Rethinking Innovation for a Post-growth Society

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Innovations are conventionally conceptualised as one of the crucial driving factors fuelling the 'growth machine' of capitalism, whereas science and technology are the core of the innovations that facilitate the 'endless' economic growth. In the dominant economic paradigm, innovations became imperative for the survival of all forms of organisations—the creative force that brings economic dynamism and greater welfare for the broader common good. However, critical innovation and science, technology and society scholarship have challenged this orthodox position. Drawing from the recent debates within degrowth and science, technology and innovation literature, the panel explores how innovations can be theorised in post-growth societies. In other words, how can innovations be conceptualised by keeping people and the planet at the centre rather than economic growth and profit?

Keywords: Innovations, alternative innovations, degrowth, post-growth, S&T

The write-up presents an edited and modified version of the plenary dialogue moderated by Aviram Sharma (University of Vigo) with Alejandra Boni (Technical University of Valencia), Adrian Smith (University of Sussex) and Andrea Jiménez (University of Sheffield) on Rethinking Innovations: Alternative Approaches for People and Planet during the 10th International Degrowth Conference and 15th Conference of the European Society for Ecological Economics at Pontevedra, University of Vigo, Spain. We have added references in the text as notes to make the edited version of the dialogue suitable for the readers. Please bear in mind the majority of the audience at the conference was from the degrowth and ecological economics community rather than the regular STS audience.

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Aviram Sharma: In 1928, Mahatma Gandhi said,

> God forbid India should ever take to industrialism in the manner of the West. The economic imperialism of a single tiny island kingdom is today keeping the world in chains. If an entire nation of 300 million took to similar economic exploitation, it would strip the world bare like the locust.[1]

Gandhi pointed to the imperial mode of living[2] and the danger and threat it created for humanity and the environment.

The imperial mode of living and exploitation at the peripheries have remained the core of the capitalist system and many other similar economic systems.[3] These extractive practices and relationships have shaped the world economy for several centuries. After the Second World War, the economic centre of the empire shifted to the USA from Western Europe, and the USA emerged as the most hegemonic economic power.[4] Today, we see a more multipolar world, with the rise of China and many other emerging nations. Yet, one thing that remains common among these new geographies of the empire is how innovations, science and technology are conceptualised, envisioned and shape the world. In the mainstream literature, innovation has been dominantly imagined in a techno-economic way.[5] Economic-based values emerged as the dominant principle driving the process of innovation. All other values of innovation have been sidelined. If this is the hegemonic thinking on innovation, and there is only one dominant way of conceptualising innovation, how can we talk about the alternatives to innovation?

With this background, I will start the discussion with Andrea. We know from science, technology and society (STS) and the history of science literature that the dominant science, technology and innovation (STI) paradigms are critiqued as a colonial project. These paradigms fuel economic growth but devour people and the planet at the peripheries of the capitalist system (beyond the national geographies of the imperial nations) and, at times, within the system (within the national boundaries). In such a context, how can we reimagine a post-growth critique of innovation from a decolonial lens?

Andrea Jiménez: I am really glad you bring a historical perspective because I wanted to start by mentioning two history books. The first was by the historian Michael Adas, titled *Machines as the Measures of Men.* Adas explains how technology and science were crucial in establishing and maintaining Western dominance over other cultures.[6] He argues that the so-called explorers of the eighteenth century believed that their technological advancements were not just tools but were ideological weapons. He points out that they saw their perceived scientific achievements and technological advancements as markers of cultural and racial superiority. And this in itself justified the dominance over others.

A particular feature of this was the European colonisers' desire to dominate nature through technology, which reinforced their view of being the supreme race.

So, for example, engineers' designs and the machines extracting the Earth's resources were, for them, the highest form of human expression and confirmed that they were destined to be dominant. So that is one part of history.

There is another book that is worth highlighting, edited by Edin Medina, Ivan da Costa Marques and Christina Holmes, titled *Beyond Imported Magic: Essays on Science, Technology, and Society in Latin America*.[7] They are writing from the Latin-American context and is challenging the view that science and technology travelled unchanged from the Global North to the Global South. Instead, they share stories of resistance, local creation and use of technology and adaptation of some technologies.

So, just as there was a technological imposition, there was also creative resistance. And I am telling you these two different and yet interrelated parts of history because I think it is really important that we recognise that just as STI were key in the process of colonisation to reinforce it, justify it and maintain it, there has also been always a push for resisting, adapting and creating innovation and technology for this context. And I think that is really, really important. I think that we can think about innovation as instrumental in the capitalist, militarised systems of power, but we can also consider it as ways in which people resist and adapt and create.[8] I think that the second one is the one that perhaps will be much more relevant from a degrowth perspective and for the kind of conversations we have been having at this conference.

Having said that, I think it is really important that we spend some time critiquing that dominant narrative of innovation that assumes we can continue to use innovation and technology within a capitalist productive system. I want to mention here a little bit of the eco-modernist perspective, because I know that in the degrowth community, there is a big critique towards the eco-modernist perspective. So, the eco-modernist manifesto, for example, proposes generating and applying technology designed to reduce environmental impacts while maintaining high standards of living.[9] So, in other words, they suggest that technology can help sustain capitalist production. And it can allow us to continue with our ways of living. There is a big emphasis on growth. But it is also more than that.

For those who were in the session on Tuesday, Samer made a very compelling argument on how technology and innovation are leveraging the military.[10] We know that many of our technological gadgets were created, and some of the digital and biometric technologies of today are being tested in refugee camps as we speak.[11] It is important to know that this form of innovation, besides being about growth, is incredibly damaging to people and nature.

Technology seems to be something that has helped destroy the world and also that which will save it.[12] So it feels like the conversation is that we either accept it or we reject it altogether. And to me, this presents a very simplistic, binary perspective, which is perhaps not too helpful. So, how do we think about technology and innovation in that context? Our destiny feels closely dependent on what we think about innovation and technology. In a kind of post-growth world or a

decolonial world, as you were saying, how do we think about innovation? Is there even a space to talk about innovation?

I think we need to bring it back to basics. So, what do we mean by innovation? There are loads of different definitions. But to me, innovation in the broadest sense is the process of developing new goods, new services, new processes and new products for the collective good.[13] I think this is the definition, but obviously, we know that the most dominant one is that which is patentable technological commercial, because those are the kinds of innovations that get adopted in business models and that generate profit.

But there are multiple ways of thinking about innovation. I mean, if you come from a business school or a management school, you might have already heard about loads of definitions of innovation that try to operate outside a logic of growth and that are meant to be more environmentally sound and kind of promote more of a collective way of being. Frugal innovation, jugaad innovation, reverse innovation, bottom of the pyramid innovation.[14] I mean, you name it, there is an endless list of concepts that are trying to explain other forms of innovation.

Now, there are two issues with these concepts. Either they operate at a small-scale pilot level, often experiencing challenges for not necessarily being supported, or they get co-opted, absorbed and sometimes stolen from their origins to try to scale them up. And there are always problems when they are trying to scale them up. I think that is a really important thing to think about because when we talk about these alternatives to innovation, they already exist; they are already there. So it is not necessarily about reimagining innovation, but it is about centring those experiences and those stories. It is also more about trying to think about what the societal arrangements are, where the institutions are and what the organisational arrangements are that need to exist for these initiatives to flourish and for these initiatives to be able to thrive. And that is perhaps the more interesting conversation.

So, just to conclude, I think the point of my presentation is to argue that innovation is not a monolithic concept and that it has the power to either uphold or challenge existing structures of power, and so we need to be able to criticise innovation where it is needed. But we also need to be able to appreciate when it is convivial, socially just and ecologically sound. And I think that is the interesting innovation story that we need to be telling.

Aviram Sharma: Thank you, Andrea. Andrea has rightly rephrased the debate: Is this the high time to decide whether we need to throw out the idea of innovation completely, or do we need to re-conceptualise it? She argues for the recentring of the concept and creating space for alternative ways of conceptualisation. To recentre these alternatives, we need institutions, we need governance model and there can be no better than Adrian to speak on what kind of institutions and governance paradigms can support alternate innovation models and how the alternate framing of innovations can go beyond solutionism and offer more radical possibilities for people and planet.

Adrian Smith: Thank you very much, Aviram. And thanks, Andrea, for setting things up so clearly. I think I should start my answer to you, Aviram, with solutionism. It is a term that, as far as I know, was coined by Evgeny Morozov a few years ago, who is a well-known thinker and writer on matters of technology politics. I believe his criticism of solutionism draws upon his experience working in and observing the digital sector and Silicon Valley. He coined the term solutionism to describe the phenomenon by which complex social issues are reduced into seemingly neat, well-defined technical problems that can be fixed with new technologies (and the businesses that own and operate them). We just need to get the right technological fix, is the basic idea. The smart city is an example. Cities are not running very well, so the argument goes. They are not very green, we have got problems of unhealthy populations and mobility, the infrastructures and services are creaking, and so on. But, if we just insert enough digital sensors around the city, including people's phones, and generate enough real-time information about urban processes that city authorities can control over digital platforms, then they will all be able to better manage and solve these problems.

That is the solutionist pitch. It is alluring because it skirts over the trickier task of looking deeper into some of the underlying political causes of urban dysfunction, such as economic inequalities, speculative land ownership or undemocratic decision-making. The smart city tries to avoid these things because it is all about pitching for investment in technological solutions.

Solutionism is technocratic. Indeed, I would go further and say it is anti-democratic, owing to the worrying and incorrect presumption about technological determinism that underlies it. It plays into popular notions in modern culture that see technology as an autonomous progressive force in society that shapes our futures. We have to learn how to adapt and capture the promise of the latest technologies whilst avoiding their threats.[15] We see this currently with AI: it is the latest technology that is going to solve problems of health, make administration more efficient or fix cities. But decades of research in the sociology of technology teach us that technologies do not determine the future. Rather, it is social choices and social forces that influence key decisions and commitments that shape the development of specific technologies. Thus, it is these social choices that really influence the future more than the technologies that come to embody choices. Seen this way, society can and should exercise greater agency over technology. We can do better than solutionism.

For sure, technology development is an important stage for social debates about the future, and as certain technologies attract investment and commitments, they develop and build momentum to the extent that it can often feel as though they are determining the future. But we always need to look beneath the technologies at the social terrain that shapes them and moves their development: that sets the research agendas, decides what kinds of engineers to train, and that commits investment and governs the distribution of benefits and risks. As French sociologist Bruno Latour once put it, technology is society-made durable. And solutionism is social development left to technologists.

We have to challenge solutionism, and I think post-growth does challenge it because it starts with very different assumptions and aspirations for the productive base of society. The kinds of political and economic relationships and material culture that post-growth would like to see in the world are very different to the green growth vision underpinning things like smart cities. And so, if you push and mobilise for post-growth, then you are going to reset the basis for technology development and thus the kinds of technology that develop and propagate in the world. This critical questioning of the basis for technology in society is something that the field of science and technology studies has been exploring for decades. Unpacking and critiquing the social shapers of technologies and questioning who and what is determining our futures is its bread and butter. And STS provides us with many useful theoretical resources, diverse methods and frameworks for doing technology differently. Even if it seems that our futures are determined by technology, STS gives us tools to open up the black box and peer into the political, economic and cultural forces that are shaping technology choices and commitments in our society.

STS is not rooted in post-growth, but I think there are lots of exciting potential for engagements and fruitful dialogue between them. Obviously, the Post-Growth Innovation Lab here in Pontevedra is pioneering a lot of that conversation. They are hosting this joint Conference of the European Society for Ecological Economics and the International Degrowth Conference, and at the opening session on Tuesday, we were asked what fields of research beyond ecological economics could enrich analysis and strategies for post-growth. I think STS could be a valuable field. And given the conference theme is Science, Technology and Innovation Beyond Growth, I would hope that by its end, some of you will agree.

Actually, an interesting parallel with post-growth is that STS was also born of activism. It emerged from a mobilisation of young science and engineering students mainly, and some social scientists and humanities researchers, who were challenging the military–industrial complex in the 1960s and 1970s. They were questioning the technology systems into which they were graduating. How do we counter the violent and destructive purposes to which science is put? How do we build a science for the people—in some cases, even asking how do we dismantle scientific culture and build alternatives? Now, STS has developed a lot since then. In some places, it retains activist roots, but in other places less so, and research is oriented to informing improvements in business performance or reforming policies for science and technology. Nevertheless, the critical insights it brings into the operations of science and technology in society and the influential roles it identifies in social movements and amongst policy reformers are really valuable.

So I think there are good reasons to be hopeful that there can be fruitful encounters with post-growth, in particular, by looking at technology questions more widely than its specious role in solutionism and considering instead technology in much more sociological and political terms. Technology is a site of struggle when transforming the productive base of society along more ecological lines, and we need to understand what we are involved in with technology.

Where I think STS and post-growth could really collaborate successfully is in the construction of sociologically rigorous alternative approaches in technology. Already there is interesting work on the kinds of design criteria and innovation processes for post-growth technologies, and there is still lots of work to be done on that. I have collaborated with many colleagues and activists looking at community energy, eco-housing, food, agroecology and with colleagues here in Pontevedra looking at the right to repair and repairable things.[16] Learning from settings and groups that are already anticipating post-growth innovation is very important.

And in doing this, it is important to recognise that fields such as community energy and eco-housing do not just produce valuable prototypes or artefacts. They are also producing new methods, new narratives, new communities and relations, new subjectivities and anticipating new political economies and so on and so forth. Some of these things are of much wider significance. It becomes important to go much deeper into the kinds of social basis for these processes and especially the institution-building that is needed so that post-growth design criteria and innovation processes become an everyday sensibility or culture for technology. And that institution building needs to happen across the board, from local organisations through to the United Nations, and work its way into corporate activity as well as public policy. If you like, the direction of travel becomes reversed: instead of understanding our technological worlds by peering into their underlying social basis, we are trying to reinforce the building of new social bases through technologies that anticipate them.

An important part of that is countering the allure that solutionism has in many existing innovation institutions and the grip this approach has on policy imagination and practice. Here, reconceiving what we mean by innovation becomes important. Take, for example, the recovery and recuperation of older or traditional practices that might today be reconceived for post-growth priorities of social and ecological well-being. It might be vernacular construction techniques with local materials or plastic-free non-disposable packaging, and where its recovery today involves novelty in terms of integrating and adapting it into what we are doing with buildings or packaging today. Or if we take a practice from elsewhere that has been established there for many, many years and we bring it to another locality, it is still novel and innovative for that new locality and requires work to put it into effect. Innovation is not solely about the shiny new technologies of the solutionists' dreams. Or if you are thinking about repair or even maintenance and how to improve that, then it is going to involve some forms of novelty and creativity and therefore some forms of innovation. These plural forms of innovation contrast very sharply with the sort of conventional kinds that Andrea was talking about. Our innovation policies need to become much more diverse and devolved and appropriate to the social needs of particular settings.

I would like to illustrate some of this by recalling an historical attempt that we studied a few years ago. I chose it because, in contrast to what I was just saying, it is an industrial example and involves high technologies. Industrial technology is somewhere post-growth research and activism needs to be involved.

The movement for socially useful production emerged and flourished in the UK in the mid-1970s up until the mid-1980s.[17] It took root initially amongst grassroots trade unions involved in struggles against the demise of British manufacturing at that time and wanting to develop a democratic socialist alternative for production. A particular inspiration and focus were the workers at a company called Lucas Aerospace that made a wide range of products, including electromechanical components for warplanes. So, the company had contracts with the state to provide weapons, and the workers decided that they had had enough of that. At the grassroots level, the local branches of the trade unions began working together to say, 'How do we challenge this? What could we make instead?' They were facing redundancy because defence spending was in one of its periods of decline, but also because new computer technologies were coming into the workplace and displacing human work rather than enhancing it, and various other things like growing international competition and capital shifting out of manufacturing and into services and real estate, and so on. It is a complex story. But the important thing is what the workers did at the factory.

Alongside the more usual repertoires of repertoires of resistance, such as strikes and factory occupations, the Lucas workers looked at the design of alternative technologies that they could make using the skills and machinery available in their workplace. They looked at the way relations between the shopfloor, the design shop and management could be restructured and democratised. They talked with their communities about their needs. And they talked with comrades in leftwing institutions in their neighbourhoods, such as the trades councils. And they came up with an alternative strategy for the company that included over 150 designs and prototypes for what they called socially useful production. With this they launched a campaign demanding their right to make socially useful products in place of weapons of war, and that included things like wind turbines, heat pumps, electric vehicles, health equipment, equipment for children's play, and so on and so forth. And instead of the State spending its resources on welfare for the unemployed and warfare for defence, they argued it should be investing in markets for socially useful production and supporting people to work.

What was significant was that this movement was driven by a different set of values in technology development compared to the conventional economy. They were proposing design criteria through their prototypes, such as arrived at democratically, appropriate scale, easily repairable and ecologically sensitive. And there were ideas about doing this in solidarity with what was called the Third World back then.

Their designs were not only practical possibilities but they also served as what they called technological agit prop. With their unmade products they were trying to provoke people to think, 'Well, why aren't these socially useful products being made? How do we do that?' And they were pressing for workplace democracy, community participation in planning, production for social use rather than for commodification and exchange and so forth. They wanted industrial democracy and democratic socialism. These innovations were anticipating and demanding wider changes in society.[18] So, in this example, they were calling for linstitution building for

socialised markets and a democratic state that would support these innovative activities: institutions for public ownership, investment and democratic planning.

Here is an example of an approach to innovation and technology that was looking way beyond solutionism. But these workers could not do it alone. They needed institutions that embodied wider political and economic changes. In contrast to solutionism, technology was not conceived as a way of evading structural change but rather as a route to enabling it. Of course, the movement for socially useful production was ultimately unsuccessful. The institutions they were building with left social movements were swept aside by the New Right and its neo-liberal counter-revolution. Some of the practices and innovations the movement pioneered, such as participatory design or wind turbine technologies, did endure and become widespread. And it is striking that today, as progressive think tanks and groups in the UK seek to transform the economy, it is not unusual to hear calls for a 'Lucas Plan for the twenty-first century'.

Of course, today, institution building for alternative approaches to technology, such as free software, open hardware, commoning and so forth, takes place through very different kinds of networks of activism and social entrepreneurship—although I believe trades unions remain vital, as we see with calls for just transitions. But this institution building remains quite weak in the face of conventional institutions for science, technology and innovation in society. These alternatives lack the political and economic base for building strong counter-institutions. And I think that is where the challenge is for post-growth, really: thinking about how to build appropriate innovation institutions and make them strong. How to shed our institutions for innovation based on economic growth and international competition, and build knowledge and institutions based in post-growth?

Aviram Sharma: Adrian has talked about how there are alternate ways of doing things. It is not only about product innovation or, like, the economics of the innovation, but it is also about how innovations are governed and how new ways of doing are imagined. In this background, we will move to Alejandra, who will talk about how alternate innovation policies can be made accountable and responsive towards vulnerable communities and threatened environmental resources in peripheries within the industrialised, emerging and developing economies in post-growth scenarios and societies.

Alejandra Boni: I will begin by discussing policies, specifically innovation policies, and I would like to start with a particular example. This example involves a collaborative effort between various organisations, policymakers and government entities at the local and provincial levels in Catalonia. Based in Valencia at Ingenio, I have had the opportunity to work closely with a group of policymakers, some of whom are present here today. In my view, this case represents a potential example of a transformative innovation policy, which we can evaluate further to determine its transformative impact.

To provide some context, the example is situated in Catalonia, one of Spain's regions, and more specifically in Lleida, a rural area in the interior of Catalonia. This region is characterised by a low population density and significant geographical and territorial imbalances. Approximately half of the population in this region resides in four large cities, while the remaining population is dispersed across numerous smaller municipalities. Notably, 40% of the total area consists of small municipalities with fewer than 500 inhabitants, characterised by small rural towns. This is a predominantly rural area with an economic model heavily reliant on the primary sector, offering limited capacity to create alternatives or generate job opportunities. This lack of opportunity particularly affects young people, many of whom migrate, leading to significant challenges related to rural depopulation and outmigration. The region's economy is further characterised by an intensive model of livestock and agricultural production, where large corporations dominate the market, creating additional barriers for smaller producers. This provides a snapshot of the socio-economic and geographic context in Lleida, located within the broader Catalonia region.

In 2018, eight small municipalities, supported by the provincial government, local producers and some research organisations—though primarily led by local authorities—identified the circular bioeconomy as a potential avenue to add value to local production and retain people in rural areas. This initiative has since evolved. Six years later, in 2024, it had grown into what is now known as the *Agenda of Lleida, Pyrenees, and Aran*. Initially focused on Lleida, the initiative has expanded northward to encompass a larger geographic area.

Over this six-year process, in which we have had the opportunity to participate, a shared vision was formulated: to transform the region into a territory that leverages its strategic location, resources, capacities and potential to develop a fair, competitive and sustainable green economic model. This model emphasises the principles of circularity, high digitisation and smart growth. The entire effort is framed within the context of an innovation policy aimed at achieving these ambitious goals.[19]

The ongoing efforts in this region encompass a range of activities aimed at fostering sustainable development and innovation. These initiatives, still in progress, include establishing a bio hub to explore and produce alternative proteins and prototypes of bioproducts, primarily using waste from livestock farming. Additionally, the initiative works closely with local authorities to promote energy transition through the creation of local energy communities, empowering residents to shift towards renewable energy sources. Another key focus is the development of an observatory for indigenous resources, designed to identify and promote nature-based solutions and services that leverage the region's unique assets.

These efforts are being driven by a diverse group of stakeholders, including local authorities, the provincial government, with support from the regional government, as well as small-scale farmers, university researchers, small businesses and engaged citizens. Notably, larger corporations have not shown interest in par-

ticipating in these alternatives, leaving the leadership to smaller, more localised actors.

The shared agenda guiding these efforts exemplifies a transformative innovation policy.[20] It is rooted in addressing place-based challenges and relies on initiatives that engage local actors to tackle specific needs. Central to this approach is the idea of starting from the ground up, ensuring that the challenges addressed are meaningful and relevant to the community. In this case, the priorities have been to create job opportunities and provide alternatives for small farmers, aligning solutions with the region's distinctive circumstances and aspirations.

In another area of Catalonia, efforts are focused on addressing challenges in healthcare, particularly the pressures created by an ageing population. This demographic shift places significant strain on the medical system, prompting the development of solutions tailored for families, individuals and patients through a distinct approach. By identifying the core challenges, stakeholders have developed a portfolio of initiatives supported by regional and local governments, along with other public authorities. These bodies provide funding, resources and structural support to implement these innovative policies.

This transformative innovation policy approach is characterised by its holistic, dynamic and systemic nature. While technology plays a role, it is not the central focus; instead, the process is shaped by the region's social and cultural characteristics. Unlike traditional policy approaches that rely on strategic plans, blueprints or rigid frameworks, this method emphasises on experimentation. It adopts a 'try and learn' philosophy, encouraging iterative testing and adaptation of alternatives.[21]

For such an approach to succeed, it requires public authorities who believe in and are committed to this experimental and collaborative style of policymaking. In Catalonia, there has been a fortunate alignment with a group of policymakers and stakeholders who embrace this method. Experimentation and learning are central to this model, which operates systemically and incorporates a governance structure that actively includes local actors. Rather than being dictated by policymakers alone, decisions are made collectively, though power imbalances naturally exist, reflecting the complexities of real-world dynamics.

Furthermore, this policy approach aspires not only to address local challenges but also to scale successful solutions beyond the immediate community. The ambition is to ensure that these initiatives have a broader impact, extending their reach and applicability to other contexts and regions.

I would like to share three key questions that come to mind for this audience. The first relates to what was mentioned earlier: technologies do not operate in a vacuum. They are deeply shaped by cultural, economic, social and geographical factors. For instance, the example of Lleida cannot simply be replicated elsewhere because it is specific to the unique conditions of that region. This is why we employ the concept of the socio-technical system, which frames technology as being interconnected with social values, policymaking, knowledge production and other contextual factors.

The second question concerns the role of policy. Policymakers and policies act as enablers of innovation, creating spaces for diverse actors to develop solutions. While policymakers are key players, they are not the sole agents of change. Innovators from various sectors contribute significantly to the development of initiatives. Policies should aim to open these spaces, fostering environments that encourage experimentation and alternative governance approaches, as discussed earlier.

The third point, which I find particularly relevant as someone working in a research institution, addresses the type of knowledge needed for effective engagement in these policy processes. Transdisciplinary knowledge is crucial—knowledge that is co-produced with actors beyond academia, including policymakers, farmers and others involved in specific experiments. This is why we employ participatory methodologies, such as action research and formative evaluation, which are grounded in co-production. While theoretical frameworks are valuable, their practical application is equally, if not more, important. Through engagement, we constantly revisit and refine our theoretical approaches to ensure they remain relevant and effective.

Finally, it is essential to acknowledge and address power imbalances, including those between different forms of knowledge. Creating spaces where all actors can contribute equitably is a central challenge but also a critical goal. These reflections encapsulate what I wanted to share with you today.

Aviram Sharma: Thank you, Alejandra. Before moving further, let me pose one question based on the discussion so far: How to imagine technologies in this whole debate? We live in a technology-mediated world, and even though there are alternate ways of doing things, there are different innovation models, various governance models and diverse political ways of engaging with innovation and promoting innovation. Yet, most spheres of our lives are guided by complex, modern technologies and politics around technology. Does technology have one value, or does technology have many values? And how the material politics of technology needs to be conceptualised in this context.

Just to give you one example, a lot of times people assume that bicycling is convivial. Bicycling is an alternative to many other forms of technology, but even the global bicycle industry is more than a $77 billion US dollar industry. Big multinational companies are involved in production and innovation, and the material requirements for producing these bicycles are huge on economies and the environment. Any technological change or the use of this particular good has a significant impact on common people's lives in diverse settings, from where the materials are extracted for the production of these specific technologies or machines.

Similarly, solar energy is another example. People often assume solar energy does not need huge material requirements as other energy technologies and systems. However, there are many studies which argue against such simplistic binaries. Let me give you an example from India. To achieve the solar and overall

renewable energy target, India needs as much land as around 95,000 sq. km., which is equivalent to the geographical area of Portugal in Europe or the size of Bihar, one of the eastern states of India.[22] So even though the material requirement is less, to install this particular kind of technology and generate adequate energy for the growing economy, you still need large tracts of land and minerals. The minerals need to be extracted from specific geographical locations, and finally, the waste emanating from these systems needs to be managed. How can we go beyond the simplistic understanding of technology or innovation while talking about these material politics around diverse technological artefacts and systems so that we do not end up harming marginalised communities or the environment in faraway places?

Adrian Smith: Many thanks, Aviram. Your questions make me think about scale and materiality and the kinds of worlds technologies help bring about and for whom. Both your examples appear to be small-scale technologies that help promote more healthy and convivial forms of mobility, in the case of bicycles, or decentralised energy systems in the case of solar photovoltaics. But as you say, each is becoming part of large-scale industries and applications: a global industry for bicycles and their electrification, and large energy installations taking up vast tracts of land. And as you say, in both cases, these have real consequences for material consumption, whether that is land or minerals.

Another example that came to my mind whilst you were talking in this way was the case of wind turbines. There is a physical relationship between the swept area of the blades of the turbine and the amount of electricity it generates: electricity generation increases with the square of the blade length. So here is a material affordance that prompts developers to pursue ever bigger turbines in order to get more profit from the capital they invest. There are many other complicating material and social factors, but bigger is more is a basic scalar relationship for this technology. Whilst that might work for energy utilities and large-scale investors, it leads to a technology that is increasingly beyond the means of energy communities. The early pioneers of modern wind energy technologies, for example in the alternative technology movement in Denmark, necessarily had to start with smaller scale turbines. They developed designs that were more robust and reliable compared to the large-scale turbine research programmes in other countries at the time. As those designs became more commercially interesting, so the scaling effect came into operation and they got bigger and bigger. The only people who can own them are massive investment firms whose offices are on the other side of the world and so forth. However, for the pioneering communities this was not necessarily a goal. The use of wind turbines was conceived within a vision for a low-energy society. Smaller turbines under democratic control was the original aim and that would facilitate a social transformation from industrial society and towards ecological societies. For the alternative technology movement, smaller scale wind energy was part of what philosopher of technology Langon Winner once called technologies as forms of life.

When technologies like wind energy enter into conventional technology institutions, particularly in capitalist economies, there is powerful interest pushing the square law to the maximum. That is why we get these mega wind farms: the technology has to try and supply energy-intensive societies, and in effect, the technology helps vested interests to evade social transformation rather than movement hopes for it enabling transformation. I think scale is important, but just as important is thinking where does that drive for scaling up comes from; and how to resist it or allow people to deliberate what is an appropriate scale technology for their community?

Alejandra Boni: Our daily actions have far-reaching consequences, often impacting other parts of the world. From my perspective, technology can serve as a powerful tool, particularly for individuals with fewer opportunities. For instance, the case of Lleida illustrates how local farmers engaged in agriculture face challenges in achieving a sustainable livelihood.

In this context, implementing a specific technology tailored to the community's needs offers a potential solution. Moreover, it is crucial to ensure the active participation of local stakeholders in the design and deployment of such technologies. While the success of large-scale projects, like the proposed plant in Lleida, remains uncertain, the role of local farmers and their involvement should not be overlooked.

To ensure equitable outcomes, governance mechanisms must be participatory and reflect the needs and contributions of the communities directly impacted. This approach underscores the importance of designing solutions that are context-specific and inclusive of the people who inhabit these areas.

Aviram Sharma: Thank you all for your insightful thoughts.

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NOTES

1. To read more on the Gandhian thoughts on technology, society and imperialism, please refer to the work of Prabhu and Rao (1962).

2. To read a more elaborate conceptualisation of the 'imperial mode of leaving', please refer to Brand and Wissen (2021).
3. The relationship between imperial centres, centres of capitalism and the peripheral zones is brilliantly explained in the work of Walter Rodeny (1974).
4. Recent work of Kehinda Andrews (2021) explains the new age of empire and elaborate how the modern world is shaped by colonial, racial and exploitative power relations.
5. To read an elaborate critique and history of innovation, please refer to Godin (2015).
6. Please refer to Adas (1989).
7. Please refer to the book edited by Medina et al. (2014), which is a good entry point to delve into this discourse.
8. To read a decolonial approach to innovation, you may refer to Jimenez et al. (2022).
9. Please refer to Kallis and Bliss (2019) for an elaborate critique of eco-modernist approaches.
10. One of the recent works of Abdelnour (2023) elaborates the military innovation system in Israel and the globalisation of violence.
11. Madioanou (2019) work presents the idea of techno colonialism.
12. To read an elaborate explanation of how race and gender shapes technological production and world making, one may refer to Paulson (2024).
13. Pansera and Fressoli (2021) offer a possibility of innovation paradigm beyond growth.
14. You may refer to Pansera and Owen (2018) to get a broad overview.
15. You may refer to Smith and Fressoli (2021) for an elaborate critique.
16. You may refer to the work of Lloveras et al. (2024) to get an overview of the STS informed degrowth debates.
17. Please refer to Smith et al. (2017) to get an historical overview of this debate.
18. Please refer to Smith and Stirling (2018) to get an overview of these diverse debates.
19. To know more about these initiatives, you may refer to Velasco et al. (2024).
20. Schot and Steinmueller (2018) explained in detail the idea of transformative change and innovation.
21. To know more about the project and the general details, please refer to the report produced by Generalitat de Catalunya (2023).
22. For details, please refer to Worringham (2021).

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