



Geoeconomic Uses of Global Warming: The “Green” Technological Revolution and the Role of the Semi-Periphery

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Abstract

While some semi-peripheral countries have seen renewable energies as an opportunity to build their industrial and technological capacities, core countries and global governance organizations have been promoting “green growth.” Since the 2008 global financial crisis, global warming has been used as a catalyst for big business. As the global economy may be entering the first stage of a “green industrial revolution,” neo-Schumpeterian economists have regained visibility. We intend to show how, as a consequence of the lack of a world-systemic perspective, crucial inconsistencies arise in neo-Schumpeterian contributions that weaken their conceptualization of the role of non-core economies in technological change. We examine the case of the tortuous trajectory of wind energy in Argentina to show the specific organizational, institutional, and macroeconomic constraints faced by a semi-peripheral economy as it attempts to develop its own technological and industrial capacities. The neo-Schumpeterian view of the “green industrial revolution” must be understood as valid only for the core-economy subsystem, which seems to require as well polarization of the world-system through what we call “semi-peripheral neoliberalism,” a peripheralizing force upon the semi-periphery necessary in order to rejuvenate core economies.

Keywords: Global warming; Green industrial revolution; Semi-periphery; neo-Schumpeterian economics; semi-peripheral neoliberalism



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Technology policy-making is one of the main challenges faced by semi-peripheral countries striving to achieve industrialization and economic development.¹ The evidence that transitions from semi-periphery to core have been “very rare” (Chase-Dunn 1998:121) can be explained, in part, by high access barriers—both formal and informal—to technologies that drive leading industries. “In the end, economic development is about acquiring and mastering advanced technologies,” Chang (2008: 81) summarizes.

From an endogenous perspective, semi-peripheral economies seek access to productivity-enhancing technologies that help reduce overreliance on primary commodities by enabling export of manufacture products, mainly to other non-core countries.² Semi-peripheral economies have to deal with deeply rooted socio-economic weaknesses, however. These include: institutional instability that hinders the efficacy of public policies; scant private investment in R&D; dynamic industrial sectors dominated by transnational firms whose maximizing strategies are largely unconnected from local economic ecosystems; the growing and harmful influence of speculative finance since the late 1970s; and geopolitical disadvantage in negotiations on the “rules of the game” for technology transfer, catching-up, and learning processes (Correa 2005; Deere 2009: Ch. 5; Nguyen 2010: 244-255; Michalopoulos 2014: Ch. 7). From the perspective of core countries, semi-peripheral countries’ aspiration to upgrade their technological capabilities as a crucial part of the pathway to endogenous develop economically strategic areas is perceived as having a potentially destabilizing effect on the geopolitical and geoeconomic order. At the same time, however, industrialization and modernization of public infrastructure in semi-peripheral countries are coveted by core countries as means to gain scale and scope in global technology markets.³ This contradiction, as green technologies become a leading sector, is turning out to be critical.

Since the beginning of the millennium, core economies and global governance organizations have had an intense interest in transitioning the world energy infrastructure—one of the most massive infrastructures already in existence—to renewable energy sources, a situation viewed by semi-peripheral countries like Argentina, Brazil, India, or South Africa as an opportunity to develop endogenous technological capabilities from the initial stage of a new leading sector. After the 2008 financial crisis, however, global environmental policy collided with the interests of those countries. Closely aligned with the “ecological modernization” and the Environmental Kuznets

¹ We assume that world-economy structure has been stable over a substantial period of time and that the semi-periphery is not a transitional stage from the periphery on the road to the core, but a permanent one (Babones 2005: 53). On the concept of semi-periphery, see Arrighi y Drangel (1986); Martin (1990); Chase-Dunn (1998: 210-214); Clark (2010).

² On technology policies in non-core economies, see, e.g., Di Maio (2009); Fu and Soete (2010).

³ For an estimate of imported public expenditures on procurement of machinery and equipment in developing countries, see Yülek (2012: 12-13).

Curve schools of thought—the mainstream approach to global environmental crisis which posits that economy and environment can decouple, presumes the profit-and-growth imperatives, and is “less critical of the unequal power relations that exist in the current world economic system” (Thombs 2017: 542)—,⁴ it has come to conceive the environmental threat as an opportunity to boost a massive transference of green technology to non-core regions. The underlying “logic” is that this path would not only avoid environmental catastrophe but also act as a big business catalyst that brings the promise that capitalism can be reshaped. However, this great leap forward would need not only scale and scope but also speed. As we will see, catastrophe, urgency, and speed are all key components of our argument.⁵ Thus, while endogenous semi-periphery development should follow its own pace, core economies attempt to impose the global financial temporality.

If we accept the hypothesis that the global economy is going to enter the first stage of a “green industrial revolution” and that, therefore, the growing relevance in the global economic arena of institutional, organizational, and technological machinery of innovation should become a highlighted topic, then neo-Schumpeterian economists do, in fact, have a lot to say. What is the position of the most visible representatives of that perspective? First, their position is presented as an alternative to neoliberal failures regarding rising inequality and the decline of investments and demand. Insofar as they have a better understanding of sectoral patterns of technological change, neo-Schumpeterian policies are based not merely on market failures but also on the recognition of dynamic interrelatedness of technologies, industrial structures, and capabilities formation (Pavitt 1984), heeding the relevance of the State to coordinating and commanding the pace and orientation of technological trajectories (Dosi 1982; Freeman and Soete 1997; Mazzucato 2013). As a progressive economic voice, the neo-Schumpeterian perspective is appealing to Keynesians, some post-Keynesians, and neo-developmentalists (Cassiolato and Lastres 2008; Cimoli et al. 2009; Cimoli and Porcile 2016). Second, neo-Schumpeterians urge core-state governments and global governance organizations to bolster pro-entrepreneurship policies in order to further the green industrial revolution, conceptualized as a new long wave of innovations driven by a new cluster of leading technologies.⁶

While this strategy seems to advocate an alternative path without questioning the urgency imposed by the global financial temporality, the lack of a world systemic perspective appears as a blind spot in neo-Schumpeterian conceptualizations of the role non-core economies play in

⁴ See, also, Ewing’s (2017) characterization of ecological modernization theory as a version of “green growth.”

⁵ The novelty of the present is that the acceleration of innovation that produce “recurrent waves of geographical restructuring, global expansion, and the growing spatial compass of the hegemon that lead and coordinate great waves of economic growth” (Moore 2011: 110) seems to be reaching a structural limit (Moore 2016: 114; Harvey 2014: 238-245).

⁶ See, e.g., Mazzucato (2013; 2016).

technological change. By default, their policy recommendations for peripheries are closer to the mainstream perspective of market failures than to the systemic failures they diagnose to core-economy subsystem. We will begin, then, by addressing what is, in our view, an internal inconsistency in the neo-Schumpeterian approach when it assigns a subsidiary role to non-core economies in processes of institutional, organizational, and cultural transformations as crucial components to make the “green industrial revolution” viable.

In view of these constraints, we believe that the relevance of neo-Schumpeterian perspective as well as its influence, since at least the 1990s, on policy makers and scholars from semi-peripheral countries (Cimoli et al. 2005; Cassiolato and Lastres 2008) justify our intent to consider the following questions: What place does the neo-Schumpeterian perspective assign peripheries in the new cycle of economic dynamism that might trigger green technologies? What would the impact of that perspective be on semi-peripheral economies that have laboriously developed endogenous capabilities in order to advance technological change but must, nonetheless, accept that global warming and the pace of finance—the two faces of urgency, presented as if they were coupled—inexorably impose foreign technology acquisition? How, in these terms, would semi-peripheral economies benefit from a green industrial revolution?

As a specific example, we will focus on the tortuous trajectory of wind energy in Argentina—a semi-peripheral country that has, in Patagonia, one of best sources of wind power anywhere and the only country in South America with three firms having their own wind technology. The Argentine case shows the specific organizational, institutional, and macroeconomic constraints faced by a semi-peripheral economy as it strives to take part in a new cycle of technological change. We will also show that neither the neo-Schumpeterian mainstream nor global governance organizations contemplate these constraints in their approaches for “mobilizing the transition to a green economy” (GGKP 2016a: 7).

Finally, as a primary component in the drive to “appropriating nature’s free gift”—wind, solar radiation, Earth’s heat, ocean waves—would renewable energy suffice “to launch a new phase of accumulation, or are we witnessing the exhaustion of a Cheap Nature strategy”? (Moore 2016: 110). In their criticism of the neoliberal economic policies and their global consequences, and in their support of the “entrepreneurial state” as antidote (Mazzucato 2013), neo-Schumpeterian economists enthusiastically advocate the “green industrial revolution” as a new phase of accumulation. We will also discuss how the neo-Schumpeterian approach, promoting that core economies should massively gain green-technology markets—that is, non-core markets—as a necessary condition imposed by environmental and financial temporality, seems to coincide with the “green capitalist” perspective in considering non-core states as an economic buffer that allows core states to recover businesses’ dynamism.

We argue that, for these reasons, neo-Schumpeterians fail to capture the systemic component emphasized by critical theoretical approaches, like ecologically unequal exchange or global climate justice perspectives (Jorgenson 2016a; b; Cipler et al. 2015: 11-12; Cipler and Roberts 2017), which advocate for, among other things, the necessity to decommodify climate technology (Bond 2012: xiv). Additionally, the neo-Schumpeterian approach does not seem to find it necessary to consider the restructuring of power relations, or the empirical evidence showing that “new forms of prosperity that challenge the axiom of economic growth are critical to overcoming the perpetual environmental degradation associated with global capitalism” (Thombs 2017: 558). It also fails to take into account increasing inequality.⁷ We will show, then, how the neo-Schumpeterian perspective ultimately contradicts its own premises regarding the institutional, organizational, and cultural transformations required by technological revolutions (Perez 2002).

Catastrophe as a Business

In 2002, the year after the US failed to ratify the Kyoto Protocol, the European Union initiated a “policy dialogue with developing countries” through the Energy Initiative for Poverty Eradication and Sustainable Development program. Five years later it was clear that the developing world presented “one of the best windows of opportunity for the promotion and use of renewable energies.” Opportunity for whom? “Financial aid is only needed to kick-start the process of creating the right framework and the momentum for renewable energies” (Piebalgs 2007: 21, 24). At the same time, the global carbon market—mainly through the Clean Development Mechanism (CDM)—sought not only to allow wealthy states to reduce emissions voluntarily at lower cost, but also to enable “developed countries to support renewable energy sources in the developing world to provide global gains” (Tang 2007: 43).

Since the 2008 global financial crisis, the global warming threat has been used increasingly as a big business catalyst. “All manner of scams has emerged” instead of polluters paying their “climate debt” (Bond 2012: 111, 114-115). At the COP 15 in Copenhagen in 2009, the Green Climate Fund was created to channel US\$ 100 billion per annum by 2020 from developed to developing countries for mitigation and adaptation measures. Since rich nations are responsible for most greenhouse gases while the burdens of a warming planet fall mostly on poor countries—the reasoning went—, “the fund takes from the rich and gives to the poor—like Robin Hood, but with the legal and political backing of the U.N.” (Gunther 2016). However, there not only “remains an ever-widening chasm between funds that are needed and what has been promised and delivered”

⁷ See, also, Jorgenson and Clark (2012); York and Mcgee (2017).

(Ciplet et al. 2015: 129), there is limited evidence that the promise is taking place (Ciplet and Roberts 2017: 388).⁸

At this point, it seems important to keep in mind that when we talk about finance and technology, the history of capitalism shows that terms like “aid,” “assistance,” “collaboration,” or “support” have only meant one thing: business opportunity. And a potential catastrophe is a perfect opportunity. Let us take a sample of the “green capitalist” argument to see how it articulates global warming and a green-technology panacea: “The world is heading in a difficult and dangerous direction” and “the great advances in development [...] of the last few decades would likely be reversed”; notwithstanding, “2°C path is still achievable but the window is fast closing.” The “logic” is: catastrophe, urgency, and opportunity (for business). Opportunity, here, is conceptualized as an “energy-industrial revolution,” where “revolution” means “strong actions and major investments in all regions of the world and in all economic sectors, leading to a transformation throughout the economy to low-carbon growth” (Rydge and Bassi 2014: 9, 10).

Rydge and Bassi (2014: 10) appeal to the Christopher Freeman and Carlota Perez model—the most detailed accepted neo-Schumpeterian approach to “technological revolutions,” which embeds financial dynamics into a long-term view of technological change cycles (Perez 2002; see below)—to explain: “This process of ‘creative destruction’ generates a dynamic and extended period of innovation, opportunity, employment and economic growth.” Opportunity, employment, and economic growth for whom? And what kind of economic, institutional, and cultural impact can we expect from an energy-industrial revolution on core, semi-peripheral, and peripheral economies? After explaining that emissions in a rapidly growing developing world “are likely to rise strongly over the period to 2030,” Rydge and Bassi (2014: 7, 8) conclude that:

“Developing countries will require global cooperation to achieve action on this scale; they are unlikely to be able or willing to achieve these ambitious reductions without substantial corresponding action in developed countries and without assistance to shift to a low-carbon growth path, including the transfer of technology and financial support” (Rydge and Bassi 2014: 16).

We have selected Rydge and Bassi (2014) as an example of an argumentative strategy that attempts to demonstrate that a green industrial revolution is necessary as a means to “assist” developing countries and as a business opportunity for core economies attempting to overcome the 2008 financial crisis. However, we find these kinds of arguments are either one-dimensional—in the sense that they assume technological innovation can solve anything—or, when they consider other variables like the “rules of the game,” transaction costs, or institutional change, they seem to refer to an homogeneous world of core countries.

⁸ On CDM and the Green Climate Fund framed in the demand from developing countries in favor of more donor-friendly institutions to manage mitigation and adaptation funds, see Ciplet et al. (2015: 122-124).

A similar strategy was deployed in the mid-1950s with the launching of the “Atoms for Peace” program, when the US government, with the consent of the main players in the US military-industrial complex, began building a global market for “peaceful uses of nuclear energy.” Since then, nuclear energy began to be represented as the new energy panacea. Promoting access to research reactors among non-core countries was the first step towards a then promising market of nuclear power plants (Medhurst 1997). Simultaneously, the new combination of planet-destruction capacities developed by nuclear powers and the potential imminence of nuclear war made plausible a new political rhetoric that Chernus (2002: 120-127) calls “apocalypse management.” Though it outraged some semi-peripheral countries, it is not surprising that the nuclear market came with restrictive controls and increasingly discriminatory regulations that favored an oligopolistic structure of the nuclear fuel cycle market (Hartigan et al. 2015: 15).

At present, the evidence of a possible environmental catastrophe is being assimilated into a renewed version of apocalypse management. It proposes “harmonizing the destructive and constructive sides” (Chernus 2002: 126) of global warming imageries. This discursive maneuver provides the economic rationale for “mobilizing the transition to a green economy” (GGKP 2016a: 7) that would, supposedly, lead to a new cycle of economic prosperity suggested in the term “green growth.”⁹ While this argumentative strategy depicts green technologies as a new energy panacea, the urgency associated with this apocalypse management framework is, as we shall attempt to show, exogenous and disruptive to the pace of economic development required by non-core states.

More precisely, while some semi-peripheral countries conceive climate change as an opportunity to nurture endogenous development of green technologies—assuming that “acquisition of technology abroad is not substitute for local efforts” (Cassiolato and Lastres 2008: 7), an elementary neo-Schumpeterian postulate—, global warming’s sense of urgency seems tailored to meet the needs of a new cycle of global technological change led by core economies and functional to their recovery from the 2008 financial collapse. Global governance organizations, meanwhile, bolster this process by spreading a naive ideology of collaborative internationalism that, exploiting the unequal competencies on technology management between core and non-core states, presents the “green growth” challenge as a one-dimensional problem of financing.¹⁰ It either overlooks or conceals a restrictive global framework conceived to hinder technology transfer, catching-up, and learning processes (Correa 2005; Deere 2009: Ch. 5; Nguyen 2010: 244-255; Michalopoulos 2014: Ch. 7). Moreover, this ideology also ignores the

⁹ In 2012, the concept of “green growth” has begun to be spread at the United Nations Conference on Sustainable Development or Rio + 20.

¹⁰ See, e.g., GGKP (2016a; b); FMI (2016).

temporalities required by non-core countries' processes of institutional, organizational, and cultural transformations.

The “Green Industrial Revolution” from a Neo-Schumpeterian Perspective

In the recent book *Rethinking Capitalism*, edited by Jacobs and Mazzucato (2016), a group of renowned economists contest the “orthodox prescription of ‘fiscal austerity’”—that is, “cutting public spending in an attempt to reduce public deficits and debt”—, a recipe that “has not restored Western economies to health.” They point out that “decline in investment is also related to the market ‘financialisation’ of the corporate sector” and that, since the 1980s, labor-productivity growth has decoupled from wage growth; since 1999, in thirty-six developed economies, labor productivity has almost tripled real wages. “The result of these trends has been a rise in inequality across the developed world,” and this socioeconomic scenario is coupled with an increase in greenhouse gas emissions, “which have put the world at severe risk of catastrophic climate change” (Jacobs and Mazzucato 2016: 1, 5, 8, 9, 10). In this sense, this discourse of economic urgency associated with a highly visible progressive sector of the English-speaking academy asserts, among other things, that massive public investments in “green technologies” are essential to recovering the dynamism of core economies.

Through a neo-Schumpeterian evolutionist perspective, the rhetorical strategy of these economists is to address their governments—mainly the US, Britain, and the European Union—to explain that the greatest prize of massive investment in green technology is not only the neutralization of climate change but also the beginning of a new period of global prosperity similar to the three golden decades that followed Bretton Woods and the new Keynesian order: “We are now in a crucial moment in history similar to the 1930s, requiring thinking and measures as bold as those of Keynes, Roosevelt and Beveridge and as ambitious as the Bretton Woods agreement,” argues Perez (2016: 199) in the last chapter of *Rethinking Capitalism*. But what about peripheries? Although this economist recognizes that “the international community needs to implement new and effective ways of giving support to development, recognizing the new possibilities opened by ICT and globalization,” her most tangible proposal is a vague allusion to something like a Marshall Plan for “lagging countries” (Perez 2016: 213).

If we set aside the hollow rhetoric of altruistic international collaboration, we are left with a new utopia for rich countries where non-core economies would act as a stabilizing factor for transnational corporations' expectations on massive technology export and foreign direct investment. In the process of diverting fossil fuels investment flows towards renewable energies, peripheries are necessary components to scale the demand for turnkey green technologies: “Facilitating and funding investment in the lagging countries of the developing world would create markets for green engineering, infrastructural and equipment technologies from advanced world”

(Perez 2016: 204). Then, the planet and global capitalism would once again be sustainable—environmentally and economically sustainable—though it is by no means clear how non-core countries would benefit from this new global cycle of technological change.

This agenda poses an insurmountable contradiction between, on the one hand, the pace of non-core countries' processes of institutional, organizational, and cultural transformations needed to move towards a green economy and, on the other, the speed demanded by the “advanced world.” The Freeman-Perez neo-Schumpeterian model does have the virtue of evidencing this contradiction insofar as it mentions institutional, organizational, and cultural transformations as well as financial dynamics as constitutive parts in global cycles of technological change (Perez 2002; 2007).¹¹

From the perspective of this model, upon the emergence of a “techno-economic paradigm” and its associated leading sectors, peripheral and semi-peripheral countries are not considered until the final phase of “maturity,” when core economies are forced to relocate their declining industries while, simultaneously, a new revolutionary cluster of technologies begins to take the first steps that ultimately might trigger a new technological revolution in core economies. But in the phase of maturity, the complementarities and synergies that make leading technologies an engine of growth tend to decline (Perez 2002: 154-155).

The combination of market saturation, technological exhaustion, and political unrest in core societies leads firms in mature industries to try to diversify investments into other industries and geographic areas. One of the strategies deployed to extend the life cycles of mature industries and to sustain the pace of capital accumulation has been the relocation of production in peripheral or semi-peripheral countries—where a variable combination of lower business costs, greater profitability, and mature technologies can delay technological obsolescence (Nurse 2011: 288; Perez 2002: 83). It is not until this point that semi-peripheral countries can find a window of opportunity to access technologies entering their maturity phase, “as it happened in the migration of mature industries to the Third World in the late 1960s and 1970s” (Perez 2004: 221).

Therefore, if we consider that green technologies either are a primary component of the ongoing techno-economic paradigm or are driving the emergence of a new techno-economic paradigm, it seems important to clarify the role non-core countries are supposed to play. Semi-peripheral countries like Argentina, Brazil, India, or South Africa have, for at least two decades, been promoting public policies to develop endogenous capabilities and to provide domestic firms with incentives to enter the renewable sector (Recalde et al. 2015; Aquila et al 2017; Jolly et al.

¹¹ Since the late eighteenth century, according to the Perez-Freeman model, technological revolutions have been taking place about once every half a century through “techno-economic paradigm shifts” characterized by the following sequence: irruption of technological novelty; frenzy and financial bubble; collapse; golden age; and maturity and political unrest. On the relevance of the Freeman-Perez model, see Drechsler et al. (2011).

2017; Baker and Sovacool 2017). However, from the neo-Schumpeterian view encoded in the Freeman-Perez model, semi-peripheral economies could only play the role of passive receptors of foreign green technologies and they would only be able to enter this markets a few decades later, when this industry has reached the stage of maturity.

But if non-core countries are responsible for 40% of the planet's greenhouse gases emissions—not including China (23%)—and if it is necessary to mobilize their transition to a green economy in order to avoid reaching the threshold of 2 °C, then the Freeman-Perez model (Perez 2002) poses a flagrant problem in terms of timescales. As we have already seen in the Rydge and Bassi (2014) proposal, the novelty motivated by global warming urgency seems to imply that the massive sale of green technologies to non-core countries should accompany the installation of the new techno-economic paradigm from the very beginning or at least before it reaches the stage of maturity.

Perez argues that a new techno-economic paradigm triggers a complex process of construction of a new “common sense” in leading economies that unleashes “a profound transformation in ‘the way of doing things’ across the whole economy and beyond.” It means “radical changes in the patterns of production, organization, management, communication, transportation and consumption, leading ultimately to a different ‘way of life’” (Perez 2002: 7, 15, 153). Nevertheless, as the Freeman-Perez model acknowledges when it assumes non-core countries enter into the picture only during the maturity stage, these complex institutional, organizational, and cultural transformations, which include processes of creative destruction and radical innovations, do not occur in non-core economies. Hence, the conditions of possibility for the deployment of a new techno-economic paradigm—based on the subsequent accumulative incremental innovation activities—only reach core economies.

For this reason, as core economies enter the new techno-economic paradigm, non-core economies are simultaneously integrated, in a subordinated way, on one side, into the final stage of the former techno-economic paradigm by incorporating mature technologies by public R&D, technology transfer, and/or foreign direct investment initiatives (Amsden 2001) and, on the other, into the initial stage of the new techno-economic paradigm by becoming buyer-consumers of leading global products and services. In non-core societies, trendy basic research agendas as well as underfinanced (or failed) attempts at developing cutting-edge technology can be seen as means of building consumer cultures around leading global products and services.¹²

In other words, if the green-technology revolution hopes to incorporate non-core economies before the maturity stage in order to generate market scale and scope and to speed up global

¹² An in-depth discussion of this issue should consider the emerging topic of undone science and technology and the cultural production of ignorance in peripheries. See, e.g., Proctor and Schiebinger (2008).

reconversion towards renewable energies, then the assimilation of green technologies in non-core countries should be accompanied by systemic transformations in modes of organization, management, communication, transportation, and consumption. But, as we have seen, those goals are by no means in keeping with how capitalism has worked since the industrial revolution. No previous technological revolution has entailed an early multidimensional mobilization—like a Marshall Plan for “lagging countries” (Perez 2016: 213)—that might embed (foreign) frontier technologies in the socio-economic dynamics of non-core countries.

By default, this scenario should be interpreted as a new set of impositions of even tighter conditionalities in order to open up new channels for financial flows and green technologies produced by core economies on the assumption that such maneuvers are necessary in order to mobilize the transition to a green economy. That interpretation is supported by the growing supranational power of large corporations and a global financial economy that savagely seeks short term profit decoupled from productive economies (Kregel 2011: 217-219)—a predatory approach that has been ravaging peripheries.¹³ In that context, it seems unlikely that “green growth” will be able to bring about a balanced shift in development patterns in non-core countries. In fact, just the opposite is happening.

Wind Energy in a Semi-Peripheral Context

This blind spot in the Perez-Freeman model regarding institutional, organizational, and cultural transformations according to non-core economies’ specific temporalities can be considered as a particular expression of the lack of a world systemic perspective in neo-Schumpeterian contributions and the subsidiary role played by non-core economies in their theorizations. In this sense, the Freeman-Perez model reflects the internal temporality—stages or economic cycles, structured into sub-stages—of core-economy subsystem, where the coevolution of technological as well as institutional, organizational, and cultural change does actually take place. In contrast, within non-core economies, there is no such coevolution but rather belated adaptation to exogenous technological change.

Furthermore, if we apply the Freeman-Perez model to green technologies, we must consider that their development and assimilation would be underway during a stage of global capitalism (the near future) when the amount of investments needed to maintain the world economy’s compounded growth rate casts doubts on its sustainability (Maddison 2007: Ch. 6; Harvey 2014: Ch. 15). That is the framework for the assertion “that by 2020, about \$5.7 trillion will need to be invested each year into green infrastructure in developing countries—a significant portion in Latin America” (Gallagher 2016: 188).

¹³ See, e.g., Global Financial Integrity (2017).

An analysis of public policies and institutional initiatives to promote wind energy in Argentina—a semi-peripheral country that has a high quality of winds in Patagonia—provides some clues about how the ongoing green industrial revolution works in a concrete case. In summarizing this decades-long trajectory, we shall see how technological change in this country has had to deal with organizational, institutional, and macroeconomic constraints that are not contemplated by the idealized neo-Schumpeterian conception of a green industrial revolution or by the profit-oriented “green growth” promoted by global governance organizations.

Argentina’s first incursion into wind energy dates back to the late 1970s, when the National Atomic Energy Commission (CNEA for the acronym in Spanish) began measuring winds at selected locations in Patagonia (CNEA 1980: 33; 1982: 32). The automatic wind measurement equipment installed was manufactured and operated by the state-own company INVAP, a spin-off of the CNEA that now manufactures geostationary satellites and exports nuclear research reactors (CNEA 1982: 32; Brendstrup 2009). Pursuant to a bloody dictatorship in power from 1976 to 1983 whose orthodox economic policy devastated domestic industry, the democratically elected government of Raúl Alfonsín (1983-1989) launched, in the context of an incipient attempt to restore productive capacities, the Rational Use of Energy Program in 1985.¹⁴ The program encouraged R&D in renewable energies. That year, the Regional Center of Wind Energy was created. Although during its first two years the Alfonsín administration tried to run a developmentalist economic policy, the huge burden of the foreign debt inherited from the dictatorship, along with the structural adjustment policies imposed by IMF and the World Bank, pushed the country into a hyperinflationary spiral that ended up paralyzing energy policies (Ortiz and Schorr 2006; Recalde 2015: 98).

The novelty introduced by the Carlos Menem administration (1989 to 1999) was an ideology that could be called “semi-peripheral neoliberalism.” Its distinctive traits included the geoeconomic and geopolitical subordination to core neoliberalism through deregulating financial flows and economically strategic sectors,¹⁵ and promoting privatization and massive direct foreign investment; its consequences included deindustrialization and the dismantlement of State capacities. Outrageous privileges conceded to concentrated corporations, astronomical foreign debt coupled with equally high capital flight, and the mass influx of direct foreign investment led the Argentine economy to reach an unprecedented level of foreignization. In March 1991, the

¹⁴ Decree 2247, November 1985. On this program, see Calleja (2005).

¹⁵ In the 1990s, the neoliberal approach gave rise to the issue of “governmental assistance to economically strategic industries” as “a major bone of contention in the international political arena” (Michalski 1991: 7, 8). Due to its technology and R&D contents, its technical spillovers, and its dominance in international trade, a hegemonic consensus assumed that core economies’ governments should intervene and support economically strategic industries while promoting their deregulation in peripheries. See, e.g., Block (2008).

“Convertibility Act” was enacted.¹⁶ It established a fixed exchange rate between the US dollar and the Argentine peso (Basualdo 2006: Ch. 6; Azpiazu and Schorr 2010: 268-289)—a monetary policy that, as we will see, would have very negative consequences for the local energy sector.

In the 1990s, most wind projects formed part of collaboration agreements with members of the European Community. Although during that initial period the first wind farms using foreign technology were installed and the first specific regulations to encourage the domestic development of geothermal, solar, and wind energy enacted, that was not enough to ensure sustainability. It was not until 1998 that the first regime for the promotion of wind and solar energy through a feed-in tariff system was established.¹⁷

During the brief presidential term of Fernando De la Rúa (1999-2001), a recession curtailed the positive impact of the incentive policies for the wind sector. The economic collapse of 2001 that drove Argentina to default on its debt proved a very negative framework for the renewable energy sector. After De la Rúa’s resignation, the fixed exchange rate policy that had been established eleven years earlier by the “Convertibility Act” was abandoned. A new legal framework declared a state of emergency, set prices and tariffs in Argentine pesos according to the one-to-one exchange ratio with the US dollar, and authorized the executive branch to renegotiate prices and tariffs according to the criteria of competitiveness and income distribution. This battery of measurements had a severe and negative impact on the performance of the energy sector. The freezing of the price of electricity and the high rate of subsidies eroded the market prices foreseen in the regulated tariff. As a consequence, renewable energy subsidies became insignificant and promotion policies ineffective (Aguilar 2014; Recalde et al. 2015: 98-100).

After a two-year winding transition from default to democratic elections during which four provisional presidents held office, the Néstor Kirchner administration (2003-2007) set out to abandon semi-peripheral neoliberal policies, to pursue a developmentalist agenda, and to promote reindustrialization and a legal framework that would bolster domestic participation in upgrading the national power grid. The Argentine GDP grew at an average rate of 6.7% from 2003 to 2013, and the debt was effectively reduced. The containment of prices, including in the energy sector, was part of the government’s strategy. In 2005, the Wind National Strategic Plan was launched, and the following year Vientos de la Patagonia I—an association between the government of the

¹⁶ Act 23,928, March 1991.

¹⁷ Act 25,019, October 1998. The feed-in tariff system involves the payment of an additional remuneration per kWh of wind or solar energy generated that is supplied to the wholesale electricity market or to the provision of public services. On the feed-in tariff system, see Clark II and Cooke (2015: 237-239).

province of Chubut (20%) and the state-owned energy company ENARSA (80%)—was created to promote participation of domestic industry in wind projects.¹⁸

In 2006, parliament passed a law that established the “National Development Regime for the Use of Renewable Sources of Energy destined to the production of electric energy,” which was regulated in May 2009.¹⁹ One of the goals the law established was that renewable energies should constitute 8% of electricity consumed by 2016. Although the economic policy framework in which the law was passed remained the same during the two presidential periods of Cristina Fernández (2007-2015) and the price of energy stayed depressed, economic growth put pressure on energy demand. However, at the beginning of this government, Argentina had only one 30 MW wind farm (Giralt 2011: 65).

An engineer at the INVAP Ingeniería, a spin-off of INVAP, aptly summed up the complicated situation Argentina found itself in April 2009: “We are facing a paradox: artificially low electricity prices prevent a domestic wind industry from sprouting, while also slowing down the advent of foreign manufacturers.” If Patagonia were “the ‘showroom’ for local wind-exploitation technology,” the country would be in a position to enter a promising stage of industrial export “capable of generating tens of thousands of qualified jobs domestically.” However, that was not the actual situation: “We have next to no wind farms and our technological development in the area is incipient.” The domestic electricity market paid so little per megawatt-hour that the wind option was unappealing to private investors but public incentives were not enough. An increase in international oil and gas prices—scarce resources for the country—brought a hike in the price of electricity on the wholesale market. That combination appeared to be a window of opportunity “for some Argentine firms willing to take the risk of becoming world competitors on that immense market.” If that opportunity were not taken there would be a risk of “a flood of foreign equipment, perhaps at dumped prices,” which would neutralize Argentina’s chance of producing firms that could compete internationally. This engineer proposed a set of public incentives; he explained that INVAP aspired to sell wind turbines on the domestic market while also trying to grow its presence on the world market (Brendstrup 2009).²⁰

To offset those deficiencies, in May 2009 ENARSA issued to domestic and international firms a call for bids to generate 500 MW of wind energy under its Electricity Generation from

¹⁸ Energía Argentina SA (ENARSA) was created in November 2004 by Act 25,943 and Decree 1529.

¹⁹ Act 26,190, December 2006. This Act established a system of premium per MW/h generated. The premium was guaranteed by the Renewable Energy Trust Fund created for that purpose and feed by a specific levy. The Act was complemented by fiscal policy measures.

²⁰ See, also, Giralt (2011: 68, 85 n.2).

Renewable Sources program (GENREN for the acronym in Spanish).²¹ An auction system was proposed. In the evaluation of the tenders, priority would be given to firms that manufacture and assembled equipment and materials domestically. The offer reached 1000 MW. In early 2010, ENARSA approved projects for 754 MW of wind energy (Rossi 2013; Bernal 2016).

The following year, the Argentine Wind Cluster (CEA for the acronym in Spanish) was formed. The CEA brought together sixty-five firms.²² At that time, Argentina was the only country in South America with its own wind technology. Two firms—IMPSA Wind and NRG Patagonia—had their own approved and certified wind turbines delivering energy to the grid, and the state-owned company INVAP was developing low-power wind turbine technology (Rey 2013a; 2015).²³ Despite the GENREN's apparent intentions, the early initiatives showed the shortcomings of “buy-in” policies. Argentine newspaper *Página/12* explained that “while there are domestic firms that export wind technology and build parks in the rest of the world, the mills at the Rawson Wind Farm come from Denmark” (Mansilla 2011).

In late 2013, the scant progress in domestic wind-power generation was used by corporate elites, with the support of startlingly concentrated media conglomerates, to exert pressure upon government's developmentalist orientation. By November, only two large wind farms had begun to supply power (128.4 MW). The government sent an ultimatum to those firms. In turn, they explained that banks and investment funds had held back long-term loans. They also blamed the lack of an agreement with the Paris Club, disputes with bondholders, the government's exchange rate policy, and obstacles to profit remittance. The government answered that the winning firms charged investors too much to launch projects—almost four times as much as in Brazil—thus scaring off potential new investors (Gandini 2013; Rossi 2013).

It was estimated at that time that to reach the 2000 MW—and, hence, the goal of 8% of renewable energy for 2016—an investment of around US\$ 4 billion was needed—“a challenge that at this point seems titanic” (Gandini 2013). By the end of 2014, renewable energy constituted less than 1% of electricity production. Difficulties in compliance with GENREN were due not to specific instruments or barriers of entry, but to boundary conditions. However, despite this complex scenario, Arauco Wind Farm, in the northwest province of La Rioja, has equipment manufactured by the firm IMPSA in its planta in Brazil and Mendoza province. Inaugurated in two

²¹ Licitación Nacional e Internacional de ENARSA N° EE 001/2009 “Provisión de Energía Eléctrica a partir de Fuentes Renovables.”

²² The CEA endorsed by the Chamber of Industrial Projects and Capital Goods Engineering (CIPIBIC for the acronym in Spanish).

²³ IMPSA is a firm that produces hydraulic turbines and large cranes. NRG Patagonia, formed by domestic oil firms, has pursued joint ventures with an international manufacturer to build equipment in Argentina. Both firms are successful exporters of complex technologies (Brendstrup 2009).

stages, during 2011 and 2014, it now has an installed capacity of 50.4 MW. El Tordillo Wind Farm in the province of Chubut opened in 2013. It has two wind turbines—the first ones manufactured in Argentina, one by NRG Patagonia and the other by IMPSA—with a capacity of 1.5 MW each (Bernal 2016).

In order to improve sectoral performance, the parliament passed a new Renewable Energies Act in December 2015. It reformulated quantitative goals for incorporating renewable energy in the electricity grid and set new deadlines: 8% by the end of 2017 and 20% by the end of 2025. This law established a new investment regime whose main instrument is a public trust fund (known as FODER for the acronym in Spanish) that supports the financing of domestic firms' investment projects. Fifty percent of the savings in liquid fuels generated by replacement with renewable energies and by specific charges on demand would be allocated to FODER. Additional other benefits were also considered.²⁴

This situation triggered a debate within the wind sector in Argentina. Tax exemptions and other benefits that promoted investment in wind turbine equipment made indiscriminate import possible with total disregard for the domestic industry that had invested a great deal at considerable effort and was waiting for demand to materialize. The new law was criticized for assuming that there was no Argentine industry capable of competing with foreign technology and for supporting imports in this sector wholesale, regardless of economic and social effect. While it contemplated some incentives for the domestic industry, the new regulatory framework assumed that the domestic wind energy industry would not, for the time being, be able to keep pace with demand (Rey 2013b; 2015).

It seemed clear at that point that one important feature of the problem was—and continues to be—the temporality set by public policies. If the intention was to prioritize the contribution of local R&D and domestic industry, wind energy policies had to be allowed to set an endogenous pace. As Bernal (2016) explains: “While the pace at which wind and solar [energy] were brought into the mix by Kirchnerism may have been slow, the domestic industry in the sector was allowed to grow, despite limitations.” From 2003 to 2015, then, “Kirchnerist” governments protected the domestic wind industry from the invasion of foreign equipment, at least to the extent possible given the entangled circumstances and legal framework.

After at least five years of campaigns in the “post-truth” media and financial operations geared to destabilizing Cristina Fernández’s government, Mauricio Macri was elected president in 2015. When Macri took charge of the government in December, he inherited 187 MW of wind energy already up and running and projects that would add 282 MW by 2018.²⁵ However, breaking

²⁴ For details on FODER, see Navia et al. (2016).

²⁵ Of the 12,250 MW of power added to the grid from 2003 to 2015, 2,838 MW were from renewable sources.

all its election promises, the new administration abandoned developmentalist policies and turned to semi-peripheral neoliberal schemes. Characterized by low institutional quality, this administration encourages speculative finance, deregulates strategic economic sectors, and downsizes local industry while dismantling technology projects. It has implemented drastic budget cuts in R&D and purchased turnkey technology packages.²⁶ Huge fiscal benefits have been granted to the agricultural and mining sectors while, according to Bloomberg, the Argentine finance minister is “selling debt for the biggest bond issuer in the developing world” (Russo 2017).

On March 23, 2016, President Barack Obama visited Argentina “to deepen efforts to increase cooperation between our governments in a range of areas, including trade and investment, renewable energy and climate change, and citizen security” (*The White House* 2016). A week later, the Macri administration issued a decree regulating the Renewable Energy Act.²⁷ In mid-May, RenovAr was launched. That program opened bidding for 1000 MW of renewable energy: 600 megawatts of wind; 300 MW of solar; 65 MW of biomass; 20 MW of small hydroelectric projects; and 15 MW of biogas. The initial public investment was estimated at around US\$ 1.8 billion (*La Nación* 2016; *Página/12* 2016). The government also committed to adding 20,000 MW from 2016 to 2025, of which 50% would be renewable. Reaching that goal would entail an investment of some US\$ 15 billion in renewable energies over the next ten years.

The new legal framework has shaped a new market: industrial electricity consumers will have to purchase 8% of their electricity from renewable sources by the end of 2017, and 25% by 2025. The reaction of some players in the local wind cluster was positive for two main reasons: the starting point was demand ensured by the public wholesale market at a price twice as high as the one paid in neighboring countries; some 8100 firms—70% of all SMEs—had to comply with the new legal framework (*La Política Online* 2016; *Urgente24.com* 2016).

However, domestic firms were surprised by the conditions of the bid for wind-energy generation since they were relegated to marginal components. The bulk of the RenovAr program’s contracts in the wind sector was awarded to firms and investment funds from Europe, US, and China (Ennis 2017). Representatives of the Argentine Industrial Union complained that the technical requirements excluded the domestic wind sector, making it impossible for Argentine firms to compete on equal footing with foreign firms, which—furthermore—were allowed to enter the country with a zero tariff (*El Cronista* 2016). The trust fund established by law for financing domestic industry was not implemented, which meant that “developers have turned to credits from foreign technology suppliers, reducing local industry to a marginal share” (Fabrizio 2016).

²⁶ See Kornblihtt (2017). Significantly, Michel Temer’s “institutional coup” against Dilma Rousseff at the end of August 2016 has led to a similar situation in Brazil. See Angelo (2017).

²⁷ Decree 531 of Ministry of Mining and Energy, March 2016.

Moreover, the costly organizational and institutional learning process that was bolstered by the previous developmentalist government is being shut down: public R&D marginalized to focus state investments in foreign renewable technology; patient public-private partnership incentives that no longer make sense; and vanishing trajectories of public procurement of renewable technologies. This reorientation has been accompanied by a simplistic version of the “ecological modernization” discourse (Mol 2002; Ewing 2017) conceived to attract foreign investment. Macri administration’s semi-peripheral neoliberalism seems to have launched an accelerated process of disregarding (and unlearning of) domestic wind capabilities.

This winding trajectory shows the impact of the supposed “green industrial revolution” on a semi-peripheral country that managed to accumulate industrial and technological capabilities only to, nevertheless, end up purchasing foreign technology.²⁸

Epilogue: Another Paradigm for Renewable Technologies

Had Argentina, as a condition of possibility for the mobilization of energy mixes into a green economy, been able to produce “radical changes in the patterns of production, organization, management, communication, transportation, and consumption, leading ultimately to a different ‘way of life’” (Perez 2002: 153), then Argentina would have become a core country. On the contrary, we can infer that, ignoring the damaging consequences of structural links between non-core economies’ export-oriented primary production, increasingly stronger intellectual property rights that “make ‘catching up’ processes in developing countries more difficult” (Correa 2005: 254) and force non-core economies “to pay exorbitant prices for the use of foreign technology” (Michalopoulos 2014: 178), and direct foreign investment of the sort increasingly encouraged by global financial institutions reinforce ecologically unequal exchange as well as global inequity (Jorgenson 2016a; b).

As a consequence, neither global warming nor inequity will be solved, but only business in core economies will benefit and, perhaps, the required pace of capital accumulation will be regained. If this were to happen, the “end of cheap nature” (Moore 2014; 2016) could be delayed by yet another technological revolution and another long wave cycle could be grabbed at the cost of still greater global environmental unbalance and still deeper global inequality. In this sense, the combination of environmental catastrophe and business opportunity through the carbon-trade and green-technology market can be understood as part of the process of constructing a new frontier of commodification in the context of a long-term capitalist crisis.

²⁸ The situation in countries like Brazil, India, and South Africa is strikingly similarly: after huge efforts made to encourage the creation of domestic wind technology insurmountable hurdles appear that slow down or impede the domestic wind industry. In all three cases, the main manufacturers of wind power are, today, foreign companies. See, e.g., Aquila et al. (2017); Jolly et al. (2017); Baker and Sovacool (2017).

From the world-system perspective, the “entrepreneurial state” recommended by the neo-Schumpeterian view (Mazzucato 2013) is viable only for the core economies and its conceptualization of the green industrial revolution—self-conceived as an alternative to the neoliberal framework—a way to rejuvenate them at the expense of peripheries. The neo-Schumpeterian formalization represented by Freeman-Perez model seems to suggest that less neoliberalism in core economies, as a condition for restoring dynamic economic growth with greater degrees of intramural equity, requires more “free market” in non-core economies. As a peripheralizing economic force, semi-peripheral neoliberalism in countries like Macri’s Argentina or Temer’s Brazil seems to fit neatly into this evolving puzzle.

Thus, while the green industrial revolution is presented as a new panacea, it can hardly contribute to solving global warming unless the institutional, organizational, and cultural conditions for “mobilizing the transition to a green economy” are fostered in non-core economies, a complex process that, as the history of technological revolutions teaches, requires sophisticated societal capacities to boost the necessary “radical changes.”

And what about the connections between global warming, inequity, and poverty? In the book *Rethinking Capitalism*, which we have taken as an example due to its authors’ visibility in the field, the “great challenges” laid out by Mazzucato (2016: 99) are “climate change, natural resource scarcity, and healthcare,” not poverty. While Stiglitz’s (2016) chapter in that book is entitled “Inequality and Economic Growth,” his analysis focuses on US and OECD intramural economic performance. Like Perez (2016), Zenghelis (2016: 176) seems to recognize the problem when he says that “Because carbon is so central to capitalism [its eliminating] is a much larger task, involving a fundamental reshaping not just of individual technologies but of the entire system of production, distribution, and consumption.” It is disappointing to discover, however, that Zenghelis does not mention peripheries or developing countries; his analysis of “feedback loops,” “network effects,” “processes of dynamic innovation,” “clear price signals,” “mission-oriented goals,” etc., are all focused on core economies.

Like the business-oriented “green capitalism” mainstream, the neo-Schumpeterian approach rules out the conflicts, asymmetries, contradictions, and vested interests that compose the fabric of global power relations (Ciplet et al. 2015; Ciplet and Roberts 2017). It ignores non-core states’ capacities and temporalities required for the complex cultural, organizational, and institutional complex transformations involved in neo-Schumpeterian vision of technological revolutions. Argentina’s case seems quite eloquent. From the skewed neo-Schumpeterian perspective, the key problems appear to be pathways to innovation for core economies and speed in mobilizing finance for investment (Semieniuk and Mazzucato 2016), as if the “rest” of the capitalist world-system, spurred by the deployment of a new technological revolution, could spontaneously reshape itself in order to revert the secular tendency towards global warming, inequity, and poverty.

Since the 1980s, a sort of hidden component of the ICT revolution in the realm of “social technologies” made it possible, with increasing efficacy, to compress time and establish a dense network of new routes across geography for capital circulation (Harvey 1989: Ch. 17). One of the crucial goals of this dark side of ICT revolution in the realm of social-technology is *to normalize—to discipline and dehistoricize—peripheries in order to impose financial temporality*. In the 1990s, “Latin America,” for example, was deployed as an analytical category to “describe” a supposedly homogeneous set of countries coerced into applying identical recipes. The neo-Schumpeterian perspective contributed with mantras like “national system of innovation” where there were neither systems nor innovations. Semi-peripheral neoliberalism in Argentina, Brazil, Chile, or Mexico employed neo-Schumpeterian formulas to further entrepreneurship and innovation in devastated socioeconomic scenarios. Today, when semi-peripheral neoliberalism is regaining momentum in the region, the neo-Schumpeterian green industrial revolution is repeating promises that harbor back to the 1990s.

Critical alternative theoretical approaches, which refuse to naturalize the profit-and-growth imperatives and the unequal international relations of the capitalist world system, highlight that “disorder”—with symptoms like institutional, political, and socioeconomic instability, as well as growing poverty and inequity—in non-core economies co-evolves with—and is inextricable from and complementary to—the coal, gas, and oil economy responsible for global warming.²⁹ Any proposed solution that addresses these components separately is fictitious and the results of its application are random.

As the long-term cycle of “cheap nature” comes to an end, the globalization project (McMichael 2008) tends to polarize the capitalist world-system by peripheralizing the semi-periphery with mechanisms that, among their main goals, intend to undermine their technology and industrial policies.

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²⁹ For a map and discussion of critical perspectives, see Ewing (2017).

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