlands), Mechelen (Belgium), Malmö (Sweden) and West Suffolk (the UK) have implemented innovative energy technologies and concepts in their communities, which have reduced the municipalities' carbon footprint and boosted their bottom line.

"We worked closely with local authorities and mapped the different strategic issues that they face when developing and implementing their sustainability and energy transition strategies to deliver on the national and EU net-zero targets," said Senior Solution Development Specialist Dr Diana Khripko.



## IFM ENGAGE CONSORTIUM COMMISSIONED BY UK GOVERNMENT TO BOOST SEMICONDUCTOR SECTOR

The Department for Science, Innovation and Technology (DSIT) has been leading a review of the UK semiconductor industry and the development of a national semiconductor strategy to strengthen the UK supply chain and promote economic growth through innovation.

To support this strategy, IfM Engage, the knowledge-transfer arm of the IfM, along with consortium partners CSA Catapult, Techworks NMI, Silicon Catalyst, the Photonics Leadership Group, Cambridge Econometrics, Future Horizons, Semiwise, the University of Leeds and researchers from Imperial College London, were commissioned by the DSIT to explore the feasibility of developing infrastructure to support commercial R&D and a strategic coordination function for the UK semiconductor sector.

The 9-month study identified five capabilities that could be developed to build on UK strengths. These capabilities include silicon chip production for prototyping and piloting, compound semiconductor foundry, advanced packaging, design tools and intellectual property, as well as a strategic coordination function.

## STUDY FOR UK GOVERNMENT EXPLORES IMPACT OF MADE SMARTER ADOPTION PROGRAMME

A study commissioned by the Department for Business and Trade (DBT) to provide expert advice on improving the impact and measurement of the Made Smarter Adoption (MSA) programme has been published.

The report, Made Smarter Adoption Research Project, authored by IfM Cambridge Industrial Innovation Policy's Jennifer Castañeda-Navarrete and David Leal-Ayala, provides recommendations for programme design and improved monitoring and measurement approaches for programme impact.

Made Smarter Adoption is the UK's manufacturing digital adoption programme. It ensures that manufacturing small- and medium-sized enterprises (SMEs) benefit from industrial digital technologies that can improve efficiency and productivity. Since its launch in November 2018, it has reached over 4,000 manufacturing SMEs.



## IFM PAPERS LAUNCHED AT WORLD ECONOMIC FORUM IN DAVOS

Two IfM papers were launched prior to the 2024 meeting of the World Economic Forum (WEF) in Davos; the papers explore the role of collaboration between stakeholders to enable economic and industrial change.

### PARTNERSHIPS FOR THE CIRCULAR ECONOMY

Dr Jagjit Singh Srai, Director of Research in the Department of Engineering, and Head, Centre for International Manufacturing, IfM, and Doctoral Researcher and WEF Fellow Lisa Rossi, in the Centre for International Manufacturing, collaborated with the WEF Circular Transformation of Industries initiative to publish "Circular Transformation of Industries: The Role of Partnerships". The White Paper builds on evidence that global resource use exceeds Earth's ability to regenerate by 70% and argues that the appropriate industry response to this problem is to adopt a circular economic model built on partnerships between companies.

### TECH PERSPECTIVES FROM THE FRONT LINE

In collaboration with the WEF, Dr Thomas Bohné and PhD student Jessica Horn from the IfM's Cyber-Human Lab published the report "Views from the Manufacturing Front Line: Workers' Insights on How to Introduce New Technology", which explores the perspectives of an under-represented group in industry decision-making.

Jessica said: "The perspectives of front-line workers, who are often end users of technologies on the shop floor, are frequently overlooked, both in research and when projects are implemented in industry. Our report provides insights from workers on how new technologies may be more successfully introduced. Our findings thereby add value to companies, resulting in higher employee retention, improved employee satisfaction and a measurable return on investment (ROI) due to more efficient and effective technology introduction."

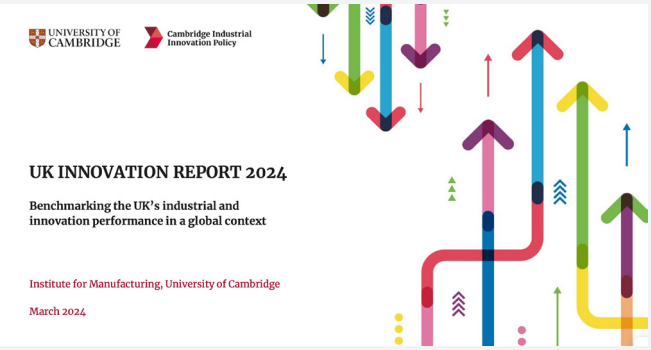
## "NO-EXCUSE" STRATEGIES ANNOUNCED TO CONFRONT SCOPE 3 EMISSIONS IN MANUFACTURING AND VALUE CHAINS

A paper released by the World Economic Forum's Industry Net Zero Accelerator initiative offers a framework to inspire industry action towards reducing Scope 3 emissions.

Co-authored by David Leal-Ayala of Cambridge Industrial Innovation Policy (CIIP), the paper, entitled "The 'No-Excuse' Opportunities to Tackle Scope 3 Emissions in Manufacturing and Value Chains", is part of a series of activities designed to help businesses collaborate and accelerate change across industrial sectors. The paper highlights emerging opportunities and best practice to inspire private- and public-sector leaders to act and drive the net-zero transformation of global balance chains with "no excuses".

The paper was launched in January at the World Economic Forum (WEF) Annual Meeting in Davos, where David Leal-Ayala joined a panel to discuss how industries must confront Scope 3 emissions if they are to achieve net zero by 2050 or sooner.

The WEF launched the Industry Net Zero Accelerator initiative in 2022 in collaboration with knowledge partners CIIP, Capgemini, Rockwell Automation and Siemens, and a community of more than 30 global manufacturing companies, to help accelerate the industry transition to net zero.




## THE UK INNOVATION REPORT 2024

Policy experts from the IfM's Cambridge Industrial Innovation Policy have published the latest data on the UK's innovation activity and industrial performance globally.

The report provides a clear and easy-to-navigate overview of key trends across UK industry. It is an essential resource for navigating the evolving landscape of innovation and technological progress in the UK, answering questions such as: Is the government and private sector spending enough on research and development? And is the UK producing enough scientists and engineers?

The 2024 edition also contains information about the structure and performance of the UK machinery and equipment sector, which is crucial to supporting productivity and competitiveness across various industries. According to Lord David Sainsbury, Chancellor of the University of Cambridge and former Minister of Science and Innovation, the report "contains an enormous amount of important information… which is essential for the government to know in order to develop the policies necessary to speed up the innovation rate of UK industry sectors."

## TACKLING MANUFACTURING'S IMAGE PROBLEM THROUGH POLICY

Despite fewer young people wanting to pursue a career in manufacturing than before, the sector remains central to the UK economy. Without widespread public knowledge of the diversity of highly skilled roles that keep the sector competitive and thriving, as well as efforts to encourage more women to work in manufacturing, outdated perceptions will continue to steer people away.

With funding from InterAct, the IfM's Dr Guendalina Anzolin and Dr Jennifer Castañeda-Navarrete, together with Dr Dalila Ribaudo of Aston University, produced the report: "How to make manufacturing charming again? It is everything, everywhere, all at once."

The report examines the public perception of manufacturing, the factors influencing it, and how it has evolved in the past decade.

## THE FUTURE OF UK MANUFACTURING

In April 2024 the IfM collaborated with the High Value Manufacturing Catapult and the Engineering and Physical Sciences Research Council (EPSRC) to organise the Future of UK Manufacturing Conference in Sheffield.

The conference brought together experts from the manufacturing research and innovation community to explore future research priorities, investment areas, and opportunities, with the aim of shaping a resilient and balanced UK manufacturing sector. The event took place over 2 days at the historic Cutlers' Hall in Sheffield city centre, and attendees included leading figures from government, academia, innovation agencies and industry. The conference featured presentations, panel discussions and workshops, providing plenty of opportunities for open dialogue and networking.

Head of the IfM, Tim Minshall, discussed emerging trends in manufacturing research and innovation, Carlos López-Gómez from Cambridge Industrial Innovation Policy presented the key highlights from this year's UK Innovation Report, and Duncan McFarlane shared the mission of Digital Manufacturing on a Shoestring to help smaller manufacturers with low-cost, simple digital solutions. Other keynote speakers included Sarah Sharples from the Department for Transport, Katherine Bennett CBE from the High Value Manufacturing Catapult, Warwick Spearing from Technical, and Benjamin Nicol from the Department for Business and Trade.

## IFM OPEN DAY AT THE CAMBRIDGE FESTIVAL

Staff and students were delighted to welcome members of the public to the Cambridge Festival open day at the IfM on Saturday 16 March. Guests came to enjoy the talks and activities on offer and left with new knowledge about the role of manufacturing in all our lives.

Professor Tim Minshall's talk on the diversity and omnipresence of manufacturing took the audience on the long journey of a toilet roll, from its raw material to the supermarket shelf. He drew upon the research conducted by various IfM research groups to demonstrate that the processes involved in making, moving, and using goods are much more complex and fascinating than most of us usually realise.

"Inspiring! Tim's talk was interesting, fun, very well explained, great for adults and children," says Elena Bastianello, who visited the IfM for the first time. "Definitely not a typical academic presentation, he clearly didn't talk 'for himself' but for us to understand and enjoy. What an amazing experience! Please let me know when he will be up for another one, I will be there — and bring friends!"

RESEARCH GROUP IN FOCUS

# RESEARCH GROUP IN FOCUS: FLUIDS IN ADVANCED MANUFACTURING (FIAM) EXPANDS CAPABILITIES IN THEIR WORK TO TACKLE HARD-TO-TREAT CANCERS

The Institute for Manufacturing (IfM) comprises over twenty research groups working towards creating a better world through manufacturing.

The Fluids in Advanced Manufacturing (FIAM) research group has been leading in-house research on fluids, interfaces, biomaterials, and chemical systems since 2014. The group is committed to promoting affordability, accessibility, and environmental sustainability. They strive to connect technological advancements with market demands. Currently, the group is focused on three main areas of research: healthcare, agritech and inkjet printing/additive manufacturing.

On the healthcare research side, FIAM's largest project is the EPSRC-funded Interdisciplinary Research Centre (IRC) in Targeted Delivery for Hard-to-Treat Cancers. This national project spans eight universities: Cambridge, Imperial, University College London (UCL), Glasgow, Birmingham, Nottingham, Liverpool and Strathclyde. Professor George Malliaras, from the Department of Engineering, is the project PI and leads the collaboration to develop new technologies that enable more efficient drug delivery for four hard-to-treat forms of cancer: mesothelioma, pancreatic cancer, and two types of brain cancer — glioblastoma and ependymoma. At the IfM, FIAM leads the Manufacturing Research cross-cutting theme, in close collaboration with UCL. They collaborate to help technology-focused groups address research questions at the intersection of device development and translation, particularly in cases where clinical needs require engineering expertise.

"The survival rate for most cancers has doubled over the last 40 years but for hard-to-treat cancers the survival rates remain below 14%," says Professor Ronan Daly, Head of FIAM.
"We need to improve delivery of cancer therapeutics to tumours and make treatment more effective. The IRC team is progressing five innovative technologies, and our role here is to use engineering research where needed to support the teams at the interface between the exciting new technology research and translation to the clinic."

The FIAM team frequently aids collaborators by creating systematic analysis capabilities for new delivery techniques. This helps in validating new forms of drug delivery and speeding up their translation. Moving forward, the healthcare theme in FIAM will prioritise the development and implementation of new medical technologies while also focusing on affordability, accessibility and environmental sustainability.

Find out more about FIAM's work here: www.ifm.eng.cam.ac.uk/research/fiam

*Image: Adobe stock*

# DRIVING CHANGE: IN PURSUIT OF COBALT-FREE BATTERIES

The increasing demand for electric vehicles has led to an increase in the demand for cobalt, which is used in Li-ion battery cathodes. However, concerns about the environment, ethics and the challenges inherent in cobalt production are motivating researchers to explore alternatives.

Head of the IfM's Nanomanufacturing Group, **Professor Michael de Volder**, sheds light on the pioneering efforts to eliminate cobalt from electric vehicle batteries, offering a glimpse into a more sustainable era for electric mobility.

## EMBRACING A MULTIDISCIPLINARY APPROACH

Multidisciplinary research is proving to be a game changer in advancing electrochemical energy storage research. Professor Michael de Volder, who leads the IfM's Nanomanufacturing Group, believes this approach is paving the way for the creation of devices that can deliver quick and efficient electrical energy: "When I started working on batteries about 10 years ago, they seemed to be a simple set of anodes and cathodes plunged in an electrolyte. However, I quickly realised that the simple battery schematics we learned at school are deceptively simple, and the operation of a modern battery is nothing short of a chemistry and engineering miracle. This explains why the invention of the Li-ion battery was awarded the Nobel Prize in 2019."

The manufacture of batteries involves many complex operations. In particular, the manufacturing processes used for the battery electrodes have a more profound impact on the battery operation than previously assumed. Michael explains: "For instance, using the same active materials on the anode and cathode, changing the manufacturing process can influence how fast the battery can be charged or discharged and the overall energy and power density of the battery pack. More interestingly, manufacturing steps can also influence the lifetime of the battery and, therefore, its sustainability.

"However, modern batteries are such complicated ecosystems that optimising manufacturing by itself, without considering how this influences the chemical and physical processes taking place, is meaningless. This is exactly what makes batteries so exciting to study – they force you to understand disciplines that engineers don't usually engage in much."

Collaborating across departments in Cambridge and other UK universities, and fostering partnerships with industries and research centres, the group's work addresses the intricate challenges of advancing battery technology. The same multidisciplinary ideology is reflected in Michael's research group composition, which consists of engineers, material scientists, chemists and physicists.

## CHALLENGES OF COBALT-FREE BATTERIES

Lithium-ion (Li-ion) batteries are the dominant technology used in the manufacture of electrical vehicles (EVs) because of their high energy density and rechargeability. Therefore, research focused on battery technology plays a significant role in developing solutions to mitigate climate change.

A shift towards electric vehicles poses a significant challenge to the mining industry, particularly the mining of crucial battery elements such as cobalt, nickel and manganese. Cobalt, in particular, is a cause for concern because of the environmental and ethical issues associated with mining it, including unsafe working conditions, environmental pollution and the use of child labour. Although cobalt is necessary for enhancing battery stability and lifespan, its high cost and the associated issues have prompted researchers to investigate alternative cathode chemistries.

Researchers have developed new cathode chemistries that replace cobalt with nickel and manganese: "One such group of materials, which the automotive industry has increasingly adopted, are lithium nickel manganese cobalt oxides (NMCs)," says Michael. "Over time, various generations of NMCs have been developed with a decreasing amount of Co and an increasing amount of Ni content. In the most recent generations of these materials, up to 90% less Co is used in the cathode than the original LiCoO2 formulation that won the Nobel Prize."

However, the shift to cobalt-free cathodes comes with a trade-off. While these cathodes are cost-effective and more eco-friendly, they can deteriorate more quickly than their traditional counterparts, posing new sustainability challenges.

"They tend to deteriorate faster than their traditional counterparts," Michael explained. "Compared to formulations with higher Co content, these batteries experience quicker capacity fading, which means they need to be replaced more frequently, ultimately reducing their overall sustainability. This is a major concern, as the reduced lifespan of the batteries leads to their disposal in landfills, which ultimately undermines the environmental benefits of using cobalt-free cathodes."

While the EV industry is gradually embracing cathodes with lower Co content, according to Michael, either the latest versions are not in use or their capacity is intentionally limited to slow down the degradation process because of stability concerns.

## BALANCING ACT: LOW-COBALT CATHODES

Given these challenges, the mission is to reduce cobalt content without compromising battery longevity. In the spirit of multidisciplinary research, the IfM's Nanomanufacturing Group is working on a number of different projects with partners from around the UK.

The most significant project related to this research topic is a multi-university £22 million grant from the Faraday Institution, headed by Professor Clare Grey in the Department of Chemistry. Michael leads one of the three project work packages, working with colleagues from the University of Warwick, Imperial College London, Newcastle University, University College London, the University of Birmingham, the University of Oxford, the University of Sheffield and the University of Southampton. He explained: "We are looking at degradation processes that are a result of incompatibilities between classic electrolytes and new cathodes with very low cobalt content. The team is looking at developing better cathodes and the anodes of batteries.

"As part of another grant, we are looking at how manufacturing processes affect the lifetime of these batteries. This work is sponsored by a £2 million ERC Consolidator Grant, on which I am the PI. This grant looks specifically at the development of scalable continuous processes for manufacturing better battery electrodes and bridging the so-called Valley of Death between academic research and industry. These new manufacturing processes impact not only battery lifetime but also their energy and power density," said Michael.

Finally, Michael's group is part of a £14 million multi-university Faraday Institution grant headed by the University of Sheffield on the development of next-generation batteries that are entirely cobalt-free. The group is focused on the development and optimisation of manufacturing steps to suit these new material chemistries and to align their performance more closely with the requirements for their commercial adoption.

The group's research findings will contribute to the manufacture of batteries to help mitigate climate change without creating new environmental challenges by relying on unsustainable materials. Michael is optimistic that the landscape holds significant promise. "The journey towards cobalt-free batteries aligns with the commitment to combat climate change and underscores the pivotal role of advanced manufacturing in shaping a cleaner and more energy-efficient landscape."

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# MACHINING THE FUTURE: THE AI ADVANTAGE

The manufacturing industry could transform significantly as artificial intelligence (AI) is adopted across applications, including production, decision-making and operational efficiency. In this article, **Sebastian Pattinson, Associate Professor** in Manufacturing Processes, Systems and Organisations at the IfM, delves into how AI could improve processes and provides valuable tips for using AI-controlled systems effectively.

*Image: Adobe stock*

The field of AI is advancing rapidly, with ongoing improvements in AI models and sensors presenting exciting prospects for enhancing manufacturing and design processes. This expansion of AI has the potential to greatly improve how we approach conception, creation and building, resulting in innovative and efficient developments in these areas. As AI techniques mature and become more accessible and widespread, its impact is likely to grow.

Traditional methods of controlling processes typically rely on predetermined models and rules that are often based on historical data and human expertise. However, these methods have limitations, particularly when it comes to dealing with the increasing complexity, variability and unpredictability of modern manufacturing processes and the world they operate in. Also, these methods generally do not make the most of the enormous amounts of data that can be generated by modern sensors and systems in real time.

This is where AI comes in. To clarify what we are talking about here, AI is (broadly) the ability of machines to do things that we ordinarily think of as requiring human intelligence. AI boils down to mathematical relationships between variables, so we usually describe specific instances of AI programmes or algorithms as "AI models".

In the past decade a branch of AI called machine learning, where models learn to improve their performance from data rather than explicit programming, has become very prominent. More recently, this has been augmented by the rise of foundation models and generative AI. Foundation models are large models that have been trained on very large data sets, which can be adapted to a variety of tasks. Generative models learn how to create new content, such as text or images, based on the existing data that they are given. The confluence of these trends in the form of ChatGPT and similar models has propelled AI into the mainstream in ways not seen before.

## POTENTIAL BENEFITS OF AI:

- **Improving productivity**
  Often, manufacturers have more data than they know what to do with, and data fuels AI. By analysing vast amounts of data, hidden patterns, anomalies and insights can be discovered. The discovered relations may then be used to enable a better understanding of processes to make more informed decisions. This can optimise process performance and reduce downtime.
- **Enhancing quality, resilience and sustainability**
  AI can help manufacturers to monitor and maintain the quality of their raw materials, products and equipment by detecting and responding to defects, anomalies and errors in real time. With increasing data and sophistication, this can allow you to use new materials more quickly should supplies be interrupted and to effectively use natural or recycled materials, which can feature variable properties.
- **Increasing innovation and competitiveness**
  AI techniques can help to design better products, services and business models. This can include better product designs, for example, driven by rapid and efficient data-driven simulations and more rapid reconfiguration driven by supply and demand. In the future AI could even help to break down siloed knowledge across design, manufacturing and supply chains, leading to a step change in capabilities.

## CASE STUDY: AI SYSTEMS FOR PROCESS CONTROL

Together with my team at the IfM's Computer-Aided Manufacturing Group, we develop AI-based systems to control a wide range of manufacturing processes. We specifically look to develop systems that can easily transfer from one system to another. We typically use vision sensors placed in and around the system to give the AI model similar views to what a human operator might see. This can then be supplemented with readings from sensors already integrated into the system and any other data necessary to assess process quality.

Our work so far is most advanced in additive manufacturing. Extrusion 3D printing is a popular additive manufacturing technique that builds objects by depositing layers of molten material, usually plastic, through a nozzle. Extrusion 3D printing has many applications in sectors such as medical devices, automotive and construction. It faces challenges, mostly in terms of the accuracy, consistency and quality of the printed parts. In this case, we typically use vision sensors mounted on the printer nozzle and frame so that the AI model can see what is going on. In one recent project, we created a data set that includes various instances of print errors and how to fix them. We presented this data set to an AI model, which learned to identify each type of error and take appropriate actions to resolve it. This allowed for closed-loop control of the process. We are working to translate this method into other manufacturing processes and to make it more effective, for instance by enabling it to learn to prevent errors.

- **Reducing waste**
  AI techniques can reduce waste related to materials, energy, time and space. This can take several forms, from coupling in-process monitoring with anomaly detection to repair defects or discontinuing work on a failed part, to using AI to operate processes in ways that minimise energy or material use.
- **Empowering humans**
  AI systems can augment workers' knowledge by making the most relevant expert insights readily available. AI could also aid communication and coordination with customers and suppliers, for instance, using chatbots.

## TIPS ON HOW TO ADOPT AI SUCCESSFULLY FOR PROCESS CONTROL

Implementing AI for process control is no trivial task. It requires careful design, testing and deployment. It also requires continuous evaluation. Here are some tips to help you hit the ground running.

**1. Define your goals and metrics.** Before you start using AI for process control, you need to have a clear vision of what you want to achieve and how you will measure your success. You should define specific goals and key performance indicators that align with your business objectives and customer expectations.

**2. Understand your data.** Data is the foundation of AI models. Without good data, you cannot build good AI systems. You must understand the available sources and what types, formats, quality, biases and availability these may offer. Generally, more data is better, but often a small, clean data set can provide more information gains than a large, noisy and biased one. Finally, be sure to protect your data sources. AI models are often very vulnerable to adversarial attacks that can degrade decision-making.

**3. Choose the right AI techniques.** Many different AI techniques can be used for process control, and new ones are continuously being invented. You must choose the right AI techniques to suit your data characteristics, process requirements and goals. You also need to consider the trade-offs between the complexity, accuracy, speed, scalability and interpretability of your AI techniques. It is often best to use the simplest technique that gives you acceptable results.

**4. Validate and verify your AI systems.** Before deployment for process control, you will need to make sure that the system works as expected. Validate and verify by quantifying how well it satisfies the metrics you defined earlier. Generally, the point of an AI system is for it to make useful predictions in situations it hasn't seen before. Therefore, it is very important to evaluate the system on data that it has not previously seen. Also, AI-based systems can behave in unpredictable ways, so it is best to build in safeguards to control such risks.

**5. Monitor.** After deployment, you need to monitor and improve your framework on a regular basis. To monitor the results, a good dashboard providing you with reports, alerts and logs will greatly help.

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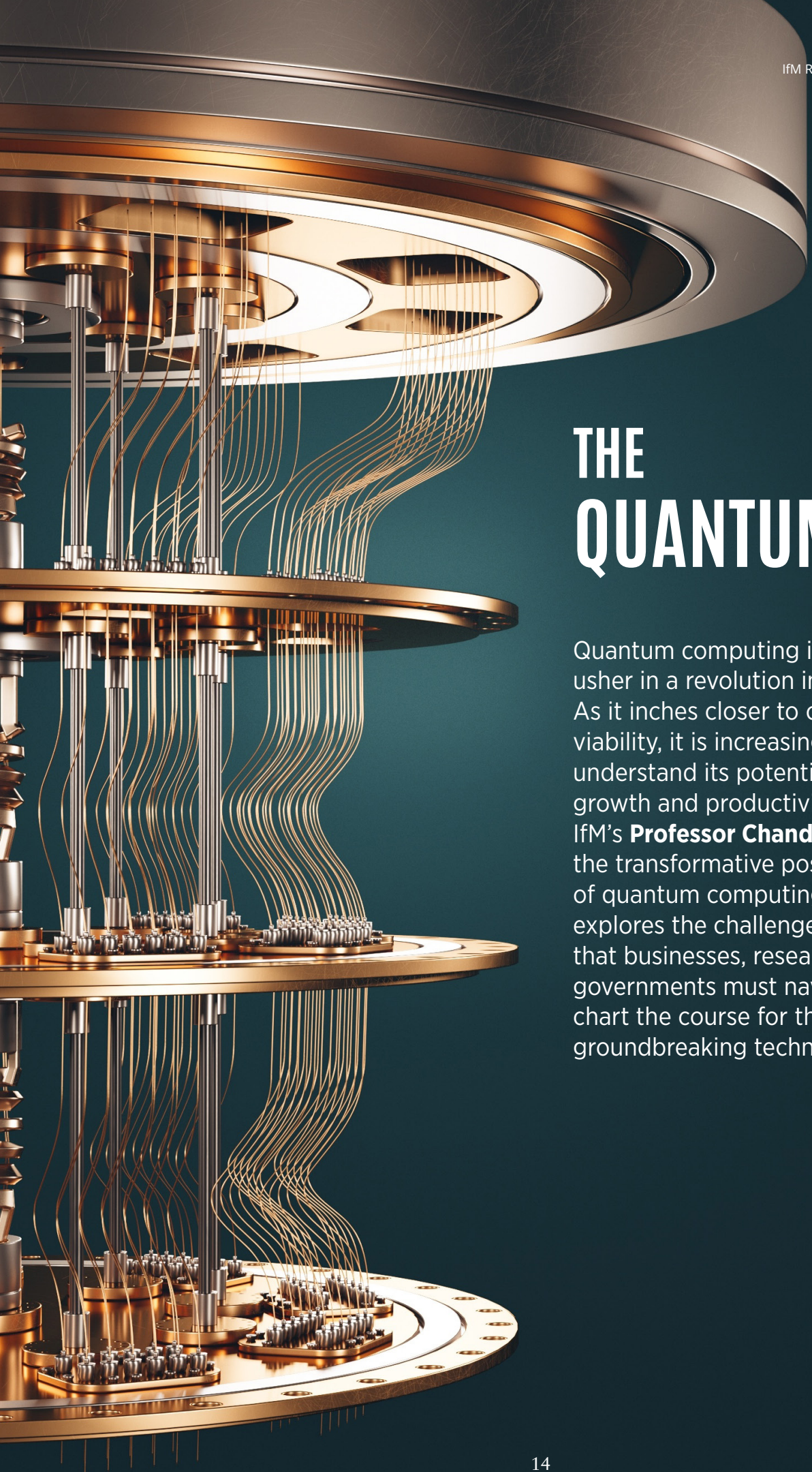

# THE QUANTUM LEAP

Quantum computing is poised to usher in a revolution in manufacturing. As it inches closer to commercial viability, it is increasingly crucial to understand its potential impact on growth and productivity. Here, the IfM's **Professor Chander Velu** explains the transformative possibilities of quantum computing. He also explores the challenges and obstacles that businesses, researchers and governments must navigate as they chart the course for the future of this groundbreaking technology.

*Image: Adobe stock*

## WHAT ARE THE KEY DIFFERENCES BETWEEN QUANTUM AND TRADITIONAL DIGITAL COMPUTERS?

Quantum computers work by being able to both store and analyse information more efficiently than conventional digital computers. The advantage of quantum computers over digital computers comes from quantum information processing, in which information is encoded in the quantum state of physical systems such as atoms, electrons and photons.

Quantum computers are posited to have a significant advantage over traditional digital computers in solving complex problems more quickly and efficiently. This is known as the "quantum advantage". Quantum computers use qubits, which can exist in a superposition of states, representing both "0" and "1" simultaneously, or any combination of these states. Furthermore, qubits can be entangled, meaning they can be interconnected as a single system.

Quantum computers are capable of processing information simultaneously and efficiently because of the unique properties of qubits. This allows them to excel in optimising and solving combinatorial problems, which are integral to many business and commercial operations. Additionally, they can simulate complex quantum mechanical phenomena that classical computers struggle to handle.

Quantum computing has the potential to redefine competitive advantage and revolutionise entire industries by quickly addressing challenging problems. It can transform business models and provide new solutions to problems that were previously impossible to solve using classical computing methods.

## WHAT ARE THE EMERGING OPPORTUNITIES WITH THE ADVENT OF QUANTUM COMPUTERS?

Quantum computing has the potential to revolutionise business and technology with its problem-solving capabilities, ushering in a new era of computational power and innovation. For example, improved simulation of materials could lead to better development of low-carbon technologies, such as catalysts for carbon capture or electrolytes for batteries, to address climate change. Simulating molecules better could also speed up drug development.

By improving optimisation, a manufacturing firm could quickly reschedule its operations on the factory floor to better meet changing demand and supply conditions. Similarly, a financial services firm could optimise its securities portfolio to enhance risk management.

Finally, the enhancement of machine learning could be applied to various areas where artificial intelligence is being used to find better customer solutions.

## WILL QUANTUM COMPUTING HAVE A SIMILAR ECONOMIC IMPACT TO THE DIGITAL REVOLUTION?

We believe that quantum computers will bring enormous economic gains, but they might initially slow productivity growth before the benefits accrue, similarly to digital computers. When digital computers spread in the 1970s and 1980s, rather than delivering efficiencies for a decade, they stalled productivity growth, the value added relative to inputs such as labour. Such a dip is known as the "productivity paradox", which arose because businesses had to invest in new equipment and learn how to program the devices, as well as working out what to do with them.

Firms initially did not invest in other innovations necessary to transform core processes and business models. Only after many sectors had adjusted in the 1990s did productivity growth rise again. We believe quantum computers could face a similar productivity paradox – but even more severe.

## WHAT ARE THE POTENTIAL CHALLENGES AND OBSTACLES FOR THE COMMERCIAL VIABILITY OF QUANTUM COMPUTING?

Three major challenges need to be addressed in adopting quantum computers.

First is the high integration costs and low short-term rewards. Businesses may adopt quantum computers initially to solve existing business problems, where improvements are likely to be incremental, while the costs of integrating digital computers are likely to be high.

Second is the difficulty in translating quantum concepts for business managers and engineers. Quantum mechanics that underpin these technologies operate on counter-intuitive principles, often unfamiliar to engineers and business managers.

Third is the cryptographic threat of quantum computers. Quantum computers could unlock information encrypted by conventional computers very quickly, which could render existing cryptography methods obsolete and potentially open to hacking.

## AS BUSINESSES, RESEARCHERS AND GOVERNMENTS PLAN FOR THE FUTURE OF QUANTUM COMPUTING, WHAT SPECIFIC TRAPS OR HURDLES SHOULD THEY BE PREPARED TO TACKLE?

To overcome the specific hurdles inherent in adopting quantum computers, the first crucial step is to demonstrate their practical value in tackling real-world industrial or societal challenges. This means showcasing their capabilities and effectiveness in solving complex problems that are currently difficult or unfeasible for classical computers to handle.

These include weather forecasting or enhancing the resilience of the financial system, among others. Second is the need to agree on a common language and build understanding between

business managers, engineers and scientists. The third step is to integrate quantum computers and quantum communication technologies into a coordinated network with secure encryption, also known as the quantum internet, enabling new business models through enhanced privacy.

## ADOPTING QUANTUM COMPUTING MAY INVOLVE A CHALLENGING LEARNING PROCESS AND POTENTIAL ECONOMIC SETBACKS. WHAT MEASURES OR STRATEGIES COULD ALLEVIATE THE ECONOMIC BURDEN DURING THIS TRANSITION?

One way to ease the economic strain is for the government to promote private investment to implement quantum computing. This could be framed as a mission to tackle the significant challenges faced by society and industry. Once the proof of concept is shown, researchers should set out what firms need to do in practice to adopt quantum technologies, including how they may need to change their business models and practices, as well as work with others along their value chains.

Second, a common semantic and syntactic language for quantum computers must be developed. This could take the form of a quantum unified modelling language, similar to the standardised Unified Modeling Language used for digital computer programming, which could facilitate effective communication, simplify the process of software development and shorten development times. Strategies for communicating about quantum computing with the public are also needed to build trust in these new technologies and ensure that benefits accrue to all parts of society responsibly.

The third is to help firms invest in new mathematical approaches or adopt quantum-based communications systems such as quantum key distribution. This would overcome security threats and enable new business models to develop, for example through improved supply chain flexibility.

## CAN YOU GIVE US AN EXAMPLE OF HOW QUANTUM COMPUTING COULD HELP MANUFACTURING?

The quantum internet has the potential to enable novel business models, with one compelling example being the use of distributed quantum computers and blind quantum computing. This technology allows for completely confidential computation, potentially enhancing machine learning capabilities while safeguarding proprietary information and erasing shared data post-computation.

For instance, blind quantum computing could enable the exchange of data or code between 3D printing machines in one company's factory and those in another company's facility without either entity gaining access to the other's operational details.

This innovation opens the door to establishing and optimising networks of factories owned by different companies to better adapt to fluctuations in product demand. Companies could even offer their unused 3D printing production capacity to others, fostering efficiency improvements, localised production and increased supply chain flexibility.

## HOW IS YOUR WORK AT THE IFM HELPING US TO BETTER UNDERSTAND THE LANDSCAPE OF QUANTUM COMPUTING?

The IfM's Cambridge Business Model Innovation Group examines how and why business model innovation enables productivity growth.

Productivity is the engine that drives economic growth. The UK and other major economies have experienced a significant slowdown in economic growth despite the prevalence of digital technologies. Many research studies have attempted to better understand this "productivity puzzle". However, many of these studies have focused on past technological adoption or current challenges in firms adopting digital technologies to improve performance.

One of the areas where we need more understanding is how companies and policy-makers can prepare for adopting emerging technologies from science and engineering. Quantum technologies, although not fully ready but developing rapidly for commercial deployment, are a particularly suitable area for study.

My research group is examining both mature and early-stage emerging technologies, including quantum technologies, to better understand how business model innovation can help firms and governments prepare to adopt them and reduce the burden on the economy while accelerating growth. Through our work, we aim to contribute to a deeper understanding of the theories of business model innovation and technology transitions.

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Scan the QR code to download "How to introduce quantum computers without slowing economic growth" by Professor Chander Velu and Fathiro H. R. Putra (Bandung Institute of Technology), which explores the potential impact of quantum computing on growth and productivity.

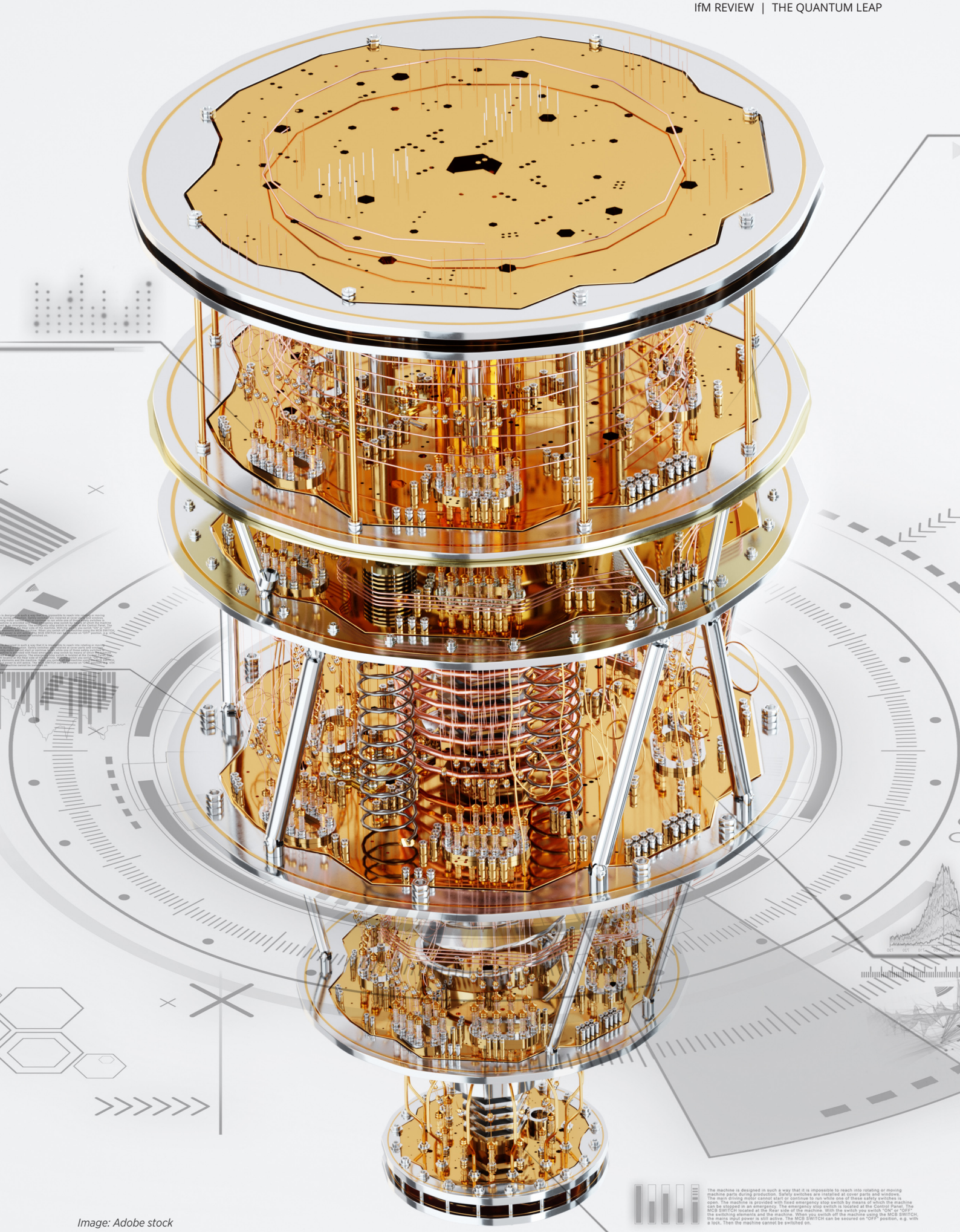

*Image: Adobe stock*

# TAKING BOLD STEPS: ISMM ALUMNA GRISELDA TOGOBO

Griselda Togobo (ISMM, Wolfson, 2006) is a successful entrepreneur and influential advocate for business diversity and inclusion. Born in Ghana, Griselda is CEO of Forward Ladies, a network dedicated to empowering and supporting women-owned and women-led businesses. In our conversation, Griselda shares her unwavering passion for promoting female leadership and discusses how attending the University of Cambridge gave her the courage to take risks and embrace failure.

Griselda Togobo graduated from Wolfson College with an MPhil in Industrial Systems, Manufacture and Management (ISMM) in 2007. Her journey from Ghana to Cambridge — and beyond — is a testament to her determination and ambition, shaping her into a successful businesswoman and advocate for diversity and inclusion. Griselda is an exceptional multitasker. Juggling her training and consulting business, personal development products, and women's networking platform, Forward Ladies, she continues to empower people to achieve their full potential, bridging gaps and creating a more inclusive future for all.

## A DREAM DEFERRED

Growing up in Accra, Ghana, Griselda excelled at secondary school and once received an offer to join a University of Cambridge foundation programme. She wanted to accept, but her family's financial situation made it impossible for her to do so. However, she never let go of the Cambridge dream, vowing to seize the opportunity if it ever resurfaced: "After missing out on that chance, I kept Cambridge firmly on my goal list and made a commitment to myself to make it happen. I promised myself that if the opportunity ever arose again, I would take it."

The stars finally aligned when Griselda was offered a chance to go to the UK on a summer exchange programme after completing her Electrical and Electronic Engineering degree at the Ghanaian Kwame Nkrumah University of Science and Technology. It was during this time that she decided to reapply to Cambridge. Her determination paid off, and she was accepted into the Industrial Systems, Manufacture and Management Master's programme at IfM: "I chose ISMM because of the mix of practical industry projects and academic modules. I knew I wanted to carry on with my engineering career, and this gave me that depth of international experience, plus exposure to leading management theory."

It was a challenging time, requiring careful financial planning and hard work to support herself through university: "I needed to work and earn to pay my way through university. So, when others were ready to sign off after a day of lectures, I'd jump on my bike to go to work. I was lucky to have flexible part-time work while at university."

However, Griselda was determined to overcome any challenge, inspired by her mother's story of struggle and perseverance. She shares: "I come from a family where I was the first to pursue higher education. As a girl in a society where girls were not encouraged to pursue the sciences, my mother was encouraging and strongly desired us to be well educated in whatever subjects we excelled at. She wanted us to be in control of our destiny and knew an education would improve our chances of a better life."

Despite being unable to read or write, Griselda's mother became a successful entrepreneur. "My mother had an engineering company, and her determination was a great source of inspiration for me," Griselda explains. "I witnessed the difficulties she faced, especially when compared to my friends' parents, who had typical corporate jobs. That's what motivated me to pursue my dreams and to believe that if my mother could be successful without a formal education then I could and should be able to do better with an education."

## ARRIVING AT CAMBRIDGE

Arriving at Cambridge, Griselda discovered that she loved both the academic aspects of the course and the chance to gain experience in the real world of manufacturing. She enjoyed visiting European factories, including cosmetics company L'Oréal and UK glass manufacturer Pilkins: "Experiencing different industries was eye-opening and transformed my perspective, making the seemingly unattainable suddenly feel within reach," she recalls.

Griselda particularly enjoyed the international mix of students: "The cosmopolitan student body of ISMM ensured that no matter where you came from, you'd find your own group, your own place. I loved this aspect of Cambridge." But perhaps the most significant impact was the friendships she forged. In just 6 months, Griselda made lifelong connections. "Cambridge has a great knack for bringing people together in ways that go beyond the classroom" — a lesson in networking that would hold immense value in her future endeavours.

By the time she left Cambridge, Griselda had gained immeasurable confidence and believed that anything was possible, knowing that Cambridge had played a pivotal role: "Cambridge was more than just an academic institution; it was a place that radiated an aura of excellence. Cambridge instilled in me a profound sense of confidence. When surrounded by some of the brightest minds globally, you gain an unwavering self-assurance."

## FROM INDUSTRY TO ENTREPRENEURSHIP

Griselda didn't have clear post-graduation plans: "I wasn't entirely sure about the steps to take next, so I did things a bit late. It was a shock to realise that many of my university peers had already secured job offers, while I was just beginning to explore my options," she says.

Although she had initially set her sights on a career in engineering, she soon discovered that engineering positions were difficult to secure, and they couldn't support her visa needs. "I couldn't secure a role in engineering, and most companies were hesitant to support my visa application," she recalls. However, a fortuitous job offer from Deloitte during a University recruitment drive provided the direction she needed. "Deloitte not only sponsored an extension on my visa but also extended a student loan. It was a lifeline I hadn't anticipated."

Griselda acknowledges that securing employment can be particularly challenging for international students: "It's important to talk about the visa barriers, because many international students grapple with understanding and navigating the process post-graduation. It's a significant burden that can't be underestimated."

Based in St Albans, Griselda embarked upon her career journey with Deloitte, where she initially served in an audit and advisory role. She also trained to become a chartered accountant, which required an additional 4 years of study.

Remaining with Deloitte for 5 years, she had ambitious career aspirations. However, she found that progression within the firm wasn't always guaranteed for people who looked like her. After getting married and starting a family, she realised that industry working conditions did not align with her need for flexible working as a parent.

So, she decided to take a bold step and establish her own business, embarking upon her entrepreneurial career with consulting. "I'm black. I'm a woman. I became a mum. I was working in a male-dominated sector. The odds were really stacked against me, and it was my experience that made me decide that if I was going to invest all this time and energy in a profession, in a career, I needed to find something that was worthwhile and worked for me and my family."

## A BOLD VENTURE: FORWARD LADIES

As a newcomer to the city of Leeds (where the family had moved for her husband's job as a medical doctor), Griselda searched for a supportive network to connect with like-minded individuals, which would help her to expand her horizons. With a young baby, it was during this search that she stumbled upon the "Forward Ladies Network".

"The previous owner had nurtured the network with government funding and dedication but had reached a point where she was contemplating retirement, uncertain about the network's future. I had never acquired a business before, and my expertise lay in engineering and accounting. This network was an unknown, risky venture, and I had reservations about running it. However, I was made an offer I couldn't resist, and I decided to accept the challenge. I thought, 'Why not?' I'll buy it and transform it into something remarkable to help more women and drive equality and positive change in the workplace."

Taking the reins of the Forward Ladies Network was transformative for Griselda. The network had been Yorkshire-centric, with a focus on face-to-face events and a limited corporate presence, primarily catering to SMEs. Griselda was determined to reshape its purpose, aligning it with the needs of women like her, ambitious professionals in their 20s and 30s, juggling myriad responsibilities while fiercely pursuing their careers.

She transformed Forward Ladies into a dynamic, nationwide platform that provided networking opportunities, mentoring and leadership development for women. "We repositioned our focus to cater to a corporate audience, attracting clients from the FTSE 100 companies with a global reach. We specialise in male-dominated sectors such as utilities, engineering, aerospace and tech. We expanded our membership to include events, on-demand content delivery and various programme offerings."

Griselda's decision to embrace this new challenge had far-reaching consequences. Forward Ladies has since grown into a thriving organisation, leaving an indelible mark on her life and the lives of countless women who have found their professional haven within its ever-expanding community.

## A DESIRE TO SOLVE PROBLEMS

As she reflects on her journey, Griselda shares her evolution and growing acceptance of the natural ebb and flow of interests. "I've realised that it's okay to have multiple interests and to get bored from time to time. While engineering was my first love, I've learned to find new ways to tackle challenges," she explains.

Her relentless pursuit of innovation is deeply rooted in her upbringing: she describes herself as her mother's daughter. When she struggled to find a planning product that helped her stay focused and productive as a working mother, she created one. "Digital planning tools are great, but when you are easily distracted when online and are trying to reduce your screen time and increase mindful moments, the last thing you need is to be tied to a digital project or your phone as your sole planning tool."

So, she created and took to market a new planning tool, the Goal Achiever Planner, designed to help high achievers plan their years and design their day with a holistic focus on what she calls mindful productivity, wellbeing and mental health, while integrating work and family life effectively.

Over the years, Griselda has learned that failure isn't the end: it's a crucial part of any success. "Developing a tolerance for risk and failure is essential," she points out. "It's about embracing new challenges and being somewhat open to the prospect of failure because, in the grand scheme of things, those small failures don't always matter if you use them as a stepping stone. I believe that as long as I have life, I can always try again, even if I fail. I want to live a life with no regrets, a life where I've tried different things, and even if they didn't all succeed commercially, I'd still have won because I did it. It's a different perspective."

## HELPING WOMEN TO THRIVE

Griselda, a staunch advocate of gender equality and workplace diversity, firmly believes that while progress has been made in workplace equality in recent years, there is still a significant gap in women holding leadership positions. "Women often find themselves hitting a roadblock when transitioning from individual contributor roles to leadership positions. Typically, at the stage in life when many women want to start families."

She explains: "This is where the issue becomes more pronounced, as women often find themselves caught in a bind. Companies, in many cases, are not doing enough to encourage men to take equal parental leave and share parenting responsibilities. The result is that women continue to bear the brunt of parenting duties, limiting their career advancement."

Griselda acknowledges that this issue is not exclusive to one industry, but

she sees room for change, especially in sectors that appear resistant to it. She notes: “Even in industries like manufacturing, often viewed as less likely to embrace change, there is potential for transformation. But it’s not about the nature of the work; it’s about a company’s openness to innovation and change and their commitment to creating an environment where women can thrive.”

Griselda offers her diversity and inclusion expertise to help companies understand the benefits of fostering inclusive workplaces. Her comprehensive approach involves various interventions, such as women’s leadership programmes, inclusive behaviour training and policy changes.

“I help companies understand that diversity and inclusion encourage diverse perspectives, which helps drive innovation,” Griselda explains. However, she admits that “traditional leaders don’t always know how to facilitate that”. She sees herself as the bridge between their intentions and actions, providing them with the guidance they need. “So, I work with their leaders and HR teams to come up with a roadmap on how to get them from where they are to a more inclusive place.”

Griselda’s approach is multifaceted and adaptable, tailored to the specific needs of each organisation. “We do that by looking at the data through different lenses,” she says. “So, the interventions that I recommend will focus on different demographics, systems or cultural practices.”

## BE BRAVE, BE BOLD

Looking to the future, Griselda has ambitious plans. Her vision is to extend her work to Africa, where she sees immense potential for growth and impact. “I’ve just established a base and company in Ghana; it is still early days. Africa holds vast opportunities, particularly considering its youthful population and adaption of leapfrog technologies.” In her pursuit of expanding her impact, Griselda will not only be breaking new ground but also bridging cultural divides, with a firm belief in empowering women and inspiring leaders while connecting people across borders.

Griselda’s journey has been remarkable, marked by a combination of courage and determination. “It’s important to be brave and bold and to go after what you want,” she says. “Because sometimes we feel we’re not going to get what we want, so we don’t even try for it. Aim high and shoot for the stars, so even if you miss you can still end up somewhere magical.

“If I were to go back to Griselda coming out of university, that’s the advice I’d be giving her,” she muses. “You really need to apply for those jobs that you really want. You need to start earlier. If it’s a business you want to run, you need to start the same as well and go for it. Make time to go out and meet people, because business is all about people — they have the answers to all your problems. I probably didn’t start investing in my network as early as I could have.

“Building a successful career or business requires more than just talent. It requires connections, investment, mentorship and learning from those who have walked the path before. So, if you want to start a business, be around entrepreneurs,” she advises. “If you want to excel in corporate life, be around corporate leaders and learn from their mistakes.”

At the end of our conversation, Griselda emphasises the significance of her time at Cambridge. “Cambridge has an amazing alumni network and events,” she says with gratitude. “You can meet some pretty amazing people through the University.”

Her parting advice? “If you can get into Cambridge, get into Cambridge. The knowledge I gained and the connections I made were life-changing.”

Discover more about the MPhil in Industrial Systems, Manufacture and Management by visiting: **https://www.ifm.eng.cam.ac.uk/ismm**

# IT'S TIME FOR ALLIANCES TO ENSURE SUPPLY CHAIN SECURITY, RESEARCHERS URGE

*Image: Adobe stock*

The COVID-19 pandemic highlighted the interconnectedness of global supply chains and showed how a disruption in one part of the world can have global effects. In 2021 supply disruptions cost the global economy an estimated $1.9 trillion.

An international team of researchers, including from the Institute for Manufacturing, are calling on government agencies and national banks to support an effort to map the billions of connections in the global supply network, which, among other things, could reduce tax evasion by as much as €130 billion annually in the European Union (EU).

The researchers say that understanding supply networks could also improve supply security, promote objective monitoring of the green transition and strengthen human rights compliance. Writing in the journal *Science*, they emphasise that international alliances, backed by government organisations and the research community, are needed for such an understanding.

Although most companies know their immediate trading partners, they depend on countless other relationships up and down the supply chain. A shortage anywhere in the supply network may affect suppliers, suppliers of suppliers, and so on, as well as customers and their customers.

"Supply disruptions caused an estimated loss of 2% of global GDP in 2021 – approximately $1.9 trillion – and significantly contributed to the current high inflation," said lead author Anton Pichler from the Complexity Science Hub (CSH) in Vienna. "For a long time, it was unthinkable to analyse the global economy at the company level, let alone its complex network of supply interconnections. That is changing now."

Co-author Professor Alexandra Brintrup from the IfM said: "Understanding supply chain interdependencies between companies, sectors and countries is vital for many challenges, from identifying how disruptions may emerge and cascade across economies, through monitoring carbon emissions and ensuring ethical and sustainable practice."

For almost a century, only aggregated data – such as the average values of entire sectors – could be analysed. Predicting how individual company failures would affect the system was simply not possible. What happens to the economy when a specific company stops its production? What if an earthquake paralyses an entire region?

"Now, a combination of new micro-datasets, methods based in machine learning, and multiple government initiatives are creating the ability to map entire economies, which can give us the tools to answer some fundamental questions with real and timely impact," said Alexandra.

Although the volume of data is vast – there are approximately 300 million companies worldwide, each with an average of 40 domestic suppliers, resulting in up to 13 billion supply connections – researchers can map the connections between individual companies.

Currently, value-added-tax (VAT) data is the most promising option for reconstructing reliable large-scale supply networks. Countries such as Spain, Hungary and Belgium use standardised VAT collection that practically records all domestic business-to-business (b2b) transactions. In this way it is possible to map the entire national trade of a country. In most countries, such as Germany, Austria or France, where VAT is not collected for individual b2b transactions but accumulated over a specific period, such mapping is not possible.

"The standardised b2b collection could reduce administrative overheads for companies and would contribute substantially to tax compliance," said co-author Christian Diem, also from the CSH. Estimates suggest that VAT-related fraudulent activities in the EU amount to €130 billion annually.

Beyond tax evasion, other global challenges also depend on detailed knowledge of supply networks. "For individual companies, it's nearly impossible to ensure that all trading partners, their suppliers, and their suppliers' suppliers operate in an environmentally friendly way and in compliance with human rights," said Pichler. "If this were centrally documented in a gigantic network, it could be more easily ensured."

The next step is to link trade data from different countries. Currently, the EU records trade in goods between its Member States at company level. If it also included services and linked them with VAT data, this could lead to a comprehensive cross-border company-level network. According to the authors, this would represent almost 20% of global GDP.

The European Commission (EC) laid the legal foundation by proposing "VAT in the Digital Age". "Unfortunately, this is far from being realised," said co-author Stefan Thurner, of the CSH. "So far, we do not have a single situation where the supply chain networks of any two countries have been joined and merged. This would be an essential next step."

To create a truly international picture of supply interconnections, hundreds of data sets must be joined, analytical tools developed and an institutional framework created, together with secure infrastructure for storing and processing enormous amounts of sensitive data.

"To advance this endeavour, a strong international alliance of various interest groups is required, including national governments, statistical offices, international organisations, central banks, the private sector and academia," said Thurner. The first collaboration in science, involving authors in macroeconomics, supply chain research and statistics, now aims to establish a foundation. The researchers hope to inspire others to join their efforts.

*Reference: Anton Pichler et al. Building an alliance to map global supply networks. Science (2023). DOI: 10.1126/science.adi7521*

*This article first appeared on the University of Cambridge website and was adapted from a CSH press release.*

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*Image: Adobe stock*


# A MORE SUSTAINABLE CUPPA: DRIVING SUSTAINABILITY AT KENYAN TEA FACTORIES

The IfM partnered with top Kenyan tea exporter Eastern Produce Kenya to promote simple – but effective – energy-saving practices at two tea estates located in the Nandi Hills.

After just 12 months of making sustainability relevant to their local workforce and by introducing straightforward energy-saving solutions, Eastern Produce Kenya has seen a reduction in energy consumption – proving that simple steps can have a big impact.

## FOCUS ON THE "GOOD" DAYS

Kenya is one of the world's largest producers of tea. The sector employs over 600,000 smallholder farmers, supporting over 3 million people. Tea production is highly energy-intensive. For example, producing 1 kg of tea requires approximately 3–6 kWh of thermal energy – supplied mainly from wood combustion – and 0.2–0.5 kWh of electrical energy from the grid, renewable energy and diesel generators. To contextualise this, running a dishwasher for 1 hour typically uses 1 kWh.

In 2020 Eastern Produce Kenya (EPK), one of the country's largest tea producers and exporters, invited the IfM to apply the Cambridge Sustain 8 Method (CSIM) to help refocus its efforts on reducing the amount of energy used at its Chemomi and Kepchomo tea factories.

Through online meetings and workshops carried out over the course of 12 months, the team worked with EPK to identify where energy could be saved and how to make sustainability relevant and understood by the factory workers.

Gary Punter, IfM Engage Industrial Associate, explained how the Cambridge Method (developed at the Institute for Manufacturing's Centre for Industrial Sustainability) makes energy saving easy to understand and apply because it aligns sustainability with business success: "The Cambridge Sustain 8 Method is eight simple steps that can be implemented over 12 months to deliver sustainability improvement with minimal investment. First, by looking at factory data, the method identifies the key drivers of the factory. We then help the factory to pick the areas where sustainability aligns with business success."

Gary explained that the final part of the method is to get the teams focusing on the "good" days and to discover opportunities to build and deliver action plans: "We don't focus on the problems," said Gary, "but we ask: What happened on the good days? It's always more motivational to ask them to focus on the 'good days' within their data and attempt to build on these good periods, rather than solving the bad days."

Gary went on to say that when asked why energy consumption was higher on some days than others, the explanation given was the wet weather, when more thermal energy was required to remove surface moisture from the green leaf.

However, when the data (on good and bad days) was analysed and correlated with the weather, they found that the factories were having good days in wet weather and bad days in dry weather. "So, we asked them to come up with the key reasons why they had good days," said Gary. "And the top three reasons were things they could control. So, their usual mantra about 'it's all about the weather' didn't apply." Having established drivers for the good days, Gary and his team were able to build on simple changes and to include staff in the journey.

## SIMPLE STEPS = BIG IMPACT

Some of the straightforward actions immediately impacted firewood and electricity improvements. "Because fuel wood stored in the open has a high moisture content," Gary explained, "we suggested improving firewood storage by expanding covered wood storage areas. Steam usage was also reduced by eliminating steam leaks and cleaning dust from radiators and heat exchangers. We also helped to develop an energy dashboard to delve further into withering and drying.

"To reduce electricity, we encouraged the simple actions of switching off lights and sockets and using natural lighting instead. At Chemomi, this has reduced consumption by 25%.

"In addition, we suggested that tea reworking should be minimised to avoid additional re-processing energy, which damages KPIs, and the use of clear roofing sheets to use solar thermal to reduce the moisture of green leaf in the withering troughs."

After 12 months, teams reported a 15%–30% reduction in thermal and electric energy consumption at both sites. There was also a significant increase in tea produced per unit of fuel wood (kWh/m3).

"Now, there is the controlled start-up of machines after a power outage," said Chris Ballard, Technical Director of EPK. "No machines are left idle or running when not in use. There is also proper work output by employees who now understand that their work has a direct impact on energy savings. The shop floor teams appreciate the load-shedding regime and no longer see it as a limiting factor in withering operations.

"We have also adopted a new way of covering firewood in the yard, resulting in high firewood utilisation efficiency compared to previous years. Data on electrical energy use is collected from each section of the factory. The data is compared between all factories, highlighting inefficient sections of a factory that must be improved.

"These actions have led to significant energy savings at both sites, and there has been an overall improvement of factory performance across all areas," said Chris.

## HOW MANY COWS HAVE WE SAVED?

Gary explained that one of the key success stories was getting the local team engaged in the changes and making the sustainability gains relevant to their context. "We engaged the factory workers on their terms and in their language. We did this by converting energy into something recognisable: not gigajoules, but 'How many cows can you buy with the savings?' This gave us all a laugh but effectively equated to how much energy had been saved. It brought understanding to the room – that energy wasn't something intangible. By the end of the project, they worked out that they had saved 2,000 cows – the size of the president's herd!"

Gary recognised that local efforts were mirrored by a strong commitment from EPK HQ to try something new, as well as supportive managerial and technical leadership on the ground in Kenya: "The open and positive culture of the Kenyan factory management and factory staff, coupled with our empathy and understanding of 'real' factory challenges and simple methodology, meant we could see impactful changes almost immediately.

"This wasn't about us coming in and telling them what they need to do, then leaving. EPK had already been engaging in various energy-saving activities. This was about walking alongside them, listening to them, and getting them involved.

*Image: Adobe stock*

"For example, we encouraged the leadership team to establish their targets, to establish local improvement teams to undertake surveys and implement their action plans and provide recognition for all the hard work involved."

For Fred Oberi, a drier operator at Kepchomo Factory, the changes have resulted in professional growth: "I was motivated to get involved since I was made to realise that my role as a drier operator was critical in sustaining the company's business as opposed to how I have been perceiving it. In addition, the awareness of energy saving has improved my ability to avoid wastage of important resources at work and on a personal level."

Chris Ballard echoed the crucial role that IfM played in engaging the staff: "Everything was in place mechanically, but the next step was to get the people involved. Crucial to this was engaging the shop floor workers in the energy-saving plan. This worked because they are the ones who understand the operations of every machine, since they are the users, and they understand the challenges and areas for improvement. They are the ones who know possible areas for improvement, and therefore they had to own the process first.

"The shop floor teams took the project as their own and not a 'Cambridge University' project. Engaging the staff created ownership of the process and how the process directly impacted their personal lives," said Chris.

"We've been working on factory efficiency for many years," Chris continued. "So, it's not just something that's happened. The IfM clarified precisely what we should be doing, focusing on, and getting the factory personnel involved.

"We knew where all the problems were, but it's getting intentions turned into action, which is challenging, and that is where the IfM helped."

## THE FUTURE IS BRIGHT

By engaging the local workforce, making sustainability relevant and identifying simple steps that significantly reduce energy consumption, the Cambridge Method is now in use at five EPK sites in Nandi Hills.

Chris: "We have learnt that small actions lead to tangible and significant improvements and that energy saving can be achieved by involving all the personnel at the shop floor level."

Gary: "Sustainability as a subject can feel large, not engaging and doesn't often relate to individual day jobs. What we do with our methodology is to engage the workers on their terms and in their language. We bring it to life. "Companies that find they have a gap between sustainability ambition/ strategy and gaining momentum/ engagement with the factory shop floor would benefit from using the tool."

Chris concluded: "Since working with the IfM, everything we implemented has been continued. Shop floor workers now own the energy-saving culture. Some team members have now moved to other factories and are implementing these ideas in these factories. So, the ideas and what we have learnt are spreading. We're working together effectively and committed to bringing our customers tea that has a minimal impact on the environment."

If you want to learn more about the Cambridge Sustain 8 Method (CSIM), scan the QR code.

*Image: Adobe stock*


SAVE ENERGY SAVE MONEY
.THE LESS YOU BURN THE MORE YOU EARN
.STEAM IS PRECIOUS SAVE IT


CHEMOMI
240 BAGS

*Image: Adobe stock*

# STAYING AHEAD OF THE CURVE: RETHINKING INNOVATION AT DOMINO PRINTING SCIENCES

Rapid technological advancements are ushering in a fresh era for commercial and industrial printing. The combination of AI, automation and inventive materials is transforming how things operate in these domains and compelling businesses to lead the way in innovation.

To keep up with the fast pace of change and withstand the resulting market disruptions, Domino Printing Sciences, a global expert in variable data printing, sought the expertise of IfM Engage, the knowledge-transfer arm of the Institute for Manufacturing.

Specialising in digital printing and traceability solutions for sectors as diverse as food, beverages, life sciences, packaging, cleaning, personal care, building and construction, Domino operates in more than 120 countries. The company employs more than 3,000 people and has manufacturing facilities in the UK, US, China, Germany, India, Sweden and Switzerland. Domino technology prints onto everyday products using a family of industrial markers, including continuous inkjet, laser, thermal-transfer overprinting, thermal inkjet, print and apply labellers and case coders.

To provide products and services that align with customer needs, Domino wanted to transition from a short-term innovation approach to revaluate its entire innovation strategy.

"To remain competitive, we knew we needed to enhance our innovation capabilities, leveraging emerging technologies that may transform our approach to delivering value to customers in the future," said Andy Clifton, Chief Technical Officer at Domino. "Our R&D generally focused on product development, so our focus was often constrained by short-term thinking and incremental innovations.

"We needed help to move away from a short-term incremental innovation model and challenge our thinking in how we view innovation as an organisation. IfM Engage were the perfect fit to help us review our capabilities and rethink how we do things."

## THE APPROACH

From 2020 to 2022, Domino utilised the IfM Engage Innovation ReThink, a collection of IfM tools and approaches that help organisations to reimagine their innovation strategy.

To kick off the process, IfM Engage facilitated a comprehensive assessment of Domino's innovation system, building a picture of its current capabilities, highlighting strengths and areas for improvement and prompting the company to identify crucial aspects aligned with its business goals. To do this, it used the well-established Innovation Management Diagnostic tool.

Andy explained how the IfM's TIM Diagnostic process shone a light on a key area of change: "Innovation doesn't happen by chance, and so by reviewing our innovation system carefully, we were able to think about the aspects that are important to us as a business and reflect on where we were strong, and where we needed to focus on and improve.

"The IfM's TIM Diagnostic process helped us move from a focus on product innovation to a focus on capability development and the impact this has on our innovation system."

The project then focused on strategy to configure areas of high potential innovation and value that would deliver growth. In workshops involving employees from across the world, IfM approaches, including ecosystem mapping and roadmapping, were used to challenge management thinking.

IfM Engage Industrial Associate, Rob Munro, who led the project with Domino, said: "These approaches are essential for any company as you need to understand strategy before you get into technology. After using ecosystem mapping and strategic roadmapping to identify attractive areas of growth, we used the IfM's make vs buy and technology acquisition tools to identify the approach to technologies and strategic workforce planning for future capabilities.

"Innovation fitness means doing things differently. We had to help everyone map out the changes they were making and make sure those changes became a natural part of how the organisation works."

## THE RESULTS

**1. More responsive to market demands**
A key outcome of working alongside IfM Engage is that Domino has effectively disentangled innovation thinking from product development, adapting its work methodology to synchronise with the rapid shifts in the business landscape. As a result, Domino has gained the agility to respond to customer demands effectively.

"We have achieved a significant result by separating innovation thinking from product development, which is crucial for staying competitive in the rapidly evolving business environment," said Andy. "We have carefully considered the necessary skills and abilities to foster innovation and agility, and we are currently undertaking projects that reflect these values."

Eleanor Betton, Print Performance Manager at Domino, explained that the process helped teams to gain a broader perspective on what R&D means to Domino: "I was able to step outside of the day-to-day focus on product development and gain a wider appreciation of how capabilities and skills contribute to the products of the future."

Paul Clarke, Portfolio Director at Domino, explained that, by shifting the focus towards capabilities instead of just products, Domino was also able to focus on cultivating the skills, capabilities and adaptive approaches within its innovation system. "It was really valuable to look at opportunities from various angles. We challenged our thinking as an organisation by bringing in views and expertise from Domino and our partners, the ecosystem and the market. And bringing in academic experts from the IfM helped to enrich conversations and made sure we were answering the right questions.

"We have reframed what innovation means to all of us across the organisation – moving from a focus on product innovation to capability changes is quite a shift," said Paul. "We are already working to build and develop the right capabilities, and you can start to see threads of ideas and collaborations that could be the foundation of responding to new market requirements in the future. I'm really glad we found the time for this, as it's already had a transformative impact."

**2. Excitement, collaboration and alignment on new technology projects**
One key factor in the project's success was Domino's willingness to integrate knowledge and skills from various departments that typically operate independently. This approach helped to break down siloed thinking and foster teamwork, ultimately driving innovation. The company achieved this by convening workshops that brought together employees from different departments, with everyone's contributions valued and acknowledged.

"I've observed a surge of enthusiasm among the team regarding innovation in Domino. We all share a common vision and goal, which propels us forward. Our focus has shifted towards a more long-term strategy centred around technology and the necessary expertise to meet market demands. As a result, we are exploring and familiarising ourselves with numerous new and intriguing technologies and concepts," said Natasha Jeremic, Inkjet Development Manager, Domino.

Eleanor Bretton also highlighted the value of the process in widening her connections across the organisation: "I have stayed in touch with many of the people I met during the workshops, collaborating with colleagues across commercial, product management, as

well as other teams within R&D. Many opportunities have arisen, which have allowed us to gain momentum and excitement for our prioritised projects."

**3. Integrating IfM approaches**
Make-vs-buy decisions are an integral part of an effective innovation strategy, and there are many factors to consider when choosing between developing technologies and capabilities in-house versus working with external partners and suppliers.

In one of the workshops, Domino used the IfM Technology Acquisitions framework to better identify the types of organisation that it should partner with to obtain specific capabilities or expertise. By working through a series of important questions, Domino understood which suppliers would best meet its procurement requirements.

"Having a structured framework like this instils confidence in crucial partnership decisions and aids in performing due diligence to avoid costly errors," said Natasha Jeremic. "We have already used it to guide our choices, helping us to consider due diligence in terms of who to partner with so you find companies that are a good fit across a range of factors, not just cost."

Rob Munro said: "IfM tools and approaches have enabled Domino to transition from focusing solely on product-related innovations, which involve small improvements, to enhancing overall innovation capabilities involving aspects like the organisation's structure, technology and people.

"This shift to a more comprehensive approach will enable Domino to be more adaptable and responsive to market demands and changes. Consequently, the company is empowered to think openly and channel its diverse viewpoints and innovative ideas at a broader organisational level."

## REFRAMING WHAT INNOVATION MEANS

By adapting its work methodologies to keep up with the fast pace of changes in the business environment, Domino is enhancing its capability to anticipate and effectively address customer demands.

"Domino has been through a robust process, so it is in a position where it can be confident that the investment decisions it makes are aligned with its business and innovation strategy," said Rob Munro.

"Outcomes will be new sources of growth and protecting critical markets from disruption and attack. Domino has been a great partner to work with. I've been impressed by the openness and excitement across the organisation to new ideas in how to restructure the organisation's innovation system."

Andy Clifton said: "IfM Engage has been a great partner for this project. They have challenged how we think about innovation as an organisation and have done it in a way that has brought genuine excitement towards these new approaches.

"We're already seeing some of the benefits of the new approach, with seeds of ideas emerging, and I'm excited to see how this progresses in the future," he concluded.

To watch a video about the Domino Printing Sciences and IfM Engage rethinking innovation project, scan this QR code.

# DIGITAL TECH REPORT CONTRIBUTES TO £147 MILLION RESEARCH FUNDING BOOST FOR UK MANUFACTURING SECTOR

A Cambridge Industrial Innovation Policy report on the impact of adopting digital technology in the manufacturing sector contributed to a UK government funding boost of £147 million to support investments in digital manufacturing research.

## THE CHALLENGE

Many predictions have been made about the potential economic impact of the digital revolution on manufacturing and the wider economy. The forecasts point to a potentially disruptive effect of digital technologies across all aspects of industries – from the way in which products are made, the types of jobs that manufacturers can provide, and the functionalities offered by digitally enabled products and services.

In keeping with this outlook, the Made Smarter Review for the UK government in 2017 projected that adopting digital technologies in the UK industry could lead to a 25% increase in productivity by 2025. However, these evaluations were almost entirely focused on future predictions, mainly based on rough macroeconomic projections and survey data. Very few countries had published data on the real impact of digitalisation across their national economies, and there was a lack of availability and analysis of such evidence.

UK Research and Innovation (UKRI) sought evidence for inclusion in their business case for investments in digital manufacturing technology research under Wave 3 of the government's Industrial Strategy Challenge Fund (part of the government's 2017 Industrial Strategy). Their objectives were twofold: first, to learn from other countries and identify potential lessons that the UK could apply; and, second, to explore the economic impact of digital transformation initiatives and how they were measured.

## THE APPROACH

To understand the potential impact in the UK if similar initiatives were created, UKRI engaged the expertise of the Cambridge Industrial Innovation Policy (CIIP) team and senior academics from the Institute for Manufacturing (IfM) to evaluate the evidence on the real-world impact of digital manufacturing.

The outcome was the "The Practical Impact of Digital Manufacturing: Results From Recent International Experience" report, which delved into how digitalisation technologies were being implemented in key manufacturing countries and examined the outcomes for the companies adopting them. Through this analysis, the aim was to identify the expected and observed results of digitalisation in manufacturing, drawing on real-world examples from various regions around the globe. The comprehensive study provided valuable insights to support UKRI's case for investment and to help shape effective strategies for digital transformation in the UK manufacturing sector.

To do this, the team developed a common framework to collate and compare data from different countries and types of organisation. The study also identified which activities are being prioritised for digitalisation investments by manufacturing firms and where the business value is being created. Much of the data was drawn from small and medium-sized enterprises (SMEs) from key manufacturing countries such as China, France, Germany, Korea, Japan, Singapore, the US and Canada.

The team identified over 1,000 use cases from across these economies

*Image: Adobe stock*

and selected 200 companies (all participating in government-backed initiatives supporting digitalisation) for closer study. In each of these 200 cases, the team examined the business areas being prioritised, the types of digital application that companies were using, and the benefits they reported from digital adoption.

The report was presented to UKRI leads building the case for investment in the Made Smarter Innovation challenge, including the interim challenge director.

## THE IMPACT

Thanks to the report, CIIP made a significant contribution by examining the impact of manufacturers worldwide implementing digital applications and solutions across their operations, with an emphasis on small and medium-sized enterprises (SMEs). This analysis offered strategic insights that could inform future policies to support digital manufacturing in the UK.

"By focusing on real-world outcomes, the evidence gathered provided UKRI with key evidence for inclusion in their business case, which was successfully awarded a £147 million investment for 'Made Smarter', announced in autumn 2018," said Dr Carlos López-Gómez, from Cambridge Industrial Innovation Policy. UKRI went on to successfully secure a substantial £147 million investment for the Made Smarter Innovation challenge, which focuses on development and research in emerging industrial digital technology.

The initiative covers a broad spectrum of activities, including conducting practical research in dedicated research centres, supporting the growth of start-ups through accelerator programmes, expanding successful endeavours in innovation hubs, and ultimately refining and implementing these technologies through collaborative research and development initiatives.

"When developing the business case for the Made Smarter Innovation challenge, we identified some substantial knowledge gaps in our understanding of the international landscape. We were keen to learn from the approaches adopted by other countries and explore the economic impacts they had generated. Cambridge Industrial Innovation Policy provided us with extremely important evidence on these points, on a fast timescale, which supported our successful business case," said Katie Daniel, Deputy Director Partnerships, UKRI–EPSRC.

Scan the QR code to download "The Practical Impact of Digital Manufacturing: Results from recent international experience".

# MANUFACTURING A MORE EQUITABLE WORLD THROUGH INFORMED POLICY-MAKING

**Jennifer Castañeda-Navarrete** is a Senior Policy Analyst working as part of the Cambridge Industrial Innovation Policy team at IfM Engage. Her work involves informing policy-makers worldwide and assisting stakeholders in making decisions that benefit both the local community and industry while considering the global perspective.

Central to Jennifer's work is her dedication to addressing the problem of women's under-representation in the industrial sector and industrial policy. This issue has a special place in her heart, and she actively works to find good ways to tackle it.

Here, she shares how she takes on the various challenges in her field and her motivation for pursuing her particular career path.

## CAN YOU TELL US ABOUT YOUR ACADEMIC AND PROFESSIONAL BACKGROUND?

Both my education and my work have taken me back and forth across the Atlantic a few times. By training, I'm an economist – I did my undergraduate Economics degree in Mexico and a Master's degree in Development Economics at the University of Nottingham. Then, I went back to Mexico to do a second Master's degree in Government and Public Policy before I came back to the UK for my PhD in Development Studies several years later.

I started my career working in regional government in the Mexican Yucatan region, where I used to live. Later, I became a lecturer at a university in the region. It was through my work there that I first became aware of IfM Engage, the knowledge-transfer arm of the IfM. When the Policy Links team first came to the region, they were interested in a study I had done, so I offered to conduct a survey for them. A few years later, in 2019, I joined IfM Engage full-time.

## WHAT DO YOU AND YOUR COLLEAGUES DO?

The Policy Links team, which sits within Cambridge Industrial Innovation Policy (CIIP), informs policy-making by working with governments and international and regional organisations around the world on industrial and innovation policy. In practice, we provide consultancy, write reports, deliver training, conduct consultations and review international practice, so we're involved in many aspects of the processes surrounding policy-making. Approximately half of our projects are based in the UK and half overseas.

In the UK we work with government organisations such as the Department of Trade and Industry and internationally with the United Nations Industrial Development Organization (UNIDO) and other UN organisations. Recently, we've been involved with a lot of projects in Southeast Asia, but we have also worked in Latin America and the Caribbean, collaborating with organisations such as the Inter-American Development Bank, the Association of Southeast Asian Nations and the Asian Development Bank.

## MUCH OF YOUR WORK INVOLVES CHAMPIONING WOMEN IN MANUFACTURING – WHY IS THIS IMPORTANT?

The obstacles that women encounter when trying to take part in various aspects of industrial progress are often not given adequate attention; and the impact of these obstacles is often not fully considered. That encouraged me to start working on gender in industry and to try to understand it in a more systematic way: Why are there fewer women, what are the missed opportunities, and what can be done to change this?

It seems that the main barrier to women's equal participation in industry and innovation is gender norms and how these affect the distribution of care and domestic tasks. Perceptions of different careers as being more suitable for either men or women also remain, and that leads to something we refer to as the leaky pipeline problem. That's a metaphor for how, at each stage of career progression, fewer women remain in the science, technology, engineering and maths (STEM) fields.

## WHY DOES INDUSTRIAL POLICY NEED MORE GENDER-FOCUSED VOICES?

It's not just about gender; it's about diversity and the benefits it brings. Even if women, particularly in developing countries, dominate some manufacturing sectors, women's voices are often absent in industrial policy debates. In developed countries, manufacturing is facing critical skills shortages, and involving more diverse voices in policy-making would help to create a better understanding of the opportunities and barriers that the digitalisation and decarbonisation of manufacturing offer to population groups that are under-represented. I'm a development economist and tend to be people-centred, and I think it's good to strive for a team that can reflect and consider the needs of the people we work to serve.

## WHAT DO YOU WANT TO ACHIEVE WITH YOUR WORK?

Our general aim is to support governments and industrial organisations and inform the work that policy-makers do. I think my experience working in government really helps. I'm familiar with the constraints that policy-makers usually face. From the outside, it's often easy to criticise them for not doing enough, but in government you face numerous limitations. You know you don't have much time, and you must achieve many things simultaneously, with political pressures making it even more complex. The way I see it, our work is to help them. A lot of the time, we map different policies being deployed around the world and bring all the different options to policy-makers so that they can decide what makes sense in their particular context.

## COULD YOU SHARE SOME WAYS THAT YOU AND OTHER WOMEN SEEK SUPPORT TO SUCCEED IN THE INDUSTRY AND POLICY WORK?

I've been fortunate to always receive support from my team when I want to continue developing my skills or attend a conference. That helps, but when opportunities to meet and work with women in my sector all but disappeared during the pandemic, I felt isolated at times. Searching for networks helped me, and that was when I found the International Association for Feminist Economics (IAFFE).

Being part of the IAFFE has been positive, even if I don't always have the time to attend the meetings and events they organise. I have already built some relationships and good friendships through the association, and we keep in touch as much as possible. Having that network is inspiring for me because it lets me see how different people are evolving their careers, and it also offers opportunities to reach out to others about collaborations. It's important to establish valuable networks for mutual support, but it's equally crucial to have support from your own team. I feel fortunate to have both.

## WHY ARE PROFESSIONAL NETWORKS IMPORTANT?

Based on experience, professional networks are important because they offer young women role models. It's conceivable that more women would remain in STEM after university if successful women in their field were more visible to them, and professional networks can play a part in that. When you're in a field dominated by men, it's good to talk to other people who experience the challenges that arise from that dominance, but networks aren't just places to share things that are difficult. They can also be ideal arenas to share opportunities and cheer each other on.

For example, I joined an excellent mentoring group where I had the chance to deliver a training session. My own mentors were very supportive and complimentary about my work – positive feedback always gives a nice confidence boost, and confidence is key for both students and professionals to remain motivated and enthusiastic about their field of work.

## WHICH PROJECTS DO YOU TAKE PRIDE IN OR CONSIDER SIGNIFICANT TO YOUR CAREER?

In terms of impact, I think one of the projects that we're currently working on, the implementation review of the action plan for science, technology and innovation in ASEAN nations, is really important. Interacting with all the different stakeholders across the 10 Member States has been an enriching experience. They're very knowledgeable people, very committed.

When it comes to gender, I think the policy brief I did for the United Nations Industrial Development Organization (UNIDO) will be a good contribution now that it's been published. It shows how we need to generate more data to better understand the gender gaps in different areas of manufacturing and technology.

## IS THERE A DIFFERENCE BETWEEN WORKING ON ISSUES THAT ARE SPECIFIC TO WOMEN IN THE UK AND ISSUES THAT AFFECT WOMEN IN OTHER PARTS OF THE WORLD?

The bulk of my work has taken place in the UK and Mexico, and I've been surprised to find a lot of commonalities between them in the work on women-specific issues. I think the main differences depend on the people and companies you work with, but I have noticed some differences that seem characteristic of each region.

In Mexico much of the discussion is about the participation of women in leadership, but more basic discussions remain very challenging. For example, gender-based violence is still a key issue in Latin America, and it's very difficult to address because the problem is systemic.

In Asia we have seen improvements in how many girls and women are enrolled in STEM subjects, but at the same time the number of women participating in the labour market has decreased. Even in the Scandinavian countries, which are often noted for their high levels of gender equality, areas with gender gaps remain. For example, significantly more men than women work in the technology sector there, just like in the UK, so the fight for female representation in STEM can't be said to be won anywhere yet.

## WHAT IS THE WOMEN IN MANUFACTURING (WIM) INITIATIVE?

The Women in Manufacturing initiative was set up by some of my colleagues in IfM Engage who have worked in manufacturing for a long time and who are acutely aware of the gender disparities in the field. The aim is to boost diversity and inclusivity in the manufacturing sector through networking, events and peer support. When the initiative was being developed, I happened to learn about a funding offer from the InterAct network. That's part of the Made Smarter programme, and because of this we managed to join efforts and have enough funding to conduct a panel discussion and a follow-up policy brief, which I'm currently working on.

Since the recent WiM events at Manufacturing and Engineering Week in Birmingham and the first Women in Manufacturing conference in Coventry, the initiative has gained momentum. The initiative is already raising awareness about women-specific obstacles in a very successful way, and it has given us a big win – partly because men are also showing an interest and want to understand. It can be easier for women to participate in an initiative like this because we may have experienced the problems that we seek to tackle, so I'm encouraged to see that many men are making the effort. Beyond everything that has happened already, it would be great to see more networking events come from this and for companies to start making tangible commitments to make manufacturing an easier sector to work in for women. I look forward to seeing what happens next!

## WHERE IS YOUR WORK TAKING YOU NEXT?

There's a project funded through InterAct – a network led by the Economic and Social Research Council and Made Smarter UK – about perceptions of manufacturing. It aims to provide insights into international attitudes towards manufacturing and industrial strategies and entails a systematic review and expert validation, with a specific focus on how manufacturing is discussed in a selection of countries where digital technologies have been adopted and widely addressed at the political level. This project, together with a systematic review of "Manufacturing and the metaverse", will inform InterAct's work on the future of manufacturing. There are a few other things in the pipeline as well, but I can't talk about them just yet.

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# CAMBRIDGE SUSTAIN 8

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