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

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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.

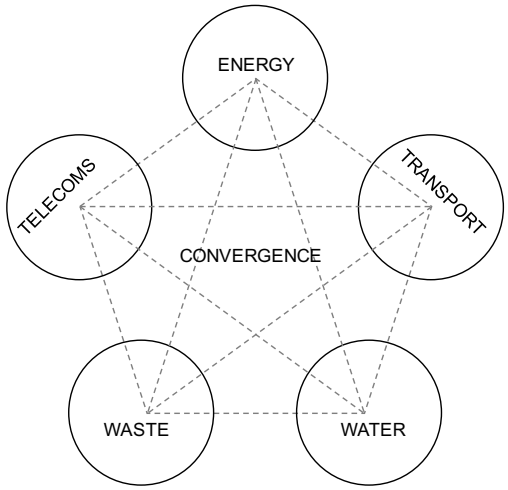

Figure 1. Network industry sectors. Source: the author.

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.

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.

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

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.[1]

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.

[1]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.

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.

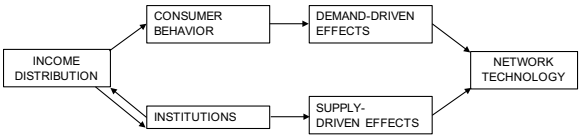

Figure 2. Heuristic model including proposed relations between income distribution and network technology adoption and diffusion. Source: the author

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 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).