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Reflections

A Conversation with Carlota Perez: A Life of Revolutions

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Carlota Perez, now in her mid-80s, is one of the world's leading thinkers on innovation and technological revolutions. Her intellectual journey, which has been anything but conventional, unfolded through a series of revolutions: from aspiring to become a missionary to studying architecture, from leaving behind a Marxist revolutionary movement to joining the civil service, from advising corporations and governments to ultimately entering academia. In the process, Carlota has developed a unique view of the global economy: where it is headed and where it could potentially go instead.

Her career in researching technology began in the 1970s with an investigation into the structural causes of the energy crisis in her home country, Venezuela. After working on international technology transfer at the Institute of Foreign Trade in the 1970s, she became the founding Director of Technological Development at the Ministry of Industry (1980–83). There, alongside other policy instruments to promote innovation, she created the country's first venture capital fund. After holding the position of visiting researcher at Cambridge University and Centennial Professor at London School of Economics, she currently is an Honorary Professor at the Institute for Innovation and Public Purpose (IIPP) at University College London (UCL) and at the Science Policy Research Unit at the University of Sussex. She is also Adjunct Professor of Technology and Socio-Economic Development at the Ragnar Nurkse School of Innovation and Governance at TalTech, Estonia. She sits on the advisory boards of IIPP, at UCL, the Development Leadership Dialogue at School of Oriental and African Studies, University of London, and the Technology and Industrialisation for Development Centre, at the University of Oxford. Over the past few decades, her pioneering work has shaped our collective understanding of technological transformations and their interactions with broader economic, financial, social and political changes. Her book *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Perez, 2002), has become a classic and was chosen as one of the 'books of the century' in economic history by the journal *Foreign Affairs*. That book is where she

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first advanced her theory on the emergence and diffusion of technological revolutions, and the role of finance in the process. She is currently working on a sequel, *The Social Shaping of Technological Revolutions*, which will analyse the roles that government, business and civil society play in bringing about the golden ages of each revolution.

Why is it so important to have this conversation today? The world is undergoing considerable changes. We are living through a turning point in history, one defined by technological disruption, climate emergency and growing inequality — yet also by unprecedented opportunities for transformation. In many ways, the historical transition we are witnessing now may also require a fundamental shift in theoretical paradigms. As we seek to explain contemporary dynamics, we need to both understand past trajectories and develop new conceptual tools. It is in this sense that Carlota Perez offers a unique perspective on today's unprecedented challenges and ecological crises. How can societies reconcile the urgent need for environmental sustainability with the imperatives of economic and social progress? What role should the state play in steering innovation and industrial development towards a greener and more equitable future? These pressing questions form the backdrop to this interview, in which Carlota Perez discusses the contradictions and possibilities of pursuing sustainable development, the merits and limits of the degrowth paradigm, the causes of populism and the role of green industrial policy to avoid ecological collapse while ensuring shared prosperity. This conversation not only offers a critical engagement with contemporary debates on state intervention and the role of finance, it also delves into her personal life and experience to draw reflections and advice for the next generation of scholars to better equip themselves to deal with the challenges of our times.

Carlota, as one of the world's leading thinkers on technological revolutions and socio-economic development, what first sparked your interest in technological revolutions? Was there a particular moment or experience that shaped your thinking?

In the mid-1970s, I was involved in a post-graduate course on petroleum economics at the Central University of Venezuela. I was part of a research team connected with Juan Pablo Perez Alfonzo, the promoter of the Organization of the Oil Producing Economies (OPEC). We knew that the price hike of around US$ 2 to US$ 7.50 per barrel was completely unprecedented (the usual changes were in cents up or down). Such an enormous leap would normally have been unacceptable to the powerful oil cartel, but we knew that it had been 'suggested' by the oil companies. They needed it to produce profitably in the North Sea and Alaska, where they had already made major investments. But we suspected that there might also be structural causes, and I was given the task of finding out. So, I looked at the main technologies developed since the automobile replaced trains, horses and tramways and

since electricity became basic to home life. What I found was astonishing to me: everything, absolutely everything, used either oil or electricity or was made of some petrochemical synthetic material. Even agriculture depended on it! And since oil had been so cheap for so long, an increase in price was likely to hit both manufacturing and lifestyles brutally. No wonder the 'oil shock' was such a shock! So, then my question was, 'What will happen now that oil is expensive'? Will technologies change? And that was when I discovered the potential and the decreasing cost of microelectronics. It was my Eureka moment: cheap microelectronics would replace cheap oil as the driver of innovation! This led me to the notion of technological revolutions as the focus of my early work and, from there on, it was non-stop sailing in a sea of questions and discoveries about technological change and its impact on society. The interesting thing is that, even though I went to do postgraduate work to develop that new understanding (Perez, 1983), it didn't occur to me to become an academic. My goal then was to work in government, not as a politician but as a civil servant, to deal with development under the new conditions.

Thankfully, you have not stopped and have indeed become a public intellectual and academic. But how has your thinking and theoretical model evolved after decades of analysing technological revolutions? What has changed the most in your research?

Until the mid-1990s my focus had been on innovation, Schumpeter's (1939/1982) 'long waves', paradigm shifts and the impact on firms in terms of changing products, production methods, their organization and opportunities. I was also very interested in how these changes would open possibilities for developing countries (Perez, 1985). As you probably know, in Latin America, since Prebisch (1950) wrote the article about the price scissors between expensive imports of manufactures and cheap exports of raw materials, we had adopted import substitution industrialization. Prebisch himself guided the process as head of the UN Economic Commission for Latin America (CEPAL in Spanish). It implied importing parts rather than products and assembling them locally. It created employment but, being mature technologies, we were conscious and concerned about technological dependency. That is what the structuralist school argued,[1] and what practitioners of industrial and technology policy like me were grappling with. What I then began to explore was the possibility of partially escaping dependency by early entry into the new technologies of the nascent information revolution (Perez, 1986/2009).

But the really big shift in my thinking came in the late 1990s. It was during the Nasdaq boom, after the US government had handed the internet

1. See Furtado (1964), Sunkel (1973) and the compilation by Bielchowsky (2016).

over to the private sector, that I discovered the crucial role of finance (Perez, 2002). I understood that it was the driver of the experiments with the new technologies and of the 'creative destruction' that forced mature industries to modernize or die. Schumpeter (1911/1980) was right, the entrepreneur and the banker needed each other. Relatively unfettered finance is indispensable for experimenting with the potential of each revolution. But he did not see the social harm done by finance in those times, in terms of job destruction and increasing inequality, nor the indispensable role of the state to overcome it.

Looking at the history of previous revolutions, I found three recurring facts: change in market economies occurs by revolutions; the early decades are experimental and led by finance; and the later decades are production-centred with clear directionality provided by the state. Those are the years during which the potential of the revolution benefits society more broadly. They are the golden ages: the Victorian boom (1850–1873), the Belle Epoque (1871–1914) and the post-war boom (1950–1973), and it could be what lies ahead. The crucial role of the state in bringing the good times was a blind spot for Schumpeter. What he saw was a sequence of long-term upswings and downswings happening within the market, without state intervention.

Along with Schumpeter and Marx, I believe that innovation is the propeller of capitalism. The fact that technological innovation happens by revolutions is at the origin of the regular pattern of propagation that I have identified. And understanding that is crucial for shifting the focus towards the most effective policy in each period of the diffusion process. So, rather than the unexplained 'progress' held by standard economics or the equally unexplained sequence of upswings and downswings held by the 'long wave' theorists,[2] I have leaned towards a more Polanyian (1944/2002) view of the internal evolution of the system, involving economics, history, technology and politics, as Chris Freeman (2019) also did. What is missing from all traditional economic theories is an understanding of technological change. That is absolutely essential.

Are you a technological determinist then?

Not at all. The range of the possible with any technology is very wide. What technology opens up is the space where economic, social and political forces confront each other to determine in which of the many possible directions to guide the technological potential. The space of the technologically feasible is always greater than the socially acceptable, which in turn is greater than the economically profitable. The state often gives shape to the final result through regulation to resolve the conflicts of interest between business and

2. See Kondratieff (1925/1935).

society. Those who believe in the inevitability of certain outcomes because it is what the technology can do — and therefore will do – also believe that we must accept and adapt. They have obviously not looked back at history. There is always a range of options and the choice of the most socially beneficial is always there (Johnson and Acemoglu, 2023). But ignoring the role of technology is as harmful as being a technological determinist. Guiding policy and politics without understanding the role played by technology in opening and closing options leads — and has led — to huge policy blunders.

You are almost suggesting that we need a new economic theory! You are putting technology in a central place but also seeing an important role for the state in shaping it. Can you elaborate more?

Yes, I do think we need a new economic theory. Keynes saw the role of the state but not of technology; Schumpeter saw the role of technology and not of the state; Friedman ignored both and trusted the market to do everything. I believe we need to develop an economic theory, rooted in history, that includes the interactions between technology, the economy and the state, and that understands the difference between financial and production capital. Evolutionary economics is the most useful,[3] although it still needs to work more on understanding finance and institutional innovation. Chris Freeman's (1974, 1992) work on innovation and technology systems and policies, together with evolutionary economics and the whole school of innovation studies that developed around the Science Policy Research Unit at the University of Sussex, was crucial for my understanding of technological trajectories from introduction to maturity (Perez and Soete, 1988). My work with Chris (who in the end became my husband) was essential. It made me understand much more deeply why change occurred through revolutions, based on the notions of technological trajectories and paradigms (Dosi, 1982). It is because the industries of each technological revolution reach maturity more or less simultaneously — exhausting their possibilities for increasing productivity or for expanding markets, thus putting enormous pressure on profits — that the search for radically new technologies becomes intense and the next revolution emerges (Freeman and Perez, 1988). That is what happened in the 1970s, resulting both in the catastrophic stagflation of that decade and in the articulation of the electronics, computing and information revolution. It was also then that, seeing government action (and impotence) as the problem, Friedman's theory became the new gospel, and what followed was the Reagan–Thatcher demolition of all regulation and the disempowerment of the state.

3. See Dosi (2023), Dosi et al. (1988), Freeman and Louçã (2001), Nelson and Winter (1982), Nelson et al. (2018).

They simply handed control over to finance, which soon entered into a frenzy of investment in intense 'creative destruction' mode. The social consequences in terms of job and skill losses worsened as both crashes — in 2000 and 2008 — were met, not with punishment for the culprits, but with free money to continue the casino. So, the process of income polarization went on unabated, and we find ourselves facing two emergencies: the resentment of the majorities who lost their future, handing democracy over to the autocratic populists, and the climate emergency resulting from the unfettered continuation of the intense and careless way in which the mass production revolution used fossil fuels and materials.

Recognizing the recurring pattern of propagation is essential. If, during the stagflation of the 1970s, we had understood that the problem was the maturity and exhaustion of the mass production paradigm, we would have had criteria for action. When the new revolution begins replacing the exhausted one, the state must both facilitate experimentation and protect the victims of job and skill destruction and regional decay. Instead, Keynes was abandoned, Friedman's theories were adopted, and markets and finance were given free rein without regard for the many inevitable victims of creative destruction.

The current situation is very different, the wide-ranging potential of the new technologies has been tested in the market and finance has become self-serving and dysfunctional in terms of social progress. It is time for the state to come back proactively and tilt the playing field in the most socially beneficial directions. Having understood both the beneficial potential and the perils of the information technology revolution, including artificial intelligence (AI) as the latest addition, it is possible for the state to provide directionality towards constructing a smart, green, fair and global golden age (Perez, 2016, 2019). And hopefully, we have learned to recognize the maturity and exhaustion of a revolution and will know how to face it when it inevitably occurs.

It is hard to see how the vast change that is needed can come about in a financialized and geopolitically tense context that is marked by the proliferation of populist autocrats. However, the 1930s depression, with Mussolini, Hitler and Stalin in action, and leading to a devastating war, was followed by a golden age, with blue-collar workers in the North enjoying secure and comfortable lives. This time it is technologically feasible to lift the Global South to development while improving the lives of the majorities in the North and stopping climate change; it is only politics and policy that can turn the possible into the probable. And the signs of abandoning the 'free market' ideology are everywhere, as well as the questioning of mere GDP growth as the goal. It is unfortunate that President Trump's government, with its simplistic notions and chaotic actions is creating such tension and disorder in world markets, instead of reshaping them for the better. Nevertheless, industrial policy is trying to come back, and it is possible that even such disruptive actions will favour its intelligent readoption.

How do you see that ideological re-orientation? How likely is it that it will really prioritize sustainability and well-being over GDP growth, overproduction, planned obsolescence and material consumption? And do you think that recent green industrial policy attempts are ambitious enough?

Of course they are not ambitious enough. The EU Green Deal or the US Inflation Reduction Act have been isolated patches in the context of the old framework. Unfortunately, capitalism only makes significant changes when confronting a major crisis. Just look at what happened with COVID-19. Business abandoned the free-market mantra and ran to the state asking for help, which came in abundance, from paying part of people's salaries to handing out a sort of 'basic income' to everybody. All unthinkable but responding to a real crisis. I think the current populists might be creating enough chaos to lead to a critical moment requiring major changes; there is also a financial crisis in the making with world debt at almost four times global GDP; and finally, there is the potential for climatic catastrophes unfortunately becoming serious enough to result in a call to action. But even then, you cannot fix the system if you don't understand how it works. Every technological revolution has required a socio-institutional revolution. That has been the basis of the golden ages. They have required a massive overhaul of the whole policy framework and of the way it is handled.

The historical research for my new book has led me to identify the three areas where the state in the leading country or countries made major changes to bring about each of the previous golden ages. One is providing *directionality* while equipping the state for the new tasks. Policy and regulation were each time made to clearly favour the chosen directions, while ensuring sufficient public revenue and a competent civil service to handle them. A second area has been aimed at *handling the powerful*, in the sense of regulating the monopolistic giants as well as getting finance to recouple with production. This also required maintaining a stable geopolitical scene and achieving sufficient consensus among the national elites. And finally, and most importantly, the fostering of the *common good*. The reversal of the inequality trends that prevail in the early decades of diffusion of every revolution, with welfare and other measures as well as investing in infrastructures, science, education, skills, health and security. That is how the shift is made from 'creative destruction' to synergistic 'creative construction'. And that is how the term 'middle class' which referred to the bourgeoisie in the first industrial revolution moved to the educated, then to the highly skilled and the white-collar workers, and finally to the blue-collar workers in the advanced countries. In doing historical research, it is remarkable to find that in different circumstances and in different ways, the same objectives have been pursued and succeeded in unleashing the good times for a greater proportion of society. The regularity of financial casino behaviour is followed by social unrest and populism, in turn bringing forth the political leadership that will unleash and guide the golden ages.

It is important to note that the reason such progress occurs in a system that is moved by profit is that the social advances create dynamic demand for business. It is because the mass production of goods needed mass consumption, that the post-war golden age in the advanced world was based on strong unions, the welfare state and home ownership. A golden age now, with the information and communications revolution, is more likely to need growing demand for equipment goods, major infrastructure and high-tech products and services. Since currently China and the West are competing for each other's markets, only the development of many more countries can provide the required dynamic demand for all.

All that is what the book I'm currently writing is about. I agree that it seems daunting, especially given the extremes the system has reached in this long installation period. But if the various progressive movements, scattered and fighting for partial goals or aiming for impossible utopias could get together, the likelihood of success would increase significantly. Currently, the majority of the population that should be supporting a change for the better are following the demagoguery of the populists.

We are indeed seeing the rise of populist narratives in many parts of the globe. But how do you explain populism?

First of all, it should be noted that the main supporters of the populists are not the poor but the impoverished. Populist leaders emerge as the legitimators of the resentment of those who have lost their future. And that happens with every technological revolution. After the first few decades of 'creative destruction' there is a difficult interval between those early decades of installation and the golden age deployment — what I have called the Turning Point. It tends to be either recession, as in the 1890s and 1930s, or slow and very uneven growth, as in the late 1840s in the UK and now across the world. And the loss of jobs and skills has happened every time, and populist leaders have also emerged. But some are just serving their own ambitions of power, like Hitler before and some today, riding the wave, and promising what they cannot and will not deliver, while blaming a scapegoat like the Jews or the Muslims or the migrants. Such leaders offer to avenge the impoverished and give them their future back. That is why they use slogans like 'make America great again' or 'take back control'. But there are other leaders at these times, like Franklin D. Roosevelt in the fourth revolution who did improve the lot of those majorities while appealing for their support with his 'fireside chats' through radio, which was the 'social medium' of the 1930s.

So, populism is a sign of the need for an institutional revolution to respond properly to the needs it is expressing. In my view, that is the moment we are living now. It is time, not for using a wrecking ball to destroy the state, but for creating a positive sum game between business and society, such as the post-war welfare state which made it possible for the majorities in the

advanced countries to attain 'middle-class' lifestyles. Unfortunately, those advances had a high cost for the developing world and for the planet. And that is a lesson to learn towards shaping the golden age of the current revolution. But we are late. This time the record in length has been broken, for both the installation and the turning point itself. The good news is that we could have a golden age ahead; the bad news is that we are not doing very much towards achieving it.

Reading your work, it becomes as evident as ever that there is a lot to learn from understanding patterns in the past. In that sense, how does the current digital and green transformation compare with past technological revolutions?

The first thing to understand is that green technologies are not a revolution; they are a set of different solutions to a very serious problem that must be confronted. But they are not synergistic in the sense that being an expert in solar does not make you an expert in wind, whereas expertise in microelectronics, computers, software, the internet and AI interact and mutually reinforce each other. Environmental sustainability is the direction in which all technologies must be developed and used (Lema and Perez, 2025) in order to make sure we can continue to live on the planet. That is a very serious and urgent challenge. Fortunately, in contrast with the mass production revolution, information and communications technologies are capable of contributing to a green future, given their intangible nature and their capacity to turn products into services (as they have already done with music, film and partly books and newspapers). But they themselves must also respond to the challenge.

Let me clarify further what I mean by green not being a revolution. The transition will involve massive changes in both production and lifestyles, in that sense, they are revolutionary. But I am talking about political economy. The sequence I identified is internal to capitalism and has to do with productivity and profitability. There are three features that make a set of technologies a revolution: the first is its capacity to increase productivity and reduce costs across the economy. The second is the strong synergy among the knowledge bases and the skills required to use them and to innovate with them, as happens with electronics, computers, software, the internet and so on which, unfortunately, does not apply to wind or solar energy or regenerative agriculture. The third is the provision of a new infrastructure, such as in the case of canals, national and transcontinental railways, transoceanic telegraph, highway networks and now the internet. They provide a massive expansion of markets and ease of access to them. So, with a revolution, business tends to invest in it naturally, exploring it in all directions, because most are likely to be profitable, even very profitable. And it is precisely because those synergies are capable of bringing massive advances across all technologies that social progress has occurred.

Green technologies are not synergistic, unless the state tilts the playing field in their favour, making it not only beneficial for society but also the most profitable option. The current low cost of solar energy, with the low cost of Chinese panels, is due to subsidies for innovation, followed by economies of scale. The process originated in the German policy that required the introduction of solar energy to the grid at a price that was sufficient to make it profitable; the Chinese government subsidies did the rest.

And that is precisely what golden ages are about; they give direction to the available technological potential by setting up a win-win game between business and society. Essentially, the state creates a context where doing what is good for the broader society is made to be the most profitable option for business. The information revolution itself is still spreading but without directionality. There is an almost 'juvenile' concentration in games or space travel or social media and now a not-so-juvenile focus on military technology. In the meantime, the planet is warming, and social problems are going unattended. Only proactive state action to redirect innovation and investment can change that. In the previous revolution there were two directions: suburbanization and the Cold War. The first improved the lives of millions of workers while leading to the current climate crisis; the second kept alive the threat of war while leading to the main innovations of the current information revolution. For this revolution we need to go green and global. And this time, it's more urgent than ever — it's about survival — and we are taking longer than ever!

You have argued that capitalism is only legitimate when wealth creation by the few improves the lives of the many. In the context of the ecological crisis, do you see a serious challenge to capitalism's legitimacy as tool for economic progress, or do you see scope for reforming capitalism?

Unfortunately, socio-political systems are not replaced because they are socially illegitimate, as has been shown by the long-lasting corrupt dictatorships across the world. Neither have we seen the self-declared 'socialist' systems improve the lives of the majorities. In some cases, it has been the opposite, such as Mao's 'cultural revolution' which brought famine and millions of deaths, or my country's Chavez-Maduro regime which managed to impoverish two-thirds of the country in 25 years, even after receiving a trillion dollars in oil revenue.

Capitalism is not a system for the majority, but even with its selfish goals, it has historically needed to bring social progress to increasing numbers, both for keeping the peace and to count on sufficient and dynamic demand as well as on dynamic supply of inputs and skills. It is not by chance that we have come from the 'satanic mills' of the early years to a time when many millions of blue-collar workers own a house full of electrical appliances with a car at the door and children attending university. We now need to redefine the aspirational good life to be environmentally sustainable and to

create the socio-institutional framework that will make it available to the many, globally.

Currently, I see a triple opportunity for the Global South that will also move the green transition and improve the lot of the impoverished masses in the advanced world. The very confrontation between China and the West is creating the possibilities. Engaging in trade wars for the same markets of the Global North, is a lose-lose game. Moving consumer goods production to the South, apart from helping develop the receiving countries, creates new dynamic demand for green capital goods, equipment, infrastructure, high-tech services and others from the North. Processing minerals *in situ* with renewable energy would reduce the carbon footprint of the whole world. Taking advantage of the fact that the internet connects every corner of every country to the whole world, it is now possible to overcome the need to migrate to overcrowded and violent city slums to search for urban work and escape the rural lack of opportunities. The possibility is there to develop every corner of every national territory, through 'localized globalization'. It would also stem the flow of migrants to the North, which, while creating tensions in the countries of arrival, causes a brain drain and, even more so, a courage drain in the countries of origin.

In the North, there are also new opportunities for multiple changes that can be environmentally sustainable, create jobs and be profitable for business. An example could be moving from sales and short-life disposal of electrical home appliances to a rental economy with maintenance of truly durable goods. Most of them are currently made abroad and bought on credit, rarely surviving much longer after full payment is made. The new, much greener, business model could involve design, rental, maintenance (with web-based information for 3-D printing of parts) and eventually recycling, in a global circular economy (World Economic Forum, 2024). It could foster competition in durability among suppliers and could create hundreds of thousands of jobs in production, maintenance, disassembly and recycling in the North and in the South. By guaranteeing many decades of use, such a rental system would give early low-cost access to the 'comfort' consumption ladder, while being profitable and avoiding the limits to original materials. The obvious aspiration to a refrigerator in every home on the planet would otherwise be impossible to attain. Many other such changes in policy and business are feasible once the smart, green, fair and global directions are agreed and promoted.

So, you are also proposing ambitious changes towards a green transition. What are the main points of agreement and disagreement you have with the degrowth movement? Is your theoretical framework compatible with degrowth?

Although I agree with the motivation of degrowth scholars and understand their desperation, I find their proposals insufficient and their political

economy absent. Avoiding the potential climate catastrophe is urgent and action towards it is dangerously slow. But, as Chris Freeman wrote in answer to the 'Limits to Growth' (Meadows et al., 1972) report, it is not the rhythm of growth but its nature and the distribution of its fruits that are really at stake. We need massive innovation in the green transition, in lifestyle changes and in the policy and institutional framework, nationally and internationally. As Mariana Mazzucato (2021) would argue, they don't seem to understand directionality in technical change, and they often use extrapolations from the mass production past to argue the impossibility of both growth and green. If we really want to overcome poverty, we must produce enough for all whilst changing direction and innovating intensively towards a massive green transition.

That can only be achieved by determined state action with clarity of purpose. That is precisely what golden ages have been about. And that requires building a broad consensus, including a fraction of the capitalist class and especially the great majorities. One of the saddest things about the green movement today is that we have not been able to attract popular support. Much to the contrary, asking people to give up their car, which can be the only asset they possess and is often the only way to get to work or to the market to sell their produce, is not going to attract the masses to the climate battle. Instead of beginning with electric cars (EVs), we could have started with energy conservation, insulating homes, moving to rental and maintenance of all appliances, thus reducing their cost and creating hundreds of thousands of jobs, promoting urban agriculture in food cooperatives to enable producing healthy vegetables at affordable prices and so on. Politically, we have been running up the down escalator while providing fodder to the far Right.

That is what I find missing from the degrowth movement. It is not clear how its proponents plan to convince the majority of the population. There is no realistic political analysis behind their proposal and no understanding of how the system works. The alternative they seem to propose would perhaps require a revolution and an autocratic government deciding which industries should disappear and which should be allowed and incentivized to grow. How that revolution would take place is not clear either. Who would support it? Who would lead it? The majorities today are electing right-wing populists and climate deniers in one country after another. The green transition is not at the top of the popular agenda and many of the changes are resisted vigorously: remember the *gilet jaunes* in France or the anger against the taxes on polluting vehicles in London, or the widespread resistance to windmills on land, without mentioning the questioning of man-made climate change by the likes of Donald Trump and others.

Climate change is advancing full speed ahead. But there is another serious problem where I also coincide with the degrowthers. Social inequality has reached unbearable levels while the wealth of the few has grown to astonishing heights. Although this has historically been typical of the initial decades

of propagation of each revolution, this time it has reached extremes. To make it worse, the political parties that used to represent shared prosperity within a welfare state have become helpless by tying their hands with the free-market-small-government ideology. The rich have found a myriad of ways of avoiding taxes and finance has become a global casino, playing one country off against another. The present situation is so unacceptable and the current leaders so uninspiring that only the idea of a complete demolition of the system seems to offer hope of redemption. Such helplessness naturally leads to populists at one end and utopian dreamers on the other. Even if theirs are only dreams, I understand the degrowthers well and, from an academic standpoint, they can be very impressive. But I don't think they can gather the forces that would be required to change the world their way. History is full of wonderful utopian ideals and even experiments. Indeed, Marx, who tried so hard to understand the system and to identify the forces within it that could lead to its transformation for greater justice, criticized the utopians who dreamt of changes that were not inherent to the functioning of society and the economy. Of course, we must be ambitious in our fight for a better world. But there are impossible impossibles and possible impossibles. We need to join forces to fight for — and achieve — the latter.

As I mentioned above, it is the nature of growth we must change, as well as its distribution. Unfortunately, every windmill and every solar panel needs an enormous amount of materials that must be mined, processed and transported (hopefully with green energy too). They also need investment and experience. And EVs replacing internal combustion engine (ICE) vehicles require massive amounts of materials for the cars and for the infrastructure for charging, as well as the recycling of the billions of existing vehicles. Should we have concentrated on innovation in fuel (as biofuel intended to do?) or on transforming the current ICE vehicles into hybrids? Or better still innovating in better and more convenient public transport? One would tend to say yes, but it is too late now.

The real challenge is to gear the forces of capitalism — the system we have and cannot change quickly enough to face the urgency with a revolution — towards social and environmental sustainability. Unfortunately, we are in a minority. We must re-connect with the workers and their interests, and we must find a way of saving the planet while making the lives of the majority better. Many working people have become vulnerable to right-wing populists who blame the immigrants and deny climate change. And even though it is true that the advanced world has overused its carbon budget, we cannot deprive the workers and the poor within these countries of their dreams of better lives. What we need to do is to redefine the good life so that it is smart and green (Perez and Murray-Leach, 2018). It is not by guilt or fear that we will induce changes in behaviour, but by desire and aspiration. And we must provide realistic programmes that can enthuse leaders and people to engage actively in the necessary transformation. Even

as academics, we cannot ignore the urgency, and we cannot stay away from those that are next to the fire.

Your ideas seem to be very coherent today, but was there a moment in your career when you doubted them? In what ways have you changed your mind throughout your life and intellectual journey?

When the 80-year-old philosopher Bertrand Russell was asked in an interview whether he had changed his beliefs during the course of his life, he replied 'I have changed my beliefs, but have never changed my hopes'. That is exactly what I can say today. In my late teens, I thought religion was the vehicle for social justice, and I even wanted to be a missionary. I was soon disappointed. I then became a revolutionary and was willing to give my life for the Marxist theories and their ideals of justice. After 10 years of struggle, I discovered the disappointing reality of the Soviet system claiming to represent the 'socialist' ideals, and I broke with such movements and the dreams I attached to them. But I didn't give up. I decided to study social change and how it was brought about, how and by whom. I began a new career in my early thirties, studying economics, history, sociology, psychology, political science, etc. in an interdisciplinary way. That gave me the tools that would lead to my understanding of technological revolutions, the roles of innovation, business, finance, social movements and especially the state.

My first attempt was to join the civil service in my country, Venezuela. It was a very powerful experience that made me understand the complexities of social, political and economic change when you are in the driver's seat. I became Director of Technological Development in the Ministry of Industry and worked with public and private industries, just when the threat of the Washington Consensus was about to hit us. All of our protected industries were in danger. They worked with imported technology and, except for the oil industry, very few engaged in innovation, because it was prohibited by the brand and technology contracts, among other reasons. My team and I achieved incredible things, but it was not easy. Yet, that experience strengthened my faith in the feasibility of change for the better. It also taught me the value of engaging directly in the process of change.

What lessons can you share with policy makers, especially those in small developing nations? How can they take advantage of those technological waves, rather than just suffer their consequences? In other words, how much agency is there under a 'Perezian' framework and how does it differ as technologies evolve and across different types of governments?

Well, the obvious thing to distinguish is the power you have in a front-rank country, where you can probably 'shape' the revolution for all and what you can do from a developing country perspective. In my article with Luc

Soete, we introduced the concept of 'windows of opportunity' in relation to the changing conditions of entry into new, evolving, and mature technologies (Perez and Soete, 1988). Years later, when I had already identified the pattern of propagation, I saw that what applied to individual technologies, applied also to whole revolutions (Perez, 2001). Now that I have studied the historical cases in detail, I see that there are indeed windows, in the sense of opening and closing opportunities, almost all the time. Obviously, some are better than others. The question is identifying them and judging whether the country in question meets the conditions to take advantage of one window or the other, as they appear. The leaps to the front rank, as China has made in the current fifth revolution, and the US and Germany did in the third, seem to only happen precisely when one revolution is reaching maturity and another is beginning to take shape. Leaps in development, such as that made by the 'Four Asian Tigers' (Korea, Taiwan, Singapore and Hong Kong) also take place in such junctures. But those moments occur only every half century or more.

As windows of opportunity open and close, each country can aspire to take advantage of them, depending on its endowment of resources, skills and accumulated innovation capacity. Identifying the window is the first step, making the best of it is the challenge. As I told you before, I think the current geopolitical tensions are opening an important triple opportunity by attracting investment for assembly and for minerals and their processing, as well as empowering localities. Learning to negotiate with both 'camps' with clear objectives is probably the most important goal in terms of policy skills. But that also means learning what the advanced countries (and companies) need from you, so you can propose a win-win game.

All countries can advance within the space of the possible. Obviously, the difference between Brazil and Lesotho is enormous, but so is the difference between what has to be done in each case to achieve significant progress. Not only technological, but also institutional and policy innovation are crucial. So, don't despair. Study what's going on in the world, identify the opportunities, be bold and innovative and 'if at first you don't succeed, try, try again', as the first king of Scotland is supposed to have said.

And what is your take on the state of academic research now? What would you say to researchers?

I sometimes read the 'policy recommendations' at the end of academic papers and I want to cry. The ivory tower today is more isolated than ever. Together with the free market economy, most of academia became a 'data-based' internal discussion club, with very little contact with reality. In fact, data is seen as reality, when in fact it often conceals more than it reveals. Interviews with the actors in business or government are no longer fashionable; neither are forward-looking studies. Interdisciplinarity has not become the norm, however obviously needed it is for acting in the real world. And

the young are tied to the 'publish or perish' world dominated by the journals, most of which are not committed to improving the world but to adding tiny bits to the 'map of knowledge'. It is very painful, given that we are at a crucial moment of transformation and academia, with very few exceptions, is not joining in the struggle. In a context of massive technical change, data extrapolations from the past are not valid as projections towards the future. Progressive forces must be out in the world, acquiring knowledge and sharing it. Social impact should be valued much more highly than it is, and the same can be said for good teaching. There are times when research can isolate itself without much harm, but today it is almost criminal. We must understand the world in order to change it for the better, and to see it as our responsibility, as privileged members of the elite in an unfair world.

Finally, many young people today feel overwhelmed by economic and environmental crises. What advice would you give them about shaping the future rather than feeling powerless?

I would begin by saying: 'You can change the world! No less'. I would immediately add: 'But you need to understand how it works'. The young are overwhelmed by the injustice and the dangers they see. The power of finance and monopolies; the unbearable poverty; the selfishness of the winner-take-all society and the impotence of those who fight for justice are all overwhelming and lead to anger, desperation and dreams of radical change. I lived that experience. But nobody told me that it was worth fighting to get the best out of the system because it is possible. It has taken me decades to understand that significant progress is not impossible, although it is obviously not easy either. And it will not be perfect and ideal progress, but it can be a real advance that benefits millions of people when achieved. So, my basic message is one of institutional innovation. Conditions are there for setting up a positive sum game between business and society, between the advanced and developing worlds and between humanity and the planet. It will not be Utopia, but it is feasible, and it is urgent. It is the main challenge for this generation.

REFERENCES

Bielchowsky, R. (ed.) (2016) *ECLAC Thinking: Selected Texts (1948–1998)*. Santiago de Chile: ECLAC.

Dosi, G. (1982) 'Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change', *Research Policy* 11(3): 147–62.

Dosi, G. (2023) *The Foundations of Complex Evolving Economies: Part One: Innovation, Organization, and Industrial Dynamics*. Oxford: Oxford University Press.

Dosi, G. et al. (eds) (1988) *Technical Change and Economic Theory*. London: Pinter Publishers.

Freeman, C. (1974) *The Economics of Industrial Innovation*. Harmondsworth: Penguin Books.

Freeman, C. (1992) *The Economics of Hope*. London and New York: Pinter Publishers.
Freeman, C. (2019) 'History Co-evolution and Economic growth', *Industrial and Corporate Change* 28(1): 1–44.
Freeman, C. and F. Louçã (2001) *As Time Goes By: From the Industrial Revolution to the Information Revolution*. Oxford: Oxford University Press.
Freeman, C. and C. Perez (1988) 'Structural Crises of Adjustment: Business Cycles and Investment Behavior', in Dosi G. et al. (eds) *Technical Change and Economic Theory*, pp. 38–66. London: Pinter Publishers.
Furtado, C. (1964) *Development and Underdevelopment*. Oakland, CA: University of California Press.
Johnson, S. and D. Acemoglu (2023) *Power and Progress: Our Thousand-year Struggle Over Technology and Prosperity*. London: Basic Books.
Kondratieff, N.D. (1925/1935) 'The Long Waves in Economic Life', *Review of Economic Statistics* 17(6): 105–15. Translated from the Russian by W.F. Stolper.
Lema, R. and C. Perez (2025) 'The Green Transformation as a New Direction for Techno-economic Development', in J. Mathews and A. Oqubay (eds) *The Oxford Handbook on the Greening of Economic Development*, pp. 54–78. Oxford: Oxford University Press.
Mazzucato, M. (2021) *Mission Economy: A Moonshot Guide to Changing Capitalism*. London: Penguin Books.
Meadows, M. et al. (1972) '*Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*'. Winterthur: Club of Rome.
Nelson, R. and S.G. Winter (1982) *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.
Nelson, R. et al. (eds) (2018) *Modern Evolutionary Economics: An Overview*. Cambridge: Cambridge University Press.
Perez, C. (1983) 'Structural Change and Assimilation of New Technologies in the Economic and Social System', *Futures* 15(5): 357–75.
Perez, C. (1985) 'Microelectronics, Long Waves and World Structural Change: New Perspectives for Developing Countries', *World Development* 13(3): 441–63.
Perez, C. (1986/2009) 'Las nuevas tecnologías: Una visión de conjunto' ['The New Technologies: An Integrated View']. Technology Governance and Economic Dynamics Working Paper No. 19. Tallinn: Tallinn University of Technology; Oslo: The Other Canon Foundation. https://carlotaperez.org/wp-content/downloads/publications/theoretical-framework/paper19.pdf
Perez, C. (2001) 'Technological Change and Opportunities for Development as a Moving Target', *Cepal Review* 75: 109–30.
Perez, C. (2002) *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages*. Cheltenham: Edward Elgar.
Perez, C. (2016) 'Capitalism, Technology and a Green Global Golden Age: The Role of History in Helping to Shape the Future', in M. Mazzucato and M. Jacobs (eds) *Rethinking Capitalism*, pp. 191–217. Oxford: Wiley Blackwell.
Perez, C. (2019) 'Transitioning to Smart Green Growth: Lessons from History', in R. Fouquet (ed.) *Handbook on Green Growth*, pp. 447–63. Cheltenham: Edward Elgar.
Perez, C. and T. Murray-Leach (2018) 'Smart & Green: A New "European Way of Life" as the Path for Growth, Jobs and Well-being', in the Austrian Council for Research and Technology Development (ed.) *Re-thinking Europe: Positions on Shaping an Idea*, pp. 208–23. Vienna: Holzhausen.
Perez, C. and L. Soete (1988) 'Catching Up in Technology: Entry Barriers and Windows of Opportunity', in Dosi G. et al. (eds) *Technical Change and Economic Theory*, pp. 458–79. London: Pinter Publishers.
Polanyi, K. (1944/2002) *The Great Transformation: The Political and Economic Origins of Our Time*. Boston, MA: Beacon Press.

Prebisch, R. (1950) *The Economic Development of Latin America and its Principal Problems*. Lake Success, NY: United Nations Department of Economic Affairs.
Schumpeter, J.A. (1911/1980) *Theory of Economic Development*. New York: Routledge.
Schumpeter, J.A. (1939/1982) *Business Cycles*. Philadelphia, PA: Porcupine Press.
Sunkel, O. (1973) *Past, Present, and Future of the Process of Latin-American Underdevelopment*. Budapest: Center for Afro-Asian Research of the Hungarian Academy of Sciences.
World Economic Forum (2014) 'Towards the Circular Economy: Accelerating the Scale-up across Global Supply Chains'. Geneva: World Economic Forum.

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