CUSPE 2017 Communications Special Issue:

Science, Technology and Inequality

Editor's Note

Victoria Plutshack, C-EENRG, Department of Land Economy

Too often science and technology feel futuristic. We envision flying cars, robot soldiers, the end to all disease. We envision the world of science fiction. What we forget is that science fiction's truest interest lies with the way in which society and science coexist in a kind of tension, influencing and influenced by one another. Science and technology don't exist in a vacuum, and they don't exist solely in the realm of the futuristic.

I brought together the following articles with the intention of grounding our thinking in the now. The current world we live in is abuzz with opportunity, for solutions not just to technical problems but also social ones. When we think of the future of science and technology, we often think too much about developed countries, about issues that plague one half of the population, about talking robots. It really is a lot about talking robots.

These articles think more about how society's current inequalities interact with science and it's more outgoing sibling, technology. In our first article, Shivi Chandna takes on a topic dear to my heart – the impact of rural electrification on women. Ms Chandna brings forward the ways in which technology impacts have gendered effects, and how technology-based projects can maximize their influence on social inequalities.

Taking the issue of gender inequality from a slightly different angle, Sumana Sharma explores the ways in which women have been encouraged to stay in the STEM fields. Rather than focusing on the ways in which women are discouraged from science and technology careers, Ms Sharma clearly outlines how attrition from the fields is an ongoing problem, and the policies needed to tackle it. Given that the research we pursue and the technologies we create are so dependent upon personal experience, Ms Sharma's arguments for how to keep diversity in the STEM fields have repercussions beyond the individual.

The final two articles here take a more future oriented approach, while dealing with the technology already embedded in our day to day. First Karen Stroobants reviews Utopia for Realists by Rutger Bregman, a book on Universal Basic Income that's particularly relevant as technology is fast replacing human labor in almost all segments of the economy. What will we do now that machines can do our jobs for us? Rather than simply displacing the lowest paid jobs and worsening inequality, Ms Stroobants outlines Bregman's argument for a basic income for all. Given that over seven countries have started basic income trials, this 'utopia' might be just over the horizon.

Last but not least, Nicolás Valenzuela-Levi weaves a fascinating argument about how income inequality shapes

network technologies, such as telecommunications and energy. Once again we're oriented to see how current inequality is not just shaped by, but also shapes technology. Here, Mr Valenzuela-Levi explores how the trend of countries towards greater or less inequality influences the dispersion of innovation and what that might mean for the coming Internet of Things.

I hope that you will enjoy and be enriched by these articles. Their breadth of topics and approaches highlights how science and technology permeate our everyday and intersect with the inequalities of our society today – not just in a science fiction future. Of course, these are only snippets of this all-encompassing subject, and I look forward to hearing so much more from our writers, lecturers, and participants here at CUSPE.

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Empowering through Light: Women and Solar Home Systems in Rural Bihar, India

Shivi Chandna, University of Cambridge

In rural India, women in poor households spend a large part of their day performing basic tasks such as collecting fuel wood or kerosene, which keeps them away from employment or education opportunities and makes their lives more difficult. Access to electricity is therefore increasingly regarded as a means to improve their status in society. Although a large number of small-scale and community-based off-grid renewable energy projects are in place to provide access to electricity with a women-centric approach, research on the benefits to women has been largely anecdotal. A review of the evidence for the impact of rural electrification on women's lives concluded that electricity access has a positive effect on women's practical needs by reducing drudgery and providing better health, time-savings and income generation. However, it was found that electricity policies only look at women as end-users of electricity and do not explore gendered impacts of policy and productive end uses [1].

When researchers asked questions about life before and after access to solar home systems, they were struck by the fact that none of the answers centered on the women's own needs in their life

Photo of the researcher in the field

A collaboration between an energy technology initiative by The Energy Resources Institute (TERI) and a women-centric poverty reduction intervention Bihar Rural Livelihoods Project (BRLPS) has enabled researchers to gather feedback directly from women who had been provided electricity access with solar home systems. Solar home systems are stand-alone photovoltaic systems that generate sufficient power for basic lighting and appliances in a household that is not connected to the grid. Such units are commonly distributed as part of rural electrification projects in several countries, including Peru and Bangladesh. In 2013, women from the Purnia district of Bihar, where a large number of poorly electrified and un-electrified villages exist, were lent solar home systems as part of the initiative by TERI. These women live in small windowless homes with walls and roofs

made of straw and bamboo. They perform a wide variety of activities including farming, post-harvest activities and animal husbandry, in addition to their domestic responsibilities of supervising children and cattle, cooking, and cleaning. Some of them own small shops to sell basic grocery items. Researchers conducted semi-structured interviews and focus groups discussions regarding the impact of solar home systems on the women's lives, who were already members of small self help groups through BRLPS.

When researchers asked questions about life before and after access to solar home systems, they were struck by the fact that none of the answers centered on the women's own needs in their life. Instead, many women highlighted the benefits of prolonged lighting provided by the solar home systems for their children. The women stressed how important it was that their children were able to study in the evenings and do well at school. Child welfare was a recurrent topic, with women responding to abstract questions such as "what do you value the most in life?" and "what is important to you?" with answers like "my child's welfare, his health and education". The extent to which the women would do anything for the welfare of their children also spurred creative uses for the power supplied by solar home systems, as indicated by an anecdote from the state project manager of the poverty-reduction intervention program: "A mother in a household told me that her new 'smokeless' cook-stove with a fan attachment benefited her a lot. I went to her house and noticed that the fan had been removed and placed next to her sleeping child. The mother mentioned her child was ill and she wanted to give him some relief from the heat."

What transpired from further interviews was that the women viewed giving their children a good life as a key parental responsibility, and something to be proud of. Ownership of an asset like a solar home system, and the fact that they were the ones to bring light to the household, gave them pride and self-respect. Several women said that of paramount importance to them was "my child's education, so that he grows up and makes me proud", whilst others explained that they felt good seeing their children do well in life. Participation in BRLPS's self help groups themselves was also observed to have a beneficial effect on the women's confidence, with women who had actively participated in such activities over 9 years speaking in great detail about their views and treating everyone as an equal. In contrast, women in newer groups usually had a few women speak on behalf of others, with some joining in agreement only if there was something they felt strongly about.

Image of household cookstove, courtesy of S. Chandna

This study shows that the benefits of rural electrification extend beyond measurable factors such as income generation and improved health. Whilst the primary impact of providing off-grid electrification to women in Bihar appears to be enhanced child welfare, the initiative also seems to have increased levels of self-respect and pride for the women who bring the technology into their households. This outcome is

arguably far more important than small savings on kerosene fuel or better quality light, it contributes to women's empowerment and should therefore be taken into account when planning projects or policies looking to subsidize solar home systems.

Key to this favourable outcome was the collaboration between the energy technology initiative and Bihar Rural Livelihoods Project, with the former bringing expertise in renewable energy products and the latter providing access to rural, poor communities as well as infrastructure for monitoring the use of the technology. Indeed, a major part of any energy-access project should be devoted to engagement and building good relationships with the local community by partnering with individual and organisations who are already known and trusted by the community when possible [2]. For instance, the energy initiative's provision of trained local technicians to deal with maintenance of solar home systems helped eliminate any insecurity about adopting the technology, whilst the self-help group sessions can be said to have promoted some of the women's confidence in giving voice to their opinions and experiences regarding off-grid electrification. This indicates that rural electrification efforts can be directed in a way that is particularly beneficial to women in rural areas through synergistic partnerships with well-established women-centric development programmes.

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About the Author

Shivi completed her MPhil in Engineering for Sustainable Development at the University of Cambridge in 2016. She is passionate about the use of technology for social impact, especially gender development and sustainability in developing countries. Prior to her masters Shivi has worked as an engineer and technology consultant at Qualcomm/Cambridge Silicon Radio for six years. Shivi has a BEng in Electronic Engineering and Computer Science from Aston University.

A Look at the Attrition of Women in STEM

Sumana Sharma, PhD Candidate, Wellcome Trust Sanger Institute

The underrepresentation of women in leadership positions in Science, Technology, Engineering, and Mathematics (STEM) is usually attributed to the 'leaky pipeline phenomenon', according to which an increasing proportion of women leave their occupational fields at each stage along their career paths. This attrition is most pronounced for the academic biological sciences, in which the most significant attrition occurs at the postgraduate-to-group leader transition. To illustrate: in the UK in 2014/15, 66% of bioscience postgraduate students, but only 18% of professors, were female [1]. A huge gender difference in leadership positions is evident across all STEM fields: overall, 82% of all professors are men, as of 2014 [2]. This attrition of women in the STEM workforce raises questions over specific barriers faced by women in this field for career advancement. These barriers can be multi-faceted; thus, accurately identifying the main barriers and designing policies to address them will be essential to resolving gender disparity in the field of STEM.

Researchers have studied the decline in female representation in STEM over the course of a standard academic trajectory and have suggested family choices and work-home balance as the most important contributing factors. The suggestion is that issues such as workplace culture; long weekly working hours; and inflexible schedules make women more prone to leaving their academic jobs [3]. While others agree that these issues account for some attrition, they argue that the

importance of these factors has been over-emphasised compared with issues surrounding pay and promotion among women in STEM [4]. Glass et al. (2013) observe a higher attrition rate in STEM compared with other fields, suggesting that the difference between attrition in STEM versus other fields seems to be that women from STEM are moving into non-academic STEM-related fields, rather than out of the job market [5].

This appears true in practice; for example, as one female post-doctoral researcher at the Wellcome Trust Sanger Institute (WTSI) states, "I would like to stay in academic research, but the pressure of producing high-impact papers on a regular basis; moving every few years to a new place; and no job stability makes me look into careers in other science-related sectors." She is not alone. Among female bioscience researchers, many women who leave academia prefer to stay connected to science and often migrate to publishing, research funding, teaching, and science-based industry positions. The prospects of flexible hours, job security and longer contracts with promotion opportunities that are often associated with these jobs may make them more desirable than academia [6].

In addition, when comparing women in medicine with academic biologists, it has

been noted that the medical field has been able to successfully retain women despite being less family friendly, with inflexible working hours [7]. This suggests that it is not starting a family itself, but its interaction with other factors, that drives the decision of women to leave their academic fields. One such factor in academia is fierce competition on the job market. While competition for medical programs is also intense, this occurs at an earlier career stage, at which family formation decisions are usually not paramount [7]. Furthermore, the current requirement for a successful academic career to be continuous is hostile to family- related interruptions, as it requires constant evidence of productivity (e.g. publication records). An analysis of the Biotechnology and Biological Sciences Research Council (BBSRC) grant application process in the UK has suggested that mid-career women are less successful because when they take time out, they lose their presence in the field [8].

The loss of skilled women from the STEM workforce in academia has not gone unnoticed. In the UK, programs like the Equality and Diversity Challenge Athena SWAN Charter have been established in order to address unequal gender representation across academic disciplines. Institutions, departments, and universities can apply for an Athena SWAN award based upon their commitment to addressing gender imbalance. This initiative has led to 'good practices'[1] being implemented by various organisations across the UK. For example, post-doctoral coaching and mentoring programs are being used widely by research institutions in order to provide support and encouragement to female scientists in their early careers. Institutions such as the UCL-MRC Laboratory for Molecular Cell Biology have compiled selected lists of women in science, to provide role models for aspiring female scientists. To address disadvantages caused by career gaps, various re-entry programs[2] are being implemented, in order to facilitate the return of female STEM professionals after career breaks. Fellowships such as Dorothy Hodgkin Fellowship that allow flexible working have also been introduced in many institutes for early stage researchers who have parenting responsibilities. Recruitment processes are also being reviewed by many institutions, with measures such as unconscious bias training for interviewers and yearly appraisals, to further guard against unfair disadvantages for women in academic STEM.

The loss of skilled women from the STEM workforce in academia has not gone unnoticed.

Since 2015, the UK government has introduced shared parental leave that allows up to 50 weeks of leave (37 of which are paid) which can be split between partners. Institutions are also making their own changes to the maternity scheme—for example, Queen's University Belfast has made provisions for those taking maternity leave to be exempt from teaching for six months on their return. The University of Reading and the WTSI's own policies allow for shared parental pay to come from the

[1] Only few examples are cited here; a complete list of 'good practices' can be found at www.ecu.ac.uk.

[2] Some examples of re-entry programs are: the Wellcome Trust Career Re-Entry Fellowship; the Daphne Jackson Trust Fellowship; and the Janet Thornton Fellowship.

central budget. With such policies, one can hope that issues of women attrition from motherhood are slowly being recognised and addressed.

Even with policies in place, a change in broader culture will be necessary to precipitate the desired changes. A UK government assessment in 2016 suggested that while 285,000 working fathers are eligible to take shared parental leave, only 2–8% would do so. Organisations can help by, for example, advertising policy changes to staff and keeping track of leave take-ups. High-quality childcare should also be easily available to support parents who wish to return to their academic careers.

Some scholars have argued that the 'leaky pipeline' metaphor may itself exemplify problems for female retention in STEM—arguing that such careers should be viewed not as a linear 'pipeline', but rather as a network of pathways, allowing for movement both in and out [9]. A 'leak in the pipeline' suggests that once one's out, one cannot re-enter; moreover, the metaphor devalues those women who have opted for a career outside of academia. By contrast, the 'network' view is consonant with the above-mentioned re-entry fellowships for those women who wish to return to STEM research after time away from the field.

The competitive nature of academia is unlikely to change, both because of the low number of faculty positions available, and because of the driven nature of those in the field. However, talented women are currently discouraged from academia due to the added pressure of parenting responsibilities, to which the academic environment is hostile. The solutions are twofold: (i) the nature of academia has to change so that it no longer puts researchers with parenting responsibilities or career breaks at a disadvantage; (ii) similarly, caring responsibility has to be truly shared. Now that our consciousness of these issues is raised, it is important for us to develop policies to identify and encourage women wishing to pursue academic careers, but who are discouraged by the current state of the affairs.

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Book Review: Utopia for Realists by Rutger Bregman

Karen Stroobants, University of Cambridge

Are we still able to think big, to imagine a better world than the one we currently live in? Rutger Bregman, a young Dutch historian, certainly thinks so. I have been following his activities for a while now, as he strongly believes in the concept of 'a basic income for everyone', and so do I. Although the idea is appealing, it is hard to establish firm arguments that cannot in any way be refuted by critics, and maybe even by realists. So when Bregman announced that he was about to publish a book, 'Utopia for Realists', I knew it would be my next read. I was determined to arm myself with stronger arguments to discuss the topic with housemates, colleagues and friends.

Put on your utopic glasses, and get inspired...

Bregman takes off with a pledge for imagination, picturing utopia. With vivid anecdotes, he illustrates how men's dream to fly and women's desire to vote have become realities that can no longer be questioned. The author stresses the importance of imagined utopias as a propeller of our happiness and progress. He further points out that 'the left' arguably needs to think bigger, create a vision that is able to inspire not only the electorate, but also, more importantly, itself.

A spirit of utopian thinking, from a liberal-left perspective, sets the tone. In the following chapters, Bregman introduces, from a historical point of view, the concept of a general basic income. His evidence-based approach is powerful and the anecdotal but bold style walks you through his advocacy fluently. Bregman introduces two additional concepts; the 15-hour working week, and open borders for all. The former is introduced in relation to the abundance of purposeless jobs, defined as those that do not add value to society, for which a basic income arguably would be a good alternative as it would allow everyone to decide what to do with their lives. The latter is proposed as an ideal manner to make the basic income inclusive to developing countries, which would be given the freedom to move to 'the land of plenty'.

While Bregman's case for a basic income is convincing, his argument for a shorter workweek is clearly less established. Although the author very much takes home the point of 'bullshit capitalism', he proposes working less, and thus more leisure, as the single solution for these value-less jobs that have become the norm. Surely there is a possibility to re-focus society towards more value-creation as an alternative? More flexible systems without doubt are desirable, but I would not be jumping to live in

Bregman's 15-hour workweek utopia where Netflix and virtual reality might provide hours of occupation. I am sure a practised utopist can come up with more meaningful solutions.

Similarly, Bregman touches on the idea of open borders, but fails to develop in detail how developing countries would be included in his model. His concepts are proposed from a very Western-centric viewpoint, and he might as well have better left them in the West. I cannot get over the feeling that the open border concept is pulled into the story as a fast solution for inclusivity, unfortunately not a very convincing one. Again, some more dreaming might be in order to arrive at a more holistic formulation of the basic income 'for all (of humanity)'.

Overall, Bregman did meet my expectations as he considerably strengthened my insights into the perks of a basic income. While I was 'a believer' in the first place, I can see how his book can be enriching for every reader, whether they do or do not agree with the concepts advocated for. The extent to which Bregman has provided me with the more practical arguments I had hoped for, is less clear. Although he has equipped me with experimental evidence on the success of basic income as a right, the poorly supported case for inclusivity through open borders might harm rather than strengthen his advocacy as it highlights more problems than solutions. On the other hand, his concepts leave plenty of room for others to put on their utopic glasses and suggest ideas to improve upon both our valueless job market and Western-focused perspective.

Bregman's debut certainly sets the tone for progressive thinking, and does so in style. 'Utopia for realists' has been described as a brilliant, truly enlightening must-read, and I wholeheartedly agree with this praise. Bregman challenges us to explore new ideas, think boldly, and be receptive to new ways forward. Reason enough to indulge in his lively prose, and get inspired.

About the Author

Karen Stroobants is a Marie Skłodowska-Curie post-doctoral Fellow at the Centre for Protein Misfolding Diseases at the Chemistry Department. With a strong background in biophysical characterisation of proteins, she recently engaged in the study of membrane protein aggregates and their potential role in neurodegenerative diseases. Before moving to the UK, Karen received a prestigious PhD fellowship at KU Leuven, Belgium, where she worked on the development of a novel biotechnological methodology for protein hydrolysis under ambiguous conditions. Apart from being a researcher, Karen has always been engaged in promoting the communication between different academic players, industry, policy makers and society in general.

Income Inequality and the Internet of Things: interesting links between 'socially just' and 'environmentally sustainable'

Nicolás Valenzuela-Levi, PhD © in Land Economy, University of Cambridge

Public interest on income inequality increased during the last decade. Among scholars, one of the aspects that has been researched is how does income distribution affect innovation and technology adoption. On the one side, hopes for long term economic development highlight the need to understand what drives innovation. On the other side, inequalities are fuelling social unrest and public debate on what is the fair distribution of opportunities and benefits in our societies. Consequently, the question about the link between income inequality and innovation is becoming more and more attractive.

Yet, existent academic literature on the topic has paid little attention to innovations that occur in one particular but relevant context: network industries. Telecommunications, energy, transport, water and waste management are usually considered as network industry sectors. The convergence between these sectors (Figure 1), along with advanced technology and diffusion, are the base of a new vision that is bringing excitement to technology enthusiasts and avant-garde urban planners. This vision is the Internet of Things: one sole global integrated network of infrastructures and services where information, logistics and energy permanently circulates.

Smart meters plugged in every corner of our homes; apps using algorithms and data from our fridges to balance our diet; both sugar levels of patients' blood stream and of their food being controlled online by their doctor; public lights that react to the levels of sunlight not only according to the time of the day and season but also to minute-to-minute changes in the weather; a world in which all waste is transformed into energy; transport systems that use real time travel data to efficiently manage all the motorised trips within a city or region. All these ideas seem futuristic, but some progress has been made towards making them real. They are what the Internet of Things should look and feel like.

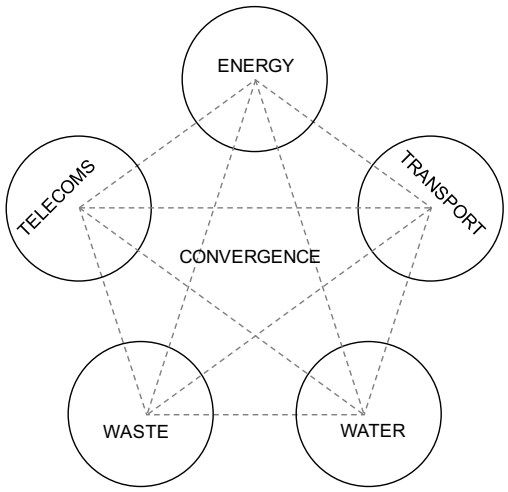

Figure 1. Network industry sectors. Source: the author.

Technology diffusion in natural monopolies

As we can see, most of this vision relies

on technology adoption and diffusion. In many cases, it will be about people buying innovative products like a smartphone, a new car, or a new fridge. That is the kind of innovation that is in the centre of what economics has studied so far. For most economists, technology adoption and innovation is demand-driven. This means that it occurs because consumers demand new innovative products. Entrepreneurs respond to this demand because of the opportunities that innovation opens for their businesses. Two strongly influential models are the basis of this intuitive view on technology adoption. One is the Bass diffusion model, and the other is Schumpeter's understanding of the innovative process. While a literal adoption of these models´ assumptions would imply that natural monopolies should see little innovation, public policy in recent years has spurred innovation across these network industries.

On the one side, the Bass diffusion model, developed by Frank Bass in the late 1960s, describes a curve to account for total adopters, which accelerates and then reaches a plateau. This curve is fuelled by waves of innovators, early adopters, early majority, late majority and laggards (see Lee et al 2013 for a more detailed discussion on this). Most of these assumptions are easily confirmed when doing empirical research on consumer goods such as the aforementioned. Under this vision, we will experience a smooth process of gradual diffusion that will depend on consumer's preferences. The speed and final diffusion level will, of course, vary according to each technology. Most of the studies linking income inequality to innovation are based on these concepts: therefore, they discuss how different income distributions will affect the behaviour of early adopters and late majorities.

On the other side, Joseph Schumpeter´s notion of innovation explains how supply responds to these changes in demand [4]. In competitive markets, entrepreneurs have the incentive to innovate because a new technology or product will establish a temporal monopoly that will give them advantage over competitors and, therefore, profits. Since this advantage is only temporal and ends when other suppliers imitate or even go beyond the original innovation's features, entrepreneurs have the incentive to keep innovating, introducing new innovative supply to the market.

In terms of policy, it appears that 'socially just' is very close to 'environmentally sustainable.'

The problem with the Internet of Things is that, as much as it relies on technology adoption within the fields of consumer goods, it is also based on network industries. Yet, sectors such as telecommunications, transport, energy, water and waste management, do not work as normal markets. They are usually regarded as natural monopolies, because of economies of scale that make a sole supplier to be more efficient, enormous sunk costs that make entry barriers too high for new actors to participate, or strategic considerations that make control over the supply unavoidable for governments. Although sectors such as telecommunications have gone through the process of liberalisation – meaning privatisation, de-concentration and deregulation – most of the other sectors still involve state owned enterprises and municipal public utilities. The Internet of Things relies as much on innovation within these sectors as it does on routers, smartphones, cars, LED lights, and

fridges.

The problem when looking at technology adoption within network industry sectors, is that assumptions such as those by Bass and Schumpeter do not seem to match with what happens in reality. For instance, innovations such as implementing energy recovery when incinerating municipal waste (waste-to-energy) will not depend on what consumers do. Waste disposal by households can keep being the same, but what will change is what occurs at the end of the process. On the other side, when testing Schumpeter's ideas within natural monopolies, it will be problematic to find any incentive to innovate. If that incentive comes from expected profits due to a temporal monopoly that is based on new innovation… what happens when we already have the monopoly and nobody can challenge it? Are there not going to be innovations at all?

On the contrary, innovations keep occurring within network industry sectors. Fuelled mainly by public policies that want to tackle Climate Change, sectors such as energy, transport and waste management have rapidly evolved in the last years. Old business-models, and even the definition of value itself, have been radically modified. The most notable example is Smart Grids, where consumers are becoming now producers of energy.

Inequality and technology diffusion in network industries

But let's go back to the initial question: what is the link between inequality and the development of the Internet of Things? There is a strong link, and I would like to add some evidence to the existent literature.

Literature so far can explain cases such as diffusion of internet, broadband, and cell phones, as well as other more general measurements of innovation such as patenting and R&D. In general, it has been easy to find negative correlations between income inequality and technology diffusion. However, all those studies use the already mentioned demand-driven view on innovation [2, 4, 5, 7, 8, 11]. Among network industries, the evidence on diffusion within the telecommunications sector fits with this view, probably because of the aforementioned levels of liberalisation in fields such as mobile phones, internet and broadband, which cause the sector to function similarly to competitive markets.

However, the intended contribution of my particular research has to do with understanding the effects of income inequality when innovation is supply-driven. What I have discovered so far is based on panel data on improved water source and incineration of municipal waste with energy recovery (waste-to-energy), supported also by other more qualitative and anecdotal evidence. These techniques involve the use of fixed-effects regressions on data over a period that covers between 1995 and 2015.

Regressions control for GDP per capita, years of schooling, and other factors related to financial depth and openness. Results show that, although there are no evidences of correlations between countries when considering one specific moment of time, a different story emerges after looking at changes over time. Rises in coverage of improved water source and proportion of waste incinerated with energy recovery are significantly correlated with reductions of income inequality over time within a

country.[3]

We can say that levels of technology diffusion in the water and waste sector are higher in countries with more egalitarian trajectories. Reductions in income inequality, as it has been discussed by mainstream economists such as Stiglitz (2013) and Piketty (2014), are related to institutional contexts that involve particular policies oriented to redistribution and production of public goods [9, 10]. That orientation towards public goods might be a common denominator both for socially redistributive and environmentally progressive policies. The latter seeks, for instance, to redefine value and radically change business-models (as discussed by Hall & Roelich 2016) in network industry sectors, which are usually privatised and owned by powerful shareholders [3].

The difference between the waste or water sectors, and other ones such as telecommunications, is that within the former investment decisions can hardly be segmented to make them commercially efficient – which, as discussed by Graham & Marvin (2002) implies to distribute access according to ability to pay [1]. In telecommunications, on the one side, it is easy to find segmentation of market decisions both by supply and demand; both investment from suppliers and revenue from users occur based on different groups' ability to pay and how they are distributed in the territory. On the other side, both investment and revenue are almost impossible to segment within the waste sector: waste management needs to be provided for an entire city, and the costs are usually charged to users via local or general taxes, which might vary according to households' characteristics but not on the basis of real-time changes in their consumption of the service. Water is somewhere in the middle. Although fares can differentiate among users' real-time levels of consumption, investment involves enormous sunk costs, and it is politically very difficult to justify to leave people without access to water because they cannot pay for it.

That is why technology adoption in the telecommunications sector is demand-driven, while in the water and waste sector it is supply-driven. Supply-driven means that it has to do more with institutions and government action that on variations in consumer demand (as explained in Figure 2). The interesting fact here is that, although there is no evidence of correlation between diffusion of these water and waste technologies and inequality across countries today, their income trajectories do matter. Countries that are succeeding at producing income distribution do better when it comes to adopt supply-driven innovations.

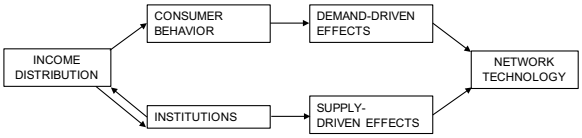

Figure 2. Heuristic model including proposed relations between income distribution and network technology adoption and diffusion. Source: the author

In conclusion, income inequality is relevant for the future of network industries, and therefore for the materialisation of visions such as the Internet of Things. My research confirms previous findings in the literature about higher levels of diffusion of innovative consumer goods when

[3] Regressions were run over an OECD sample in the case of waste and both on an OECD sample and a wider world-wide sample in the case of water.

there is lower income inequality. However, it also highlights the relevance of supply-driven innovations within network industry sectors, and their link to income inequality. In these cases, what seems to be crucial is the connection between efforts to reduce inequality and to adopt technologies in sectors such as water and waste management, which are absolutely crucial for Climate Change policies. In terms of policy, it appears that 'socially just' is very close to 'environmentally sustainable.'

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About the Author

Nicolás is a first year PhD student at the Department of Land Economy. Previous to his current research, he obtained an MPhil degree in Development Studies also in Cambridge, and a Master in Urban Development as long as his architecture degree from the Pontifical Catholic University of Chile (PUC). Before coming to Cambridge, he served as Director of Planning in one of the central boroughs of Santiago de Chile, was a lecturer in Urban Planning at PUC, and was co-founder and president of the NGO Reconstruye after the 2010 earthquake in Chile. The latter was selected by UN Habitat among the world´s 'best practices' for 'its outstanding contribution towards improving the living environment' in 2012.

Nicolás' research interest is the link between social inequalities and network infrastructures and services. His PhD research focuses on the influence of income inequality on technology adoption within network industry sectors such as transport, telecommunications, water, energy distribution, and waste management. If you want to discuss this research further, feel free to email him at nv284@cam.ac.uk).