



Cambridge
Journal of
Science
& Policy



CUSPE | Cambridge University
Science and Policy
Exchange



CAMBRIDGE JOURNAL OF SCIENCE & POLICY
Volume 1 (2020) – Editorial Board

Editor-in-chief Michele Sanguanini (Univ. of Cambridge)

Editors

Timothy D. Arvan (Univ. of Cambridge)
Emma Brown (Univ. of Cambridge)
Katie Cohen (Univ. of Cambridge)
Jenny (L.) Jiang (Univ. of Cambridge)
Daniella Wenger (Univ. of Cambridge)

Rosie Bell (Univ. of Cambridge)
Prashanth S. Ciryam (Univ. of Cambridge)
Simone Eizagirre Barker (Univ. of Cambridge)
Tom Spencer (Univ. of Cambridge)

Communications Officer James Dickinson (Univ. of Cambridge)

Cover artwork Filip Jović (Univ. of Cambridge)

Publishing this volume would not have been possible without the CJSP Associates, who support the Journal's triple blind peer review process.

CJSP Associates 2020

Maria Bada (Univ. of Cambridge)
Ieva Čepaite (Univ. of Strathclyde)
Timothy Chisholm (Univ. of Cambridge)
Kanta Dihal (Univ. of Cambridge)
Victoria Ford (Univ. of Cambridge)
Thomas Freitag (Univ. of Pittsburgh)
Marcos Gonzalez Hernando (Univ. of Cambridge)
Zira John (Univ. of Cambridge)
Akhila K. Jayaram (Univ. of Cambridge)
Ryan Prestil (Univ. of Cambridge)
Darius Sultani (Univ. of Cambridge)
Anna Tran (Univ. of Cambridge)
Victor Yip (Univ. of Cambridge)
Karolina Zieba (Univ. of Edinburgh)

Josh Brian (Univ. of Cambridge)
Anna Chaplin (Univ. of Cambridge)
Ruby Coates (Univ. of Cambridge)
Tiarnan Doherty (Univ. of Cambridge)
Eleanor Fox (Univ. of Cambridge)
Alexei Halpin (Council of Canadian Acad.)
Ernestine Hui (Univ. of Cambridge)
Leia Judge (Univ. of Cambridge)
Anne Kellers (Un. of Hamburg/Un. of Zürich)
Dillon Rinauro (Univ. of Cambridge)
Eleni Tente (Univ. of Cambridge)
Alexia Wilson (Univ. of Cambridge)
Valeria Zambianchi (Univ. of Cambridge)

CAMBRIDGE JOURNAL OF SCIENCE & POLICY
Volume 2 (2021) – Editorial Board

Editor-in-chief Emma Brown (Univ. of Cambridge)

Editors

Paolo Andrich (Univ. of Cambridge)
Paula Martin Gonzalez (Univ. of Cambridge)
Jenny (L.) Jiang (Univ. of Cambridge)
Zak Lakota-Baldwin (Univ. of Cambridge)
Carolyn Rogers (Univ. of Cambridge)

Thomas Freitag (Univ. of Cambridge)
Kate Howlett (Univ. of Cambridge)
Akaash Kumar (Univ. of Cambridge)
Dillon Rinauro (Univ. of Cambridge)
Darius Sultani (Potsdam Institute
for Climate Impact Research)

Copyeditors

Muzammil Arif Jabbar (Univ. of Cambridge)
Katherine Taylor (Univ. of Cambridge)

Adrià Segarra (Univ. of Cambridge)

Managing editor Michele Sanguanini (Univ. of Cambridge)

Communications Officer Kayla Pincus (Univ. of Cambridge)

Contents

Vol 1 Issue 2

Perspectives

'Processing' nutrition advice: how to inform guidelines on ultra-processed food – <i>Jennie Leggat</i>	73
Human germline gene editing needs global regulation – <i>Ryan Prestil</i>	79
Competition policy in the age of 'Big Tech': Assessing the EU's approach – <i>Pranjali Gupta</i>	87

Communications

International perspectives on mining rare earths: a case study in the Southern Jiangxi Province, China – <i>Colin Barnes</i>	97
Fracking in Colorado: Evidence, politics and policy change – <i>Zira Quaghe John</i>	109
Implementing the Mutualism Theory of Intelligence in the Classroom – <i>Ivan L. Simpson-Kent</i>	119

Reviews

Quantum Key Distribution: Advantages, Challenges and Policy – <i>Victor Lovic</i>	123
--	-----

Focus on: Science, Policy and the Public in Italy 2019

Science, Policy and the Public in Italy: A full day conference for UK-based researchers to meet with Italian policymakers – <i>Iacopo M. Russo</i>	133
Science, Policy and the Public in Italy 2019: Poster Abstracts	137
Social Media: A New Tool for Peacebuilding in Italy – <i>Jasmine Anouna</i>	143



'Processing' nutrition advice: how to inform guidelines on ultra-processed food

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | **PERSPECTIVE** | REPORT | REVIEW

Jennie Leggat

Department of Clinical Biochemistry
University of Cambridge
j1687@cam.ac.uk

ABSTRACT

Food processing has been part of our food environment for millennia, but recent advances in technology have taken processing to the next level, creating myriad packaged foods that our ancestors would not even have recognised as edible. Whilst this advancement in processing was certainly advantageous at a time of significant malnutrition following the World Wars, its adoption as a staple of our diet has fundamentally changed the way we eat and, along with it, our health. Recent evidence suggests that the consumption of ultra-processed foods is linked to metabolic morbidity, but these findings are not reflected in nutritional advice in the UK. I argue that public health advice and policy in the UK does not go far enough to highlight the risks of consuming ultra-processed food and, by focusing on a reductionist approach to nutrition, actually promotes the consumption of these products. I further recommend that Public Health England should consider adopting a whole foods approach to nutrition advice. Not only would this serve to minimise the confusion over macronutrient balances, it would also promote the consumption of whole, unprocessed or minimally processed foods, thereby fostering an improvement in our collective health and wellbeing.

The food and nutrition landscape has changed rapidly over the last few decades. In the 1950s, rationing was still in place for many foods across the UK, and convenience foods were a rarity. Fast-forward 70 years and you find an almost unrecognisable food environment, with supermarkets full of ultra-processed food, and fast-food restaurants dominating high streets. This may not seem problematic; technology has brought myriad changes to the way we live our lives, largely to the benefit of our collective wellbeing. Indeed, industrial food

processing arose as a solution to the crisis of malnutrition in Europe following the Great Depression and World Wars [1]. Efforts were channelled into producing energy-dense food that does not readily spoil, resulting in the introduction of vast quantities and huge varieties of ultra-processed food into our food environment. This certainly achieved the initial goal of population survival but has now fundamentally changed the way we eat and, along with it, our health.

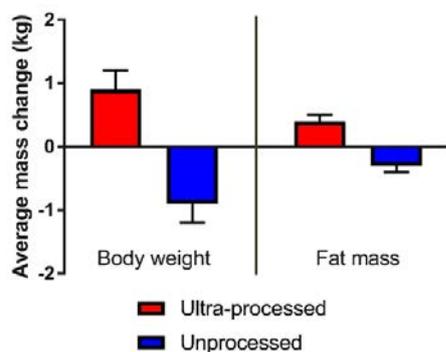


Figure 1: Ultra-processed diets increase body weight and fat mass as compared to energy- and macronutrient-matched unprocessed diets. Consumption of an ultra-processed diet for two weeks significantly increases both body weight and fat mass (0.9 ± 0.3 kg and 0.4 ± 0.1 kg, respectively), whereas ad libitum consumption of an energy- and macronutrient-matched unprocessed diet over the same time period resulted in significant body weight and fat mass loss (-0.9 ± 0.3 kg and -0.3 ± 0.1 kg, respectively). Data are expressed as mean \pm standard deviation. Figure produced using data from [2].

Food processing in some manner, such as heating, grinding or chopping, has formed part of our food environment for millennia. However, the commercial production of ultra-processed food is a relatively recent development. Ultra-processed foods are defined as ‘formulations of food substances often modified by chemical processes and then assembled into ready-to-consume hyper-palatable food and drink products’ [3]. Examples of this are everywhere, including biscuits, crisps, breakfast cereals and ready meals. As such, the amount of processed foods consumed in the UK has increased dramatically since the 1960s, such that an average of 65.6% of calories are from processed food, 86.6% of which is ultra-processed [4]. In the same timeframe, rates of obesity have increased significantly, from only 1% of the population to a staggering 28% in 2018, accompanied by a concurrent increase in the rates of other non-communicable metabolic conditions such as type 2 diabetes mellitus, hypertension and dyslipidaemia [5]. Whilst the emergence of this metabolic disease epidemic occurred concurrently with ever-increasing consumption of ultra-processed foods, this by no means provides evidence that the two phenomena are linked. However, their associa-

tion has prompted many scientists to question why they have tracked together, and whether one may be causative of the other. Observational studies have demonstrated that the availability of ultra-processed foods is positively associated with the prevalence of obesity in both adults and children [6, 7], and that increasing consumption of ultra-processed foods is associated with significantly increased risk of not only cardiovascular and cerebrovascular diseases – such as coronary artery disease and stroke – but also of all-cause mortality, with each additional serving increasing mortality by 18% [8, 9]. These cohort studies are of course limited by confounders, such as differences in physical activity levels and dietary compositions, as well as the known association between socioeconomic status and compliance with health initiatives. However, they indicate that ultra-processed food consumption may be negatively associated with general wellbeing, and positively associated with body mass index.

These observations have subsequently been supported by randomised controlled trials and animal studies, which are significantly more robust in terms of scientific rigour. Comparison of ultra-processed food with unprocessed food using energy- and macronutrient-matched diets (i.e. diets that are similar in terms of calorie, protein, fat and carbohydrate content but that vary in their level of processing) demonstrated that energy intake was significantly increased on the ultra-processed diet, averaging an extra 508 calories per day with associated weight gain (Figure 1) [2]. Animal studies have shown that consumption of ultra-processed foods alters the microbiome, resulting in dysregulation of satiety mechanisms – the mechanisms that control how ‘full’ we feel – and thereby promoting increased food consumption and subsequent metabolic diseases such as obesity, diabetes and colitis [10, 11]. All of these findings combine to form evidence in support of an association between ultra-processed food consumption and adverse health outcomes. Though causality remains to be established, findings like these have important implications for nutrition advice and policies, providing a robust basis for public health initiatives. As such, countries like Brazil and France have added ‘avoidance of ultra-processed foods’ to their nutrition guidance. However, the situation in the UK is quite different.

The NHS' response to the aforementioned studies has been to state that the evidence is 'not strong enough' to advocate against eating such products, and that some foods need to be processed in order for them to be safe for consumption [12]. Admittedly, no causal link between ultra-processed foods and disease has been established yet, and we'd still be contracting tuberculosis from milk if we didn't have some forms of processing such as pasteurisation. However, neither is the evidence so lacking that they can entirely ignore the issue. The Eatwell Guide is a document issued by Public Health England with the aim of improving the health and wellbeing of the British public through nutrition [13]. Whilst containing many good tips on nutrition for health, such as advice to limit refined sugar consumption, it fails to even mention the potential dangers of ultra-processed food. The term 'processed' is only used in the context of meat, and is not used at all to describe any other food. The guide does say to limit 'foods high in fat, salt and sugars', and states that these foods 'are not needed in the diet', but a lot of ultra-processed food does not fall into that category. In fact, the Guide actively promotes the consumption of some ultra-processed food, suggesting that an 'ideal' food diary would be cereal for breakfast, a sandwich for lunch, and an evening meal of pasta. This gives the impression that ultra-processed food is safe for consumption, and that there is no evidence to the contrary. Whilst one can say that there is insufficient evidence to establish causality, should that be a reason to completely ignore the worrying implications of the research that has been performed so far?

Another issue with the Eatwell Guide is the fact that all advice is based on macronutrients and caloric intake. It recommends daily upper limits for calories as well as limits the consumption of certain individual nutrients by weight. Whilst this reflects the reductionist view of much scientific research, it does not translate very well into the real world: not many people would eat an apple or a cucumber while knowing its exact nutritional composition. Unprocessed foods do not require a nutrition label under EU Regulations [14] so by virtue of eating unprocessed foods, one is essentially unable to follow public health nutrition guidance because quantifying nutrient intake is extremely difficult indeed. This

means that people inevitably move towards buying processed food in order to find a nutrition label that allows them to count up and control for each macronutrient in order to follow nutrition guidance, thereby raising the consumption of additives such as artificial sweeteners, emulsifiers and flavourings, and displacing the consumption of nutrient-dense whole foods. I would argue that these actions will actually serve to *reduce* the nutritive benefit of our diet and therefore impact *negatively* on our health, despite following government-issued advice to the letter. This reductionist approach also permits processed food manufacturers to reformulate products to comply with guidelines, adhering to arbitrary upper limits for saturated fat and sugar in order to market products as 'healthy', despite those products being highly processed and therefore likely to be significantly worse for health than any whole food. What's more, various 'tricks of the trade' are still permitted in these products, such as the known act of intentionally altering macronutrient composition to achieve 'the bliss point'; the perfect ratio of fats, sugars and sodium that humans find irresistible, promoting both overeating and addiction [15]. In the words of Pringles, '*Once you pop, you can't stop*'.

It seems strange that there isn't a mention of the dangers of ultra-processed food in the Eatwell Guide, given the evidence (or lack thereof) for historical nutritional advice. The research that initiated the vendetta against saturated fat is the Seven Countries Study by Ancel Keys and colleagues, which stated that consumption of saturated fat was associated with the incidence of coronary artery disease [16]. However, this research was plagued with scientific errors, not least that countries and populations that did not fit the hypothesis were excluded, such as the Inuit and the Maasai who consume large amounts of saturated fat and have significantly lower rates of heart disease than populations of developed nations [17]. Further studies ensued, but the theory was still highly contested. Nevertheless, dietary advice changed. Since then, both the most comprehensive systematic review with meta-analysis, and the most up-to-date analysis of prospective trials concluded that there was no effect of consuming saturated fats on cardiovascular events nor mortality [18]. Yet Public Health England continues to advocate against the consumption of

saturated fats. On the other hand, the accumulating evidence to suggest that the consumption of ultra-processed food is associated with poorer health outcomes is not sufficient for even a paragraph in our nutrition advice on the potential dangers of these foods. Perhaps the £28.2bn *per annum* contributed to the UK economy by the food and drink industry is complicating matters, as it is likely that no government would wish to issue guidance that deprives the economy of this investment – regardless of the potential health benefits such guidance may have [19].

Given all of this evidence, my advice to Public Health England would be to issue new guidance that *at the very least* highlights the growing evidence suggesting ultra-processed foods may be detrimental to health. Whilst my favourite advice from writer Michael Pollan – ‘*Don’t eat anything your great-grandmother wouldn’t recognise as food*’ [20] – may be a little extreme, sufficient evidence has accumulated to justify warning against the consumption of such foods. Advocating for a ban on the sale of ultra-processed food would be both unreasonable and untenable, thus policy makers need to rethink their priorities, placing more emphasis on promoting the health benefits of unprocessed foods and improving their affordability and accessibility. Additional policy should be implemented to restrict marketing of ultra-processed foods and to add warnings to their packaging. Reformulation of processed foods to comply with arbitrary macronutrient limits defined by the Eatwell Guide should be discouraged. Programmes to educate children and young adults on the health benefits of whole foods as well as the potential dangers of ultra-processed foods should be included in the National Curriculum. Whilst these are just a few examples of relatively simple policies, they have the potential to alter the health of our nation for the better. Without their implementation, I fear the current epidemic of chronic metabolic disease will continue to expand, and our waistlines along with it.

© 2020 The Author. Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

References

- [1] European Food Information Council, “Evolution of food processing and labelling in food production,” December 2014. [Online]. Available: <https://www.eufic.org/en/food-production/article/food-production-1-3-the-evolution-of-meeting-nutritional-needs-through-proc>
- [2] K. D. Hall, A. Ayuketah, R. Brychta, H. Cai, T. Cassimatis, K. Y. Chen, S. T. Chung, E. Costa, A. Courville, V. Darcey *et al.*, “Ultra-processed diets cause excess calorie intake and weight gain: an inpatient randomized controlled trial of ad libitum food intake,” *Cell metabolism*, vol. 30, no. 1, pp. 67–77, 2019.
- [3] C. A. Monteiro, G. Cannon, R. B. Levy, J.-C. Moubarac, M. L. Louzada, F. Rauber, N. Khandpur, G. Cediel, D. Neri, E. Martinez-Steele *et al.*, “Ultra-processed foods: what they are and how to identify them,” *Public health nutrition*, vol. 22, no. 5, pp. 936–941, 2019.
- [4] F. Rauber, M. L. da Costa Louzada, E. M. Steele, C. Millett, C. A. Monteiro, and R. B. Levy, “Ultra-processed food consumption and chronic non-communicable diseases-related dietary nutrient profile in the uk (2008–2014),” *Nutrients*, vol. 10, no. 5, p. 587, 2018.
- [5] A. Conolly, S. Craig, and S. Gebert, “Health Survey for England 2018: Overweight and obesity in adults and children,” *NHS Digital*, December 2019. [Online]. Available: <https://files.digital.nhs.uk/52/FD7E18/HSE18-Adult-Child-Obesity-rep.pdf>
- [6] C. A. Monteiro, J.-C. Moubarac, R. B. Levy, D. S. Canella, M. L. da Costa Louzada, and G. Cannon, “Household availability of ultra-processed foods and obesity in nineteen European countries,” *Public health nutrition*, vol. 21, no. 1, pp. 18–26, 2018.
- [7] C. S. Costa, B. Del-Ponte, M. C. F. Assunção, and I. S. Santos, “Consumption of ultra-processed foods and body fat during childhood and adolescence: a systematic review,” *Public health nutrition*, vol. 21, no. 1, pp. 148–159, 2018.

- [8] B. Srour, L. K. Fezeu, E. Kesse-Guyot, B. Allès, C. Méjean, R. M. Andrianasolo, E. Chazelas, M. Deschasaux, S. Hercberg, P. Galan *et al.*, “Ultra-processed food intake and risk of cardiovascular disease: prospective cohort study (nutrinet-santé),” *bmj*, vol. 365, p. 11451, 2019.
- [9] A. Rico-Campà, M. A. Martínez-González, I. Alvarez-Alvarez, R. de Deus Mendonça, C. de la Fuente-Arrillaga, C. Gómez-Donoso, and M. Bes-Rastrollo, “Association between consumption of ultra-processed foods and all cause mortality: Sun prospective cohort study,” *bmj*, vol. 365, p. 11949, 2019.
- [10] T. Sen, C. R. Cawthon, B. T. Ihde, A. Hajnal, P. M. DiLorenzo, B. Claire, and K. Czaja, “Diet-driven microbiota dysbiosis is associated with vagal remodeling and obesity,” *Physiology & behavior*, vol. 173, pp. 305–317, 2017.
- [11] J. Suez, T. Korem, D. Zeevi, G. Zilberman-Schapira, C. A. Thaiss, O. Maza, D. Israeli, N. Zmora, S. Gilad, A. Weinberger *et al.*, “Artificial sweeteners induce glucose intolerance by altering the gut microbiota,” *Nature*, vol. 514, no. 7521, pp. 181–186, 2014.
- [12] NHS Website, “Does ‘ultra-processed’ food cause earlier death?” May 2019. [Online]. Available: <https://www.nhs.uk/news/food-and-diet/does-ultra-processed-food-cause-earlier-death/>
- [13] Public Health England, “The Eatwell Guide: helping you eat a healthy, balanced diet,” 2018. [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/742750/Eatwell_Guide_booklet_2018v4.pdf
- [14] European Parliament and Council of the European Union, “Regulation No 1169/2011,” *Annex V. OJ L*, vol. 304, no. 47, 2011.
- [15] M. Moss, “The extraordinary science of addictive junk food,” in *Expanding Addiction: Critical Essays*, R. Granfield and C. Reinarman, Eds. Routledge, 2013.
- [16] A. Keys, A. Mienotti, M. J. Karvonen, C. Aravanis, H. Blackburn, R. Buzina, B. Djordjevic, A. Dontas, F. Fidanza, M. H. Keys *et al.*, “The diet and 15-year death rate in the seven countries study,” *American journal of epidemiology*, vol. 124, no. 6, pp. 903–915, 1986.
- [17] G. Taubes, “What if it’s all been a big fat lie?” *The New York Times Magazine*, July 2002. [Online]. Available: <https://www.nytimes.com/2002/07/07/magazine/what-if-it-s-all-been-a-big-fat-lie.html>
- [18] Scientific Advisory Committee on Nutrition, “Saturated fats and health,” 2019. [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/814995/SACN_report_on_saturated_fat_and_health.pdf
- [19] Food and Drink Federation, “The food and drink industry: economic contribution and growth opportunities,” 2017. [Online]. Available: <https://www.fdf.org.uk/publicgeneral/FDF-GT-Exec-Summary.pdf>
- [20] M. Pollan, “Unhappy meals,” *The New York Times Magazine*, January 2007. [Online]. Available: <https://www.nytimes.com/2007/01/28/magazine/28nutritionism.t.html>

About the Author

Jennie is a 2nd year British Heart Foundation PhD student at the Institute of Metabolic Science, researching the impact of non-alcoholic fatty liver disease on cardiac function. Having seen the impact of public health initiatives on quality of life in her capacity as Clinical Cardiac Scientist in the NHS, she is passionate about contributing to public policy, particularly with regard to prevention of non-communicable disease.



Conflict of interest The Author declares no conflict of interest.

This page intentionally left blank.



Human germline gene editing needs global regulation

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | **PERSPECTIVE** | REPORT | REVIEW

Ryan Prestil

Cambridge Institute for Medical Research
University of Cambridge
rmp61@cam.ac.uk

ABSTRACT

The first gene-edited human babies were born in China in late 2018, but no new legislation has been enacted despite widespread outrage. There is a pressing societal need to address the moral and ethical issues associated with germline gene editing before more cases occur. A temporary worldwide moratorium on reproductive germline gene editing should be instituted immediately until such a time as an International Gene Editing Agency is established to develop an enforceable global regulatory framework with broad public engagement. This will, in turn, give us the opportunity to rethink the ethics of heritability in a post-gene editing world.

Introduction

On 25th November 2018, Dr He Jiankui, an associate professor at the Southern University of Science and Technology in Shenzhen, China, released a series of Youtube videos in which he announced the birth of the first gene-edited human babies [1]. Unlike any experiment that came before, Dr He edited the genomes of two single-cell female embryos with the aim to edit every cell in the body. Since this includes the egg and sperm cells, known as germline cells, these edits may be passed down to any future descendants these babies eventually have. In contrast, editing of adult (somatic) cells cannot be passed on to future generations and is therefore isolated in the individual patient [2].

While I was immediately captivated, I was hesitant to publish a response. Surely this was the stimulus that policymakers needed to finally regulate emerging gene editing technologies, so any policy recommendations that I could make would be immediately superseded by an actual proposal. Instead, the worst has come to pass: the news cycle moved on, and few remain talking about the little girls who made history.

To perform this experiment, Dr He used CRISPR, a technology for cutting DNA at precise, customisable locations. While this article focuses on the ethics rather than the science of CRISPR, those unfamiliar with how it works may find a review article about its history and technical specifics helpful [3]. Full details of Dr He's work have not been published, so unfortunately many scientific questions remain unanswered, such as whether

both copies of the genome were edited in every cell as claimed, but the Chinese government has confirmed that the editing did take place [4].

After presenting selected data at the Second International Summit on Human Genome Editing just three days following his announcement, Dr He was met with nearly unanimous criticism by fellow scientists [5, 6]. The next day it was reported by Chinese state media that the Chinese government had suspended his lab's research [7], and his lab website was taken offline. Dr He himself has not spoken publicly since the summit, and he has since been fired by his university and was sentenced to three years in prison for performing 'illegal medical practices' [8].

In Dr He's defence, it was not at all initially obvious that what he did was illegal. Unlike in the UK, where the Human Fertilisation and Embryology Authority (HFEA) explicitly bans germline editing [9], there was no law or regulation specifically banning it in China. Instead, the 'Technical Norms on Human Assisted Reproductive Technologies' published by the Chinese Ministry of Health in 2003 states 'the use of genetically manipulated human [...] embryos for the purpose of reproduction is prohibited' [10]. While this should have dissuaded Dr He, such technical norms are generally unenforceable without being authorised by law, so it was not until this case became a sensation that it was clear that flouting the norm would actually be punishable. Meanwhile, many countries including the United States have no laws regulating this new technology (although the US has banned federal funds from being used for germline editing research) [9].

It is unknown where germline gene editing research will go from here. On one hand, Dr He shows us that a small team of scientists is capable of performing a germline gene edit on a human embryo resulting in a live birth. Over the past year, Dr Denis Rebrikov at the Pirogov Medical University in Moscow has also been vocal about performing similar edits on human embryos—although he claims he will not implant them until he gains regulatory approval [11]. On the other hand, the vilification that Dr He has received will hopefully deter the majority of scientists from repeating his work, and, at present, the expertise and resources required to perform this feat are a sufficient hurdle to prevent non-

scientists from trying to replicate it. However, there is a real possibility that research will be done in secret or that future advancements will remove technical barriers to entry, so the time is ripe to act on a global scale to regulate germline gene editing.

Available Policy Pathways

We are at a crossroads with four paths forward: we could deregulate germline gene editing by either repealing or choosing not to enforce existing regulations, we could ban it entirely, we could fracture into a patchwork of national regulations with no global cohesion, or we could work to determine a single path forward as a species. While it is the most difficult, I see the final option as the only viable scenario in the long term. However, there are still many traps that must be avoided, and I will seek to both justify this belief and outline what it might take to bring it about.

At the dawn of the modern genetic era, the 1975 Asilomar Conference on Recombinant DNA Molecules recognised that unrestricted manipulation of DNA in the lab presents many unknown risks, and, in the absence of laws, scientists resolved to set restrictions on themselves [12]. For over forty years, this voluntary self-regulation has been the norm for much of biotechnology, especially in the US, but this should only be seen as a stopgap and not a permanent solution.

There are numerous technical risks for both individuals and the species should germline gene editing go ahead unchecked: CRISPR is relatively inefficient, often successfully editing only a small percent of cells, and it can also cause off-target mutations, where it cuts DNA at the wrong location, which could cause cancer or any number of genetic diseases [13]. However, the field of gene editing moves fast. New research is published daily in this highly competitive and lucrative field, such as one study detailing how to design CRISPR edits to reduce the chance of off-target effects [14] and a recent clinical trial demonstrating the safety and feasibility of using CRISPR-edited immune cells to target cancer [15].

There is good reason to be hopeful that the technical problems with CRISPR will be fixed, but the

ethical concerns are much more complex. There is no clear line between eliminating a genetic disease and enhancing a desired trait; the same gene that causes muscular dystrophy when lost could increase physical strength if amplified [16]. Additionally, the US allows patenting of both the editing technology and the edits themselves, which grants the companies developing them immense power over their implementation. One needs only to look at the price of prescription drugs in a for-profit market to see that access to any gene editing technology developed by private companies would be restricted to only the wealthiest. A report published by Goldman Sachs last year states 'given the possible one-time curative nature of gene therapy, we believe price tags of \$1mn+ [per patient] are likely' [17]. Such a price would be inaccessible for the vast majority of patients and would stretch social healthcare systems beyond many of their capacities.

Moreover, tampering with the natural human gene pool is inherently a major risk in the long term. Differences in environments and cultural ideals (e.g., beauty standards) could lead to the promulgation of different traits in different populations far faster and more effectively than the existing mode of sexual selection, which could fracture humanity into various subspecies over time or put unedited individuals at a social disadvantage. Additionally, homogenization of human genetics could reduce diversity and resistance to infectious diseases. Similarly, we know that planting only one variety of crop makes a field more prone to disease than planting crops with more genetic variation [18]. The risks of germline editing are simply too great to allow a *laissez-faire* approach.

Technological advancements cannot inform our morality, and likewise CRISPR cannot tell us whether we want to direct human evolution or how. It is my personal belief that we are simply not ready as a society or a species for germline gene editing, and if or when we do allow it, it should be a conscious collective decision after suitable scrutiny, education, and debate rather than an individual deciding to pursue it simply because they can.

However, the potential for misuse does not make gene editing itself immoral. CRISPR is an incredibly powerful research tool which has rev-

olutionised biology, allowing scientists unprecedented ability to manipulate the genetics of cell and animal models. This has opened doors for the discovery of novel pharmaceuticals and gene interactions via whole genome CRISPR screens, and new variants of CRISPR can, among other things, transiently affect gene expression without permanently altering the DNA [3].

Applications in adult (somatic) cells also promise to translate CRISPR to human health in untold ways. From curing chronic diseases to eliminating mutated cancer cells with pinpoint accuracy, several such treatments are starting to make their way to patients and showing promising results [15, 19]. No matter one's objections to germline editing, it is difficult to justify accepting the status quo of congenital diseases when so many could be cured in the individual by somatic gene therapies or prevented entirely by existing genetic counselling practices coupled with limited and precise germline edits. In order to reap these benefits, fundamental research and somatic clinical applications should be enthusiastically supported, and a complete ban on gene editing or even a permanent ban on just germline editing should not be pursued.

Our current situation, and the most likely scenario for the near future, is that each country will form its own policies to regulate gene editing as they have done with fertility treatments, stem cell therapies, and other medical procedures [20]. This has worked in the past and should work for somatic gene editing, since treatments are confined to the individual patient. However, once a germline gene edit enters the gene pool, the only way it can be removed is if none of the carriers have children, or at least if none of these children receive any edited chromosomes. Should any country allow widespread germline gene editing, nothing short of completely closing them off from the rest of the world would prevent comingling of edited and unedited populations. A hypothetical genetic edit should not deprive a person of basic human rights, so any program of compulsory genotyping, labelling of gene-edited individuals, or limiting of reproductive rights should be immediately rejected. And even should such draconian measures be put in place, they would be ineffective; every generation acquires numerous new random mutations in their

genomes which are afterwards indistinguishable from most targeted edits. Therefore, a germline editing ban—or even limits and regulations—in a single country but not the world is effectively meaningless.

Policy Recommendations

So, if a single path forward is the best option, what should it be? Any policy must be both global and enforceable to be effective; therefore, a binding international treaty should be immediately pursued to:

1. impose a temporary, 5-year moratorium on human germline gene editing, until such time as
2. an International Gene Editing Agency can be established and enact initial regulations. This agency would also be empowered to act as a watchdog.

This approach may appear reminiscent of a failed attempt in the early 2000's to ban human cloning via treaty, where a lack of real urgency and vague technical language resulted instead in a non-binding declaration [21]. A similar fate befell a Convention on Human Rights and Biomedicine proposed to the Council of Europe in the late 1990s [22], and both resulted in a patchwork of national regulation. Instead, if it had been announced that human cloning was actively ongoing, countries seeking a full ban would likely have compromised for some restrictions, and likewise had the treaty included a sunset clause, it likely would have placated the countries that were against a full ban. UNESCO has also published declarations on bioethics [23], but they too suffer from unenforceability. Instead of adding enforcement to the broad scope of UNESCO's Constitution, establishing an independent organisation will provide greater transparency, efficacy, and manoeuvrability.

The International Atomic Energy Agency serves as a particularly useful model, as they are invested with the power to issue standards and perform inspections ensuring the safety of nuclear power and preventing the proliferation of nuclear weapons while also operating autonomously from the UN. Although it would be significantly

more difficult to detect germline gene editing than atomic bombs, independent audits of reproductive therapy providers and research funding portfolios would be widely effective, coupled with public outreach to encourage reporting of rogue actors. Additionally, China's strong response to Dr He's work suggests that there is the political will for individual states along with the UN to isolate and sanction those that refuse to subscribe to the regulations in a manner comparable to nations in violation of the Treaty on the Non-Proliferation of Nuclear Weapons. In this way, we may not prevent all cases of germline editing, but we can prevent it from becoming mainstream while also providing a mechanism to permit certain applications in the future.

This recommendation builds on previous calls for a global gene editing observatory [24]. Jasanoff and Hurlbut envision the establishment of new institutions for careful deliberation across professional and national boundaries, but it is now clear that there is an urgent need for action while policymakers can come to terms with the details—therefore, a temporary moratorium on germline editing while the Agency is created. And while their proposed observatory would be an ideal model for determining the rules for CRISPR moving forward, it lacks power and must be coupled with a mechanism of enforcement—therefore, the establishment of the proposed Agency.

In an apparent attempt to get out ahead of the backlash, Dr He published a list of principles for regulating human germline gene editing just before his announcement [25], such as 'only for serious disease, never vanity,' and 'wealth should not determine health.' This article has since been retracted by the journal, but it offers a glimpse into the reasoning Dr He used to justify his work. In fact, his recommendations would have been useful if we lived in a world in which germline gene editing was broadly accepted, but that is simply not the case, and the risks of implementation on a global scale have not been properly evaluated. Dr He clearly miscalculated how hostile the response to his news would be, and as a result these suggestions have been largely lost in the noise.

I cannot say exactly what specific regulations should be made, and neither is it any individual's place to dictate what these regulations should be.

Instead, it is the responsibility of everyone in a society to say what they want in order to determine policy, via a concept coined by Jasanoff called civic epistemology, or the ‘stylized, culturally-specific ways in which publics expect the state’s expertise, knowledge, and reasoning to be produced, tested, and put to use in decision making’ [20]. While the proposed Agency provides a vessel for making and enforcing regulations, we must decide together how to fill it. We therefore face the enormous task of synthesising our various culture-specific epistemologies into a single new one as a species.

A Brave New World?

CRISPR technology fundamentally changes our understanding of heritability and of what it means to be human. Before, it was impossible to separate the genome from the individual or to conceive of a way to design or alter the genetic code of one’s offspring. The entire concept of familial heritage is intimately connected to the assumption that your genome is unique, inalienable, and, to put it simply, yours to begin with. How, then, can the ethics derived before gene editing carry over? Instead, we should see the development of germline gene editing as an opportunity to re-examine how we conceive human evolution.

Genetic variation is necessary for evolution to occur; we must then decide whether to end the evolution of humanity by eliminating variation, whether to allow it to proceed as the slow and random process it has for the history of life, or whether to accelerate it deliberately through genetic intervention. As this is a monumental decision, it should not be made hastily and certainly not by a privileged few. Instead, scientists must seek to effectively communicate with and educate everyone about the possibilities of gene editing as they develop, and perhaps someday the proposed Agency can be replaced with ongoing global referenda with equal, universal suffrage to determine our course forward.

Two years before *Asilomar*, science fiction writer Robert A. Heinlein predicted a future of uninhibited genetic editing. When the protagonist of the novel is cloned (and these clones genetically edited) without his knowledge, he reasons

‘You don’t own your genes—nobody does. Genes belong to the race; they’re simply lent to the individual for his-her lifetime’ [26]. Heinlein’s vision should scare us, but there is perhaps some truth to his reasoning. We should think of our genetics as a Commons that we all share and all must protect, and rather than assigning different values to certain genetic varieties as ‘good’ or ‘bad’, we should realise that all DNA has the same value. We may recognise that specific mutations which lead to disease are detrimental, but even these do not alter the moral worth of the DNA or of the individual who is ‘borrowing’ it from the species. Instead, it is the depth of the gene pool that is our strength as a species, and in order to be good stewards of the human genome, we must actively restrain and refocus the use of this powerful technology in a manner that is democratic—and never plutocratic or eugenic. We all have a share in this, so we all deserve a say.

Acknowledgements

Thank you to Prof Krishanu Saha and Prof Linda Hogle of the University of Wisconsin-Madison and to Laura Ryan and Sarah Carlo from the University of Cambridge for their support and advice. Thank you also to the many colleagues and friends who participated in spirited discussions on these issues.

© 2020 The Author. Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

References

- [1] The He Lab, “About Lulu and Nana: Twin girls born healthy after gene surgery as single-cell embryos,” Nov 2018. [Online]. Available: <https://youtu.be/th0vnOmFltc>
- [2] A. J. Griffiths, S. R. Wessler, R. C. Lewontin, W. M. Gelbart, D. T. Suzuki, J. H. Miller *et al.*, *An introduction to genetic analysis*. Macmillan, 2005.

- [3] M. Adli, “The CRISPR tool kit for genome editing and beyond,” *Nature communications*, vol. 9, no. 1, pp. 1–13, 2018.
- [4] J. Cohen, “Inside the circle of trust,” *Science*, vol. 365, no. 6452, pp. 430–437, 2019.
- [5] International Summit on Human Genome Editing (28 Nov 2018), “He Jiankui presentation and Q&A.” [Online]. Available: <https://youtu.be/tLZufCrjrN0>
- [6] D. Cyranoski, “CRISPR-baby scientist fails to satisfy critics,” *Nature*, vol. 564, no. 7734, pp. 13–15, 2018.
- [7] S. Jiang, H. Regan, and J. Berlinger, “China suspends scientists who claim to have produced gene-edited babies,” Nov 2018. [Online]. Available: <https://edition.cnn.com/2018/11/29/health/china-gene-editing-he-jiankui-intl/index.html>
- [8] D. Cyranoski, “What CRISPR-baby prison sentences mean for research.” *Nature*, vol. 577, no. 7789, p. 154, 2020.
- [9] M. Araki and T. Ishii, “International regulatory landscape and integration of corrective genome editing into in vitro fertilization,” *Reproductive biology and endocrinology*, vol. 12, no. 1, p. 108, 2014.
- [10] A. Rosemann, L. Jiang, and X. Zhang, *The regulatory and legal situation of human embryo, gamete and germ line gene editing research and clinical applications in the People’s Republic of China*. Nuffield Council of Bioethics, 2017.
- [11] D. Cyranoski, “Russian ‘CRISPR-baby’ scientist has started editing genes in human eggs with goal of altering deaf gene.” *Nature*, vol. 574, no. 7779, p. 465, 2019.
- [12] P. Berg, D. Baltimore, S. Brenner, R. O. Roblin, and M. F. Singer, “Summary statement of the Asilomar conference on recombinant DNA molecules.” *Proceedings of the National Academy of Sciences of the United States of America*, vol. 72, no. 6, p. 1981, 1975.
- [13] X.-H. Zhang, L. Y. Tee, X.-G. Wang, Q.-S. Huang, and S.-H. Yang, “Off-target effects in CRISPR/Cas9-mediated genome engineering,” *Molecular Therapy-Nucleic Acids*, vol. 4, p. e264, 2015.
- [14] A. M. Chakrabarti, T. Henser-Brownhill, J. Monserrat, A. R. Poetsch, N. M. Luscombe, and P. Scaffidi, “Target-specific precision of CRISPR-mediated genome editing,” *Molecular cell*, vol. 73, no. 4, pp. 699–713, 2019.
- [15] J. Couzin-Frankel, “Cutting-edge CRISPR gene editing appears safe in three cancer patients,” *Science*, February 2019. [Online]. Available: <https://doi.org/10.1126/science.abb1990>
- [16] E. P. Hoffman, A. Bronson, A. A. Levin, S. Takeda, T. Yokota, A. R. Baudy, and E. M. Connor, “Restoring dystrophin expression in Duchenne muscular dystrophy muscle: Progress in exon skipping and stop codon read through,” *The American journal of pathology*, vol. 179, no. 1, pp. 12–22, 2011.
- [17] S. Richter, R. Yeh, R. Weinreb, C. Ziyi, K. Patel, and A. Astor, “Profiles in innovation: The genome revolution,” *Goldman Sachs Equity Research*, April 2018. [Online]. Available: <https://www.gspublishing.com/content/research/en/reports/2019/09/04/048b0db6-996b-4b76-86f5-0871641076fb.pdf>
- [18] H. M. Alexander, A. Roelfs, and G. Cobbs, “Effects of disease and plant competition on yield in monocultures and mixtures of two wheat cultivars,” *Plant Pathology*, vol. 35, no. 4, pp. 457–465, 1986.
- [19] M. Zipkin, “CRISPR’s ‘magnificent moment’ in the clinic,” *Nature Biotechnology*, December 2019. [Online]. Available: <https://doi.org/10.1038/d41587-019-00035-2>
- [20] S. Jasanoff, *Designs on nature: Science and democracy in Europe and the United States*. Princeton University press, 2011.
- [21] A. Sotaniemi, “International convention against the reproductive cloning of human beings - report of the sixth committee,” *United Nations 59th General Assembly, Resolution 59/516/Add.1*, February 2005. [Online]. Available: <https://undocs.org/a/59/516/add.1>
- [22] Council of Europe, “Convention for the protection of Human Rights and Dignity of the Human Being with regard to the Application of Biology and

- Medicine: Convention on Human Rights and Biomedicine,” April 1997. [Online]. Available: <https://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/164>
- [23] UNESCO 29th General Conference, “Universal Declaration on the Human Genome and Human Rights,” November 1997. [Online]. Available: <https://unesdoc.unesco.org/ark:/48223/pf0000110220.page=47>
- [24] S. Jasanoff and J. B. Hurlbut, “A global observatory for gene editing,” *Nature*, vol. 555, pp. 435–437, 2018.
- [25] H. Jiankui, R. Ferrell, C. Yuanlin, Q. Jinzhou, and C. Yangran, “Draft ethical principles for therapeutic assisted reproductive technologies [retracted Feb 1, 2019],” *The CRISPR Journal*, vol. 1, no. 6, 2018.
- [26] R. A. Heinlein, *Time Enough for Love*. G.P. Putnam’s Sons, 1973.

About the Author

Ryan Prestil is a fourth-year PhD student in Medical Genetics at the Cambridge Institute for Medical Research and a member of the NIH OxCam Scholars program. He is researching the molecular mechanisms of autophagy in neurodegenerative diseases and has used CRISPR in his research since 2013. Previously, Ryan received a Bachelor of Science with Honors from the University of Wisconsin-Madison.



Conflict of interest The Author declares no conflict of interest.

This page intentionally left blank.



Competition policy in the age of 'Big Tech': Assessing the EU's approach

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | **PERSPECTIVE** | REPORT | REVIEW

Pranjali Gupta
Judge Business School
University of Cambridge
pg496@cantab.ac.uk

ABSTRACT

This perspective article analyses the EU's approach to digital competition policy, focusing on its investigations into 'Big Tech' i.e., Google, Apple, Facebook and Amazon, or GAFA. It assesses the changing nature of competition policy and looks at the legal and institutional context of the EU's investigations. Analysing the impact on stakeholders and the broader policy implications, it concludes that digital regulation should not be regional and that the inclusion of technology companies coupled with the establishment of a global framework is necessary for the process of adapting competition policies for the digital age.

Introduction

On 17th July 2019, the European Commission (EC) formally opened an antitrust investigation into Amazon [1]. The term 'antitrust' is defined in the EU's competition policy publication as 'the action of preventing or controlling trusts or other monopolies, always done with the intention of promoting competition in business' [2]. This is the latest in a growing number of global investigations into the so-called 'Big Tech' firms: Google, Amazon, Facebook and Apple (GAFA). Other notable recent cases include the European Union's (EU) combined €8.25 billion fine levied against Google across three abuse of dominance cases (Google Shopping in June 2017 [3], Google Android in July 2018 [4], and Google AdSense in

March 2019 [5]).

While these firms are growing to dominate an increasing number of markets, the accompanying technological advancement and disruption of established business models have tested the limits of traditional competition policy, both within the EU and beyond. This perspective article examines why traditional competition policy is not entirely applicable to 'Big Tech' by analysing the legal and institutional environment around the EU's antitrust cases against GAFA firms and their impact on relevant stakeholders. It then considers the broader policy and industry implications for digital competition regulation and the need for global cooperation and standardisation to effectively ensure competitive digital markets.

Competition Law in the EU

Antitrust law is a subset of competition law, which refers to the broader legal framework in a particular jurisdiction that aims to ensure a fair and free market to the maximum extent possible by laying out a set of rules governing anti-competitive conduct [2]. EU competition law is derived from Articles 101-109 of the Treaty on the Functioning of the European Union (TFEU) [6], in conjunction with relevant Regulations such as Regulation 139/2004 (the EC Merger Regulation) [7] and Regulation 1/2003 [8] (the Modernisation Regulation) [9]. It encompasses four main policy areas.

Of these four areas, cartels and anti-competitive agreements (covered by TFEU Article 101), and abuse of market dominance (covered by TFEU Article 102), form the basis of European antitrust law. 'Anti-competitive agreements' are agreements between companies that restrict competition. These can be vertical, such as between suppliers and retailers, or horizontal i.e., between competitors in the same market. The most extreme of these is the formation of 'cartels', which are collusive groups created between companies who are market competitors, to control prices, limit production and share markets or customers amongst themselves [2, 10]. 'Abuse of a dominant position' refers to the company exploiting the strength of its market position to restrict or eliminate competition [2, 10]. Note that a dominant position in itself is not anti-competitive unless the company in question has exploited it. This adds a layer of complexity to abuse of dominance investigations, especially when dealing with GAFSA companies, as explicit misuse of market dominance has to be clearly established.

Thirdly, the law covers merger control, per the Merger Regulation, which establishes the EC's power to prevent mergers or acquisitions that threaten to restrict competition. Finally, TFEU Article 107 deals with Member State aid control, prohibiting the Member States from using public funds to influence markets by investing in or otherwise granting financial advantages to private undertakings [2, 10]. EU competition law applies to the 27 Member States and the 3 non-member countries in the European Economic Area (EEA) - Iceland, Liechtenstein and Norway - in conjunc-

tion with their national laws [10]. Regulation 1/2003 also set up the European Competition Network (ECN) as a platform for further co-operation, and obligated national competition authorities (NCAs) and courts to consistently enforce TFEU 101 and 102 across the EU and EEA [9].

Competition Policy in a Digital World

'Competition policy' refers to the application and enforcement of the rules set out by competition law [2]. Definitions and enforcement are specific to individual jurisdictions (such as individual nations and transnational blocs like the EU), as there are no binding multilateral standards or agreements. However, organisations such as the International Competition Network (ICN), the Organisation for Economic Co-operation and Development (OECD) and the United Nations Conference on Trade and Development (UNCTAD) facilitate international dialogue and discussion to encourage global regulatory standardisation [11].

The original definitions of anti-competitive behaviour were established for traditional business models, where it was possible to demarcate markets for different industries [11]. They were also firmly set in price theory, as consumer welfare and harm were broadly considered in monetary terms [12]. For instance, consumers were being harmed if they were being forced to pay a higher price than was fair without any alternatives. Identifying a dominant player as one who held the greater market share or classifying inter-business agreements as collusive in nature was thus more straightforward. It was also easier to define anti-competitive activities, such as price-fixing (an agreement between rival sellers to raise or fix prices to restrict competition and increase profits [13]). A well-known case of collusive agreements is the famous 1961 electrical equipment price-fixing case in the United States. Multiple high-profile electrical equipment manufacturers including General Electric and Westinghouse were charged and indicted by a Philadelphia grand jury with having colluded to 'raise, fix and maintain' the prices of equipment estimated to be worth \$1.7 billion annually [14].

The digital revolution has fundamentally altered the nature of markets and industries, creating more fluid business models and leading to new obstacles for the enforcement of competition law. For example, 'zero-price' services such as social media [12] require considerations beyond monetary repercussions to customers. GAFAs business models are now increasingly platform-based, acting as intermediaries that facilitate transactions between different user groups. They serve different sets of users in different ways, with different pricing models for each [15]. Additionally, they are no longer confined to a single industry. For example, Amazon's e-commerce business places it in the traditional industries of retail, logistics, manufacturing and advertising, whilst also having a completely different business model as an online marketplace of physical and virtual goods, along with its software businesses. Similarly, Google operates in the sectors of internet search, advertising, software development and analytics, to name but a few. Companies no longer operate in industries, but ecosystems.

This makes it difficult to (a) define a particular market, and (b) establish a company's position in it from a revenue perspective, especially with the 'zero-price' nature of digital services [12] (such as social media, retail product comparisons and travel booking searches), which compete for customers' attention rather than their money. In the absence of clear revenue gains, identifying a dominant market player or defining collusive behaviour is significantly more difficult. This complexity is compounded by the fact that GAFAs companies, which often own the largest online platform marketplaces, also compete in them. Thus, a creative and flexible approach is required to justify the application of competition frameworks to digital markets.

The EU released a report on how competition policy should evolve for the digital era in April 2019, which concluded that while the existing legal framework of competition law was still sufficient, enforcement methods would need re-thinking to keep pace with the digital economy [16]. It is also the most active jurisdiction in bringing regulatory action against technology firms. According to a global Hogan Lovells survey on proposed digital regulation, 49% of the 452 entries recorded for the first half of 2019 were from the EU, with the US

displaying its recent surge in digital regulation in second place at 28%. Antitrust regulation was the largest category overall, with 26% of the total proposals being competition-related [17].

Notable Cases

Google has been the subject of three high-profile EC investigations so far: Google Shopping in June 2017 [3], Google Android in July 2018 [4], and Google AdSense in March 2019 [5]. In all three cases, it was charged with abuse of dominance and fined by the EC under TFEU 102. In the Android decision, Google was charged with restrictive practices for demanding pre-installation of proprietary apps on devices using the Android operating system [4]. The AdSense decision found the company guilty of forcing third-party websites using its advertising service to do so exclusively and prominently [5]. The Shopping case acknowledged Google's dominance in the online search market but penalised it for abusing this position in a supplementary market, i.e. the online shopping comparison market, by prioritising its own results above those of its competitors [3].

The validity of these claims has been disputed in the legal community, and critics stress the necessity of establishing a firm causal link between simply being in a dominant position and being found guilty of abusing it [18]. In this matter, the Android and AdSense cases were potentially stronger [18], as Google's restrictive practices in the first and insistence on exclusivity in the second broadly fit the criteria for anti-competitive conduct.

The Shopping case is more contentious. It penalised Google for abusing its position in a different market than the one it was claimed to be dominant in, which made the causal link between the two less clear. Google has stated that not only were its own results marked as 'advertisements' [18], but online marketplaces such as Amazon and eBay are equally prominent in this regard and therefore competition was enforceable with a single click, given the 'zero-price' nature and subsequent low switching costs of the market in question [19, 20].

It is important to view the three cases discussed above in the context of the limitations of the

EU's jurisdiction as well as the scale at which companies like Google operate. The EU has an administrative enforcement system. For competition cases, this is led by the EC, whose role is to investigate cases, announce a decision (and/or a settlement) and propose remedies, which the defendant can then accept or appeal [10]. By contrast, other jurisdictions such as the United States (US) have a more adjudicative system, with both parties (the investigating agency and the defendant) presenting their case and remedies and/or penalties being decided by the courts. The former relies more on financial sanctions, while in the latter criminal sanctions are also a realistic possibility [21]. However, the EC's fines are capped at 10% of a company's global annual turnover, and within that, to 30% of revenue related to the infringement multiplied by years of participation [22]. While this still allows the EC to levy fines in billions of euros, it is important to consider whether this has significant impact, given the scale of the companies involved. For instance, Alphabet (Google's parent company) listed the €4.34 billion Android fine (a mere 3.7% of Google's annual revenue) under standard costs and expenses in its 2018 annual statement [23]. This renders the effectiveness of financial sanctions on the multi-billion dollar GAFA companies questionable.

Another notable case, albeit at the Member State level, is the German Federal Cartel Office's (FCO) abuse of dominance decision against Facebook in February 2019. The FCO found Facebook's collection and leveraging of user data beyond its own website to be an abuse of its dominance as a social network. In a landmark ruling, the Düsseldorf Higher Regional Court (the first court of appeal) suspended this decision, stating that even if Facebook was found to have violated data protection law by its actions, it did not automatically constitute anti-competitive conduct simply due to its dominant position [24]. Investigations conducted by Member State NCAs such as the FCO are important as they can supplement current or upcoming EC cases if they are investigating the same company, which gives the EU's antitrust investigations a level of coordination that is absent from other jurisdictions [9].

Currently, Amazon is being investigated [1] for its dual role as a retailer in its own marketplace, i.e.

selling goods on a platform that the company itself owns. The EC is investigating whether it has used confidential data from retailers on its platform to its advantage (to price its own products lower and position them better in searches), either by abusing its position over them (TFEU 102) or by colluding with them (TEFU 101) [25]. This case is similar to Google's cases in that both these companies are online gatekeepers as well as market players i.e., they control the very interfaces that they compete in. It also has parallels to Facebook's case where the alleged anti-competitive behaviour stems from infringement of protected data. However, in Amazon's case, the causal link to abuse of dominance would be more direct than Facebook's case, as the data was allegedly used to directly undermine competitors [26]. In many of these notable cases against different GAFA firms, conducted by different authorities across the EU and worldwide, comparisons can be drawn. This helps give weight to the argument that it is possible to develop a more standardised global framework to help different jurisdictions, even beyond the EU, to effectively regulate competition in digital markets.

Role of institutions

The EU's competition rules are applied and enforced by the authority of the EC. Within the EC, the Directorate-General (DG) Competition is the department responsible for direct enforcement. It can open investigations on its own initiative or based on complaints registered. Based on the result of the investigations, the EC can prohibit the discovered anti-competitive conduct, impose fines, and require remedial actions. For example, in the AdSense decision, the EC stated that Google had ceased the problematic conduct by that time [5], and in the Shopping and Android decisions, Google was given 90 days to cease the stated conduct or face penalty payments of up to 5% of Alphabet's average daily global turnover [3, 4].

The EC usually investigates cases that impact three or more Member States, or where the situation necessitates an EU-level precedent. Cases involving dominant technology platform companies like GAFA usually fulfil both criteria (Google was concluded to possess over 90% market share

in most or all EEA countries). For cases within a Member State or between two of them, the respective NCAs are better suited and can independently enforce competition rules in their respective jurisdictions [2, 10]. This is reflected in recent independent NCA investigations, such as the German FCO's Facebook decision [24] and the 2018 and 2019 investigations into Amazon initiated by the FCO [27] and the Austrian Federal Competition Authority (FCA) [28] respectively. Should the EC initiate proceedings into the subject of an NCA investigation on the same charge, the respective NCA will lose its authority to investigate further to the EC (although it can pursue parallel investigations) per Regulation 1/2003 [9].

The EU's General Court and the (higher) Court of Justice of the European Union (ECJ) have the power to annul or modify EC decisions. Companies and Member State governments periodically launch appeals against EC decisions and have sometimes seen successful outcomes in the past [2]. National courts have the same power for decisions by respective NCAs, as seen in Facebook's success with an interim decision in the Düsseldorf Higher Regional Court. However, final decisions in both cases are expected to take considerable time, and challenging complex EC decisions of magnitude is a lengthy and drawn out procedure. For example, Google has appealed the EC's decision in each of its cases, with the hearings for the first case, Google Shopping, starting in February 2020 [29], almost 10 years after the investigation was first opened. The decision could take years, and in the meantime, Google has to comply with the EC's decisions proposed remedies to limit anti-competitive conduct [30].

This system is thus far from ideal for the fast-moving digital ecosystem. The lack of precedence or any formal guidance that could serve as a reference further slows down the process, since most cases are treated as novel, and arguments already established in parallel (but not identical) cases have to be reformulated. Again, this is where a standardised enforcement framework for applying competition law to digital models is essential, both to the investigating authorities and to the organisation under investigation.

The impact of increased regulation

Antitrust investigations invariably involve a large number of stakeholders, both in industry and in government. As discussed above, 'Big Tech' firms operate in an ecosystem of multiple adjacent industries and have a huge global presence, with most of the market-leading digital platforms operating in over 100 countries. Furthermore, the EU's recent investigations have set precedents as they are the first of their kind into GAFAM firms, leading to divided public and legal opinions on the validity of some of the charges (such as the abuse of dominance charges in the Google Shopping and Facebook cases detailed above), and a series of appeals from the companies themselves. Thus, these investigations and their outcomes have a significant impact, not only on the parties directly involved (the EU governing bodies, Member State governments, firms and competitors) but also on other jurisdictions, consumer welfare groups, international competition policy organisations and the broader legal community.

The new EC of 2019 has made robust policy for digital markets a priority. President von der Leyen has stated as much in her agenda [31] and has charged Competition Commissioner Margrethe Vestager with the responsibility of shaping a 'Europe Fit for a Digital Age' [32]. The EU already leads globally in this regard, and its position as the first mover could lead to other national and international standards being framed accordingly. This is reflected in the various regional data protection regulations such as the California Consumer Privacy Act (CCPA) of 2020, that have been modelled after the EU's 2018 General Data Protection Regulation (GDPR) [17]. Thus, the cases discussed above are crucial not only in terms of their outcomes but in helping to create a blueprint to regulate digital and 'zero-price' business models.

However, the EU's agenda has been critiqued as tending towards protectionism and stretching competition law to target companies simply for being successful [33]. These critiques bear some thought given Commissioner Vestager's statements that the EC will consider more far-reaching tools such as 'interim measures' to force

companies to cease suspected anti-competitive behaviour during an investigation and not after, or shifting the burden of proof onto dominant companies to prove pro-competitive conduct [34, 35].

The heightened scrutiny on 'Big Tech' has also spurred other countries into action. Chief among them is the US, with multiple investigations against GAF A companies being launched in the last year at both the federal level by the Department of Justice (DOJ) and the Federal Trade Commission (FTC) and the state level by many state Attorneys General's (AGs) [32]. Digital regulation has also become a hallmark of many political platforms - a turnaround from the US's relatively minimalist approach so far [32]. The UK government has also stated that they are looking to adopt recommendations by the UK's Competition and Markets Authority (CMA) to enable effective regulation [36].

For the GAF A companies, the multitude of investigations requires them to be constantly vigilant for a change in the competition policy and the enforcement in any particular jurisdiction. They then have to adapt according to the investigations at hand to minimise potential fallout. For example, in 2015, Google restructured itself to create a holding company (Alphabet Inc.) and listed itself as a subsidiary. This enabled it to separate its chief revenue-generating arms of search and advertising from its other less crucial businesses [37]. Amazon agreed to amend its terms of service with sellers on its platform to appease the two Member State authorities investigating it [38]. GAF A companies are thus attempting to minimise potential fallout in various ways. While they are often successful since they have the capacity and resources to do so, it makes them less likely to cooperate with information-gathering or knowledge-sharing attempts should any government attempt them, as these can easily turn investigative in nature.

Another unintended consequence of a piecemeal approach to regulating digital competition is that the burden of increased and rapidly evolving regulation can fall disproportionately on smaller technology companies, as they lack the resources and public affairs experience to keep up [17]. Although many of these companies, especially European ones, were among those who filed complaints to start the GAF A investigations, by most

accounts the remedial measures are proving ineffective, with the 'Big Tech' companies finding workarounds and newer areas of expansion while simultaneously appealing every decision [39]. Thus, these companies might be benefited from industry partnerships, trade coalitions and advocacy groups instead of relying solely on regulatory frameworks.

Broader implications and conclusion

This shift to increased enforcement and vigilance in digital competition policy has long-lasting implications, both within the EU and globally. The national scope of regulation so far is especially concerning - per the aforementioned Hogan Lovells survey, 85% of all tracked proposals were at a national level [17]. Thus, a standardised global framework to help jurisdictions enforce competition policy is still a long way off. This is highly problematic since a long-term consequence could be global regulatory fragmentation, with different rules in different national digital markets. This can prove highly detrimental to global trade, especially where the sharing or exchange of data across jurisdictions is concerned, and could result in reduced choices for consumers. The international community needs to recognise that this is not a region-specific issue, and regional policing of digital ecosystems is therefore not a sustainable or an enforceable solution. Further, the EU should consider that an overly complex and drawn-out approach to enacting competition legislation is as difficult to enforce for them as it is for the companies in question to adhere to. As discussed above, GAF A companies are becoming increasingly adept at finding workarounds to sidestep any substantial changes or restrictions to their operating models and by extension, their revenue. This increases the potential for non-compliance and could realistically lead to more companies subverting the legal system if similar cases continue to be brought in this piecemeal fashion.

Authorities also need to remember that digital business models can vary and thus cannot be regulated using a single template, as it requires a ground-up approach to enforcement which is both

time-consuming and resource-intensive. Governments should, therefore, take an adaptable and inclusive approach to digital regulation. The EU cases against GAF A companies have proven that traditional remedies such as fines are unlikely to be a sustainable solution, and extreme remedies such as 'breaking up' large companies might serve little purpose other than to create a larger set of smaller monopolies, which would be even harder to regulate [23]. The true barrier to effective regulation, then, is a lack of transparency in the operating models of these firms as well as the precise legal violations that they have committed. Much of the divide in public opinion on GAF A companies stems from the complete opacity in their operations [40]. An alternative to the current case-by-case investigatory approach employed by individual jurisdictions could be to include technology companies in the global standardisation process, and foster compliance by design in digital products and services so that potential concerns are addressed from the onset. If a benchmark for regulatory compliance in digital ecosystems is established and accepted by both the regulators and the industry, then both new and existing products can be held accountable to it.

To conclude, since the EU is regarded as a trendsetter in technological regulation, it should leverage its influence to push for an inclusive and sustainable global framework to approach it. The EU's own legal and policy framework, both at a national and trans-national level, allows for a fair degree of coordination between multiple competition authorities, and can serve as a starting point in envisioning an inter-jurisdictional framework for the enforcement of competition policy in digital ecosystems. The rapid adoption of digital ecosystems globally has made global practices for adapting existing legal frameworks a necessity. Coupled with pragmatic and flexible enforcement, industry cooperation and a mechanism for inter-jurisdictional coordination, a global framework will be instrumental in preventing the regional fragmentation of digital ecosystems and the subsequent consequences to the global economy going forward.

© 2020 The Author. Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

References

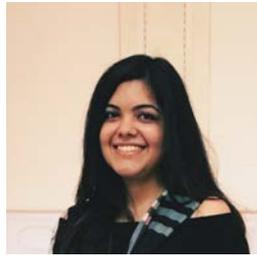
- [1] European Commission, "Commission opens investigation into possible anti-competitive conduct of Amazon," July 2019. [Online]. Available: https://ec.europa.eu/commission/presscorner/detail/en/ip_19_4291
- [2] Directorate-General for Communication (European Commission), "Competition: Making markets work better," 2014. [Online]. Available: <http://op.europa.eu/en/publication-detail/-/publication/9f857b2e-e25a-4fc3-9550-81a9de3b0429>
- [3] European Commission, "Commission fines Google €2.42 billion for abusing dominance as search engine by giving illegal advantage to own comparison shopping service," June 2017. [Online]. Available: https://ec.europa.eu/commission/presscorner/detail/en/IP_17_1784
- [4] —, "Commission fines Google €4.34 billion for illegal practices regarding Android mobile devices to strengthen dominance of Google's search engine," July 2018. [Online]. Available: https://ec.europa.eu/commission/presscorner/detail/en/IP_18_4581
- [5] —, "Commission fines Google €1.49 billion for abusive practices in online advertising," March 2019. [Online]. Available: https://ec.europa.eu/commission/presscorner/detail/en/ip_19_1770
- [6] Council of the European Union, "Consolidated version of the Treaty on the Functioning of the European Union," *Official Journal of the European Union*, C326, vol. 55, p. 47–390, 2012.
- [7] —, "Council Regulation (EC) No 139/2004 of 20 January 2004 on the control of concentrations between undertakings (the EC Merger Regulation)," *Official Journal of the European Union*, L 24, vol. 47, pp. 1–22, 2004.

- [8] —, “Council Regulation (EC) No 1/2003 of 16 December 2002 on the implementation of the rules on competition laid down in Articles 81 and 82 of the Treaty (Text with EEA relevance),” *Official Journal of the European Union, L 1*, vol. 46, pp. 1–25, 2003.
- [9] C. Gauer, L. Kjolbye, D. Dalheimer, E. De Smijter, D. Schnichels, and M. Laurila, “Regulation 1/2003 and the Modernisation Package fully applicable since 1 May 2004,” *Competition Policy Newsletter*, no. 2, pp. 1–6, 2004.
- [10] M. Szczepeński, “EU competition policy: Key to a fair single market,” October 2019. [Online]. Available: [https://www.europarl.europa.eu/RegData/etudes/IDAN/2019/642209/EPRS_IDA\(2019\)642209_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/IDAN/2019/642209/EPRS_IDA(2019)642209_EN.pdf)
- [11] P. Akman, “Competition policy in a globalized, digitalized economy,” December 2019. [Online]. Available: http://www3.weforum.org/docs/WEF_Competition_Policy_in_a_Globalized_Digitalized_Economy_Report.pdf
- [12] J. Newman, “Antitrust in zero-price markets: Foundations,” *University of Pennsylvania Law Review*, vol. 164, pp. 149–206, 2015.
- [13] R. Khemani and D. Shapiro, “Glossary of industrial organisation economics and competition law.”
- [14] D. Armentano, “The great electrical equipment conspiracy,” *Reason*, 1972.
- [15] T. Eisenmann, “Platform-mediated networks: Definitions and core concepts,” *Harvard Business School Module Note 807-049*, 2007.
- [16] J. Crémer, Y.-A. de Montjoye, and H. Schweitzer, “Competition policy for the digital era,” May 2019. [Online]. Available: <https://op.europa.eu/s/omif>
- [17] F. Schöning, M. Farquhar, and P. Watts, “A turning point for tech – global survey on digital regulation,” *Hogan Lovells Publications*, October 2019. [Online]. Available: https://www.hoganlovells.com/~media/hogan-lovells/pdf/2019/2019_10_30_tmt-final_05319-tmt-study-09-tw-digital.pdf
- [18] R. Hourihan and J. Finn, “Google and the six billion dollar fine(s): We have the technology, but do we have to rebuild the competition rules?” *Kluwer Competition Law Blog*, April 2019. [Online]. Available: <http://competitionlawblog.kluwercompetitionlaw.com/2019/04/18/google-and-the-six-billion-dollar-fines-we-have-the-technology-but-do-we-have-to-rebuild-the-competition-rules/>
- [19] J. Garside, “Google attacks Brussels antitrust case in 100-page response,” *The Guardian*, August 2015. [Online]. Available: <https://www.theguardian.com/technology/2015/aug/27/google-attacks-brussels-antitrust-case-european-commission-shopping-price-comparison>
- [20] K. Walker, “The European Commission decision on online shopping: the other side of the story,” *Google in Europe (Blog)*, June 2017. [Online]. Available: <https://blog.google/around-the-globe/google-europe/european-commission-decision-shopping-google-story/>
- [21] G. Erbach. (2014, March) EU and US competition policies: Similar objectives, different approaches. [Online]. Available: [https://www.europarl.europa.eu/RegData/bibliotheque/briefing/2014/140779/LDM_BRI\(2014\)140779_REV1_EN.pdf](https://www.europarl.europa.eu/RegData/bibliotheque/briefing/2014/140779/LDM_BRI(2014)140779_REV1_EN.pdf)
- [22] European Commission, “Competition: Commission revises Guidelines for setting fines in antitrust cases,” June 2006. [Online]. Available: https://ec.europa.eu/commission/presscorner/detail/en/IP_06_857
- [23] A. Griswold and A. Shendruk, “It will take more than big fines to tame Big Tech,” *Quartz*, November 2019. [Online]. Available: <https://qz.com/1744038/why-antitrust-fines-arent-enough-to-rein-in-the-tech-giants/>
- [24] R. Mackenzie, A. Dimitriou, D. Slater, and E. McNeill, “Round 2 to facebook: Landmark german data collection ban blocked by court,” *Ashurst Competition Law Newsletter*, September 2019. [Online]. Available: <https://ashurstcde.azureedge.net/~media/ashurst/documents/news-and-insights/legal-updates/2019/sep/ashurst-competition-newsletter-september-2019.pdf>

- [25] G. Prodhon and F. Chee, "Explainer: What is the EU's antitrust investigation into Amazon about?" *Reuters*, July 2019. [Online]. Available: <https://www.reuters.com/article/us-eu-amazon-com-antitrust-explainer-idUSKCN1UC24R>
- [26] T. Hoppner and P. Westerhoff, "The EU's competition investigation into Amazon's Marketplace," *Hausfeld Competition Bulletin*, November 2019. [Online]. Available: <http://dx.doi.org/10.2139/ssrn.3495203>
- [27] Federal Cartel Office (Bundeskartellamt). (2019, July) Bundeskartellamt obtains far-reaching improvements in the terms of business for sellers on Amazon's online marketplaces. [Online]. Available: https://www.bundeskartellamt.de/SharedDocs/Meldung/EN/Pressemitteilungen/2019/17_07_2019_Amazon.html
- [28] Federal Competition Authority. (2019, July) BWB informs: Amazon modifies its terms and conditions. [Online]. Available: https://www.bwb.gv.at/en/news/detail/news/bwb_informs_amazon_modifies_its_terms_and_conditions-1/
- [29] J. Espinoza, "Google stands firm in its appeal against €2.4bn shopping fine," *Financial Times*, 2020. [Online]. Available: <https://www.ft.com/content/a5c0a64c-4d9a-11ea-95a0-43d18ec715f5>
- [30] S. Dionnet and G. Zacharodimos, "Digital markets: recent competition law developments in the EU," *Financier Worldwide Magazine*, 2019.
- [31] U. v. d. Leyen. (2019, October) A Union that strives for more: My agenda for Europe: Political guidelines for the next European Commission 2019-2024. [Online]. Available: <https://op.europa.eu/s/omih>
- [32] B. Byrne, E. Ewing, P. Bock, C. Huang, and Y. Sun. (2020, January) Active Times for Antitrust. [Online]. Available: <https://www.clearygottlieb.com/news-and-insights/publication-listing/active-times-for-antitrust>
- [33] P. Todd, "'Big Tech' and competition law explained," *Legal Cheek*, October 2019. [Online]. Available: <https://www.legalcheek.com/lc-journal-posts/big-tech-and-competition-law-explained/>
- [34] S. Evans, T. Wilson, S. Jones, and A. Chandran, "2020 EU Antitrust Update," *Kirkland Alert*, March 2020. [Online]. Available: <https://www.kirkland.com/-/media/publications/alert/2020/kirkland-alert-2020-eu-antitrust-update--publicat.pdf>
- [35] M. Sandbu, "Is EU competition policy a drag on digital innovation?" *Financial Times*, December 2019. [Online]. Available: <https://www.ft.com/content/3185ca26-233a-11ea-b8a1-584213ee7b2b>
- [36] N. Parr, A. Dimitriou, M. Holzhäuser, and R. Allen, "Competition policy in the digital era: a comparative guide," *Ashurst Competition*, 2019. [Online]. Available: <https://www.ashurst.com/en/news-and-insights/legal-updates/comparative-guide-to-digital-competition-policy/>
- [37] A. Barr and R. Winkler, "Google creates parent company called alphabet in restructuring," *Wall Street Journal*, August 2015. [Online]. Available: <https://www.wsj.com/articles/google-creates-new-company-alphabet-1439240645>
- [38] S. Heinz, "Bundeskartellamt ends abuse probe after Amazon agrees to changing business terms for dealers," *Kluwer Competition Law Blog*, July 2019. [Online]. Available: <http://competitionlawblog.kluwercompetitionlaw.com/2019/07/30/bundeskartellamt-ends-abuse-probe-after-amazon-agrees-to-changing-business-terms-for-dealers/>
- [39] G. Sterling, "Google's EU shopping comparison rivals say their situation is getting worse," *Search Engine Land*, November 2018. [Online]. Available: <https://searchengineland.com/googles-eu-shopping-comparison-rivals-say-their-situation-is-getting-worse-308520>
- [40] J. Powles, "Europe is targeting Google under antitrust laws but missing the bigger picture," *The Guardian*, April 2015. [Online]. Available: <https://www.theguardian.com/technology/2015/apr/15/europes-targeting-google-under-antitrust-laws-missing-bigger-picture>

About the Author

Pranjali Gupta is a student in the MPhil in Technology Policy at the Cambridge Judge Business School. She has an undergraduate degree in engineering from



IIT Bombay, India, and has worked in software engineering, research roles and the non-profit sector prior to her MPhil. She is interested in shaping the impact of growing digitalization on public and private institutions and plans to explore solutions to growing security and privacy concerns raised by the increased adoption of AI technologies through public-private partnerships.

Conflict of interest The Author declares no conflict of interest.



International perspectives on mining rare earths: a case study in the Southern Jiangxi Province, China

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | PERSPECTIVE | REPORT | REVIEW

Colin Barnes

Centre for Energy, the Environment and Natural Resource Governance
University of Cambridge
crebarnes@gmail.com

ABSTRACT

The international profile of rare earth elements (REEs) has increased rapidly in recent years—highlighted by their importance in a wide range of applications including lasers, wind turbines, medical equipment, mobile phones, cars, electrical vehicles and defence equipment. Given the increasing demand for these minerals for crucial uses within the ‘green economy’, securing supply to the major consumers of REEs is essential. At the international level, the current dominance of China in known reserves, REE based processing, industries and international trade strengthens the country’s importance in geopolitical terms. This article provides a background to REEs at the international level, focussing on mining REEs in southern Jiangxi province in south east China and highlights the upcoming challenges faced by the sector.

Introduction

This article consists of two main sections: firstly the importance and geographical location of rare earth elements (REEs) globally will be discussed, and secondly the case study of an REE mining area in Dingnan county (Jiangxi Province) will be described; the case study [1] included field-work and work with a number of universities and government bureaux based in Nanchang, the capital of Jiangxi Province. A noticeable difference between REE mining in Dingnan county, as compared with REE mining in other countries including Australia and the US, is that in the

former mining has been carried out on populated areas with agricultural activities.

Rare earth elements (REEs)

Despite their name, REEs are commonly found in the Earth’s crust. However, the extraction of individual REEs via mining and processing is problematic and requires the use of potentially polluting chemicals. REEs comprise the 15 elements known as lanthanides and the transition metal yttrium (Figure 1). Scandium, another transition metal, is sometimes considered a REE

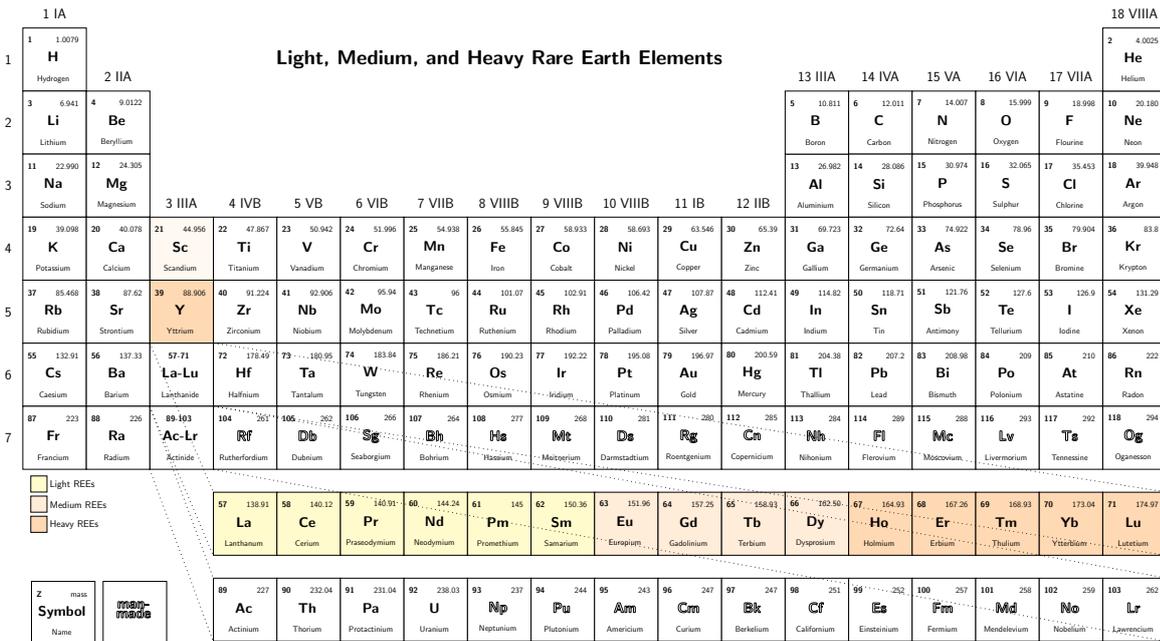


Figure 1: Periodic table showing heavy, medium, and light rare earths [1].

due to its presence in REE mineral deposits, but its status is subject to debate [1].

REEs are commonly divided into heavy (HREEs) and light REEs (LREEs) according to their atomic weights, and their association in mined deposits. For example, scandium and yttrium, which have a lower atomic weight than LREEs, are grouped with HREEs because of their paired electronic configuration: LREEs have unpaired electrons and HREEs have paired electrons [1]. Some divisions also include medium REEs (elements between europium and dysprosium).

The International context

The REE mining and processing industry continues to be not only an important part of the development and manufacture of high-end technologies, but also a geopolitical tool in an increasingly unstable and unpredictable global market. The high-end technologies referred to will mostly be related to the development of ‘green economy’ and the transition towards low-carbon economies. There are several comprehensive reviews within the REEs sector; for example, the report from the British Geological Survey which includes information on REE deposits worldwide, their extraction and processing routes, the specification of uses

in new technologies and substitutes, REE mining developments, and global trade [1]. Disruptions to supply chains caused by tariff changes and geopolitics pose important issues for the global REE economy [2].

Figure 2 shows estimates of the projected demand for REEs by end-use sector [2] and how the demand is divided across different REEs, while Table 1 summarises the overall demand for REEs by end-use sector [2, 3]. The existing and future demand for REEs is projected to increase, and the demand will be dominated by neodymium (Nd), terbium (Tb) and Dysprosium (Dy). These elements are required to manufacture magnets used in wind turbines and other applications for renewable energy globally.

There are two stages in the exploitation of REEs resources: the first is mining, which is mainly surface mining, and the second is the processing and extraction of individual REEs.

Figure 3 shows the overall distribution of REE mines, deposits and reserves globally. The main concentrations of these minerals are to be found in China and Australia, with other important reserves in Brazil, India, Malaysia, Russia and Vietnam.. Apart from these REE reserves, many other countries—like Burundi and Malawi, as well as Denmark (Greenland), Norway and Sweden—

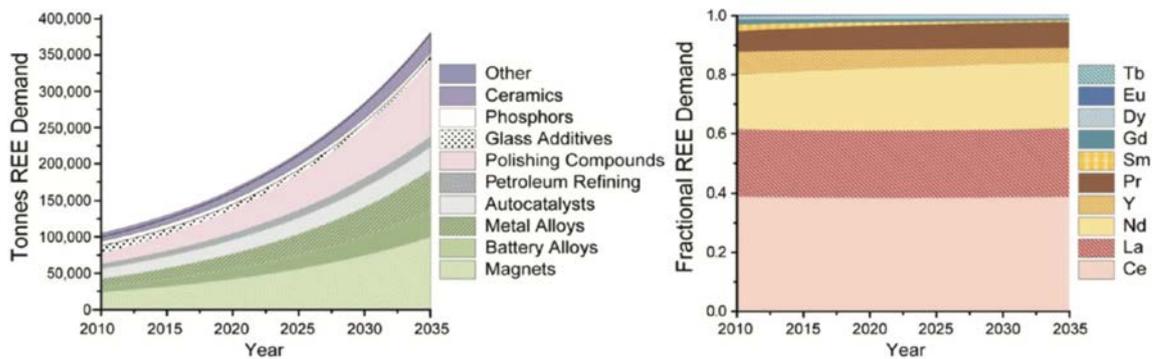


Figure 2: **Projected demand for REEs by end-use sector.** Reprinted with permission from [2]. Copyright 2020 American Chemical Society.

Table 1: Uses of key REEs by sector. *Italic*: REEs used in metallic state; **bold**: REEs used in oxidised state. Data from [3].

Sector	REEs	Uses
Phosphors	Eu, Y, Tb, Nd, Er, Gd, (Ce, Pr)	LED, lasers, flat panel display, fluorescent lamps, Xray imaging, optical sensors, fibre optics
Catalyst and Chemical Process	La, Ce, (Pr, Nd)	Petroleum refining, automotive catalysts, diesel additive, water treatment
Ceramics and Glass	Ce, La, Pr, Nd, Gd, Er, Ho	Polishing media, UV resistant glass, thermal glass, capacitors, sensors, colourants, refractories, fuel cells, super-conductors
Metal alloys	<i>Ce, La, Pr, Nd, Y</i>	NimH batteries, Superalloys, Al-Mg alloys, steel
Magnets	<i>Nd, Pr, Sm, (Tb, Dy)</i>	Motors and generators, HD drives, microphones and speakers, MRI machines, defence industry, magnetic refrigeration
Other		Fertilisers, pigments, nuclear energy, medical tracers

have these resources, but mining is currently exploratory or there is relatively small production. [4].

The dominance of China in the resourcing, mining and processing of REEs (Table 2) has increased the dependence of the rest of the world, particularly the US and the EU, who are the main importers, on REE supply from China. REEs are considered to be critical minerals and therefore of major importance to economic development and geopolitical strategy [5, 6]. Supply security is of crucial importance for the US [6], where REEs imported from China are employed in the defence industry. During the recent trade disputes between China and the US, China had threatened

to curtail REE exports to the US, highlighting the geopolitical power these elements have [7].

The US, EU and other major users of REEs are prospecting for alternative, non-chinese sources of REEs in a number of countries including Norway, Sweden, and more recently Greenland. Initial geological exploration indicates that there are considerable deposits of REEs in Greenland—in many cases associated with uranium—and this attracted investments from both Australian and Chinese companies¹. Exploitation may develop after environmental impact assessments have been carried out and the mining companies have received government approval.

¹Chinese companies are increasingly investing in REE mining and REE resources outside of China in order to better conserve some of the national REE resources.



Figure 3: Global mining of REEs. Reprinted from the US Geological Survey [4].

Environmental risks and REE mining

The environmental risks associated with mining REEs, as with other surface mining, are associated with air pollution and soil and groundwater contamination, with consequent impacts on local human populations, biodiversity, agriculture and other land use (Table 3). The presence of radioactive elements, notably thorium and uranium and other LREEs, is a further risk at the processing level (water leachate, formation of dust); however the overall risks from radiation are considered to be small. A review from Ault and colleagues discusses further environmental and social aspects of REEs industries [8].

Table 2: Current reserves of REEs worldwide (in metric tons of rare earths oxide equivalent). Data from the US Geological Survey [4].

Country	Reserves (<i>metric tons</i>)
China	44 Million
Brazil	22 Million
Vietnam	22 Million
Russia	12 Million
India	6.9 Million
Australia	3.4 Million
United States	1.4 Million

Process	Element	Risk	Hazard level
Mining	Open Pit	Land consumption	–
	Waste rock storage	Leachate of rain water into groundwater (e.g. heavy metal contamination)	Medium
	Damming	Tailing dam collapse due to poor construction, overtopping, seismic event	High
Milling and Flotation	Impoundment areas: water basins with extraction chemicals and tailings (small-sized particles with large surface area)	Leachate of rain water into groundwater (e.g. heavy metal and radioactive contamination)	High
		Land use Dust (e.g. heavy metal and radioactive contamination)	– Medium
Further processing	–	Air emission	Low
	–	Waste water	Low

Table 3: Ecological risks at different steps of REEs mining. Data adapted from [9].

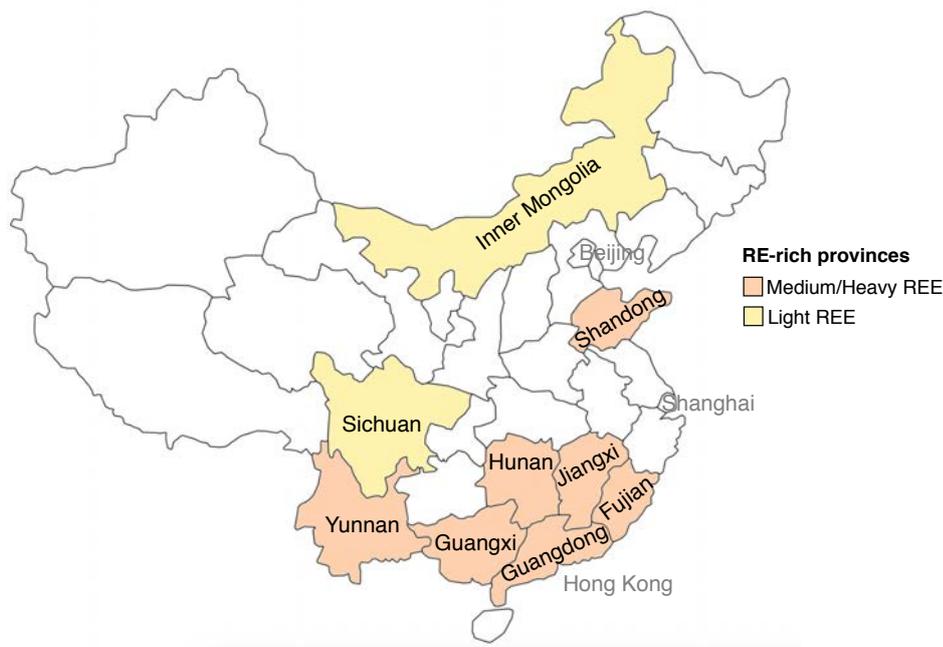


Figure 4: Chinese Provinces rich in REEs [10]. The class of the most extracted REEs is shown for each region.

REEs in China

The main deposits of REEs in China are found in the provinces of Fujian, Hainan, Jiangxi, Guangdong and Guangxi in South East China (Figure 4) [10, 11]. In 2016, a non-profit organisation called China Water Risk compiled a comprehensive review of the Chinese REE extraction sector and its future challenges, including assessments of the resource base, market share, and the history of illegal mining and its environmental consequences [10].

The central government in China produces export quotas for REE production by province (Figure 5), although in some cases these quotas are circumvented by illegal mining and exports. Illegal activities have been stopped in large part by central government policing [10]. This measure has led to a fall in REE production in China, which resulted in Chinese imports of some REE ores from the USA, Myanmar, and Vietnam.

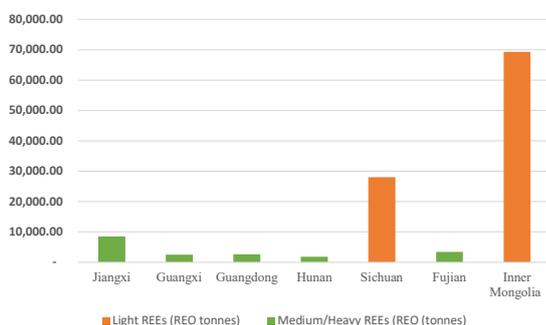


Figure 5: Control quotas for the production of REEs in China (2018) [12].

Rare earths mining in Jiangxi Province: background and costs

This section is based on survey fieldwork commissioned by the Asian Development Bank (ADB) and which was in part managed by the author in 2018 in Dignan county, which is located in the south of Jiangxi province, one of the most important centres of REE mining in the province. The contrast between REE mining in Dignan and other REE mining areas in northern China, Australia and the USA are the fact that the mining in Dignan County—now ceased after government intervention—was carried out in a populated area

with agriculture and other economic activities which were disrupted by REE mining.

The aim of the project in the Jiangxi province was to assess the impacts of REEs mining on the local physical, economic and ecological environments, as well as comparing the legal implications with other countries and international approaches to the remediation of mining areas. It was apparent that the remediation options for abandoned mines—including phasing and cost effectiveness—had not been comprehensively planned in the project area.

It is estimated that Jiangxi Province produces 38% of the total HREE and 50.3% of high grade REEs production in China [10]. These figures show how important REE mining and processing are to the Jiangxi and national economies via direct and indirect employment in mining and remediation: in fact, mining accounts for 4.4% of provincial GDP. The distribution of mining provincial GDP value by sub sector is shown in Figure 6.

The physical impacts of the REE surface mining in Ganzhou Prefecture (Jiangxi province) are illustrated in Figure 7, showing the the landscape before and after the mining activities. Estimates of the relationship between remediation costs and the sales income of the REEs industry in Ganzhou Prefecture in 2011 [14], show that while past remediation costs totalled US\$ 5.8 billion, the sales income of REEs was only US\$ 4.7 billion while the annual profit of Ganzhou's REEs industry was only US\$ 0.3 billion over 10 years.

Abandoned REE mine sites—in what is a mainly rural area—continue to offer challenges for central and peripheral provinces. The contamination of REE surface mining in China and its impacts on resources, the environment, and public health have been noted by several scientists in China and internationally [15–17].

Rare earths mining in Jiangxi Province: environmental impact

The main environmental impacts in the Jiangxi mining have been the movement of REE leachates from the surface mining into surface water courses and groundwater (Table 3). Contamination originated from both *in situ* mining and from tailing

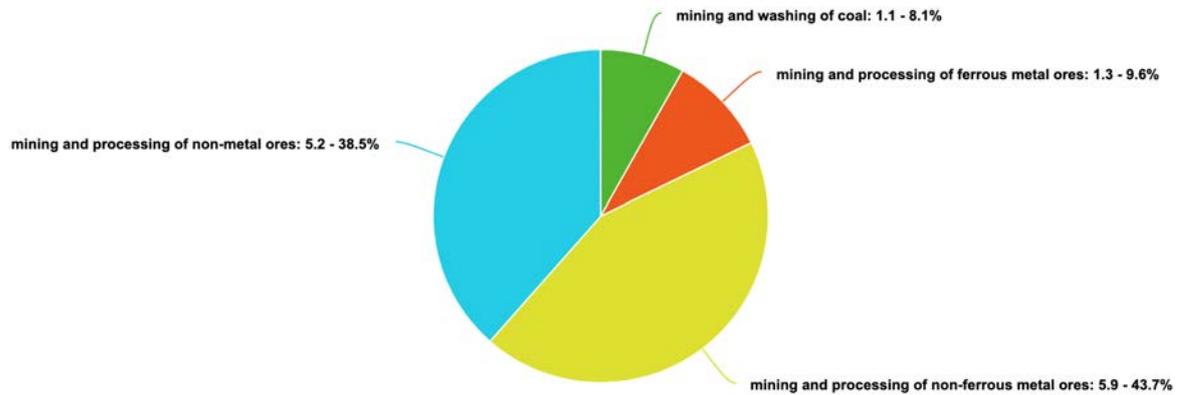


Figure 6: Contribution per extraction activity to the Jiangxi provincial GDP for the mining sector (13.5 Billion USD – 4.4 per cent of the total provincial GDP) [12].



Figure 7: Comparison of the satellite photo of a rare earth mine in Ganzhou before (April 2005) and after (February 2009) pool leaching and heap leaching processes are adopted (Source: [13]).

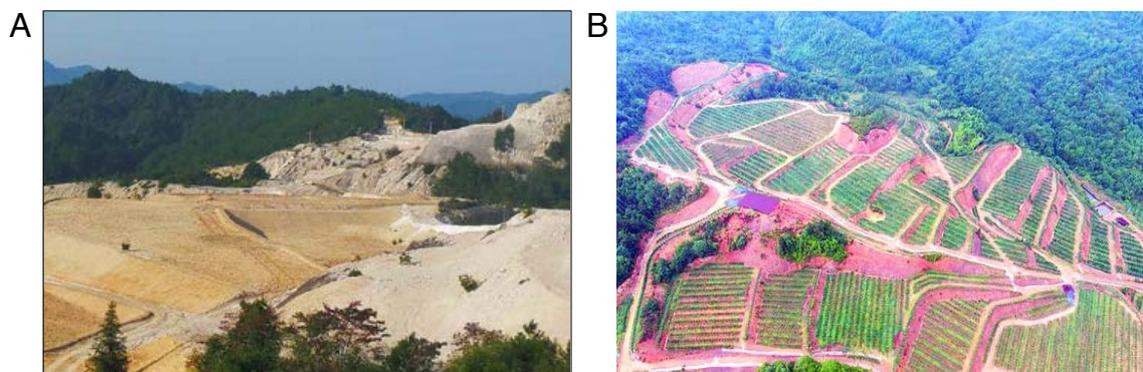


Figure 8: A) Heap leaching and a tailing site in Anyuan County, Ganzhou Prefecture. B) Bioremediation on abandoned REE mining areas in Jiangxi Province. Reproduced with permission from [12].

ponds; in one case, a potential cause may be the failure of a tailing storage dam. Additionally, the surface mining of REEs causes physical problems to the geography of the territory, including land slips, the loss of vegetation cover that results in soil erosion (Figure 8A), damage to crop production (specifically rice), and loss of biodiversity.

The impacts of REE mining in the Dingnan county and other counties in the Jiangxi Province go beyond the province's borders. The pollutants from REE mining in Jiangxi flow into the Ganjiang and Dongjiang rivers and from here into the Yangtze and Pearl rivers and other Chinese streams [10]. It is not yet clear how this impacts water quality, human and animal health and local economies beyond the mining region.

The concentration of dissolved REEs in the Ganjiang river is elevated when compared with the Chinese national average. In particular, the water concentration of europium (Eu), lanthanum (La), lutetium (Lu), samarium (Sm), terbium (Tb) and ytterbium (Yb) in REE mining areas ranged from 0.004 (Lu) to 2.412 (La) $\mu\text{g/L}$ [18]. These results emphasise the need for a regional and catchment approach to the management of REE mining and associated effluents [18].

Health impacts of REE surface mining

The impact of REEs on health has been linked to indirect atmospheric pollution from mining and associated inhalation [18, 19], as well as the presence of heavy metals in soils, which are often directly associated with REE mining [19].

Although the mining of REEs has been halted by government edict in Dingnan County, there are still some small pockets of illegal mining and the health impacts of the extraction activities still persist. Village surveys in Dingnan County show the views of respondents concerning health issues; 36.03% of respondents considered that the number of serious diseases—including various cancers—increased since the commencement of REE mining [12]. Exposure to contaminated water from surface and groundwater sources, as

well as atmospheric pollution from mining dust may have been REE-mining factors related to the surge of health issues².

Remediation of REE mining areas

Phytoremediation is an acknowledged approach to the remediation of mining areas [20], where vegetation is planted to extract and store heavy metals from the soil. In China the practice of phytoremediation, biochar (a charcoal-like substance derived from burning of biomass) [21] and associated remediation approaches is nationally widespread [12] and the challenges of mining and land remediation have been recognised [22].

Phytoremediation has been used in Dingnan and other counties of Jiangxi province to compensate for agricultural activities in a populated area where there is a predominance of heavy metals in the soils, common in REE mining areas. This involves planting certain species of trees, grasses and other flora. The plants used depend in part on the geochemistry of the soils which may affect the success of uptake [23, 24], for instance citrus trees have been used in Dingnan county (Figure 8B) [12]. The combined use of biochar in Dingnan county has been successful so far, however the success of these remediation operations depends on the planting of indigenous plants that are resistant to heavy metal contamination, while being suited to the local soil and climatic conditions.

Policy Issues and conclusions

The importance of REEs for green investments and the demand and supply balance for REEs globally has raised several policy issues in countries with the highest demand: these include the security of supply and the development of alternative raw materials as well as the policy issues relating to the environmental, economic and social aspects of REE mining.

The regulation of REE and other mining varies from country to country. In Europe, guidelines for

²The absence of historical health records for the local incidence of different diseases makes it difficult to prove causation between REE mining and different diseases.

best practice have been produced [25], however the exploitation of REEs is still at the exploratory stage; in China, the application of environmental legislation is not always effective, because it is unclear and depends on the monitoring of mining exploitation. It is also generally recognised that pre-mining environmental impacts assessments (EIAs) are important before and during mining activities.

Measures need to be taken to lessen the EU and USA reliance on the current main source of supply in China. Alternatives to REEs are also being used and developed in a number of research institutes. These alternatives include cerium – cobalt compounds (CeCO_3) and cobalt compounds with iron germanium (Fe_3Ge) for use in batteries for electrical vehicles. There is also research on the use of copper (Cu) as a potential replacement for REEs in rotating machines and direct drive generators in wind turbines. A further line of research is the recycling of REEs. The feasibility of alternatives will also depend on their cost effectiveness and the quality of performance in applications, as compared with the mining of widely diffused REEs, such as neodymium (Nd) and Dysprosium (Dy) [1]. Green economic development will also depend on the extent to which countries can use alternative sources to REEs for low-carbon applications.

Acknowledgements

The author would like to express his appreciation for the people and institutions who have contributed to this article. They include Professor Frances Wall and Dr. Robert Pell of the Camborne School of Mines at Exeter University, Dr. Kristin Vekasi at the University of Maine and Dr. David O'Connor, Department of Environmental Engineering, Tsinghua University, as well as the Jiangxi case study team: Zhouhui Huang (NAREE Ltd), Professor Yiding (Jiangxi University of Science Technology), Professor Xia Gong (Jiangxi Agricultural University), Associate Professor Luo Xiaojuan (Jiangxi Normal University), Li Zhimeng (Jiangxi Academy of Social Sciences, PRC Committee for Nanchang, Jiangxi Province), and Annabelle Giorgetti (environmental economist with the Asian Development Bank).

© 2020 The Author. Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

References

- [1] British Geological Survey, “Rare Earth Elements,” June 2010. [Online]. Available: http://nora.nerc.ac.uk/id/eprint/12583/1/Rare_Earth_Elements_profile.pdf
- [2] E. Alonso, A. M. Sherman, T. J. Wallington, M. P. Everson, F. R. Field, R. Roth, and R. E. Kirchain, “Evaluating rare earth element availability: A case with revolutionary demand from clean technologies,” *Environmental science & technology*, vol. 46, no. 6, pp. 3406–3414, 2012.
- [3] EuRare, “What are rare earth elements?” 2017. [Online]. Available: <http://www.eurare.eu/RareEarthElements.html>
- [4] K. J. Schulz, J. H. DeYoung, R. R. Seal, and D. C. Bradley, *Critical Mineral Resources of the United States: Economic and Environmental Geology and Prospects for Future Supply*. US Geological Survey, 2018.
- [5] S. Kalantzakos, *China and the geopolitics of rare earths*. Oxford University Press, 2017.
- [6] —, “The geopolitics of critical minerals,” *Istituto Affari Internazionali*, 2019. [Online]. Available: <https://www.iai.it/sites/default/files/iaip1927.pdf>
- [7] Reuters, “U.S. dependence on China’s rare earth: Trade war vulnerability,” Jun 2019. [Online]. Available: <https://www.reuters.com/article/us-usa-trade-china-rareearth-explainer/u-s-dependence-on-chinas-rare-earth-trade-war-vulnerability-idUSKCN1TS3AQ>
- [8] T. Ault, S. Krahn, and A. Croff, “Radiological impacts and regulation of rare earth elements in non-nuclear energy production,” *Energies*, vol. 8, no. 3, pp. 2066–2081, 2015.
- [9] Öko-Institut e.V., “Study on rare earths and their recycling,” *Final Report for The*

- Greens/EFA Group in the European Parliament*, January 2011. [Online]. Available: https://bit.ly/REE_recycl_oko
- [10] China Water Risk, “Rare earths: shades of grey,” June 2016. [Online]. Available: <http://www.chinawaterrisk.org/wp-content/uploads/2016/08/China-Water-Risk-Report-Rare-Earths-Shades-Of-Grey-2016-Eng.pdf>
- [11] W. M. Morrison and R. Tang, “China’s Rare Earth Industry and Export Regime: Economic and Trade Implications for the United States,” *Congressional Research Services Report*, April 2012. [Online]. Available: <https://fas.org/sgp/crs/row/R42510.pdf>
- [12] NAREE Ltd and Naree International, “Improving Ecological Protection and Poverty Alleviation Outcomes in the Mining Area in Ganzhou, Jiangxi: Technical Assistance (Asian Development Bank),” *Consultant’s Report to the Jiangxi Committee of the Chinese Political Consultative Conference*, December 2017. [Online]. Available: <https://www.adb.org/sites/default/files/project-documents/51013/51013-001-tar-en.pdf>
- [13] W. Guo, “The rare earth development can no longer overdraw ecological cost.” *China Environment News*, 2012.
- [14] X. J. Yang, A. Lin, X.-L. Li, Y. Wu, W. Zhou, and Z. Chen, “China’s ion-adsorption rare earth resources, mining consequences and preservation,” *Environmental Development*, vol. 8, pp. 131–136, 2013.
- [15] G. Pagano, M. Guida, F. Tommasi, and R. Oral, “Health effects and toxicity mechanisms of rare earth elements—knowledge gaps and research prospects,” *Ecotoxicology and environmental safety*, vol. 115, pp. 40–48, 2015.
- [16] X. Huang, G. Zhang, A. Pan, F. Chen, and C. Zheng, “Protecting the environment and public health from rare earth mining,” *Earth’s Future*, vol. 4, no. 11, pp. 532–535, 2016.
- [17] K.-T. Rim, “Effects of rare earth elements on the environment and human health: a literature review,” *Toxicology and Environmental Health Sciences*, vol. 8, no. 3, pp. 189–200, 2016.
- [18] T. Liang, K. Li, and L. Wang, “State of rare earth elements in different environmental components in mining areas of China,” *Environmental monitoring and assessment*, vol. 186, no. 3, pp. 1499–1513, 2014.
- [19] N. Haque, A. Hughes, S. Lim, and C. Vernon, “Rare earth elements: Overview of mining, mineralogy, uses, sustainability and environmental impact,” *Resources*, vol. 3, no. 4, pp. 614–635, 2014.
- [20] C. Stephenson and C. R. Black, “One step forward, two steps back: the evolution of phytoremediation into commercial technologies,” *Bioscience Horizons: The International Journal of Student Research*, vol. 7, 2014.
- [21] D. O’Connor, T. Peng, J. Zhang, D. C. Tsang, D. S. Alessi, Z. Shen, N. S. Bolan, and D. Hou, “Biochar application for the remediation of heavy metal polluted land: a review of in situ field trials,” *Science of the total environment*, vol. 619, pp. 815–826, 2018.
- [22] L. Zhou, Z. Li, W. Liu, S. Liu, L. Zhang, L. Zhong, X. Luo, and H. Liang, “Restoration of rare earth mine areas: organic amendments and phytoremediation,” *Environmental Science and Pollution Research*, vol. 22, no. 21, pp. 17 151–17 160, 2015.
- [23] H. Li, L. Yang, and X. Wang, “Assessment of ecological security in Rare earth mining area based on PSR model,” *Journal of Applied Science and Engineering*, vol. 21, no. 1, pp. 9–16, 2018.
- [24] C.-M. Zhao, X. Shi, S.-Q. Xie, W.-S. Liu, E.-K. He, Y.-T. Tang, and R.-L. Qiu, “Ecological risk assessment of neodymium and yttrium on rare earth element mine sites in Ganzhou, China,” *Bulletin of environmental contamination and toxicology*, vol. 103, no. 4, pp. 565–570, 2019.
- [25] M. Keith-Roach, B. Grundfelt, L. O. Höglund, A. Kousa, E. Pohjolainen, P. Magistrati, V. Aggelatou, N. Olivieri, and A. Ferrari, “Environmental legislation and best practice in the emerging European rare earth element industry,” in *Rare Earths Industry*. Elsevier, 2016, pp. 279–291.

About the Author

Colin is a fellow at the University of Cambridge Centre for Energy, the Environment and Natural Resource Governance. He has a background in economics, environmental economics and



natural resources law and governance and international relations with most recently, degrees from the universities of Cambridge and Manchester. He has worked extensively in China, India, East and West Africa, Brazil and EU countries. His work in China has been in the regional environmental issues (Shaanxi province), the economics of water supply (Shanghai), engineering economics (Sichuan province), environmental economics and policy (Hainan province), marine pollution (Zhejiang province) and most recently, the economics and international legal aspects of rare earth and other mining (Jiangxi province).

Conflict of interest The Author declares no conflict of interest.

This page intentionally left blank.



Fracking in Colorado: Evidence, politics and policy change

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | PERSPECTIVE | REPORT | REVIEW

Zira Quaghe John

Department of Politics and International Studies
University of Cambridge
zqj20@cam.ac.uk

ABSTRACT

This communication examines fracking (an abbreviation for hydraulic fracturing) in Colorado, analysing the degree of alignment between problem definition, data and evidence, political narratives, and policy interventions, among stakeholders (including government, industry and environmental groups). The risks associated with fracking emerged as a policy problem in 2011 following increased fracking-related complaints in Colorado. After assessing the pattern of complaints, the government identified that fracking concerns were driven by a ‘fear of the unknown’, propagated by environmental groups, not by data and evidence on actual impacts. The state government intervened by establishing three key fracking-related regulations: Rule 205A (2011) requiring disclosure of chemicals used in the fracking process, Rule 604 (2013) extending distances of fracking operations from building and public facilities, and Rule 609 (2013) on stricter groundwater monitoring. At the start of the policy process, the varying political narratives on fracking did not align with existing data and evidence. However, after a series of deliberations between the government, industry, and environmental groups, stakeholders in Colorado reached a common agreement on policy interventions that eventually aligned with the basic problem definition.

Introduction and scope of study

This paper focuses on Colorado’s major policy changes that occurred in response to fracking concerns in 2011 and 2012. This analysis does not go into the debates on fracking-induced seismicity (or earthquakes) as it is beyond the scope of this research [1]; instead, the focus is on environmental and health impacts. Fracking in Colorado makes an interesting case for a policy analysis because it is a paradigmatic example of how frack-

ing reshaped energy production in the US. Oil production in Colorado stood at about 20-30 million barrels per year between 1990 and 2005. But after fracking took off in the early 2000s, Colorado’s production grew rapidly – reaching 177.8 million barrels in 2018 [2].

Fracking usually involves drilling an L-shaped wellbore cased with cement and steel, typically about two to three kilometers from the land surface. When the wellbore reaches the shale reserves, the casing is perforated using explosive

charges to create holes in the horizontal section of the casing. The actual fracking then occurs when a mixture of water (approximately 95%), sand (3% to 4.5%) and chemicals (0.5% to 2%) is pumped into the well under extremely high pressure. The fluid mixture runs through the casing and exits through the perforated horizontal sections into the shale rock. Sand particles in the fluid help in opening the shale rocks, while the chemicals help the oil and gas seep out back into the well casing. The fluids initially pumped into the well flow back out to the surface and are disposed of or treated. Then finally, the oil and gas is pumped back out of the well, from where it is transported for sale [3].

Fracking has undoubtedly reshaped the US and global energy landscape. The technique brought about the North American ‘shale boom’ in the early 2000s, enabling extraction of oil and gas previously unreachable using conventional methods [4]. Having both geological and technological advantages, the US seized the shale opportunity to increase its domestic energy production. For the first time since 1973, the US became a net exporter of energy in 2018, surpassing the likes of Saudi Arabia and Russia [5]. In reducing its dependence on foreign oil imports, the US was also able to strengthen both its energy security and reduce domestic energy [6].

Despite its transformative impact, debates on the costs and benefits of fracking in the US remain starkly polarised, as state governments have regulated fracking in varying ways prices [7]. It is rightly argued that fracking has deepened America’s reliance on fossil fuels and delayed transition to cleaner sources of energy, especially when compared to energy transition in the European Union

(EU) [6]. Citizens and environmental groups have pressured oil-producing states, including Colorado, Ohio, Oklahoma, and Texas, to implement stricter regulations on fracking [8]. Three states – Maryland, New York, and Vermont – went on to ban fracking [9]. But in the face of environmental push-back, fracking has continually increased across the main oil-producing states in the US [10].

Problem definition

In 2010, Colorado witnessed an increased number of fracking-related complaints to state and local government authorities. The complaints were triggered by three factors. Firstly, fracking operations began to increasingly migrate from sparsely populated areas towards new oil and gas discoveries in more densely populated areas (near parks, schools, and residential areas) around 2010 to 2011 [11]. The added visibility of oil and gas operations in Colorado contributed to increased complaints. Secondly, the Deepwater Horizon spill spotlighted environmental risks of oil and gas extraction and sparked public debate on fracking in Colorado and the US at large. Third, the release of *Gasland* in 2010, an anti-fracking documentary that popularised images of dangers associated with fracking,¹ triggered many residents to advocate against fracking [15]. By 2011, media attention and public complaints on fracking in Colorado further spiked; *it became apparent that the government needed to intervene*.

The Colorado government detected a mismatch between the problem definition (Table 1) and evidence. In analysing the nature of complaints, the government observed that residents were driven

¹ *Gasland*, an award-winning HBO documentary on fracking, provides a classic example of how storytelling and images can influence problem definition in public policy. *Gasland* provided a window through which many Americans would understand the risks associated with fracking. The documentary showcased experiences of residents in proximity to fracking operations, by narrating health problems that the residents traced to air and water contamination. Notably, the documentary showed that pipe borne water in some fracking communities were contaminated with chemicals and water from taps would flame up when the host lights a match close to the faucet [12]. It was no coincidence that policy action in Colorado and three other fracking states happened a year after the release of *Gasland*. Industry associations heavily criticised *Gasland* as ‘wildly inaccurate and irresponsible’ [13]. They argued that depth of oil reservoirs and water aquifers are thousands of feet apart, separated by impermeable rocks. Geologist further explained that any linkage between groundwater and oil would take hundreds or even millions of years to happen and is unlikely to be induced by fracking. An interdisciplinary report by MIT showed that the very rare incidents of water contamination caused by fracking were as a result of breach of existing regulations [14]. A rebuttal documentary called *FrackNation* was released in 2013, but did not attain *Gasland*’s popularity, nor did it help in re-shaping public views on fracking [15, 16].

Table 1: Problem definition on fracking in Colorado.

Problem definition	Fracking is risky and potentially harmful to public health and the environment.	
	INDUSTRY GROUPS	ENVIRONMENTAL GROUPS
Observed condition	The risks associated with fracking are being effectively managed. Incidents of pollution are as a result of bad practice, not because fracking is risky.	The risks associated with fracking outweigh the economic benefits because fracking is an inherently risky technique.
Desired condition	Fracking should continue (business as usual).	Fracking should be strictly regulated or banned.

by ‘fear of the unknown’, and not by actual impacts (or evidence) [17]. Indeed, the information gap between the industry and residents was a problem in itself. Environmental groups filled the information gap and were instrumental in shaping the debate on fracking at community level, essentially deepening existing distrust between communities and the oil industry [18, 19].

Data and Evidence on Causes and Consequences

Compelling research on the impacts of fracking on public health is only recently being documented. Several jurisdictions that have banned fracking, including the UK in November 2019, did so based on a so-called ‘precautionary principle’, aiming to avoid the *potential* risks of fracking altogether [20]. However, recent epidemiologic studies from John Hopkins University and the University of Pennsylvania showed that rates of hospitalisation were higher in areas with fracking activities, when compared with non-fracking communities [21, 22]. Similar studies in Colorado US have analysed the relationships between fracking and public health risks, but researchers are still yet to establish direct causal links [10, 23].

Despite the research gaps in the public health domain, there are known dangers associated with fracking. Out of the over 1,000 different chemicals used in the fracking process, about 75% are considered dangerous to human health [24]. The chemicals in fracking fluids (arsenic, formalde-

hyde, lead and mercury) are known to affect the nervous systems, cardiovascular systems, respiratory organs, and sensory organs (including the skin and eyes) [25]. Companies, however, argue that most of these chemicals only affect people upon direct exposure, which is highly unlikely for oil workers, and even more unlikely for residents. Environmental groups in Colorado oppose this view by arguing that the health risks for chemical toxins can take decades to manifest in persons affected and that health experts need time to confirm the dangers of fracking on residents [23]. Unlike health impacts, data and evidence on the environmental impacts of fracking are more readily available, as summarized in Figure 1.

Water pollution There are two ways fracking can potentially pollute groundwater. First, poorly constructed wells could lead to incidents where fracking fluids or oil and gas migrate into groundwater. Secondly, chemicals, oil, or gas could flow from the fracked shale rocks up into groundwater even when wells are perfectly cased [26]. But several geologic and hydrological studies have shown that the second risk is highly unlikely because shale oil and gas is well below groundwater layers and separated by rock [27]. According to Colorado’s oil sector regulator, oil and gas companies in Colorado reported 516 cases of spills or releases between 2013 and 2017, but none of the spillages affected public water systems [28].

Air pollution When oil and gas flow out of wells, most of the gas (in form of methane) is captured. But there are cases where methane (which traps more than 20 times more heat than CO₂ in

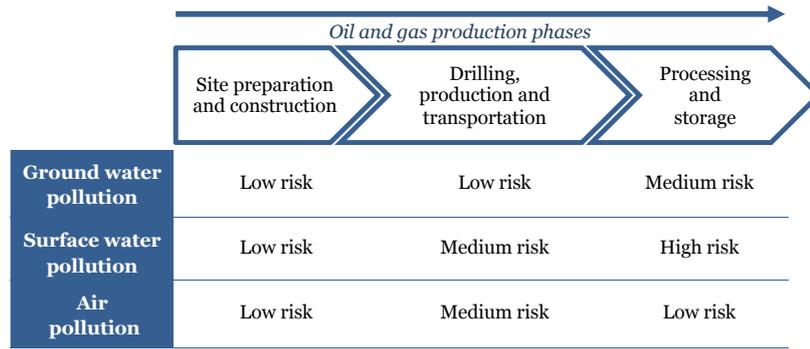


Figure 1: Pollution risk matrix.

the atmosphere) and other chemical gases such as benzene, escapes into the atmosphere during explosions or leak out of gas pipelines. These gases have strong greenhouse effects and pose health risks (such as asthma and skin disorders) upon direct or indirect exposure [22]. A 2017 study using data from Colorado’s environmental agency found that in 10 years, there were 116 fracking-related explosions in Colorado [29]. At an incidence rate of one in 3,700 active wells, air pollution risks are generally low by regulatory standards [28].

Political Narratives

Environmental Groups When fracking became a major policy issue in 2010, environmental groups downplayed the economic gains of fracking and focused on the health and environmental risks. Their political narrative combined ‘stories of power’ with ‘stories on change’ [30]. The ‘change’ narrative depicted the negative impacts associated with fracking, such as air pollution and water contamination. The ‘stories of power’ portrayed the government and companies as conspirators in environmental injustices. They argued that the governments and companies are aware of the risks associated with fracking, but kept it secret to maintain economic gains [31].

Industry Groups As shown in Figure 2 below, the industry groups showed low interest in addressing environmental concerns. However, as companies became more aware of the negative perceptions associated with fracking, they communicated that with proper regulation and safety measures, most of the risks associated with frack-

ing can be effectively mitigated [32]. Companies explained that fracking has been used in Colorado for over 40 years and that the process is engineered to ensure the safety of the environment and public health. To put the fracking process in context, an oil company once published that fracking occurs in depths about 10 times the tallest building in Denver, Colorado (7,000 ft.) [33]. Such descriptions aimed to allay fears that fracking occurs near aquifers.

State Government At the state level, fracking enjoyed bipartisan support in Colorado since the technique become widespread in the early 2000s. Governor John Hickenlooper, a former geologist and oil worker, was Governor of Colorado at the height of the fracking debate. The governor was an ideal ‘man in the middle’ because he was able to productively engage in the technical and non-technical discourse on fracking [34]. During Governor Hickenlooper’s time in office from 2011 to 2019, the government actively supported fracking. In fact, Governor Hickenlooper went as far as appearing on industry-sponsored advertisements [35]. Even though Governor Hickenlooper’s pro-fracking stance was sometimes criticised in the media, he generally enjoyed strong public support in Colorado, having previously served as Mayor of Denver from 2003 to 2011 [36].

Fracking is good for the country’s energy supply, our national security, our economy, and our environment.

- Gov. John Hickenlooper [33]

Local Governments The political narratives at local government levels are remarkably different from that of the state government. Local governments do not have strong incentives to support fracking because they do not benefit from corporate taxes paid by companies, but they are left to deal with negative externalities [37]. Longmont and Fort Collins went on to ban fracking at the county level in 2012 and 2013 respectively [38]. The ban brought about legal controversies that resulted in a Colorado Supreme Court decision to reverse fracking bans imposed by both local authorities, and effectively limited the authority of local governments to impose environmental regulations that go against laws by the State of Colorado [39].

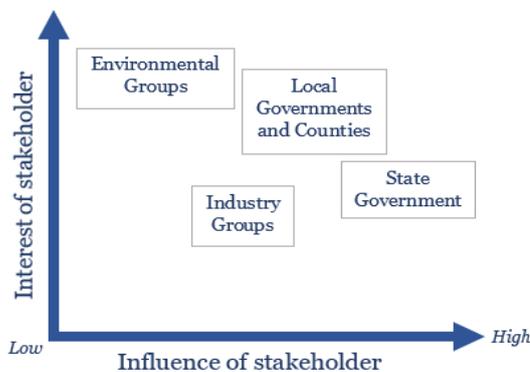


Figure 2: Stakeholder map showing level of interest and influence on fracking-related environmental impacts.

Policy Interventions

The Colorado Oil and Gas Conservation Commission (COGCC) has regulated environmental externalities of oil and gas activities in Colorado since its establishment in 1951. With the proliferation of fracking in the early 2000s, COGCC was drawn into the debate on fracking. COGCC approached fracking in a cautious and incremental manner, recognizing that even though fracking was controversial, compelling evidence on its impacts were still being researched and documented.

Colorado's policy process on fracking benefitted from legislative amendments to the Colorado Oil and Gas Conservation Act (COGCA) and the Colorado Habitat Stewardship Act (CHSA) in 2007 [40]. These amendments introduced deliberative and collaborative rule-making procedures

on environmental matters and allowed citizens or interested parties to file regulatory applications to COGCC [36]. Aside from the COGCA and CHSA amendments, Colorado handled fracking mainly as a regulatory issue via the COGCC, ensuring that specific regulations did not go through the Colorado legislature [41].

Following deliberative processes between the government, industry groups and environmental group, from 2010 to 2013, the COGCC established the three main regulations in response to fracking:

Rule 205A: Hydraulic Fracturing Chemical Disclosure (2011) [42] – The regulation requires companies to publicly disclose the types of chemicals, concentrations of chemical additives, and quantity of water used in fracking. The disclosure rule does not cover chemicals that are considered trade secrets, unless in situations where public health experts or regulators demand such proprietary information. Companies were mandated to publish the information on *FracFocus.org* to ensure transparency of operations.

Rule 604: Setback and Mitigation Measures for Oil and Gas Facilities, Drilling, and Well Servicing Operations (2013) [43] – This regulation addressed concerns about locating oil and gas drilling operations near homes, schools, parks, and other public facilities. Rule 604 now ensures that drilling cannot occur less than 500 ft (152.4 metres) from any building units, and not less than 1,000 (304.8 metres) ft from high-occupancy buildings. Under this regulation, companies are also required to conduct site-specific assessments prior to any drilling activities and ensure that any risks to public health or the environment are effectively mitigated.

Rule 609: Groundwater Baseline Sampling and Monitoring (2013) [44] – This regulation mandates testing of groundwater for toxins at various stages of well development. Even though Colorado already had some localised groundwater testing rules, Rule 609 brought about a more comprehensive groundwater-monitoring program. For baseline water assessment, companies must collect samples of groundwater from within 800 m of the well. Companies will then test for contamination

within six months to one year of commencing production, and then after 5 to 6 years to check for short or long-term contamination of groundwater.

Conclusion

The enactment of Rules 205A, 604, and 609 were considered victories by both the government, industry associations, and environmental groups. Outlined below are key factors that occasioned policy change on fracking in Colorado, and ensured policy alignment:

Regulatory approach The state government wisely calculated that it would be better to find a regulatory solution to the fracking issue else it could become politicised. This was especially crucial for Rule 205A which was passed in the run-up to Colorado's 2012 elections. The rationale for finding a regulatory solution was to avoid a situation where the fracking would enter the state legislature's agenda and become politically divisive to the detriment of evidence-based decision-making [36].

Policy entrepreneurship Former Colorado Governor, John Hickenlooper is considered a policy entrepreneur [45] because his political messaging assured residents that with strong regulation fracking was safe and economically beneficial to the state (primarily in tax revenue and job creation). The former governor also played an instrumental role in building trust between the industry and residents, by encouraging industry groups to disclose chemicals used in the fracking process to demonstrate beyond doubt that their chemicals are not harmful to the environment [34].

Policy diffusion Experiences from other oil-producing states influenced Colorado's rules on fracking, in line with political theory on 'policy diffusion'. Policy diffusion happens when policy choices in a given area is influenced by that of other jurisdictions [46]. Between 2010 and 2011, industry groups in Arkansas and Texas reached fracking disclosure agreements with environmental groups [37]. Therefore, Colorado also benefited from the existence of disclosure models and found ways to adapt the rules to the state's geology, geography, and residential characteristics.

Analysis of Colorado's fracking policies shows that environmental and industry groups altered their views on fracking over time. As the policy process progressed, environmental interests increasingly converged and stakeholders established some common understanding to facilitate policy change [41]. For example, the misinformation that fracking poisoned underground water was later revised by environmental groups [36]. On the industry side, companies relaxed their position on setbacks and chemical non-disclosure, realizing that keeping chemical compositions as trade secrets only worsened public perceptions on fracking [38]. For this reason, *it is plausible to conclude that the policy interventions aligned to a great extent with the problem definition and available evidence on fracking.*

© 2020 The Author. Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

References

- [1] J. L. Rubinstein and A. B. Mahani, "Myths and facts on wastewater injection, hydraulic fracturing, enhanced oil recovery, and induced seismicity," *Seismological Research Letters*, vol. 86, no. 4, pp. 1060–1067, 2015.
- [2] US Energy Information Administration, "Colorado field production of crude oil (thousand barrels)," Apr 2020. [Online]. Available: <https://bit.ly/ColOilBrl>
- [3] G. E. King, "Hydraulic fracturing 101: what every representative, environmentalist, regulator, reporter, investor, university researcher, neighbor and engineer should know about estimating frac risk and improving frac performance in unconventional gas and oil wells," in *SPE Hydraulic Fracturing Technology Conference, 6-8 February, The Woodlands, Texas, USA*. Society of Petroleum Engineers, 2012. [Online]. Available: <https://doi.org/10.2118/152596-MS>
- [4] L. Maugeri, *The shale oil boom: a US phenomenon*. Harvard Kennedy School, Belfer Center for Science and International

- Affairs, 2013. [Online]. Available: <https://www.belfercenter.org/sites/default/files/legacy/files/USShaleOilReport.pdf>
- [5] B. Brown and A. Kahan, "The U.S. leads global petroleum and natural gas production with record growth in 2018," *US Energy Information Administration: Today in energy*, August 2019. [Online]. Available: <https://www.eia.gov/todayinenergy/detail.php?id=40973>
- [6] World Energy Council and Oliver Wyman, "World Energy Trilemma Index 2019," 2019. [Online]. Available: https://www.worldenergy.org/assets/downloads/WETrilemma_2019_Full_Report_v4_pages.pdf
- [7] Natural Resource Defense Council, "Policy Basics: Fracking," Feb 2013. [Online]. Available: <https://www.nrdc.org/sites/default/files/policy-basics-fracking-FS.pdf>
- [8] W. J. Brady and J. P. Crannell, "Hydraulic fracturing regulation in the United States: The laissez-faire approach of the federal government and varying state regulations," *Vermont Journal of Environmental Law*, vol. 14, p. 39, 2012.
- [9] J. Pless, *The Fracking Debate: A Policymaker's Guide*. National Conference of State Legislatures, April 2012. [Online]. Available: <https://bit.ly/Pless2012>
- [10] Environment America Research and Policy Center, "Fracking by the Numbers: The Damage to Our Water, Land and Climate from a Decade of Dirty Drilling," April 2016. [Online]. Available: <https://bit.ly/earpc2016>
- [11] M. Frondel, M. Horvath, and C. Vance, "The US Fracking Boom: Impacts on Global Oil Prices and OPEC," in *International Association for Energy Economics: IAEE Energy Forum. Second Quarter of 2018*.
- [12] US Senate Committee on Environment and Public Works (Minority), "Setting the Record Straight: Hydraulic Fracturing and America's Revolution," October 2014. [Online]. Available: <https://bit.ly/SenateFrac2014>
- [13] Independent Petroleum Association of America, "Debunking GasLand," November 2011. [Online]. Available: <https://www.energyindepth.org/wp-content/uploads/2011/11/Debunking-Gasland.pdf>
- [14] Massachusetts Institute of Technology Energy Initiative, "The Future of Natural Gas," 2011. [Online]. Available: <https://energy.mit.edu/wp-content/uploads/2011/06/MITEI-The-Future-of-Natural-Gas.pdf>
- [15] J. D. Taillant, M. Glaub, and S. Buck, *Human Rights and the Business of Fracking: Applying the UN Guiding Principles on Business and Human Rights to Hydraulic Fracturing*. The Center for Human Rights and Environment, August 2015. [Online]. Available: <https://www.ohchr.org/Documents/Issues/Business/ForumSession4/FrackingAndUNGPs.pdf>
- [16] M. Hand, "'FrackNation' adopts Michael Moore's filmmaking style to rebut 'Gasland,'" *University of Colorado (Boulder) Undergraduate Honors Thesis*, January 2013. [Online]. Available: <https://bit.ly/FrackNation2013>
- [17] S. S. Ryder and P. M. Hall, "Space, place, and spatial inequality: Fracking and split estates in Colorado," *Paper presented at American Sociological Association annual meetings, San Francisco, August 17, 2014*.
- [18] Western Resource Advocates, "Fracking Our Future: Measuring Water and Community Impacts from Hydraulic Fracturing," June 2012. [Online]. Available: <https://westernresourceadvocates.org/publications/fracking-our-future/>
- [19] G. Stringer, "'Frack Off!' Strategic Framing in Colorado's Grassroots Challenge to Oil and Gas," *University of Colorado (Boulder) Undergraduate Honors Thesis*, 2017. [Online]. Available: https://scholar.colorado.edu/concern/undergraduate_honors_theses/2v23vt868
- [20] UK Government Press Release, "Government ends support for fracking," November 2019. [Online]. Available: <https://www.gov.uk/government/news/government-ends-support-for-fracking>
- [21] J. A. Casey, D. A. Savitz, S. G. Rasmussen, E. L. Ogburn, J. Pollak, D. G. Mercer, and B. S. Schwartz, "Unconventional natural gas

- development and birth outcomes in Pennsylvania, USA,” *Epidemiology*, vol. 27, no. 2, p. 163, 2016.
- [22] S. G. Rasmussen, E. L. Ogburn, M. McCormack, J. A. Casey, K. Bandeen-Roche, D. G. Mercer, and B. S. Schwartz, “Association between unconventional natural gas development in the Marcellus Shale and asthma exacerbations,” *JAMA internal medicine*, vol. 176, no. 9, pp. 1334–1343, 2016.
- [23] L. M. McKenzie, J. Crooks, J. L. Peel, B. D. Blair, S. Brindley, W. B. Allshouse, S. Malin, and J. L. Adgate, “Relationships between indicators of cardiovascular disease and intensity of oil and natural gas activity in Northeastern Colorado,” *Environmental research*, vol. 170, pp. 56–64, 2019.
- [24] T. R. Fetter, “Fracking, Toxics, and Disclosure [unpublished manuscript],” August 2017. [Online]. Available: <https://sites.duke.edu/trfetter/files/2016/11/fracking-toxics-disclosure.pdf>
- [25] M. Warhurst and G. Buck, “Fracking pollution: How toxic chemicals from fracking could affect wildlife and people in the UK and EU,” June 2015. [Online]. Available: <https://www.chemtrust.org/wp-content/uploads/chemtrust-fracking-briefing-june2015.pdf>
- [26] Food & Water Watch, “Fracking in Colorado: Illusory benefits, hidden costs,” August 2013. [Online]. Available: <https://bit.ly/fww2013>
- [27] US Department of Energy, Office of Fossil Energy, “Modern shale gas development in the United States: A primer,” April 2009. [Online]. Available: https://www.energy.gov/sites/prod/files/2013/03/f0/ShaleGasPrimer_Online_4-2009.pdf
- [28] Colorado Oil and Gas Conservation Commission, “COGCC 2017 Annual Report,” December 2017. [Online]. Available: <https://bit.ly/cogcc17rep>
- [29] B. D. Blair, L. M. McKenzie, W. B. Allshouse, and J. L. Adgate, “Is reporting “significant damage” transparent? assessing fire and explosion risk at oil and gas operations in the united states,” *Energy research & social science*, vol. 29, pp. 36–43, 2017.
- [30] D. Stone, *Policy Paradox: The Art of Political Decision Making*. W. W. Norton & Company, 2012.
- [31] S. Clancy, F. Worrall, R. Davies, and J. Gluyas, “The potential for spills and leaks of contaminated liquids from shale gas developments,” *Science of the Total Environment*, vol. 626, pp. 1463–1473, 2018.
- [32] Colorado Rising Action, “Hickenlooper’s Energy Hypocrisy,” February 2019. [Online]. Available: <https://coloradorisingaction.org/919-2/>
- [33] Anadarko Petroleum Corporation, “Colorado fracking factsheet,” 2011. [Online]. Available: https://www.anadarko.com/content/documents/apc/news/Fact_Sheets/Colorado_Fracking_Fact_Sheet.pdf
- [34] Z. Patton, “John Hickenlooper: The Man in the Middle,” *Governing (the future of States and Localities)*, Jul 2014. [Online]. Available: <https://www.governing.com/topics/politics/gov-colorado-hickenlooper.html>
- [35] J. Goad, “Colorado Governor John Hickenlooper Appears In Fracking Ad,” *ThinkProgress*, Feb 2012. [Online]. Available: <https://thinkprogress.org/colorado-governor-john-hickenlooper-appears-in-fracking-ad-aef4fe3e6f9b/>
- [36] T. Heikkila, J. J. Pierce, S. Gallaher, J. Kagan, D. A. Crow, and C. M. Weible, “Understanding a period of policy change: The case of hydraulic fracturing disclosure policy in Colorado,” *Review of Policy Research*, vol. 31, no. 2, pp. 65–87, 2014.
- [37] C. Rice, “The struggle for shared governance in hydraulic fracking policy: An interstate comparison of Texas, Oklahoma, and Colorado,” *CLOSUP Student Working Paper Series*, vol. 2, February 2016. [Online]. Available: <http://closup.umich.edu/files/closup-swp-2-rice-hydraulic-fracturing-policy.pdf>
- [38] J. Minor, “Local government fracking regulations: A colorado case study,” *Stanford Environmental Law Journal*, vol. 33, p. 59, 2013.
- [39] W. C. Mumby, “Trust in local government: How states’ legal obligations to protect water resources can support local efforts to restrict



- fracking,” *Ecology Law Quarterly*, vol. 44, p. 195, 2017.
- [40] S. of Colorado.
- [41] J. J. Cook, “Who’s pulling the fracking strings? power, collaboration and colorado fracking policy,” *Environmental Policy and Governance*, vol. 25, no. 6, pp. 373–385, 2015.
- [42] Colorado Oil and Gas Conservation Commission, “Hydraulic Fracturing Chemical Disclosure (Rule 205A),” *State of Colorado Regulations*, 2011.
- [43] —, “Setback and Mitigation Measures for Oil and Gas Facilities, Drilling, and Well Servicing Operations (Rule 604),” *State of Colorado Regulations*, 2013.
- [44] —, “Statewide Groundwater Baseline Sampling and Monitoring (Rule 609),” *State of Colorado Regulations*, 2013.
- [45] B. G. Peters, *Advanced introduction to public policy*. Edward Elgar Publishing, 2015.
- [46] P. Cairney, *The politics of evidence-based policy making*. Springer, 2016.

About the Author

Zira John Quaghe is an economic and policy researcher with experience in oil and gas, electricity, and mining sectors, studying at the Department of Politics and International Studies at the University of Cambridge.

Conflict of interest The Author declares no conflict of interest.

This page intentionally left blank.



Implementing the Mutualism Theory of Intelligence in the Classroom

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | **PERSPECTIVE** | REPORT | REVIEW

Ivan L. Simpson-Kent

MRC Cognition and Brain Sciences Unit
University of Cambridge
ivan.simpson-kent@mrc-cbu.cam.ac.uk

ABSTRACT

General intelligence, broadly defined as the ability to perform well on many and even seemingly unrelated cognitive tasks (e.g. maths and reading), is one of the most documented and empirically supported findings in psychology. Moreover, general intelligence has consistently been associated with important life outcomes such as educational achievement and occupational success. For instance, people with greater general intelligence (often measured by IQ tests) tend to get better grades in school and earn more income over their lifetime. However, despite the robustness of and cultural attention given to intelligence research, little is known about how it develops, especially in childhood and adolescence. In this Perspective, I introduce a theory of cognitive development known as mutualism, which derives its name and theoretical origins from the ecological interaction between two species in which each receives a net benefit (e.g. bees extracting nectar for nutrients from flowers in exchange for pollination). According to mutualism theory, general intelligence emerges from positive interactions between cognitive abilities such as reading and maths so that, over time, they become more related to one another. This would explain why people who are good at one task also tend to perform well on others. Lastly, I discuss possible applications of mutualism to education policy, particularly focussing on ways to improve the performance of students who struggle to learn in school.

The discovery of general intelligence and its association to important life outcomes

In the early 20th century, English psychologist Charles Spearman discovered that children (under 18 years old) who performed well in one school

subject (e.g. maths) also tended to perform well in other school subjects (e.g. reading), even if they seemed unrelated to each other [1]. In other words, performance on these cognitive tasks were positively correlated or associated with each other, which later became known as the ‘positive manifold’ of cognitive abilities. Furthermore, Spearman theorised that a single mental construct underlies these positive associations between cogni-

tive tasks, which he termed ‘general intelligence’ [1]. Since then, over 100 years of studies on human intelligence have not only replicated Spearman’s original findings but also suggest that general intelligence is a universal phenomenon, in spite of differences in how various cultures define it [2].

Moreover, subsequent research has indicated that measures of general intelligence, such as IQ, reliably predict numerous important life outcomes including educational achievement and occupational success. Specifically, higher scores on IQ tests were associated with higher performance on National GCSE/GNVQ public examination results [3] and larger gross income [4]. Together, these studies suggest that general intelligence, especially in childhood and adolescence, plays a pivotal role in successful attainment of important life outcomes, even after formal education has ended (e.g. in the case of occupational income). But how can these findings guide us in helping children who are struggling in school to learn better? Can educators improve general intelligence through cognitive training programs, which at best have yielded inconclusive results [5–8], or is there no hope for low-performing children?

In order to answer these questions and better inform policy, we need to look beyond simple correlations between IQ scores and life outcome measures and try to understand how intelligence develops in the first place. Only then can we hope to create viable interventions that can improve children’s general intelligence. This is where the mutualism theory of cognitive abilities comes in handy.

The mutualism theory of general intelligence

Despite the numerous theoretical attempts to explain the positive manifold, the nature of general intelligence remains one of the most outstanding questions in psychology. Crucial for such an account is an understanding of how general intelligence originates, specifically during childhood and adolescence. A hypothesis put forward in the psychological literature that has gained considerable attention in recent years is the mutualism theory of intelligence [9]. According to mutualism, various cognitive abilities such as maths and

reading are uncorrelated in the first few years of life. Put simply, general intelligence doesn’t necessarily exist in infants but rather arises over the first several years of development. The mechanism for the emergence of general intelligence borrows from the notion of mutualism found in ecosystems: ‘positive beneficial interactions’ [9]. Similar to how diverse arrays of species can interact and mutually aid in each other’s growth and survival, seemingly very different cognitive abilities (e.g. maths and reading) might interact and become increasingly correlated with each other during early development, eventually producing general intelligence.

While the scientific basis of mutualism is still being determined, initial studies have supported the theory. For example, in a large ($N > 500$) sample of adolescents and young adults (ages 14 to 25 years old), researchers [10] used advanced statistical models to test mutualism against competing theories of cognition, which was assessed by measures of reasoning and vocabulary. They found that starting higher in one ability (e.g. reasoning) led to greater increases in the other (e.g. vocabulary), and vice versa, over approximately two years. Their results suggest that reasoning and vocabulary skills directly and positively interacted with each other during development, in line with mutualism. Since then, this effect has been replicated in another study in a younger (6 to 8 years old) cohort [11] and rigorously verified in a large ($N = 1,800$) adult sample (ages 16 to 89 years) [12], suggesting general intelligence might still be developing even after adolescence.

Applying mutualism theory to education policy

Imagine a standard classroom comprised of young students (e.g. 8 to 9 years old), some with good grades, some with average grades, and some with low grades. Now focus on one of the underperforming (low grades) children who currently struggles in maths. This student is having trouble solving word problems involving simple arithmetic (addition, subtraction, multiplication and division). However, they perform well on exams that only test arithmetic. Moreover, they also score high on reading assessments. What does mu-

tualism suggest could be done to improve their academic performance in maths? One interpretation of mutualism is that a central component of general intelligence is developing the ability to synthesize information from disparate sources. In other words, it might be that this child is struggling to make connections between the arithmetic they are already proficient in and the new format (reading comprehension in the form of word problems) in which the maths is presented. Therefore, an approach could be to train this child in *reading comprehension* rather than continue to drill maths word problems. Doing so could help take their minds off their maths deficiency and refocus them toward something they're good at. Next, the child could be given another *maths word problem* that requires significant reading comprehension. Lastly, once the student successfully solves the maths problem, a teacher could point out to them that it was their *reading* skills that assisted them with their maths.

But what would such a strategy accomplish? First, by explicitly stating to the students the relevance of reading to maths, the teachers are establishing intellectual links between their studies. Second, doing this might boost their curiosity and motivation to further explore, especially if they already enjoy maths but just aren't confident enough in their abilities due to their low grades. Lastly, if this style of pedagogy is also done with other (applicable) subjects such as science, children might find ways to apply what they have learned inside the classroom to the outside world.

One way policymakers could implement this instructional strategy is to create a curriculum that is *inherently interdisciplinary*. This is different to how most present-day educational programs are structured, which teach individual subjects in a procedural fashion. Conversely, an inherently interdisciplinary curriculum would emphasise the use of *critical thinking*. Traditional subjects (e.g. maths, reading, etc.) would still be taught, but as foundational knowledge needed to integrate information needed for real-world problem-solving. It is vital that society doesn't view education solely as an academic endeavour. After all, most people spend most of their lives not in school but in the workforce. Therefore, students must find practical applications from school to the real world to be productive citizens.

In conclusion, recent studies have further demonstrated the influence of education in improving reasoning skills [13] and intelligence more broadly [14]. Thus, the education laws and policies we put in place have a significant impact on children's cognitive development. If policymakers provide teachers with additional training in interdisciplinary curricula and instruction, children should be better able to traverse islands of knowledge and see the 'bigger picture'. General intelligence organises knowledge into coherent networks, enabling further exploration. Classroom teaching, therefore, should be a main conduit in establishing such networks to promote curiosity and lifelong learning.

© 2020 The Author. Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

References

- [1] C. Spearman, "General Intelligence," Objectively Determined and Measured," *The American Journal of Psychology*, vol. 15, no. 2, pp. 201–292, Apr. 1904.
- [2] R. T. Warne and C. Burningham, "Spearman's g found in 31 non-Western nations: Strong evidence that g is a universal phenomenon." *Psychological Bulletin*, vol. 145, no. 3, pp. 237–272, 2019.
- [3] I. J. Deary, S. Strand, P. Smith, and C. Fernandes, "Intelligence and educational achievement," *Intelligence*, vol. 35, no. 1, pp. 13–21, Jan. 2007.
- [4] E. R. Hegelund, T. Flensburg-Madsen, J. Dammeyer, and E. L. Mortensen, "Low IQ as a predictor of unsuccessful educational and occupational achievement: A register-based study of 1,098,742 men in Denmark 1968–2016," *Intelligence*, vol. 71, pp. 46–53, Nov. 2018.
- [5] G. Sala and F. Gobet, "Working memory training in typically developing children: A meta-analysis of the available evidence," *Developmental Psychology*, vol. 53, no. 4, pp. 671–685, 2017.

- [6] —, “Cognitive Training Does Not Enhance General Cognition,” *Trends in Cognitive Sciences*, vol. 23, no. 1, pp. 9–20, Jan. 2019.
- [7] S. E. Gathercole, D. L. Dunning, J. Holmes, and D. Norris, “Corrigendum to ‘Working memory training involves learning new skills’. [J. Memory Language 105 (2019) 19–42],” *Journal of Memory and Language*, vol. 106, p. 203, Jun. 2019.
- [8] N. Scionti, M. Cavallero, C. Zogmaister, and G. M. Marzocchi, “Is Cognitive Training Effective for Improving Executive Functions in Preschoolers? A Systematic Review and Meta-Analysis,” *Frontiers in Psychology*, vol. 10, 2020.
- [9] H. L. J. Van Der Maas, C. V. Dolan, R. P. P. P. Grasman, J. M. Wicherts, H. M. Huizenga, and M. E. J. Raijmakers, “A dynamical model of general intelligence: The positive manifold of intelligence by mutualism.” *Psychological Review*, vol. 113, no. 4, pp. 842–861, 2006.
- [10] R. A. Kievit, U. Lindenberger, I. M. Goodyer, P. B. Jones, P. Fonagy, E. T. Bullmore, and R. J. Dolan, “Mutualistic Coupling Between Vocabulary and Reasoning Supports Cognitive Development During Late Adolescence and Early Adulthood,” *Psychological Science*, vol. 28, no. 10, pp. 1419–1431, Oct. 2017.
- [11] R. A. Kievit, A. D. Hofman, and K. Nation, “Mutualistic Coupling Between Vocabulary and Reasoning in Young Children: A Replication and Extension of the Study by Kievit et al. (2017),” *Psychological Science*, vol. 30, no. 8, pp. 1245–1252, Aug. 2019.
- [12] K.-J. Kan, H. L. J. van der Maas, and S. Z. Levine, “Extending psychometric network analysis: Empirical evidence against g in favor of mutualism?” *Intelligence*, vol. 73, pp. 52–62, Mar. 2019.
- [13] S. A. Bunge and E. R. Leib, “How Does Education Hone Reasoning Ability?” *Current Directions in Psychological Science*, p. 0963721419898818, Feb. 2020.
- [14] S. J. Ritchie and E. M. Tucker-Drob, “How Much Does Education Improve Intelligence? A Meta-Analysis,” *Psychological Science*, vol. 29, no. 8, pp. 1358–1369, Jun. 2018.

About the Author

Ivan Simpson-Kent is a 3rd year PhD candidate in medical science (specialising in developmental cognitive neuroscience) at the University of Cambridge. His



research aims to understand how the brain and behaviour interact with each other during childhood and adolescence to produce intelligence. He plans to apply insights from his research to help guide education policy, especially for disadvantaged youth struggling to learn in school. In his spare time, he co-hosts a podcast called *Clever Ramblings* (available on YouTube), watches anime, and daydreams about his hometown of West Philadelphia.

Conflict of interest The Author declares no conflict of interest.



Quantum Key Distribution: Advantages, Challenges and Policy

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | PERSPECTIVE | REPORT | **REVIEW**

Victor Lovic

Department of Physics
Imperial College London
v.lovic19@imperial.ac.uk

ABSTRACT

The prospect of quantum computing threatens the security of modern encryption methods, putting our private communications at risk. With experts predicting the development of powerful quantum computers as early as the end of the decade, the urgency of transitioning to ‘quantum-safe’ communications is apparent. There are two classes of solutions available: post-quantum cryptography (PQC), which refers to communication algorithms designed to be safe against quantum computers, and quantum key distribution (QKD), a new technology with unique advantages and challenges. These solutions are not mutually exclusive, and this review argues that they are in fact complementary solutions to the threat of quantum computing. However, QKD has received criticism for being a less practical solution than PQC. This review makes the case for QKD and argues that it offers significant advantages which are not adequately recognised. I conclude that the development of QKD would benefit from increased government support and I provide policy recommendations for how to best support it.

Introduction

Quantum computing is a new technology which promises to perform certain computations much faster than any modern supercomputer. Accelerated drug discovery and better climate models are just two examples of applications which will benefit from the capabilities of quantum computers. On the flip side, quantum computers will also be able to break most methods of encryption used today, putting our private communications at risk.

Since the first theoretical developments in the 1980s, quantum computers have quickly become a reality. Major investments from government research budgets and private companies have led to the development of the first iteration of quantum computers, comparable perhaps to the first (classical) computers built nearly 70 years ago using vacuum tubes. This rapid progress is cause for alarm since when a sufficiently powerful quantum computer is developed, our standard encryption methods will become inadequate and our communications insecure. Moreover, not only are our future communications under threat, our cur-

rent communications are too: modern encryption methods rely on what is known as ‘public-key’ cryptography. The word ‘public’ points to the fact that information encrypted in this way can be recorded and stored by anyone. This opens the possibility for an eavesdropper to record our private, encrypted communications and wait for a sufficiently powerful quantum computer to become available and use it to decrypt them in the future. Since we require certain communications to remain private for long periods of time, we must make the transition to quantum-safe forms of communications well in advance of the development of quantum computers. This is especially true since transitioning to ‘quantum-safe’ forms of communications could take many years.

Fortunately, alongside the development of quantum computers, there has been ongoing research into alternative, quantum-safe communication methods. Broadly speaking, two distinct classes of solutions are available, known as post-quantum cryptography (PQC) and quantum key distribution (QKD). This review gives an overview of both technologies but will focus on the advantages and challenges presented by QKD. I argue that QKD, being a truly novel technology, is poorly understood and in need of a defence. It has significant advantages which are not adequately recognised and there has been tremendous progress in addressing the practical challenges of making it a useful and cost-effective solution. The review is structured as follows: Section 2 introduces public-key cryptography and why quantum computing poses a threat to private communications; Section 3 introduces PQC and QKD as potential solutions to this threat; Section 4 makes the case for QKD and finally Section 5 discusses the outlook of both technologies and provides policy recommendations.

Cryptography and Quantum Computers

Cryptography has been used for centuries. An early example is the so-called Caesar cipher used, as the name suggests, by the ancient Romans. The Caesar cipher works as follows: two people who want to communicate, conventionally called Alice and Bob, privately agree on a secret number,

which we call the ‘key’. To encrypt a message, Alice replaces each letter with another letter a fixed number of positions down the alphabet, determined by the value of the key. To decrypt the message, Bob simply reverses the process, replacing each letter by that found the same number of positions up the alphabet. While modern cryptography has advanced a great amount, it is still based on the same principle: two communicating parties agree on a secret number, or key, which they use to encrypt and decrypt their communications. This type of cryptography is known as ‘symmetric-key’ cryptography because the same key is used for encrypting and decrypting messages. The problem with symmetric-key cryptography is that Alice and Bob need to agree on a secret key before communicating. This requires them to either meet in person or use a trusted courier, neither of which are practical solutions for securing the vast amount of information that is nowadays sent over the internet. The solution to this problem, only developed in the 1970s, is known as ‘public-key’ cryptography. In public-key cryptography, the keys that are used to encrypt and decrypt the communications are different, but mathematically related. The key which is used to encrypt messages is made public, while the key used to decrypt messages is kept private. In this way Bob can send Alice his public key, which can be seen by anyone, for her to encrypt her messages with. She can then send her encrypted message to Bob and, crucially, only he will be able to decrypt it, since only he has the corresponding private key. Since the keys are mathematically related, it is important that no eavesdropper is able to figure out the private key given the public key. The mathematical problem for doing this needs to be ‘intractable’, that is, very difficult and time-consuming. For example, the mathematical problem that guarantees the security of the widely used public-key RSA protocol is factoring: the process of finding the prime factors of a large number. It would take modern computers thousands of years to factor the public keys used in RSA encryption, which is why the communications are considered secure. If an eavesdropper was able to quickly factor large numbers, then they would be able to break RSA encryption since they could extract the private key from the public one. Although there are good reasons to think that factoring

really is an intractable problem, there remains the possibility that a mathematical or technological breakthrough will allow us to quickly factor large numbers. Indeed, in 1994, the physicist Peter Shor showed that quantum computers will be able to quickly factor large numbers and decode other mathematical encryptions currently used in public-key cryptography. A white paper published by the European Telecommunications Standards Institute (ETSI) states that

[m]ost of the public-key cryptography that is used on the Internet today is based on algorithms that are vulnerable to [attacks by a quantum computer]. These include public-key algorithms such as RSA, ECC, Diffie-Hellman and DSA [1].

This means that, in a future with sufficiently advanced quantum computers, currently used public-key cryptography is at risk. And not only are our future communications at risk: quantum computers threaten our current communications too. Public keys, by definition, can be recorded and stored by anyone, along with the encrypted messages. In this way an eavesdropper could record encrypted private communications and corresponding public keys and wait for a sufficiently powerful quantum computer to become available. They could then use the quantum computer to solve the mathematical encoding problem, obtain the private key, and decrypt the communications. This is known as ‘retrospective decryption’ and all public-key cryptography protocols are susceptible to this attack [2].

So how long will it take for sufficiently powerful quantum computers to become available? A leader in the quantum computing race, Google CEO Sundar Pichai, speaking at the 2020 World Economic Forum in Davos, claimed that

In a five to ten year time frame, quantum computing will break encryption as we know it today [3].

This is arguably an overly optimistic outlook from a tech-company executive, but predictions coming from academia are also sobering. Michele Mosca, Physics professor at the Institute for Quantum

Computing (IQC) at the University of Waterloo, predicts a 50% chance of quantum computers breaking RSA encryption by 2032 [4]. His colleague Matteo Mariantoni, also professor at IQC, believes that a quantum computer capable of breaking RSA encryption could be built by 2030 [5]. In many cases, private information needs to be kept secret for several years. For example, census data in the UK is required to remain undisclosed for 100 years [6] and it is easy to understand why health records, government communications, and other sensitive data have similar secrecy lifespans. If predictions about the development of quantum computers are correct, then these types of data are already at risk of being hacked by a future quantum computer. To make matters more urgent, transitioning to quantum-safe forms of communication could require several years, so it is apparent that we must start this transition now.

Two Solutions

Fortunately, scientific research has not focused solely on building quantum computers, but also on developing quantum-safe communications, such as PQC and QKD.

We saw that the security of public-key cryptography is based on the intractability of certain mathematical problems. For the most widely used public-key protocols, quantum computers could quickly solve these intractable problems, rendering the communications insecure. However, the possibility exists that other mathematical problems will remain intractable, even to quantum computers. This is what motivates research into PQC. PQC refers to cryptographic protocols which are thought to be secure even against quantum computers. In this way, the threat of quantum computing is averted by exchanging the cryptographic protocols we use with ones that are based on mathematical problems which are intractable even to quantum computers.

PQC is a very appealing solution since it is based on the same principles as the cryptographic methods we use today. Transitioning to quantum-safe communications using PQC could involve little more than a software update to our computers. And there are already many proposed PQC proto-

cols; currently there is active research into testing and validating these new protocols. The National Institute for Standards and Technology (NIST) in the USA is currently hosting a competition [7] to identify the most promising PQC protocols with the intention of establishing new standards for quantum-safe communications. After reducing the initial pool of 69 candidate protocols down to 26, they have now entered the second phase of this process, during which the remaining candidates will be further examined with the aim of drafting the final standards for PQC in 2022.

The downside is that public-key PQC protocols are still vulnerable to retrospective decryption and future advances in mathematics or technology that might render them insecure. The possibility remains that mathematical problems that we once thought intractable, even for quantum computers, turn out not to be.

Quantum key distribution (QKD) is a fundamentally different approach to quantum-safe communications, based on the principles of physics rather than on the use of intractable mathematical problems. QKD solves the same problem as public-key cryptography: it allows two parties (Alice and Bob) to establish a secret key between them. The key can then be used with symmetric-key cryptography to communicate securely. In QKD, Alice and Bob communicate using single particles of light, called photons. Photons obey the laws of quantum mechanics, which is the physical theory that describes the behaviour of very small objects, like single atoms, or photons. When we use single photons to carry information, we call that information quantum information, which has different properties to classical information. Quantum information has two unique properties that make QKD secure:

1. It is impossible to make exact copies of quantum information.
2. It is impossible to measure or observe quantum information without introducing a disturbance and changing it in some detectable way.

In this way, if Alice sends Bob a secret key using quantum information carried by photons, she can be sure that: 1. no eavesdropper is able to copy and store that information and 2. if an eavesdropper tried to measure or observe the secret key,

they would inevitably introduce a disturbance in the key, which Alice and Bob could detect. Crucially, quantum mechanics and these two properties of quantum information are fundamental theories in physics. This makes QKD resilient to any future advances in mathematics or technology since, unlike public-key cryptography, it does not make any assumptions about the intractability of certain mathematical problems, or about the technology available to potential eavesdroppers. In practice, QKD consists of using hardware like lasers and specialised electronics to send single photons through optical fibres between Alice and Bob. Making the transition from our current encryption methods to QKD would therefore require much more than a software update.

Clearly there are pros and cons to each solution. PQC offers quantum-safe communications based on the same cryptographic principles used today. QKD provides unique advantages at the cost of requiring large changes in infrastructure and hardware.

The Advantages and Challenges of QKD

The National Cyber Security Centre (NCSC) in the UK released a white paper on QKD in 2016 ‘[making] the case for research into developing post-quantum cryptography as a more practical and cost-effective step [than QKD] towards defending real-world communication systems from the threat of a future quantum computer’ [8]. They followed this up with a report in 2020 reiterating that they ‘[do] not endorse the use of QKD for any government or military applications’ citing the ‘specialised hardware requirements of QKD’ as a reason [9]. In light of this criticism, and the fact that QKD is a truly novel technology, I argue that the advantages of QKD are poorly understood and the practical challenges are overstated. In what follows, I will outline the unique advantages offered by QKD, as compared to PQC, and then address the main issues regarding the practicality of this technology.

First, QKD offers *future-proof* communications. This does not mean that a QKD system will never be hacked, but rather that communications secured via QKD cannot be hacked after the com-

munication has happened: either the hacking happens in real-time or it does not happen at all. With QKD, cryptographic keys are never made public and, as described in the previous section, QKD keys are impossible to copy and store. This is an important advantage over our current, and any future, public-key cryptography methods, including those based on PQC. With public-key cryptography there is always the possibility that encrypted messages and public keys are stored by an eavesdropper and decrypted at a future date when, through advances in technology or mathematics, the communication protocols become insecure. QKD is the only known solution to this retrospective decryption. QKD is therefore particularly suited to securing communications with long secrecy lifespans that must remain undisclosed for many years. Promising use cases for QKD include the storage of financial and customer data by large institutions, the handling of private health records, including human genome data, and the protection of government and military communications [10].

Second, theoretical QKD protocols have been proven to be perfectly secure, while no such proof is available for PQC. PQC relies on assumptions about the intractability of certain mathematical problems. But we have seen how developments in technology like quantum computing can undermine these assumptions. With QKD we do not need to rely on such assumptions, and we say that QKD is ‘unconditionally secure’. This is not to say that QKD systems are perfectly secure, just that the underlying theory is. It is then still important to make sure that the physical systems that implement the theoretical QKD protocols do not inadvertently introduce any vulnerabilities, which might be exploited by an eavesdropper¹. The study of these ‘implementation security’ vulnerabilities is an active area of research that is bringing QKD systems closer to achieve an ideal of perfect security.

Lastly, I argue that investing into the development of QKD promises benefits that go well beyond just securing our private communications. In the long run, we can envision a ‘quantum internet’, which is a network of quantum computers connected via QKD links. While the details are

outside the scope of this review, the quantum internet has applications not just for secure communications but also for ‘secure access to remote quantum computers, more accurate clock synchronisation and scientific applications such as combining light from distant telescopes to improve observations.’ [11]. A QKD infrastructure will serve as the foundation for such a quantum internet.

The main arguments against QKD revolve around practicality. QKD is based on hardware, like lasers used to send photons through optical fibres, while PQC is based on software, algorithms much like the ones we currently use, which could run on our computers without modification. Obviously, as suggested by NCSC, PQC is the more ‘practical and cost-effective solution’. However, there has been tremendous progress in the past 20 years towards addressing the practical challenges that come with implementing QKD in the real world. Here, I will address potential concerns and give a sense for how far the technology has come.

A central challenge in implementing QKD over long distances and at high communications rates is the ‘transmission loss’ in optical fibres: approximately nine out of ten photons are lost for every 50km of fibre they travel. In conventional communications this problem is easily solved: optical signals can be amplified at regular distance intervals using ‘repeaters’, allowing us, for example, to send signals from Europe to the American continent through underwater optical fibres. However, the process of amplifying an optical signal can be thought of as making extra copies of the photons to counteract the transmission losses. We saw that quantum information cannot be copied, which makes it challenging to develop repeaters for quantum information. Although it is an active area of research, currently QKD cannot rely on quantum repeaters to send quantum information over long distances. This means that the range of QKD is limited and that there is a trade-off between distance and the communication rate: the longer the distance between Alice and Bob, the fewer photons sent by Alice will reach Bob, slowing the communication rate.

Much of the research in QKD has been devoted to increasing the distance and communication

¹It should be pointed out that practical implementations of PQC can also introduce security vulnerabilities in the communication system.

rate. Over the past two decades, there has been great progress on this front: record distances for QKD have increased roughly tenfold from around 50km to current state-of-the-art demonstrations reaching distances over 500km [12]. These improvements are due to advances in the QKD hardware as well as to the development of newer and more efficient theoretical protocols. For longer distances QKD needs to rely on repeaters. We saw that quantum repeaters are not yet available, but by linking several QKD systems one after the other we can achieve a similar result. The drawback is that at every link, or node, the secret key is revealed. Therefore, we need to ensure that no eavesdropping can occur at these nodes. Until quantum repeaters become available, trusted nodes will be the main solution for long distance QKD.

Communication rate is another parameter where QKD falls short compared to classical communications. Current classical optical communications deliver speeds on the order of 100Gbit/s, whereas QKD communications achieve rates in the range of Mbit/s (100,000 times less). QKD is only used to distribute the secret keys used for encryption and not the private communications themselves, so the communication rate requirements for QKD are lower. However, increasing the communication rate of QKD is ‘arguably the most pressing task in order to widen the applicable areas of QKD technology’ [13].

QKD secured communications require specialised hardware and will undoubtedly cost more to develop than the PQC alternative. As QKD moves out of the lab and towards commercialisation and real-world use, cost-effectiveness is becoming an increasing focus of QKD research efforts. Two results are particularly promising: first, it has been demonstrated that QKD can be performed on the same optical fibres and at the same time as high-traffic classical communications [14]. QKD signals are so faint that there is no negative consequence for other users of these fibres. In this way QKD can make use of existing optical fibre networks, removing much of the need for expensive new optical fibre connections. Second, QKD components are being integrated onto semiconductor chips similar to the ones used in computers and mobile phones. By leveraging advances in semiconductor device manufacturing, QKD chips

can be mass-produced at low cost and with extremely small footprints. Chip-based QKD will lower costs and allow for easier integration with conventional computers and communication systems.

A testament to how far QKD has come are the many field-deployments of QKD networks around the world. Most impressive is the 2000km long QKD link (using trusted nodes) between Shanghai and Beijing in China [15]. This project included the first demonstration of QKD performed via a satellite, connecting cities in China and Austria. Other countries including the UK [16], Switzerland [17], Austria [18] and Japan [19] have also established prototype QKD networks. Most recently the ‘OpenQKD’ project, a collaboration between 38 partner universities and companies, was launched in September 2019. With EU funding, the collaboration aims to ‘raise awareness of the maturity of QKD’ as a technology and ‘lay the foundation for a pan-European quantum network’ [20].

The challenges point nonetheless to the fact that QKD will at first find applications in sectors dealing with especially sensitive information, which needs to be kept secret for many years. Less sensitive communications can benefit from the high speeds and low cost of PQC that we have come to expect from our current communication methods. QKD and PQC can be seen as complimentary solutions for building quantum-safe communication systems, together covering the whole range from low cost and high speed, to long-term high-security applications. Indeed the NCSC [9], the Blakett review [10], industry, and academia [2] agree that QKD and PQC should continue to be researched in parallel.

Outlook and Policy Recommendations

ETSI cites a ‘perception of non-urgency’ as a barrier to the adoption of quantum-safe communications [1]. This perception means that currently there are no strong financial incentives for developing quantum-safe communications, in stark contrast to quantum computing. For this reason, investments into quantum technologies, the so-called ‘quantum gold rush’, have been mostly

directed to the latter [21]. Large technology companies like Google, Microsoft and IBM are investing in their own research efforts. Companies, not countries, are leading the race in quantum computing. In this context, government support for the development of quantum-safe communications is crucial. I argue that PQC is well supported, while QKD could benefit from increased support and investment.

There are already many proposed PQC protocols, mostly coming from academia. What is needed now is to test and validate these protocols. This work has been taken up by standards bodies. As mentioned earlier NIST is planning to conclude its effort in this direction in 2022. In 2015 ETSI established the Quantum Safe Cryptography Working Group to assess and recommend PQC protocols. They recently held their seventh ‘Quantum Safe Cryptography Workshop’, bringing together academic and industry partners. Additionally, companies like Google [22], Microsoft [23] and Amazon [24] are already working towards integrating PQC protocols into their services. This all contributes to a positive outlook for PQC.

The perception of non-urgency, the practical challenges inherent to QKD, and a lack of awareness of its unique advantages make commercialising QKD challenging. Government support for this technology is crucial, not least since government and military applications are cited among the first use cases for QKD. I propose the following policy recommendations to support the development of QKD, with a UK focus:

- **Raise awareness of the threat of quantum computing to private communications and the available solutions.** This is especially important for industries and sectors with long-term security needs, which are particularly vulnerable to retrospective decryption, like government, military, and healthcare. The NCSC provides practical cyber security guidance through its Cyber Assessment Framework. This framework should be updated to account for the threat of quantum computers, especially to communications with long secrecy lifespans. Awareness of the available solutions is equally important. A survey of Information Technology and Security professionals by the Cloud Security Alliance found that ‘most respondents do not believe there is an existing solution to the quantum computing threat’ [25].
- **Clarify the unique advantages offered by QKD as compared to PQC.** QKD is particularly suited to securing communications with long security lifespans and it is complementary to PQC. In response to the recent NCSC white paper, a commentary by the QKD industry and academic community states that ‘wherever possible QKD should be used in tandem with [PQC]’ and that ‘an approach suggesting a need to choose between QKD and [PQC] is based on a false dichotomy’ [2].
- **Involve the NCSC in key programmes for the development and standardisation of QKD.** The QKD community commentary explicitly welcomes direct involvement from the NCSC in the development of new standards for QKD [2]. The ETSI QKD Industry Specification Group [26] works to ensure the future interoperability of diverse QKD systems and that these systems are implemented in a safe manner. Involvement by the NCSC would ensure these standards meet the requirements of the Cyber Assessment Framework.
- **Engage in early trials of QKD for government and military applications.** Government and military have long-term security needs that QKD is well suited to address. Direct involvement in early trials will support the development of QKD and ensure QKD systems meet the needs of this specialist sector.
- **Continue funding research addressing the practical challenges of QKD.** This funding can be seen as an investment, eventually paid off by the reduction in cost and by the increase in performance of real-world QKD systems. Progress in QKD research shows no signs of stopping, with novel theoretical protocols designed on a regular

basis and proof-of-principle experiments moving to real-world demonstrations [27]. With continued investments we can expect the great progress of the past two decades to continue.

- **Invest in a backbone QKD network.** QKD is limited in range, therefore establishing long distance connections between cities, and eventually countries, will require a large financial effort. An established backbone QKD network will make it easier for companies and individuals to connect, widening the market and demand for QKD. A backbone QKD network will serve as the foundation for a future quantum internet, with applications that go beyond just secure communications, increasing its value.

Conclusion

There is an urgent need to transition the world's communication systems to quantum-safe methods. This review made the case for quantum key distribution as a solution. QKD is:

- future-proof: communications secured by QKD cannot be retroactively hacked;
- based on provably secure theoretical protocols;
- a building block towards a future quantum internet.

The past 20 years of research and development in the field of QKD have helped to address the practical challenges of implementing QKD systems in the real-world. Proof of this are the many demonstrations of quantum networks around the world. Together, PQC and QKD can be used to secure our communications even in the presence of quantum computers. Government support for QKD in particular is crucial while the technology moves from research and development to commercialisation. Sectors with long-term security needs, including government and military, stand to benefit from the unique advantages of QKD. The policy recommendations provided will support the development of this technology and ensure that the long-term security needs of government, military and other sectors are met.

© 2020 The Author(s). Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

References

- [1] European Telecommunications Standards Institute, "Quantum safe cryptography and security: An introduction, benefits, enablers and challenges," *ETSI White Paper No. 8*, June 2015. [Online]. Available: <https://www.etsi.org/images/files/ETSIWhitePapers/QuantumSafeWhitepaper.pdf>
- [2] Quantum Communications Hub, "Community Response to the NCSC 2020 Quantum Security Technologies White Paper," *Issue 1.1*, May 2020. [Online]. Available: <http://bit.ly/NCSC2020Response>
- [3] H. Boland, "Quantum computing could end encryption within five years, says Google boss," *The Telegraph*, Jan 2020. [Online]. Available: <https://www.telegraph.co.uk/technology/2020/01/22/googles-sundar-pichai-quantum-computing-could-end-encryption/>
- [4] M. Mosca, "Cybersecurity in an era with quantum computers: will we be ready?" *IEEE Security & Privacy*, vol. 16, no. 5, pp. 38–41, 2018.
- [5] NIST, "Report on Post-Quantum Cryptography," April 2016. [Online]. Available: <https://nvlpubs.nist.gov/nistpubs/ir/2016/NIST.IR.8105.pdf>
- [6] UK Office for National Statistics, "About the census," September 2018. [Online]. Available: <https://www.ons.gov.uk/census/censustransformationprogramme/aboutthecensus>
- [7] NIST, "Post-Quantum Cryptography," January 2017. [Online]. Available: <https://csrc.nist.gov/Projects/Post-Quantum-Cryptography>
- [8] NCSC, "Quantum Key Distribution," November 2016. [Online]. Avail-

- able: <https://www.ncsc.gov.uk/whitepaper/quantum-key-distribution>
- [9] —, “Quantum Security Technologies,” March 2020. [Online]. Available: <https://www.ncsc.gov.uk/pdfs/whitepaper/quantum-security-technologies.pdf>
- [10] UK Government Office for Science, “The quantum age: technological opportunities,” November 2016. [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/564946/gs-16-18-quantum-technologies-report.pdf
- [11] S. Wehner, D. Elkouss, and R. Hanson, “Quantum internet: A vision for the road ahead,” *Science*, vol. 362, no. 6412, 2018.
- [12] J.-P. Chen, C. Zhang, Y. Liu, C. Jiang, W. Zhang, X.-L. Hu, J.-Y. Guan, Z.-W. Yu, H. Xu, J. Lin *et al.*, “Sending-or-Not-Sending with Independent Lasers: Secure Twin-Field Quantum Key Distribution over 509 km,” *Physical review letters*, vol. 124, no. 7, p. 070501, 2020.
- [13] E. Diamanti, H.-K. Lo, B. Qi, and Z. Yuan, “Practical challenges in quantum key distribution,” *npj Quantum Information*, vol. 2, no. 1, pp. 1–12, 2016.
- [14] K. Patel, J. Dynes, I. Choi, A. Sharpe, A. Dixon, Z. Yuan, R. Penty, and A. Shields, “Coexistence of high-bit-rate quantum key distribution and data on optical fiber,” *Physical Review X*, vol. 2, no. 4, p. 041010, 2012.
- [15] J. Qiu *et al.*, “Quantum communications leap out of the lab.” *Nat.*, vol. 508, no. 7497, pp. 441–442, 2014.
- [16] J. Dynes, A. Wonfor, W.-S. Tam, A. Sharpe, R. Takahashi, M. Lucamarini, A. Plews, Z. Yuan, A. Dixon, J. Cho *et al.*, “Cambridge quantum network,” *npj Quantum Information*, vol. 5, no. 1, pp. 1–8, 2019.
- [17] D. Stucki, M. Legre, F. Buntschu, B. Clausen, N. Felber, N. Gisin, L. Henzen, P. Junod, G. Litzistorf, P. Monbaron *et al.*, “Long-term performance of the SwissQuantum quantum key distribution network in a field environment,” *New Journal of Physics*, vol. 13, no. 12, p. 123001, 2011.
- [18] M. Peev, C. Pacher, R. Alléaume, C. Barreiro, J. Bouda, W. Boxleitner, T. Debuisschert, E. Diamanti, M. Dianati, J. Dynes *et al.*, “The SECOQC quantum key distribution network in Vienna,” *New Journal of Physics*, vol. 11, no. 7, p. 075001, 2009.
- [19] M. Sasaki, M. Fujiwara, H. Ishizuka, W. Klaus, K. Wakui, M. Takeoka, S. Miki, T. Yamashita, Z. Wang, A. Tanaka *et al.*, “Field test of quantum key distribution in the Tokyo QKD Network,” *Optics express*, vol. 19, no. 11, pp. 10 387–10 409, 2011.
- [20] “OpenQKD,” September 2019. [Online]. Available: <https://openqkd.eu/>
- [21] E. Gibney, “The quantum gold rush,” *Nature*, vol. 574, no. 7776, pp. 22–24, 2019.
- [22] K. Kwiatkowski, “Towards Post-Quantum Cryptography in TLS,” *The Cloudflare Blog*, June 2019. [Online]. Available: <https://blog.cloudflare.com/towards-post-quantum-cryptography-in-tls/>
- [23] Microsoft, “Post-Quantum TLS.” [Online]. Available: <https://www.microsoft.com/en-us/research/project/post-quantum-tls/>
- [24] A. Hopkins, “Post-quantum TLS now supported in AWS KMS,” *Amazon Web Services Security Blog*. [Online]. Available: <https://aws.amazon.com/blogs/security/post-quantum-tls-now-supported-in-aws-kms>
- [25] Cloud Security Alliance, “Quantum-Safe Security Awareness Survey,” January 2018. [Online]. Available: <https://cloudsecurityalliance.org/artifacts/quantum-safe-security-awareness-survey/>
- [26] ETSI, “Quantum Key Distribution.” [Online]. Available: <https://www.etsi.org/technologies/quantum-key-distribution>
- [27] S. Pirandola, U. L. Andersen, L. Banchi, M. Berta, D. Bunandar, R. Colbeck, D. Englund, T. Gehring, C. Lupo, C. Ottaviani *et al.*, “Advances in quantum cryptography [preprint],” *arXiv*, 2019.



About the Author

Victor is a PhD student in the Department of Physics at Imperial College London. His research is in the field of quantum cryptography, investigating the security of quantum key distribution and quantum random number generation. He is interested in the potential of emerging technologies to change the world, in good or bad ways, and thinks that good policymaking is key to ensuring good outcomes and mitigating any risks. Previously, Victor studied Physics at the University of Glasgow.

Conflict of interest The Author declares no conflict of interest.



Science, Policy and the Public in Italy: A full day conference for UK-based researchers to meet with Italian policymakers

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | PERSPECTIVE | **REPORT** | REVIEW

Iacopo M. Russo

Department of Engineering
University of Cambridge
imr29@cam.ac.uk

ABSTRACT

The first edition of the *Science, Policy and the Public in Italy (SPP Italy)* conference was held in Cambridge in October 2019. Organised by the Cambridge University Italian Society together with the Association of Italian Scientists in the UK, the conference invited UK based Italian researchers and policymakers from Italy to discuss policy issues that could benefit from expert scientific advice. Covering topics such as infrastructure monitoring and machine learning bias, the conference was one in a series of events promoting an initiative to set up a scientific advisory office for the Italian Parliament. This article reviews the contents of the thematic panels and keynote speeches, and suggests improvements and expansions for future editions of the event.

Introduction and goal of the conference

With multiple institutes and student societies dedicated to science and policy, Cambridge has established itself within the last decade as a centre of excellence in bridging the gap between academic researchers and policymakers. Another brick was added to this bridge last year in October when St. John's College's Old Divinity School hosted the first ever edition of Science, Policy and the Public in Italy (SPP Italy). Organised by the Cambridge University Italian Society (CUIS) in collaboration with the Association of Italian Scientists in

the UK (AISUK), the full day conference invited UK based Italian researchers and policymakers from Italy to meet and discuss policy issues the country is facing that could benefit from expert technical and scientific advice.

The goal of the conference was to help address two problems: the diaspora of highly qualified Italian students and researchers caused by a perceived lack of opportunities in their home country, and the absence of any independent scientific advisory body available to the Italian Parliament for effective legislation on issues which require technical expertise. Thus, the overarching question for the day was: how can emigrated researchers continue to positively contribute to the social and political

progress of their country of origin? Sponsored by both the Italian Embassy in London and the British Embassy in Rome, the event was a fantastic opportunity for science diplomacy, in advance of the UN Climate Change Conference of the Parties (COP) 26, to be hosted jointly by Italy and the UK in 2021.

Thematic panels

The discussion was structured around three themes: Environment and infrastructures, Public health and biotechnologies, and Digital technologies. For each theme, one experienced researcher working in the UK and one policymaker from Italy were invited to provide their perspective on a relevant topic and to start a conversation with the audience. In the Environment and infrastructure panel, Dr. Giorgia Giardina, an expert in Civil Engineering from the University of Bath, was joined by Prof. Andrea Taramelli, the Italian national delegate at Copernicus, a space programme by the European Union which provides Earth observation data. The topic of their panel was risk management and infrastructure monitoring. This is a pressing issue in Italy, where earthquakes, floods, volcanoes and other natural disasters have caused significant damage on multiple occasions over the 150-year history of the nation. Appropriate technical evaluation of the safety of infrastructures can literally save lives. On many tragic occasions, state-owned buildings and roads have demonstrated their fragility: the most recent case is that of the Morandi Bridge near Genoa, which collapsed in 2018 causing the death of 43 people. In her presentation, Dr. Giardina talked about her Crossrail-sponsored work with cutting-edge sensor techniques to monitor tunnels in London. Recently, she has been using satellite data to observe soil settlement and deformation in structures caused by underground tunnelling. The information one can gather with such techniques can be crucial in allocating financial resources to prevent damage to the infrastructures most in need. In his presentation, Prof. Taramelli gave an overview of the current legal framework in Italy for risk management. The Civil Protection Department is responsible for all activities relating to environmental disasters: risk assessment and prevention, emergency response,

and post-disaster restoration of infrastructural services. Although there have been research and operational demonstrations that illustrate the potential usefulness of Earth observation satellite data for a broad range of hazards, and the Civil Protection Department has started using such data for its activities, the operational application of these data is still quite limited. In the discussion, both speakers stressed the importance of clear, honest communication by technical experts on such matters: the limitations of the knowledge available to predict and prevent should be clearly communicated to decision makers.

In the Public health and biotechnologies panel, Prof. Carlo Rinaldi, a clinician scientist and neurologist from the University of Oxford, was joined by Mr. Marco Cappato, an internationally known activist and former Member of the EU Parliament who fights for end-of-life rights and for the 'right to science'. An expert in the study of human muscle and motor activity, Prof. Rinaldi highlighted the importance of developing therapies for muscle loss and muscle diseases, which are increasingly more common in our ageing population. He touched upon the issue of animal experimentation where scientific researchers in Italy have received dangerous threats from members of the public for their work with animals in the lab. However, animal testing remains fundamental to developing new therapies, and scientists are fighting back for the right to research. This issue was picked up by Mr. Cappato, who called attention to the lack of unionisation in the researcher workforce in Italy. He urged scientists to become more active citizens, both to defend their right to do research and to lobby the government to allocate greater funding to universities. Unlike the UK, Italian laws on experimentation, especially in the medical and biological sciences, are very restrictive. For example, research employing embryos and stem cells is currently not allowed. A UK-based scientist achieving a Nobel prize-worthy breakthrough in embryonic genome editing or stem cell research could be arrested if they worked in Italy. He concluded his contribution by proposing that the 'right to science' be included in the list of fundamental human rights by the UN.

In the Digital technologies panel, Dr. Silvia Chiappa from Google's DeepMind was to be joined

by Riccardo Luna, former Digital Champion of the Italian government, for a conversation on the opportunities and challenges of artificial intelligence (AI). However, Mr. Luna could not attend the event due to illness. Therefore, Dr. Chiappa gave a very detailed, yet surprisingly interesting presentation on her work at DeepMind to correct the bias of machine learning algorithms. Dr. Marco Basaldella, from Cambridge's Language and Technology Lab, directed the conversation, which spanned from regulation of new AI-based technologies, to government funding for start-ups. An interesting proposal was to involve the public earlier in the development of predictive machine learning algorithms, to help avoid the risk of bias against minorities.

Keynote speeches and final panel

The conference also featured three keynote speeches. Prof. Carole Mundell, Chief Scientific Advisor to the British Foreign Office and a special guest of the conference, gave an inspired talk about scientific advice in the UK, and the power of science to bring countries together. She explained how the network of scientific advisors in the UK has developed over the last few decades. They are not lobbyists but civil servants, and this has ensured that ministers and Members of Parliament (MPs) continue to trust them. She emphasised that the British Government has invested significant resources in public engagement with science. A prime example is the system of museums and institutions such as the Royal Society, which regularly provide opportunities for science communication and interaction between researchers and the public.

Prof. Massimiano Bucchi, an internationally renowned scholar in Science and Society, used the data collected in a yearly survey of the Italian population's attitudes towards science to show how Italians' public perception of science has changed over the last few years. Many scientists today are concerned with the so-called 'expert backlash', i.e. the public's dissatisfaction with the advice provided by technical experts. However, Prof. Bucchi showed that science literacy in Italy has risen steadily in the last decade and that

Italians have high familiarity with images related to science. For example, in 82.6% of the 2017 survey respondents could identify a picture of the periodic table of elements, and a surprisingly high 64.1% could identify a picture of Marie Curie. Compared to politicians and journalists, scientists still enjoy the highest credibility (51%), a trend that is mirrored in the United States. Particularly relevant for Italy is the case of vaccinations, due to a strong anti-vaccination movement that is often featured in the media. The data collected by Prof. Bucchi surprisingly shows that in 2018 only 4.5% of Italians believed that vaccination should not be compulsory.

Finally, Elena Fattori MP, current senator of the Italian Republic and a PhD in Molecular Biology, told her story as a scientist in the Italian Parliament. Author of the book *Il Medioevo in Parlamento* (The Middle Ages in Parliament), Dr. Fattori highlighted the challenges she faced in effectively communicating science to an audience with a surprisingly low level of scientific literacy. Her talk focused on many cases of unproven 'pseudoscience' finding support in the Italian Parliament. A widely talked-about case involved an unproven therapy for neurodegenerative diseases called Stamina Therapy, whose use in public hospitals received approval by the Italian government despite the protests by the scientific community. Dr. Fattori's opinion is that pseudoscientists are very effective in orientating Italian politics because they have the money to do it and use powerful emotive communication. Italian MPs wishing to oppose such pseudoscience lack an official scientific office to support them, and often fail to gather enough consensus not to be dismissed. They highlighted the need to establish a scientific office for parliament like the UK's Parliamentary Office of Science and Technology (POST).

This issue was picked up by the final panel of the day, led by Alessandro Allegra, a PhD researcher in Science and Policy at UCL and main promoter of the #ScienzaInParlamento initiative to create an office for science and technology for the Italian Parliament. The panel tackled the topic: 'How can we bring more science into the Italian Parliament?' and was joined by two current Italian MPs, Massimo Ungaro MP and Elisa Schirò MP, elected in the foreign constituencies of the UK and Germany respectively. It

was the MPs who kick-started the conversation, by commenting on what they had heard during the day. They praised the initiative of Italian students abroad, acknowledged that there is a serious problem of scientific misinformation in the Italian Parliament, and pledged support to the #ScienzaInParlamento initiative. However, many challenges were highlighted in the ensuing discussion. For example, setting up a scientific advisory office requires funding by the Government but it must remain independent from it to provide impartial advice. Selection of personnel must be independent of politics as well.

Conclusion

Overall, the day was very inspiring. Besides the talks and panels, young researchers were also given the opportunity to present their research in support of a policy recommendation in a poster. During the day a nice atmosphere of openness and collaboration was created. There is significant room for improvement for future editions of the event: in some of the panels there was not enough discussion and interaction between the speakers—it is not easy to select speakers who can have a meaningful discussion with different points of view and at the right level of technical detail for an audience to learn something new.

However, the event gave rise to many creative ideas for the future, including inviting Italian researchers from across the world to an edition of SPP Italy in Rome. Alternatively, a biannual Oxbridge Italian forum could be established, in collaboration with the Oxford University Italian Society. Moreover, the SPP concept could be expanded to all of Europe, not just Italy, which could be especially relevant now that the UK has exited the European Union. Many of these potential meetings will have been paused amid the global coronavirus pandemic, but hopefully future collaborations will continue virtually or later in person. Such ideas and initiatives are uplifting, because they show the willingness of young scientific researchers to engage with the public and policymakers to contribute to the public good.

Acknowledgements

The author would like to thank the *SPP Italy 2019* organising committee for the detailed notes taken during the conference, as well as the invited speakers for their generosity in sharing the contents of their presentations.

© 2020 The Author. Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

About the Author

Iacopo acted as the Chair of the *SPP Italy 2019* organising committee. He is a final year PhD student in the Department of Engineering at the University of Cambridge.



His research attempts to develop innovative technologies that promote resource efficiency in the metals industry, to lower its overall environmental impact. More generally, Iacopo is interested in the ways technology and policy can cooperate to address the global climate crisis. Prior to his doctoral studies, he earned a Master of Engineering from Imperial College London.

Conflict of interest The Author declares no conflict of interest.



Science, Policy and the Public in Italy 2019: Poster Abstracts

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | PERSPECTIVE | **REPORT** | REVIEW

Social Media: A New Tool for Peacebuilding

Jasmine Allegra Anouna,
University of Oxford

In recent years, gender-based violence has become a prominent focus of contemporary discourse in Italy. Notwithstanding the intensified emphasis on the issue, the homogeneity of the discourse limits its capacity to transform conditions of violence. Following Johan Galtung's conceptualisation of violence, I argue that the contemporary discourse on gender-based violence has neglected a fundamental dimension of violence: cultural violence. Accordingly, I explore the ways that sites of cultural production in Italy, namely, schools and the media, are complicit in reproducing cultural violence. The governmental lack of interest in reassessing the structure and content within these institutions sustains norms legitimising violence.

Beyond exposing the ways in which cultural violence is manifested, this study shows how it is being addressed and considers one tool that remains largely dismissed in the project to ameliorate violence: social media. The Italian collective imagination on social media has been largely dominated by its negative implications. In contrast, my research sheds an optimistic light on social media by exposing how certain projects on Insta-

gram address cultural violence. Two projects in particular convey the point: Freeda and Meglio delle Donne. Through a content analysis of the images, articles, and videos shared on the projects, I illustrate how they serve as unique and valuable resources on gender education; the content of the projects contrasts significantly to that offered in official informational institutions. The projects thus fruitfully disrupt traditional patterns of cultural formation and help to build a more confidently critical citizenship in ways that merit greater attention not only from academics but also from policy-makers. [1]

20 years after the Bologna Process—Quality assurance through learning analytics: a new paradigm in the design of online learning

*Assunta Baratta, Università
telematica Pegaso*

The universities of the future will become increasingly international, connected to the labour market, technologically advanced, designed and organized with the students at the center. Italy is a candidate for a leading role in the process

of renewing European university education, projected for 2020. In fact, the meeting of the 48 Ministers of the countries of European Higher Education Area will be held in Rome, to decide on developments in the university world over the next ten years. Italy obtained the chairmanship of the Secretariat of Bologna Process from 2018 to 2020. Rapid technological expansion has favoured the development of e-learning studies, and although we are witnessing a progressive digitalisation and dematerialisation of procedures in traditional universities, these cannot keep up with telematics universities, digital natives with just-in-time courses. The clear demarcation between traditional non-digital universities and telematics universities, has not helped a proper assessment of the quality of training offered, ending up encouraging confusion between the mode of delivery of a course and the quality of the same, feeding the reservations about e-learning by the more traditional component of public and non-public universities. The evaluation of quality e-learning is a central issue for the quality assurance of any master degree course, in relation to the different levels of integration of the technology from which it is concerned. Telematics universities, as well as all universities, must be able to operate in a national system based on clear, shared and sustainable rules, dictated by the awareness that the competitive environment goes beyond national borders, collaborates with higher education systems in other parts of the world. This contribution aims to develop a shared approach on quality assurance, highlighting the benefits of teaching and research of telematics universities, analyse the application of learning analytics techniques, according to the principles stated in the Bologna Process and subsequent ESG.

Research on Psychoactive drugs: the lack of evidence-based policies in Italy

*Laura Convertino, University
College London*

Psychoactive drugs are strictly regulated worldwide, with the theoretical aim to reduce the negative effect that their use could have for the users and for society. However, strict policies have often been guided by cultural and moral judgment rather than scientific evidence. Ideology and misjudgements contributed to build a social narrative, which progressively condemned not only the recreational use, but even the discussion about illegal compounds. At the same time, drug-trafficking has become an international economic power, with a profit of about 25 million euros only in Italy, which empowers organised crime in the first place. In recent years, many researchers have shown how some of the so-called ‘drugs of abuse’, such as MDMA, LSD and psilocybin, can have beneficial therapeutic effects, where legalised psychoactive drugs fail to treat invalidating symptoms, or lack a satisfying level of efficiency and reliability (refer to [2], for a consistent review). Despite the increasing international rise of awareness, Italy seems to be late and deaf about the issue. As a direct effect, public investment on new psychoactive drugs is insufficient, and national regulations make it difficult to undertake research in the field. I aim to review the latest scientific evidence on the beneficial therapeutic use of psychoactive drugs, and to propose alternative policies (bringing examples from other states, and from present international proposals) for an evidence-based change of paradigm. Moreover, I will compare the molecular mechanisms of legal and illegal drugs, trying to understand the historical process that drove Italy to the current legislation. Starting from distinguishing economic, social and cultural reasons from science evidence is a first fundamental step to move further steps for the present and future society.

Industrial Symbiosis and its Contribution to a Circular Economy: An overview of Industrial Symbiosis in Italy

Lukas Gast, University of Cambridge

'Industrial Symbiosis' (IS) is one of the strategies to reduce the use of natural resources and fossil fuels through a more efficient utilisation of industrial waste. Worldwide and also in Italy, there are several examples of an industrial symbiosis. A research project by the Italian agency for new technologies, energy and sustainable economic development (ENEA) funded the development of a framework for the development and implementation of the first Italian Platform for Industrial Symbiosis implemented in Sicily (2011-2015) [3]. The poster takes a detailed review paper [4] by Luciano et al. (2015) as a starting point for addressing the following three questions:

1. How has the ENEA project contributed to industrial symbiosis in Italy?
2. What is the contribution of industrial symbiosis to a circular economy?
3. What are research gaps and which policies could support further industrial symbiosis in Italy?

The findings are visualised in a 'heat map' of (major) industrial production sites and parks in Italy, a table with key results from previous IS activities and a summary of policy recommendations for further IS activities.

Towards an Italian nuclear Renaissance: a roadmap of opportunities and challenges

Giovanni Giustini, Imperial College London

The maintenance of human civilization depends entirely on our ability to generate and distribute electricity while preserving the Earth ecosystem. Electric power generation from fossil fuels is no longer an option due to huge emissions of greenhouse gases and atmospheric pollutants typical of that now obsolete technology. In contrast, nuclear power generates electricity without releasing carbon dioxide or any other pollutant into the atmosphere. Nuclear power is integral part of the energy infrastructure of all major economies, with the exception of Italy, and despite the crucial role played by Italian scientists in the development of nuclear fission technology. Yet Italy was among the first western powers to implement a civil nuclear programme, capable of achieving in a few years the world's third largest power generation capability. 'Italian' emissions from fossil-fuel plants still need to be nullified if Italy wishes to comply with the 2015 Paris agreement on climate change, an achievement which requires the development of new nuclear plants on Italian soil. Here it is suggested what possible ways forward are there for Italy to implement a financially feasible new civil nuclear programme. Starting with a few back-of-an-envelope calculations of the likely magnitude of environmental and economic damage caused by Italy's aversion to nuclear, a set of achievable goals is established for the new Italian nuclear programme to remedy the damage done, and to realign the country to the rest of the industrialised world. It is recognised that, following the necessary lift of the current nuclear ban, crucial to the success of Italy's new energy strategy will be the promotion of policies that must ensure fair competition between nuclear and other low-carbon sources of electricity. Finally, of the innovative reactor concepts currently being developed, the most suitable for the Italian civil nuclear programme of the future are identified.

Energy and sustainability between the Ecology of law, Green Law and the rights of Nature

Paola Grimaldi, *University of Naples Suor Orsola Benincasa*

Pollution and climate change are pushing us one step closer to ecological default, so we need to bet on the Green Economy and the development of Green Law. The Italian doctrine (Mattei U., Capra F., Quarta A.), which has long been denouncing the ecological crisis facing Italy, proposes an ecological conversion of the main institutions of the Italian legal system, now obsolete in the face of the dramatic environmental situation in our country; all accompanied by a necessary 'ecological literacy' of the individuals that helps them to reflect on the new proprietary forms and on the change of the relationship between the sovereign state and the shared global one. In the field of Energy and Sustainability, witnesses and models of success, worldwide, are those Latin American countries, where nature, elevated to a legal entity, is protected at constitutional level and where 98% of electricity is produced with renewable energies thanks to targeted Government Plans, use of clean sources and smart grids. The European Union has set a policy that pushes member states to increase the use of renewable sources and reduce fossil fuels. In Italy, the energy regulatory framework is now fragmented between different standards and above all, in the field of renewable energies, growth is slow and not at all competitive. The proposal that we intend to make to Italian politicians with this project is, first of all, the recognition of legal subjectivity to Nature as a 'common good'; furthermore, that of entirely transposing Directive 2018/2001 / EU on the development of renewable sources; to introduce into our system, integrating and modifying its contents, the concept of energy as a common good rather than private property; specific rules in the field of civil offense and give rise to mandatory energy education courses in schools.

Towards an effective data based infrastructure management system

Michele Win Tai Mak,
University of Cambridge

Existing bridges are not as strong as we would like them to be. As new theories develop, design codes change and evolve over time. However, existing structures that were built according to superseded models remain operational. Moreover, due to repeated loading and exposure to the environment, they deteriorate and lose strength over time. Assessing their residual strength is therefore a major challenge that has drawn a lot of attention from the engineering and scientific community. The management of existing infrastructure faces high costs associated with maintenance, repair, strengthening and decommissioning. However, the current management system is not able to differentiate between low and high priorities in an effective way. This has very high societal consequences. The big impact of infrastructure deterioration was shown by the recent collapse of several bridges in Italy. Managing the infrastructure network efficiently while ensuring the safety of the community is a challenging task. Implementing a robust system that manages risks accurately and identifies priorities is paramount. This research project aims at developing a new and more accurate assessment methodology of deteriorating concrete infrastructure. With new theories based on objective data and advanced inspection methods, a more effective management system can be implemented. This would allow engineers to estimate the residual resistance of bridges more accurately, reducing the safety risks, maintenance costs and environmental impact of the infrastructure network.

Creation of a 3D microfluidic device to study lymph node transformation

Corrado Mazzaglia, *University of Cambridge*

Lymph nodes (LN) are essential organs that serve as immune hubs and are responsible for starting immune reactions against external pathogens and cancer cells. However, in many solid tumours, they fail in defending the body becoming initial sites for cancer metastasis. We still know little about the processes involved and how the LN functions in cancer or therapy and this is also due to the current available tools. In vitro models do not incorporate the 3-dimensional nature of the microenvironment whereas animal models, in spite of their intrinsic higher level of complexity, require node dissection at each discrete time point, showing only a partial experimental datum. In addition, they carry several ethical issues. In recent years, in fact, there has been growing concern about animal welfare and values such as the 3Rs rule have been introduced to reduce animal experimentation. In this context, the aim of this project is to create a microfluidic system that incorporates in vitro and ex vivo components to model LN transformation in a controlled, tractable system: a 3D in vitro model that would easily allow us to follow events longitudinally or to manipulate the environment. Once assessed and proofed to be consistent, this novel system will be used as a model of study as well as an alternative tool to test new drugs. In conclusion, these technologies that sit in between 2D traditional systems and animal models, have great potential to make drug testing cheaper and quicker, to reduce animal experimentation and most importantly provide new insights on cancer biology.

© 2020 The Authors. Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

References

- [1] J. Anouna, "Social media: A new tool for peacebuilding in Italy," *Cambridge Journal of Science and Policy*, vol. 1, no. 2, pp. 143–157, 2020.
- [2] D. J. Nutt, L. A. King, and D. E. Nichols, "Effects of Schedule I drug laws on neuroscience research and treatment innovation," *Nature Reviews Neuroscience*, vol. 14, no. 8, pp. 577–585, 2013.
- [3] "Piattaforma di simbiosi industriale." [Online]. Available: <http://www.simbiosiindustriale.it/piattaforma>
- [4] L. Cutaia, A. Luciano, G. Barberio, S. Sbaifoni, E. Mancuso, C. Scagliarino, and M. La Monica, "The experience of the first industrial symbiosis platform in Italy," *Environmental Engineering & Management Journal (EEMJ)*, vol. 14, no. 7, 2015.

This page intentionally left blank.



Social Media: A New Tool for Peacebuilding in Italy

COMMUNICATION | EDITORIAL | INVITED CONTRIBUTION | PERSPECTIVE | REPORT | **REVIEW**

Jasmine Anouna*

United Nations Office of the High
Commissioner for Human Rights (OHCHR)
jas.anouna96@gmail.com

ABSTRACT

Gender-based violence against women, defined as the systematic harm inflicted on individuals and/or groups based on gender, persists in modern-day Italy. I find that current discussions and policies to mitigate gender-based violence neglect a fundamental direction: prevention. Experts and policymakers specializing in the issue widely neglect a cultural assessment to explore why gender-based violence persists in order to address these deeper roots. Accordingly, I explore the ways that the Italian media is complicit in reproducing a culture of violence. This review considers one tool that remains largely overlooked within the project to ameliorate violence: social media. Current opinions on social media are largely dominated by its negative implications. In contrast, my research sheds an optimistic light on social media by exposing how certain projects on Instagram address and challenge gender-based violence. Two projects in particular convey the point: *Il meglio delle donne* and *Freeda*. Through a content analysis of the images and videos shared on the projects, I illustrate how they serve as unique resources for policy, and use their work as a basis for recommendations to policymakers to promote the social development necessary to counter a culture of gender-based violence. The projects disrupt traditional patterns of cultural formation and help to build a more holistic citizenship, especially for marginalized groups, in ways that merit greater attention particularly from politicians and academics.

Introduction

Italy was among the 34 European countries to sign the Council of Europe's Istanbul Convention on 11 May 2011. The convention aims to prevent violence against women, protect its victims and prosecute perpetrators. Accordingly,

the structure of the convention is based on 'four Ps': prevention, protection, prosecution, and integrated policies [1]. Pursuant to the Istanbul Convention's terms, the Italian government has taken increased action to address the systematic harm inflicted on individuals and/or groups based on gender, known as gender-based or gendered

*This work has been presented in form of a poster at the conference: 'Science Policy and the Public in Italy' (Cambridge, 26th October 2019).

violence, in Italy. Several legislative reforms, including the recent Law No. 69 of 19 July 2019 (known as the Red Code), have led to the development of a legislative framework in line with the requirements of the convention on the civil and criminal law remedies for victims of violence [2]. Notwithstanding the increased measures, however, these have disproportionately focused on prosecution; while the prosecution of perpetrators of violence is fundamental, one of the most important clauses, prevention, is dramatically neglected. Data from one of the most recent analyses of the implementation of the provisions of the Istanbul Convention illustrates this discrepancy. The report was published on January 2020 by the Group on Action against Violence against Women and Domestic Violence (GREVIO), the independent expert body responsible for monitoring the implementation of the Istanbul Convention by the state parties. Among the most significant legislative gaps the expert group found in Italy was the failure of the government to take adequate preventative or protective measures [3]. Scholars investigating gendered violence in Italy have also followed this trend: documenting the violence itself and the punishment of violence often takes precedence over assessing why violence persists in order to address these deeper cultural roots.

Although there has been a considerable increase in academic publications on gendered violence in recent years, the studies prevalently lack an analytical narrative on violence; the dominant focus lies in merely describing the character and conditions of violence [4–9]. Many, for example, describe the issue from a medical perspective [4, 10–15]. A limited pool of literature has been published which questions why gendered violence remains, and what is being done to address this issue [16–19]. My research builds on these studies. In this article I find that one of the abiding institutions disseminating and reinforcing a culture of gender-based violence is the Italian media—in particular, RAI, Mediaset, Corriere della Sera, and La Repubblica. Peace and conflict theory scholars, notably, David P. Baradash and Charles P. Webel suggest that a greater emphasis on cultural violence and the institutions sustaining the culture is necessary for the sustainable prevention of gendered violence, considered as “peacebuilding” [20].

The peacebuilding process in Italy is well underway in a vastly undervalued area: social media. On the social network Instagram, certain feminist projects are building platforms of gender consciousness that attempt to combat a culture of gendered violence. Figure 1 shows screenshots taken from two such projects: *Freda* and *Il meglio delle donne* (‘The Best of Women’). The projects develop a counterculture with significant implications for the alleviation of gendered violence in Italy. *Il meglio delle donne* and *Freda* are addressing one of the underlying limitations of Italian policy work against gendered violence: the prioritization of prosecution over prevention.

Cultural Roots of Gender Violence in Italy

Can we talk about violence when nobody is committing direct violence?

Johan Galtung [21]

Johan Galtung posed the question more than five decades ago in his seminal work ‘Violence, Peace, and Peace Research’ [21]. In the article, Galtung suggests that sustainable peacebuilding can only progress with more intricate understandings of ‘violence’, which he divides into three core components: direct, structural, and cultural (Figure 2).

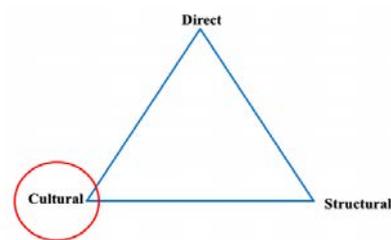


Figure 2: Galtung’s representation of violence. Adapted from [21].

At the upmost tip is the direct manifestation, a personal injustice likely traceable to concrete subjects. In contrast, structural violence is an indirect process of exploitation and marginalization felt by entire communities. Incorporated among the deeper layer of the triangle is cultural violence, the process through which violence comes to be seen as natural and legitimate. Comparing

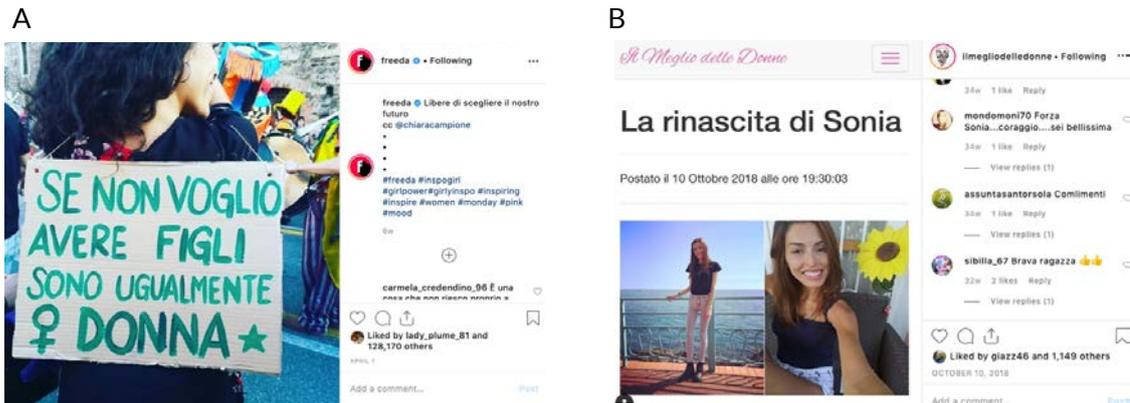


Figure 1: A) is a photograph from *Freeda* of a woman whose back reads: ‘I am still a woman if I don’t want children.’ B) is a picture on *Il meglio delle donne* from an interview with Sonia, a woman who shared her story battling anorexia.

the concept to the other two layers of violence, Galtung states: ‘it does not kill or maim like direct violence or the violence built into social structure. However, it is used to legitimize either or both’ [22]. Peace theory scholars today observe that a recurring limitation of the peace process is the tendency to focus exclusively on the upmost tip [20]. Italy is one such case. Despite the increase in research on gender-based violence, the publications seldom call to attention the institutions inciting the upmost manifestation of violence. One critical site sustaining cultural violence in Italy is the media: the media industry in Italy is a prominent agent of socialization pivotal in sustaining unequal gender relations [23].

Cultural Violence in the Italian Media

Over the last two decades, extensive literature has been published exposing how Italian media legitimizes a culture of violence against women [24–27]. Echoing these studies, foreign news outlets have also begun to document the poor and relatively unchecked female representation in Italian media [28]. A view shared among the publications is that the television industry in particular has constructed and legitimized unequal gender hierarchies. Despite the fact that 60% of television viewers in Italy are women, scholars note that the dominant images have been produced by and for the traditional male gaze, whereby women are

depicted from a heterosexual, masculine perspective that presents them as sexual objects for the pleasure of the male viewer [29, 30]. As a result, the mainstream symbolic landscape in Italian television is dominated by homogenous images of fragmented, white, youthful, and mute female bodies. This restricted set of images, or rather, as sociologist Patricia Hill Collins refers to them, ‘controlling images,’ reproduce and justify unjust hierarchies across numerous categories, including gender [31].

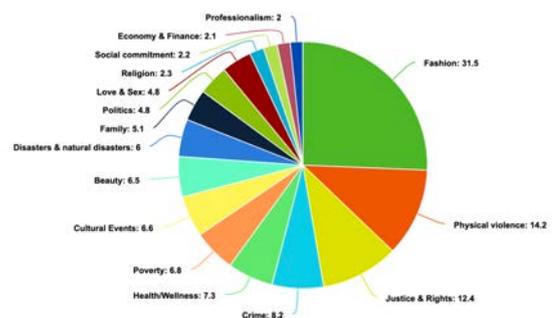


Figure 3: Content analysis of the representation of women in Italian media in 2006. Source: [32]. The top 10 and other representative themes are shown. The sum is larger than 100% because more themes were allowed per data point.

Data from international reports specific to the Italian context such as the 2011 UN’s Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW) shadow report corroborates observations in the literature [33]. Citing a 2006 survey from Italian research institute Censis, Rashida Manjoo, the United Nations Special Rap-

porteur on violence against women, reported that in 2006 53% of women appearing on Italian television did not speak [34]. The 2006 Censis survey also reflects the homogenous and highly stereotyped associations of women in Italian television: more than 45% of associations were with issues such as sex, family, fashion and beauty and less than 10% were with issues of social commitment and professionalism (Figure 3).

The trends observed in Italian media reflects those documented in major news outlets globally; at the time of the Censis survey (2005-2006), the Global Media Monitoring project collected data from major news outlets around the world and reported that women are dramatically under-represented in the news, with only about one-fifth of news subjects being female (the topic of the news stories or interviewees). There was no single news topic in which women outnumbered men as newsmakers: only 14% of political stories were on women and 20% of business news focused on women. However, women are dominant in the media as celebrities (42%) and royalty (33%). In 2010, the survey reported that only 13% of all stories focus specifically on women; 46% of all stories reinforce gender stereotypes; politics featured 19% women and figures for business stories remained unchanged in 2010 [35].

Almost a decade later, gender-specific data and statistics highlight a similar phenomenon. According to a 2018 UNESCO survey on women in media, women are the focus of only 10% of news stories, comprise just 20% of experts or spokespeople interviewed, and a mere 4% of news stories are deemed to challenge gender stereotypes [36]. The statistics emphasize that a critical issue is not just the lack of representation, but also the quality of representation; when women appear in articles on these platforms, they are primarily associated with the private sphere and framed with a 'less serious' tone than male counterparts. Reproducing the classification of women through their traditional roles legitimizes their associated status of inferiority, thereby normalizing unequal power relations, a dynamic foundational to justifying direct acts of violence. Through my research, I observed that the power imbalance is entrenched not merely in the content but also in the structure of the newspapers. The newspaper

Corriere della Sera (henceforth, *Corriere*) offers an example.

Corriere is one of Italy's oldest and most respected daily papers, first published in 1876. The online version is a popular Italian-language website, attracting more than 1.6 million readers daily; it is the thirteenth most visited website in Italy [37]. Since 1996, *Corriere* has included a weekly women's magazine supplement *IoDonna*, 'I Woman.' The *Corriere* website contains a permanent version of *IoDonna*. The online *IoDonna* supplement can be found towards the end of the menu. The placement of the section 'for women' at the bottom of the menu immediately establishes a subtle social hierarchy, where the hard news sections occupy the topmost levels. In the absence of a counterpart 'male section,' a subtle message is conveyed that the more serious sections including politics and economy are 'masculine territories.' Adding further weight to this message is the structure of *IoDonna*.



Figure 4: April 2020 Menu of the *IoDonna* section, described on the newspaper's website as the 'feminine of *Corriere*.'

The section is divided into five categories, each representing a topic stereotypically associated with women: fashion, beauty, TV gossip, royal families (substituting a former 'love and sex' section), and astrology (Figure 4). Why do the topics belong to the women's section? Why not include 'Sex and Love' alongside politics and economy in *Corriere*'s main menu? While it may be argued that the sections' inclusion was decided upon from what was popular with *Corriere*'s female audience, it is also well documented that the media play a part in creating such demand [38, 39]. In reinforcing the traditional ideals of femininity, *Corriere* helps perpetuate cultural norms that legitimize gender-based violence.

Although the government does recognize that deeply rooted gender stereotypes in Italy are a persistent obstacle to women's empowerment and equal opportunity, there has yet to be adequate national action by policymakers to address the issue. Accordingly, the CEDAW Shadow Report for Italy states:

Since 2005 no will to try to modify the stereotyped image of women in the media has been noticed. The political debate has contributed to a decline in this sense through frequent sexual references and stereotyped expressions on the role of women in society [33].

The report also documents that the Italian government currently does not have comprehensive policy to address the way in which the media industry reproduces discriminatory cultural norms [33]. However, there are extensive initiatives pursuing this work outside official institutions and one underexplored area where such efforts are underway is social media, specifically, on the platform Instagram. Certain feminist projects have emerged on social media whose unique work bolsters policy recommendations to address the ongoing institutional limitations with regards to gender equality and women's rights.

Recommendation I

Italian government institutions should mandate surveys for the Italian public on social media, focusing on the mental health benefits of engaging with social media platforms that are more inclusive in representation and information than traditional media.

The lack of diversity in the media spans from the decision makers within the institution, such as male-dominated editorial boards and top broadcast executives, to the actual content put forth, as illustrated in previous sections. Opening these positions of power to a more diverse pool of individuals across gender, race, sexuality and general socioeconomic backgrounds is essential in the endeavor to mitigate discrimination and violence,

including gendered violence, in Italy. A greater representation of marginalized groups within the structure of the media would, in turn, increase the diversity of its content, thereby disrupting the homogeneity of the images in the mainstream symbolic landscape which are, in turn, necessary to justify gendered violence.

Diversification in structure and content reportedly benefits individual and collective well-being; while such data has yet to be collected in Italy, examples outside the country offer valuable insights such as a 2019 survey in the UK. Despite negative aspects of social media use which must be addressed but are outside the scope of this review, the data collected indicates that there are notable positive health benefits to social media use, particularly as a means of self-expression, identity, community building, and awareness of others (Figure 5) [40].

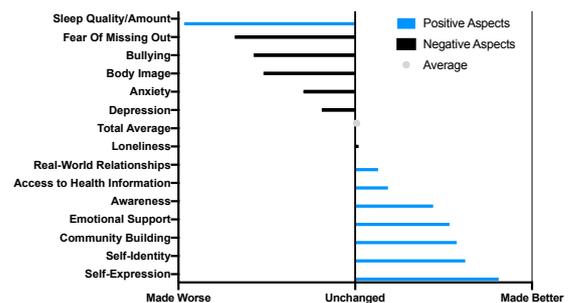


Figure 5: Social media as a tool to improve personal health. Data derived from [40] as an average of scores across five social media (YouTube, Instagram, Facebook, Snapchat, Twitter).

The latest global data reveals that more than 4.5 billion people have access to the internet, while social media users have passed 3.8 billion—and estimates are that more than half of the world's total population will use social media by mid-2020 [41]. With the exponential growth of social media use around the world, it behooves the Italian government to follow the UK's example and invest greater resources in understanding social media, focusing in particular on the individual and collective mental health effects, so as to find ways to promote healthier participation online. Several projects exist on social media whose work aims to influence social well-being in Italy for the better, and as a successive step, the government should identify and collaborate with them. Two such projects are *Il meglio delle donne* and

Freeda. Their goal is social progress through greater inclusivity and diversity in representation and information, specifically of women. As such, the projects stand as excellent case studies for policymakers who wish to learn of more creative and innovative outlets of social change outside of traditional Italian institutions.

Il meglio delle donne and *Freeda* offer digital spaces that promote a form of community building and self-identity unique to the Italian media landscape: one grounded in diversity and inclusivity. The projects displace homogenous visualizations of Italian women, namely, as cis, feminine, white, able-bodied, and heterosexual individuals. This quality renders the implications of their work fundamental; negotiating more expansive identities is correlated to stronger mental and physical well-being, a correlation shown in Figure 5. One of the ways in which the projects negotiate identity is through storytelling, an act widely recognized to hold emancipatory qualities for both subject and reader [42].

Storytelling is a foundational component of *Il meglio delle donne*. Through her posts, the founder of the project, Francesca, shares stories and interviews of individuals who are, for the most part, female-identifying, which offer valuable and inspirational lessons to her audience.² The messages these stories communicate fall into three main topics: body positivity, resilience, and diversity. Accordingly, Francesca states:

My idea was to exalt as much as possible the female figure, as she is often seen depicted with a weak image. I am trying to show the unfounded nature of this perspective and instead how we are a fundamental part of society. [43]

Francesca's project counter dominant and narrow visualizations of 'woman' by emphasizing the success of Italian women and, equally significant, the vast array of ways this quality can be expressed and achieved. Exemplary is the story of Ilaria Bidini (Figure 6A).

From an early age, Bidini lived with a disabling pathology and received significant bullying as a

result of the impairment. In the comments on Bidini, on the righthand side of the photograph, Francesca emphasizes that despite the extensive framing of her physical state as a 'weakness,' she was able to demonstrate strength; 'After years of humiliation, Ilaria decided to give a moral slap in the face to all and got a degree in education studies with a thesis entitled "Fighting Bullying" [...] Let's defeat the barriers we erect with stereotypes [...] we want to encourage her to continue fighting' [44]. Through her comment, Francesca attempted to undermine the stereotypes associated with disabilities and negotiate an expanded conception of strength. The positive frame Francesca emphasized on Ilaria's story of difficulty and difference was well-received by her audience; Ilaria's story provoked 62 comments, all of which were positive and encouraging messages of support. Although Francesca had previously shared stories on resilience, these were predominantly associated with celebrities but Ilaria's story marked a drastic and well-received shift in Francesca's project towards positive representations of diversity and body-image of everyday women.

Freeda uses social media with a similar end to *Il meglio delle donne*. As with *Il meglio delle donne*, the majority of subjects on *Freeda* are significantly underrepresented in mainstream media, and ones that face a higher risk of discrimination and violence as a result of living at the intersections of other marginalized identities, such as immigrants, people of color, and people with disabilities [46]. The story of Luca Trapanese exemplifies the point, particularly on the topic of parenthood (Figure 6B) [45]. In the dominant register of representation of traditional media, parenthood is conceived as a feminine topic. Major newspapers including *Corriere della Sera* and *La Repubblica* have a subsection within the women's section dedicated to 'family.' Further, from a content analysis of 32 images of 'parents' and 'family' between 2017 and 2018 from the two newspapers, I found that all of the images consist of a stereotyped and narrow depiction of family as a heterosexual partnership between a male and female, and where the topic of 'parenthood' is intrinsically associated with 'motherhood'; no images in the articles gave visibility to 'fatherhood', thus

²Francesca's surname has been omitted to preserve her anonymity.



Figure 6: A) Ilaria Bidini from *'Il meglio delle donne'* [44] and B) Luca Trapanese from *Freeda* [45].

portraying a very narrow conception of parenthood. The narrative of Trapanese helps challenge these constructions of masculinity and femininity. In his video-interview, Trapanese presents himself as a queer and single father: 'My name is Luca, and I am a father' (Figure 6B) [45]. This establishes an immediate contrast to the presentation of men on traditional media outlets, where they are typically presented first and foremost through their business and professional identities; seldom, if ever, do their domestic roles take precedence. The interview exposes one of the ways *Freeda* is negotiating more expansive identities.

Neither *Il meglio delle donne* nor *Freeda* is self-defined as a 'peace project', working towards mitigating gendered violence in Italy. The implications of their interventions, however, yield them this quality. Displacing dominant images through storytelling works towards peacebuilding as it disrupts the traditional classification schema necessary to justify gendered violence. Indeed, both projects work towards imperceptibility; they stress that there is no one way of being an Italian woman, and no single definition of success, beauty or resilience. The ambiguity of the projects thus challenges the homogeneity of the social hierarchies deeply rooted in the mainstream symbolic landscape which are, in turn, necessary to justify gendered violence.

At present, there is no measurable data to quantify the influence of *Il meglio delle donne* and *Freeda* in mitigating gendered violence. However, if Italian government institutions were to mandate surveys for the Italian public actively engaging with their projects, focusing on the men-

tal health effects of their engagement overtime, the data would help measure the impact of their peacebuilding. As with the UK's survey, important variables to consider in such an assessment are self-expression, identity, community building, and awareness of others; all factors which, if strengthened, expand one's social openness and acceptance, thus minimizing the likelihood of discrimination and violence. The projects would, in this way, inform policy by providing data on how to best encourage the social and psychological development necessary to mitigate gendered violence. Specifically, data on the impactful content of the projects—the content with highest engagement rate including views and comments—focused on the themes of diversity and inclusion would help policymakers understand how to diversify their own communication campaigns, thus helping them build more effective frameworks through which to engage with youth.

Recommendation II

Encourage youth to engage with social media platforms that offer resources on information marginalized in traditional Italian curriculums such as sexual health and women's rights.

The contemporary state of official institutions of social formation, namely, schools and the media, impedes younger generations from developing a critical consciousness on topics integral to countering a culture of gendered violence such as sexual health and women's rights. On social media, how-

ever, projects such as *Il meglio delle donne* and *Freedda* are building archives on these materials and promoting discussions around them. The significant following of the projects indicates a strong and growing desire across Italy to engage with this content; in January 2020, *Freedda* was ranked the second most popular media on social networks in Italy with a total of 13,8 Million interactions, and *Il meglio delle donne* has attracted over 50,000 followers including well-known thought leaders in human rights such as Rula Jebreal [47].

Il meglio delle donne's page is creating a digitally permanent educational space on the topic of femicides, where typically a woman or girl is murdered by a man on account of her gender. This is one of Italy's most pressing human rights issues: Italy has one of the highest femicide rates in Europe, with 123 women murdered in 2017, according to the National Institute of Statistics in Italy [49]. Francesca shares posts on a multitude of issues but her central goal is consciousness raising on femicide. Through this focus, her project is becoming a permanent archival space of resources and dialogue on the topic. News of femicides retains a constant visibility on *Il meglio delle donne*, as exemplified in Figure 7A. The content on femicide that Francesca publishes varies from pictures of victims with brief summaries of their murders, to articles originally published on news sources such as *Corriere*. While the lifespan on the front pages of newspapers of the articles and discussions related to femicides is predictably fleeting, on Francesca's page the articles occupy a permanent and easily visible position in the makeup of her page thanks to the Instagram mosaic format.

Freedda is building a body of resources on a range of topics neglected in the mainstream media and educational landscapes; among these themes is that of sexual health. Sex education is a resource pervasively marginalized in Italian schools; Italy is one of the few countries in Europe where sex education is not mandatory, and this absence helps fuel a culture of gender-based violence [50]. One of the reasons behind the correlation is that the absence of sexual health education typically leads youth to rely on alternative resources, such as pornography, which scholars note increase the likelihood of violent behavior, especially in young boys, as it portrays imbalanced sexual relations where the focus shifts almost exclusively towards

male pleasure [51]. The imbalanced focus on male pleasure perpetuates a dynamic central to a culture of gendered violence: women's constructed dependency on men for pleasure. Feminists across Italy have written directly to the Italian government on the correlation between depriving youth of sexual health courses, and gender-based violence. In an open letter from 2016, campaigners from the Italian feminist association 'F Come' write:

An unmistakable link exists between gender-based violence and a lack of effective education policies. Too many women suffer violence at the hands of their partners or acquaintances, without the knowledge that their experiences qualify as abuse. Furthermore, the collective imagination too often believes the stereotype that rapists and abusers are solely strangers who are encountered casually in public spaces [52].

The letter included the support of representatives from multiple organizations and professionals from the legal, education, and medical fields. The authors illustrate that comprehensive sex education is fundamental to combatting behaviors typically associated with a culture favorable to gender-based violence, such as sexual stereotypes of masculinity or narrow conceptions of sexual pleasure. *Freedda* provides resources to help disrupt the informational void on sex education in schools and mainstream media. Specifically, *Freedda* has drawn significant attention to the topic of women's sexual and reproductive health.

In a cartoon video on female pleasure, for example, the authors underscore the need to break the taboo of female masturbation. The image on Figure 7B captures the opening lines of the video. The text reads: 'Female autoeroticism is still a taboo, but women also masturbate. And rightly so! But why?' They introduce the need to break the silence on the topic with lighthearted and simple language. Later, the video illustrates how masturbation can have significant health benefits, emphasizing that the chemical reaction can bolster emotional and mental health by alleviat-



Figure 7: A) Mosaic format of *Il meglio delle donne* main page. In the center of the page, there is a photograph of an article from January 2019 which reads: ‘Brought to Italy and then killed: the slaves of organ trafficking. B) *Freeda*’s cartoon video ‘Even women masturbate’ on the topic of female autoerotism [48].

ing tension, increasing happiness, and improving sexual relations. In just under forty seconds, the *Freeda* video provides a comprehensive overview of an issue pervasively missing in Italian schools but one that challenges the widescale social norm that women are dependent on men for sexual pleasure.

Projects such as *Il meglio delle donne* and *Freeda* allocate a visual centrality to sexual health and women’s rights. Together, these qualities render the projects valuable and well-respected platforms executing preventative work against the cultural roots of gender-based violence. As such, it behooves policymakers to encourage youth to engage more with these and other social media platforms whose content proves highly educational on topics not covered on a national scale in Italian schools such as sexual health. Policymakers can undertake this action by inviting teachers to complement their courses with content from social media; more than half of Italy’s youth has access to a smartphone, which, rather than be dismissed entirely in classroom settings, should be ascribed more importance and acceptance. Opening schools to smartphones and social media also opens the possibility of introducing informational materials not offered on a national scale, such as sexual health, yet valuable to offer all students. Data from a recent UK study from charitable organisation ‘The Female Lead’ serves as a unique case study on the benefits of helping youth embrace social media as an educational and empowering tool. The study, called ‘Disrupting

the Feed’, assessed 28 teenage girls’ relationship to social media before and after being instructed to follow specific accounts with a strong focus on empowerment and women’s rights. Over the course of one year, the study found that introducing social media in a more formal setting, along with a curriculum to guide the student’s engagement online towards more educational content on women’s rights and other topics marginalized in traditional schooling, was a transformative experience for the girls:

Offering teens a diverse range of female role models to follow outside of the typical celebrity profiles and those of their friends, transformed their view of what social media could be used for and gave them ‘a completely different outlook’. At the end of the study, girls were far more likely to see social media as both for entertainment and for ‘education and learning’ [53].

The project’s success has received extensive recognition from reporters and will soon expand out to youth in schools across the UK [54]. Although the main focus of the UK study was ‘inspiring female role models’, Italian policymakers might consider supporting a similar study in Italy where the main focus might be sexual health, and women’s rights.

Recommendation III

Use social media platforms to promote dialogue between citizens and policymakers

The peacebuilding process that *Il meglio delle donne* and *Freeda* promote has important implications for the strength of democracy and policymaking in Italy. The resources, conversations, and community building the projects offer render them disruptive platforms which are valuable in strengthening one of democracy's fundamental pillars: citizenship.

Citizenship is more than a question of inclusion; formal legal equality is only a first step in the process of constructing citizenship. Once legal rights are attained, it is equally necessary to ensure access to power, representation and equal participation; yet this step is often neglected, thus perpetuating the pre-existing status of marginalized communities but in more subtle ways. This is well documented in the case of women. For decades, feminist theorists have observed that relative to men, women's citizenship is still contingent on their traditional roles in the domestic sphere, especially as wives and mothers [55–57]. The phenomenon stems largely from the conflation of women's legal equality to their holistic emancipation, see reference [58] for more details. A process of deconstruction and reconstruction is imperative to work towards emancipation so that they are treated as 'full members.' When this phase of constructing female citizenship is not pursued, their previous 'identification with the private and familial sphere' persists and women remain partial citizens. The phenomenon is especially evident in Italy. Contemporary sites of citizen formation in Italy such as the media and schools have yet to recognize their complicity in perpetuating traditional gender hierarchies. As a result, these institutions continue to reproduce a narrow conception of women's citizenship; women's image has remained depicted through their relation to male counterparts. Notwithstanding the current conditions, various tools exist that are contributing to challenge Italian women's partial citizenship; social media being an example used in this review. Social media can function as a modern tool not only to challenge, but also to expand and reconstruct female citizen-

ship. *Il meglio delle donne* and *Freeda* illustrate this; the projects disrupt traditional constructions of citizenship by providing spaces of alternative social formation. The projects encourage an expansion of female citizenship by negotiating more diverse identities, providing resources on marginalized information and encouraging conversations on these topics. Thus, the projects strengthen three core components of citizenship: representation, participation, and access to information [56]. As such, the projects offer powerful examples to policymakers on the ways social media's unique qualities can be used to strengthen democracy and the policymaking process.

Policymakers around the world are beginning to understand the positive implications of promoting greater education on engagement in society, politics, and government online, "digital citizenship" and, in particular, social media, to strengthen democratic process and offline citizenship. Two recent cases underscore the point; in both contexts, social media was a valuable resource for government officials to communicate with civilians and ensure their representation. In the Democratic Republic of Congo (DRC), WhatsApp was used in political dialogues led by the African Union in 2016. To accredit the media representatives to the dialogue process, the communications team created a WhatsApp group to share communiqués as well as other important information, including meeting programmes and schedules. The platform thus became one on which members would instantly share documents and comments about the process [59]. Further speaking to the influence and power of using social media in policymaking was the inclusion of women in Fiji's constitution-making process in 2012. Almost one-third of all the submissions to the Constitution Commission were from women thanks to the government's efforts to engage and empower them through digital inclusion tools. The final text of the Commission's draft constitution included a number of provisions that reflected the themes and positions advocated by women [59]. The examples from DRC and Fiji offer clear case studies on how social media can promote dialogue between citizens and policymakers, and the Italian government should follow their example. Examples of critical actions for policymakers endeavoring in this work are:

Create their own social media accounts if they have not yet done so; young people are more likely to rely on social media for engaging in society, politics, and government, so it has become, in many ways, the duty of politicians today to share their thoughts not only through articles in traditional newspapers or interviews on television, but also through their social media channels. The accounts do not necessarily need to cover personal matters; what is imperative is that they use the channels to complement to their work. A strong example of the point is the account of US Representative Alexandra Ocasio-Cortez, who uses her Twitter and Instagram channels actively to offer greater transparency to her work, beliefs, and occasionally to engage with her followers.

Hold national surveys and polls to gather civilian input on existing or proposed policy.

Arranging Q&As via ‘live’ functions (e.g. Instagram Live) with teachers in schools to help students understand policymaking in Italy, and to encourage more students to participate in civic studies, a course optional nation-wide and which many students reportedly do not attend.

Peacebuilding with Social Media

Italy’s conception of social media has, over the last two decades, endured as one constructed primarily around tragedy. For the purposes of this review, a content analysis of three of Italy’s major newspapers including *Corriere*, *Repubblica*, and *IlSole24Ore*, was conducted and exposed that some of the most common words and phrases connected to ‘social media/networking’ were: cyberbullying, control, violence, suicide, crime, and pe-

dophilia.³ Although these are all legitimate concerns, the peacebuilding process in Italy against gender-based violence depends on overcoming this negativity to widen the lens on social media, and to give equal consideration to its positive implications. Considerable work addressing the roots of gendered violence operates in the online in addition to the offline dimension. It is recognised that in order to develop better preventative work on the issue, it is necessary to consider both dimensions [60].

Social media offers valuable new opportunities for activism in civil society through a greater access to political information and outlets for participation [61–65]. Through my research, I observed that the two particular case studies of *Il meglio delle donne* and *Freeda* underscore the point in Italy. The projects are alternative spaces of social formation whose work can help policymakers better understand how to endeavor in more effective preventative work against gender-based violence.

Acknowledgements

The author would like to express her deepest gratitude to the Journal Editors and Reviewers for their phenomenal support, to her college Supervisor Dr Jane Garnett without whom this research would not have come to life, and to Steffan for always being a constant along the way.

© 2020 The Author. Published by the Cambridge University Science & Policy Exchange under the terms of the Creative Commons Attribution License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, provided the original author and source are credited.

³To collect data for this analysis, I searched through the digital archives of the three newspapers for any articles in English or Italian discussing social media between 2000–2018. Keywords for the search included: social media, social networks, digital media, Facebook, Twitter, and Instagram. Once I collected all relevant articles, which totalled to 134, I conducted a content analysis of the materials to identify discursive trends on the topic including any patterns in tone, content, associations, and protagonists of the articles. One of the more prominent trends was the overwhelmingly negative and pessimistic tone and portrayal of social media.

References

- [1] B. C. Meyersfeld, "The Council of Europe Convention on Preventing and Combating Violence Against Women and Domestic Violence: Council of Europe Convention on Preventing and Combating Violence Against Women and Domestic Violence," *International legal materials*, vol. 51, no. 1, pp. 106–132, 2012.
- [2] C. Andreuccioli, "Legge 19 luglio 2019, n.69-Tutela delle vittime di violenza domestica e di genere - il c.d. codice rosso (GU 25.07.2019)," Jul 2019. [Online]. Available: [http://www.archiviopenale.it/legge-19-luglio-2019-n69-tutela-delle-vittime-di-violenza-domestica-e-di-genere-il-cd-codice-rosso-\(gu-25072019\)/contenuti/9044](http://www.archiviopenale.it/legge-19-luglio-2019-n69-tutela-delle-vittime-di-violenza-domestica-e-di-genere-il-cd-codice-rosso-(gu-25072019)/contenuti/9044)
- [3] GREVIO, "First General Report on GREVIO's activities (June 2015 to May 2019)," Jan 2020. [Online]. Available: <https://rm.coe.int/1st-general-report-on-grevio-s-activities/16809cd382>
- [4] A. C. Baldry, "'Stick and Stones Hurt my Bones but His Glance and Words Hurt More': The Impact of Psychological Abuse and Physical Violence by Current and Former Partners on Battered Women in Italy," *International Journal of Forensic Mental Health*, vol. 2, no. 1, pp. 47–57, 2003.
- [5] J. Freedman, B. Jamal, and Euro-Mediterranean Human Rights Network (EMHRN), "Violence against migrant and refugee women in the Euromed region," *Case studies: France, Egypt & Morocco. Copenhagen: Euro-Mediterranean Human Rights Network*, 2008.
- [6] I. Bartholini and A. Jugović, "Gender violence in the post-patriarchalization of global age: a comparative perspective of Italy and Serbia," *Instituta za kriminološka i sociološka istraživanja (IKSI)*, 2014.
- [7] C. Peroni, "Gender violence and sexism in Italy. Norms, control and sexuality," *La camera blu. Rivista di studi di genere*, no. 10, 2014.
- [8] D. Bandelli, *Femicide, Gender and Violence: Discourses and Counterdiscourses in Italy*. Springer, 2017.
- [9] L. Pomicino, L. Beltramini, and P. Romito, "Freeing oneself from intimate partner violence: a follow-up of women who contacted an anti-violence center in Italy," *Violence against women*, vol. 25, no. 8, pp. 925–944, 2019.
- [10] N. Livi-Bacci, "Women's crisis centers and shelters in Italy: working with battered women and with health care providers," *International Journal of Gynecology & Obstetrics*, vol. 78, pp. S65–S66, 2002.
- [11] S. Farchi, A. Polo, S. Asole, M. P. Ruggieri, and D. Di Lallo, "Use of emergency department services by women victims of violence in Lazio region, Italy," *BMC women's health*, vol. 13, no. 1, p. 31, 2013.
- [12] E. Bonanni, A. Maiese, L. Gitto, P. Falco, A. Maiese, and G. Bolino, "Femicide in Italy: national scenario and presentation of four cases," *Medico-Legal Journal*, vol. 82, no. 1, pp. 32–37, 2014.
- [13] R. Capucci, C. Paganelli, S. Carboni, R. Capadona, M. Roberto, and G. Rinaldi, "Characteristics of gender-based violence determined from emergency room visits," *Violence and gender*, vol. 2, no. 2, pp. 129–133, 2015.
- [14] C. Moreschi, U. Da Broi, V. Zamai, and F. Palese, "Medico legal and epidemiological aspects of femicide in a judicial district of north eastern Italy," *Journal of forensic and legal medicine*, vol. 39, pp. 65–73, 2016.
- [15] P. Di Giacomo, A. Cavallo, A. Bagnasco, M. Sartini, and L. Sasso, "Violence against women: knowledge, attitudes and beliefs of nurses and midwives," *Journal of clinical nursing*, vol. 26, no. 15-16, pp. 2307–2316, 2017.
- [16] S. Plesset, *Sheltering women: Negotiating gender and violence in Northern Italy*. Stanford University Press, 2006.
- [17] C. Karadole, "Anti-violence centres and shelters in Italy: history and meaning of women's struggles against male violence," *Interdisciplinary Journal of Family Studies*, vol. 17, no. 2, 2012.
- [18] F. Laviosa, "Killing in the name of love: violence against women in Italy," *JOMEC Journal*, no. 8, pp. 1–14, 2015.

- [19] G. Parmigiani, “Femminicidio and the emergence of a ‘community of sense’ in contemporary Italy,” *Modern Italy*, vol. 23, no. 1, pp. 19–34, 2018.
- [20] D. P. Barash and C. P. Webel, *Peace and conflict studies*. Sage, 2008.
- [21] J. Galtung, “Violence, peace, and peace research,” *Journal of peace research*, vol. 6, no. 3, pp. 167–191, 1969.
- [22] —, “Cultural violence,” *Journal of peace research*, vol. 27, no. 3, pp. 291–305, 1990.
- [23] G. Handel, *Childhood socialization*. Transaction Publishers, 2011.
- [24] S. Capecchi, *Identità di genere e media*. Carocci editore, 2006.
- [25] G. Grossi and E. Ruspini, *Ofelia e Parsifal. Modelli e differenze di genere nel mondo dei media*. Cortina, 2007.
- [26] L. Zanardo, *Il corpo delle donne*. Feltrinelli Editore, 2010.
- [27] L. Lipperini and E. G. Belotti, *Ancora dalla parte delle bambine*. Feltrinelli Editore, 2010.
- [28] E. Povoledo, “Women take on sexist image in Italian media,” Jun 2009. [Online]. Available: <https://www.nytimes.com/2009/06/18/arts/18iht-women.html>
- [29] A. W. Eaton, “Feminist philosophy of art,” *Philosophy Compass*, vol. 3, no. 5, pp. 873–893, 2008.
- [30] L. Zanardo, “Il corpo delle donne [English version],” Jul 2009. [Online]. Available: <http://www.ilcorpodelledonne.net/english-version/>
- [31] P. H. Collins, *Black feminist thought: Knowledge, consciousness, and the politics of empowerment*. routledge, 2002.
- [32] “Women and Media in Europe: Sintesi della ricerca,” Feb 2006. [Online]. Available: <https://parita.regione.emilia-romagna.it/documentazione/documentazione-temi/documentazione-stereotipi-di-genere/donne-e-media-in-europa>
- [33] B. Spinelli, “CEDAW Shadow Report: Italy,” Jun 2011. [Online]. Available: https://tbinternet.ohchr.org/Treaties/CEDAW/SharedDocuments/ITA/INT_CEDAW_NGO_ITA_49_9220_E.pdf
- [34] R. Manjoo, “Report of the Special Rapporteur on violence against women, its causes and consequences, Rashida Manjoo. Addendum: Mission to Italy,” Jun 2012. [Online]. Available: https://www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session20/A-HRC-20-16-Add2_en.pdf
- [35] M. Azzalini and C. Padovani, “Global Media Monitoring Project 2010, National Report: Italy.” [Online]. Available: http://cdn.agilitycms.com/who-makes-the-news/Imported/reports_2010/national/Italy.pdf
- [36] UNESCO, “Women make the news 2018,” Aug 2019. [Online]. Available: <https://en.unesco.org/womenmakenews>
- [37] G. Mazzoleni, G. Vigevani, and S. Splendore, “Mapping digital media: Italy,” Aug 2011. [Online]. Available: <https://www.opensocietyfoundations.org/sites/default/files/mapping-digital-media-italy-20130605.pdf>
- [38] M. J. Kane and J. B. Parks, “The social construction of gender difference and hierarchy in sport journalism—few new twists on very old themes,” *Women in Sport and Physical Activity Journal*, vol. 1, no. 1, pp. 49–83, 1992.
- [39] C. Carter, “Sex/gender and the media from sex roles to social construction,” *The handbook of gender, sex, and media*, p. 365, 2012.
- [40] Royal Society of Public Health, *#StatusOfMind: Social media and young people’s mental health and wellbeing*, May 2017. [Online]. Available: <https://www.rsph.org.uk/uploads/assets/uploaded/d125b27c-0b62-41c5-a2c0155a8887cd01.pdf>
- [41] S. Kemp, “Digital 2020: 3.8 billion people use social media,” Feb 2020. [Online]. Available: <https://wearesocial.com/blog/2020/01/digital-2020-3-8-billion-people-use-social-media>
- [42] R. Wang, J. Kim, A. Xiao, and Y. J. Jung, “Networked narratives on Humans of New York: A content analysis of social media engagement on Facebook,” *Computers in human behavior*, vol. 66, pp. 149–153, 2017.
- [43] J. Anouna, “Interview with Francesca,” April 2019.

- [44] Il meglio delle donne, “Ilaria Bidini,” Jul 2018. [Online]. Available: <https://www.instagram.com/p/BIhxsWltI4/>
- [45] Freeda, “Woman Crush on: Luca Trapanese,” Mar 2019. [Online]. Available: <https://www.facebook.com/watch/?v=1938781402917710>
- [46] M. Campbell, “CEDAW and women’s intersecting identities: a pioneering new approach to intersectional discrimination,” *Revista Di-reito GV*, vol. 11, no. 2, pp. 479–504, 2015.
- [47] Prima Comunicazione Online, “Classifica Sensemakers su media italiani più attivi sui social e post con più interazioni a gennaio,” Apr 2020. [Online]. Available: <https://bit.ly/PrimaOnlineCjisp>
- [48] Freeda, “Even women masturbate,” Apr 2019. [Online]. Available: <https://www.instagram.com/p/Bv1vbFGIIImR/>
- [49] ISTAT, *Homicides (2017-2018)*, Nov 2018. [Online]. Available: https://www.istat.it/it/files/2018/11/Report_Vittime-omicidi.pdf
- [50] E. Tonazzolli and M. Venturini, “Educazione sessuale a scuola: il panorama italiano ed europeo a confronto,” Jun 2019. [Online]. Available: <https://www.stateofmind.it/2018/10/educazione-sessuale-adolescenti/>
- [51] M. S. Lim, E. R. Carrotte, and M. E. Hellard, “The impact of pornography on gender-based violence, sexual health and well-being: what do we know?” *J Epidemiol Community Health*, vol. 70, no. 1, pp. 3–5, 2016.
- [52] F Come, “Sexual education is power: open letter to the italian government.” [Online]. Available: <http://www.fcome.org/portfolio-view/open-letter/>
- [53] The Female Lead, “Disrupting the feed – teenage girls’ use of social media: an intervention to improve social media health,” Nov 2019. [Online]. Available: <https://bit.ly/FemaleLeadCjisp>
- [54] C. Edmond, “This UK scheme wants girls to fill their social media feeds with positive role models,” Nov 2019. [Online]. Available: <https://www.weforum.org/agenda/2019/11/uk-girls-social-media-positive-role-models/>
- [55] C. Pateman, “The patriarchal welfare state,” *The welfare state reader*, pp. 134–151, 1988.
- [56] A. Gouws, “Beyond equality and difference: the politics of women’s citizenship,” *Agenda*, vol. 15, no. 40, pp. 54–58, 1999.
- [57] G. Bock and S. James, *Beyond equality and difference: citizenship, feminist politics and female subjectivity*. Routledge, 2005.
- [58] C. McCann and S.-K. Kim, *Feminist theory reader: Local and global perspectives*. Routledge, 2013.
- [59] United Nations Department of Political and Peacebuilding Affairs and Centre for Humanitarian Dialogue, *Digital Technologies and Mediation in Armed Conflict*, Mar 2019. [Online]. Available: <https://peacemaker.un.org/sites/peacemaker.un.org/files/DigitalToolkitReport.pdf>
- [60] A. Gilioli, “La rete che doveva essere orizzontale e democratica è diventata qualcos’altro,” Apr 2019. [Online]. Available: <https://espresso.repubblica.it/plus/articoli/2019/04/11/news/c-era-una-volta-la-rete-orizzontale-e-democratica-1.333672>
- [61] D. V. Shah, J. Cho, W. P. Eveland Jr, and N. Kwak, “Information and expression in a digital age: Modeling internet effects on civic participation,” *Communication research*, vol. 32, no. 5, pp. 531–565, 2005.
- [62] H. Gil De Zuniga, E. Puig-I-Abril, and H. Rojas, “Weblogs, traditional sources online and political participation: An assessment of how the internet is changing the political environment,” *New media & society*, vol. 11, no. 4, pp. 553–574, 2009.
- [63] S. Valenzuela, Y. Kim, and H. Gil de Zúñiga, “Social networks that matter: Exploring the role of political discussion for online political participation,” *International journal of public opinion research*, vol. 24, no. 2, pp. 163–184, 2012.
- [64] H. Gil de Zúñiga, N. Jung, and S. Valenzuela, “Social media use for news and individuals’ social capital, civic engagement and political participation,” *Journal of computer-mediated communication*, vol. 17, no. 3, pp. 319–336, 2012.
- [65] R. Gibson and M. Cantijoch, “Conceptualizing and measuring participation in the age of the internet: Is online political engagement

really different to offline?” *The Journal of Politics*, vol. 75, no. 3, pp. 701–716, 2013.

About the Author

Jasmine graduated from the University of Oxford in 2019 with a Master’s in Women’s Studies. Her dissertation interweaved her interests in digital media and



human rights, and served as a basis for her participation in numerous international events at the Oxford University (2019), International Women’s Festival (Florence, 2019), Libreria delle Donne (Milan, 2019), and the conference on Social Policy and the Public in Italy (Cambridge, 2019).

Jasmine first began working on women’s rights during her fellowship in Cuba. In 2017, Jasmine was awarded a human rights fellowship to collaborate with the José Martí International Journalism Institute to assess grassroots mobilisation against gender-based violence in the country. For her final work ‘Aquí no hay protestas: Activism Against Gender-Based Violence in Cuba,’ she was presented the award for excellence in Latin American Studies by the Pan American Association.

Growing up between New York City and Florence, and currently based in San Francisco, Jasmine is passionate about building international connections between cultures, people, and ideas. She curates a weekly newsletter, ‘The Bloom’, sharing uplifting news and developments in the world of women’s rights, as well as job postings and unique inspirations from around the world

Conflict of interest The Author declares no conflict of interest.

