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Geopolitics and the Economics of Innovation

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Geopolitics and the Economics of Innovation

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International Politics **Reorientation of Multilateralism**

This policy paper reflects discussions of the CEBRI-KAS Project on the future directions of multilateralism.

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1 Introduction[1]

1.1. Geopolitics, technical change and economic development

The importance of technologies for the development of national economies is a fact that even neoclassical economists came to accept, after an initial period when technology and technical change was left outside their models, as if they were 'manna from heaven' (Reinert 2016). Early neoclassical growth models considered only labour and (generic) 'capital' as sources of economic growth. In the 1950s, Moses Abramovitz (1956) estimated the contribution of those two sources in the level of output (economic growth) of the US economy: per capita input of labour and capital together accounted for only 10% of the growth of output per capita – that is, 90% of economic growth was caused by other factors, a result that a few months later Robert Solow (1956) also found using its exogenous growth model (which earned him the Nobel Prize in 1987). Abramovitz (1956, p. 11) called that big residual "some sort of measure of our ignorance about the causes of economic growth." Since the seminal works of Joseph Schumpeter, however, we are not so much ignorant of them anymore, and we now know that technological progress is key for economic growth and development of national economies.

The 'gales of creative destruction' triggered by radical innovations described by Schumpeter (1934 [1912]) – which revolutionizes economic structures from within, disrupting old technologies, firms, industries while creating new ones – is a well-studied process by evolutionary economists. What is less studied, however, is the importance of geopolitical motivations as underlying causes for technological development. It is true that authors such as Mowery (2010), Mazzucato (2013), Weiss (2014) or Block and Keller (2011) have analysed the military research and development (R&D) of the US Department of Defence, the investments of the American 'entrepreneurial state', the works of the country's military-industrial complex, and the policies of its 'hidden developmental state'. What they have left out of their analysis is the fact that interstate competition and issues of power are the root of such actions – and not purely economic motivations, such as the pursue of economic rents or market shares.

Geopolitical motivations as causes of technological development and technical change were well-known to classical economists like William Petty and even Adam Smith, appearing also in the works of industrial economists like Alexander Hamilton and Fredrich List, but disappeared from the overly abstract theorization of neoclassical economics and (neo-)Ricardian trade theory based on natural competitive advantages (Padula, 2019; Padula and Fiori, 2019) – and, surprisingly, from neo-Schumpeterian economics as well. Indeed, combining classical geopolitics and international political economy with economics of innovation and development is an open yet non-explored research agenda. There is, however, another aspect of the relationship between geopolitics and technical change that will be explored in this chapter, which are the geopolitical *consequences* of disruptive innovations.

The techno-economic revolution brought about by the emergence and widespread diffusion of information and communication technologies is a reality at all levels of society: from individuals through firms to nation-states, all face the threat of disruption. In the past decade, the diffusion of such 'general purpose technologies' (GPT) (Ruttan, 2008) accelerated as a result of interrelated trends: increasing production capacity and decreasing adoption prices

1. I would like to thank Adriano Proença for his invaluable comments and suggestions on the first version of this chapter. I would also like to thank Dan Breznitz, Rainer Kattel, Yan Li, Raphael Padula and Mario Salerno for their generosity of sharing their time and knowledge in participating in our *Structured Conversations.* Of course, all the analysis, opinion, mistakes and misreading of the geopolitical scenario are my own.

amidst exponential growth of technological performance and decreasing size of components (Instituto Euvaldo Lodi (IEL) *et al.*, 2017). Such trends exacerbated the threat of obsolescence not only for old technologies and firms with sunk investments in them, but also – and maybe more importantly – to workers and certain geographic areas. Confronted with the threat of disruption, nation-states turned back to active industrial and innovation policies. This chapter will discuss the geopolitical aspects of the digital technology revolution, with a particular focus on the increasingly open US vs. China competition.

> "Since the seminal works of Joseph Schumpeter [...] we now know that technological progress is key for economic growth and development of national economies."

1.2. Technological eras and techno-economic revolutions

There are several ways to define the different "technological eras" since the original industrial revolution of the late XVIII century. Some authors focus on the continuity of the characteristics that define the industrial modernity, contrasting the technological developments of the past three centuries with the socio-, techno- and economic organization of the mostly agrarian world that preceded it. Others identify successive waves of industrial or technological "revolutions", which would follow recurrent patterns of emergence and diffusion and yet create unique impacts on established structures.

Amongst the former, we can point to the book by Brynjolfsson and McAfee (2014) *The Second Machine Age*, in which the authors argue that the current technologies in the era are performing cognitive tasks and therefore substituting labour, in contrast to the "first machine age" (everything that happened since the first industrial revolution), when machines and labour were complementary. Amongst the later, the seminal work of Perez (2002) *Technological Revolutions and Financial Capital,* in the neo-Schumpeterian tradition, in which the author argues that capitalism experienced five great surges of development associated with unique technological revolutions.

> "There are several ways to define the different "technological eras" since the original industrial revolution of the late XVIII century."

Schwab (2016) is another author who identified successive revolutions in the capitalist history, arguing that what the world is experiencing is the fourth industrial revolution, in which traditional manufacturing tasks are automated through information and communication technologies. More recently, Schot and Kanger (2018) developed a framework that can be seen as providing a synthesis of the two approaches, putting forth the idea that Perez' five surges of development formed a first capitalist "deep transition", and currently the world would be on the verge of a second one, possibly in a sustainable direction.

Notwithstanding these different definitions, most authors agree that the digital innovations of the last 40 years have been exceptional: despite the risk of ample disruption (for incumbent firms, regions and nations), these innovations open up opportunities for widespread socio-economic development. In this chapter, we adopt the periodization and theory of Perez (2002), because it is the most developed, detailed and coherent approach to the long term dynamics of capitalist technological development. Table 1 summarizes Perez' (2002) periodization since the original industrial revolution.

Table 1: Five great surges of growth and five major technology bubbles

Technological revolution	Popular name for the period	Core country or countries	Big-bang innovation initiating the revolution	Year
FIRST	The 'Industrial Revolution'	Britain	Arkwright's mill opens in Cromford	1771
SECOND	Age of Steam and Railways	Britain (spreading to continent and USA)	Test of the 'Rocket' steam engine for the Liverpool -Manchester railway	1829
THIRD	Age of Steel, Electricity and Heavy Engineering	USA and Germany forging ahead and overtaking Britain	The Carnegie Bessemer steel plant opens in Pittsburgh, Pennsylvania	1875
FOURTH	Age of Oil, the Automobile and Mass Production	USA (with Germany at first vying for world leadership), later spreading to Europe	First Model -T comes out of the Ford plant in Detroit, Michigan	1908
FIFTH	Age of Information and Telecommunications	USA (spreading to Europe and Asia)	The Intel microprocessor is announced in Santa Clara, California	1971

Source: Perez (2002); see also Perez (2010, p. 782).

Associated with those opportunities is the risk of hegemonic conflicts. This chapter discusses economic and political aspects and dynamic trends related to the diffusion of disruptive digital technologies amidst the process of globalization of value chains. It benefits from *CEBRI's Structured Conversations on the Geopolitics and the Economics of Innovation*, which consists of interviews, by the author of this chapter, with selected experts in the field of technical change, industrial policy and innovation management, all held in September-October 2020. Besides this introduction and a brief conclusion, the chapter is divided as following: section 2 discusses the new wave of national strategies to promote industries and technological innovation, which display common motivations and orientations, with some also seeking to address societal challenges.

The national strategies of the US and China have also an explicit geopolitical agenda, and section 3 looks at the recent US-China trade conflict. Section 4 raises four insights about how the new coronavirus pandemic magnifies interrelated geopolitical and techno-economic trends from the past decade. The section also discusses how the dynamics of regulating digital innovations present similarities with the way that automobile safety was regulated during the previous technological revolution[2]. Section 5 raises implications for developing countries and Brazil, in particular.

2. Using the periodization proposed by Perez (2002).

2 Disruptive digital technologies, globalization and national industrial innovation strategies

Amidst the process of diffusion of disruptive digital technologies, a new global division of labour emerged in the 1990s, in which transnational electronics corporations decentralized their value chains, encouraging the creation of local networks of first and second-tier suppliers (manufacturers and service providers). With the intensification of trade and investment flows, globalization became deeper and wider. Asian economies - with their ability to "govern the market" (Wade, 1990) and to slowly climb the technological ladder, combined with low wages - were well positioned to benefit from these dynamics, which resulted in a tilted "playing field" towards the East – despite neoliberal policies that sought to level the playing field to all players, be they corporations or nations.

Some observers argued that the 2008 Global Financial Crisis (GFC) put a halt to this techno-economic cycle, leading to a phase of "secular stagnation" (Summers, 2014). More thorough analysis shows that this is not the case. There are still plenty of opportunities for technological innovation and economic growth, especially related to the widespread adoption of digital technologies (*digital transformation*) and to the transition to socio-environmental sustainability (*green growth*). Still, the aftermath of the 2008 GFC was a time of reckoning for Western countries in general and the US in particular, as an important part of their manufacturing industrial base migrated to Asia, leaving behind an economic vacuum that affected individuals (workers) and whole regions.

Suddenly, the no-hands approach to industrial policy went out of fashion. Active industrial policies became the order of the day. Technological innovation and the innovation economy became centrepieces in policymakers' recipes for recovery. Following the enactment of the *American Recovery and Reinvestment Act* in 2009, the trend of industrial and innovation policy activism gained momentum with what appeared as a new wave of disruptive digital innovations – the "Fourth Industrial Revolution" (Schwab, 2016), "Industry 4.0" (ACATECH, 2013), "Digital Transformation" (Fæste, Scherer and Gumsheimer, 2015; McKinsey, 2018), or "Advanced Manufacturing" (EOP, 2012).

What all these denominations have in common is the recognition that current disruptive innovations are characterised by the abundant use of data, and the convergence of different fields of knowledge. To seize the opportunities created by new "general purpose technologies" and address the challenges their economies were facing, more and more national governments launched industrial and innovation policy plans. The United States' *Advanced Manufacturing Partnership*, established in 2012; Germany's New High Tech Strategy, published in 2014; or the United Kingdom's *Industrial Strategy,* from 2017, are all examples of such impetus. But not only the West promoted active industrial and innovation strategies, Asian countries reacted, with China, Japan and South Korea all launching their own "advanced manufacturing" and digital innovation strategies.

Table 2, based on a similar table from Labrunie, Penna and Kupfer (in press), summarizes the main pillars and objectives spelled out in national strategy documents of China, Germany, Japan, the United Kingdom and the United States.[3] These selected national strategies have six common "orientations", be them pillars or objectives, namely: (1) incentivizing advanced manufacturing

3. The documents are: *China's Made in China 2025*, published in 2015; *Germany's New High-Tech Strategy: Innovations for Germany,* announced in 2014; *Japan's 5th Science and Technology Basic Plan* (from 2015), *Robot Strategy: Vision, Strategy, Action Plan Robot Strategy* (also from 2015) and *White Paper on Small Enterprises in Japan* (from 2017); United Kingdom's *Industrial Strategy: Building a Britain Fit for the Future,* established in 2017; and United States' key documents informing its *Advanced Manufacturing Partnership,* launched in 2012.

technologies and industries, (2) increasing expenditure and funding for R&D, (3) deepening of the relations between industry-academia-government, (4) development of workforce skills, (5) incentivizing SMEs and start-ups, and (6) updating norms, standards and the business environment. Germany, Japan, and the UK also display a further commonality in that the plans seek not only to increase the rate of innovation for promoting economic competitiveness, but also the *direction* of innovative activities as a means to address societal challenges. In this sense, they represent a new kind of policy that may be seen as 'mission-oriented' policies (Mazzucato, 2018a).

Table 2: Objectives and pillars of the national strategies of the selected countries

Orientations present in at least two countriesat least two countries	China	Germany	Japan	United Kingdom	United States
Objectives and pillars associated with the promotion of industrial competitiveness					
1. Incentivizing advanced manufacturing (technological development and integration with industry)	O, P1, P2	P1, P3	P1	O1	O1, P1
2. Increasing expenditure in R&D funding, including basic research	P1, P10	O5, P4	O, P3	P1	O5, P3
3. Deepening industry-academia-government-relations	P1	O11, P2	O, P4, P6	P1	O3, O4
4. Development of workforce skills	O, P10	O7, P4	P3, P3R	P2	O2, P2
5. Promoting SMEs and startups	P10	O4, P3	P4	P4	O1, P3
6. Norms, standards and business environment	P1, P10	O4, P4	P4, P3R	P4	P3
7. Developing laggard regions		P3	O1	P5	
8. Translating research results into products/ Improving scale-up and commercialization	P1	P2			
9. Internationalization of the industry	P9, P10	P2			
10. Innovation infrastructure			P1R	P3	
Objectives and pillars associated with addressing grand societal challenges					
1. Sustainable development/Green economy	O, P5	O3, P1	O1, P2	O2	
2. Ageing of the population		P1	O2, P2	O4	
3. Mobility		P1		O3	
4. Participation of society		O2, P5	P5		
5. Challenges of the digital economy and society/Cybersecurity		P1	P2		

Caption: O = Objective; (Ex: O1 = Objective 1 of the policy) / P = Pillar (Ex: P1 = Pillar 1 of the policy);

Obs.: In the case of China and Japan, (some of) the objectives are not ordered.
Source: Labrunie, Penna and Kupfer (in press).

The national strategies of the US and China, however, pay hardly any attention to societal challenges, with a somewhat exception of 'sustainability' and the 'green economy' in the case of China, whose president Xi Jinping announced in September 2020 that the country would see a peak in its emissions by 2030 and achieve carbon neutrality before 2060 (Ladislaw and Tsafos, 2020). On the other hand, the strategies of these countries have explicit geopolitical motivations and an external agenda of opening markets and levelling the playing field for their corporations, suggesting their ultimate goal of global industrial leadership. However, these similar goals have different connotations or motivations. As Padula (2020) explains, China does not presume to itself the role of hegemon, a position occupied since World War I by the United States. Yet, the US perceives or instrumentalizes China's rise as a threat to justify expansionist policies in the military and economic field.

3 The US x China trade and technological conflict

In spite of the 2008 GFC, China not only continued but also solidified its position at the centre of the current global division of labour and world trade system. It is the first or second most important trade partner to the majority of developed and developing economies, one of the largest foreign capital investors in the world (and the largest foreign creditor of the US), and its companies are present in most manufacturing global value chains (from textiles through electronics to medical equipment). Representative of the Chinese consolidation in the global playing field is its surpassing of Japan as the second-largest economy in the world in 2010. In this context, the emergence of China became not only a matter of industrial and technological competition, but also of geopolitical tension.

In 2013, China announced the *One Belt One Road* policy, which in 2016 became known in the West as the Belt and Road *Initiative*[4]. The initiative focuses on Chinese infrastructure investments in almost 70 countries – from Asia and Oceania through the Middle East and Africa to South and North America – and was broadened to include a digital element as well. The new *Digital Silk Road* is thus based on four pillars (Cheney, 2019): investment in digital infrastructure abroad (5G cellular networks, fibre optic cables, data centres etc.); development of advanced technologies in the fields of artificial intelligence, telecommunications, cloud computing and data processing; e-commerce; and digital diplomacy and governance, which include a call for "cyber-sovereignty" over technological standards.

It is against this background that, in 2018, when the US trade deficit with China reached US$ 419 billion, the President of the United States Donald Trump announced a "trade war" against China. This took the form of significant tariff barriers, amounting to US$ 250 billion – or almost half the value of US imports from China. The top five imported goods affected by the US tariffs were: telecom equipment, computer circuit boards and processing units, metal furniture and computer parts. In retaliation, China imposed its own tariffs to US goods, amounting to US$ 110 billion – or US$ 10 billion short of what China imported from America in 2018. Trump then threated to further increase the tariffs, which he did in 2019 and was followed by another increase by China – leading also to a rhetorical escalation of the conflict. For instance, when Washington symbolically designated China as a "currency manipulator", Beijing reacted with a warning that this move would trigger turmoil in financial markets. Indeed, stock and currency markets fluctuated according to the last piece of news about the US-China trade dispute.

Aside from tariff barriers levied on Chinese imports, the United States also took other measures against China on the grounds of national security and human rights reasons. In October 2019, the "blacklist" of Chinese firms that were to seek explicit US government approval before purchasing US made components included several artificial intelligence and telecommunications corporations, amongst which the Chinese giant Huawei (officially designated as "backed by Chinese military"). A struggle also emerged around Taiwan Semiconductor Manufacturing Company (TSMC), the leading manufacturer – from the "rogue province" – of customized semiconductors, including for military use and 5G telecommunications, which would also need to seek an official US license before shipping its products to Chinese manufacturers (Huawei, in particular). Subsequently, TSMC announced plans to build a new US$ 12 billion manufacturing facility in Arizona. The US also reacted to China's *Digital Silk Road* initiative by including digital governance aspects in its diplomatic and trade negotiations and began to pressure its allies to ban Huawei's 5G equipment from national wireless networks.

4. Its official name can be actually translated as the *Silk Road Economic Belt and 21st-Century Maritime Silk Road Development Strategy.*

4 The outbreak of the Covid-19 pandemic as a magnifying glass of current trends

In December 2019, the conflict appeared to have suddenly cooled down, with the US and China announcing an initial trade deal to avoid further tariff impositions and later remove other trade barriers. The US had dropped its (mainly symbolic) designation of China as a "currency manipulator". In that same month, however, a new coronavirus (CoV-19) associated with a severe acute respiratory syndrome (SARS) appeared in the Chinese province of Wuhan. Three months later the World Health Organization (WHO) declared the outbreak of "SARS-CoV-19" a pandemic, triggering a new rhetorical war between the United States and China, which blamed each other for the responsibility over the emergence of the virus.

The SARS-CoV-19 pandemic hit the world hard. As of October 2020, there were more than 37.5 million confirmed cases and about 1.1 million deaths worldwide. The economic impact of the pandemic represents the most severe economic downturn since the Great Depression of the 1930s. Even though stock markets have recovered from the generalized crash of late March 2020, the effect on the real economy is still unfolding. Calling it "a crisis like no other", in June 2020 the International Monetary Fund (IMF) estimated an average growth rate of the global economy of -4.9% in 2020, with advanced economies declining 8% on average (-10.2% for the Euro area) and emerging markets and developing economies contracting 3% on average (mainly because China's economy is still projected to grow) (IMF, 2020). The IMF also forecasted a severe impact of this economic downturn on employment, with unemployment rates surging to more than 10% in countries like France and Italy – even the US, whose unemployment rate reached only 3.7% in 2019, is projected to display an unemployment rate of 10.4% in 2020. With soaring unemployment, many countries were forced to relax their austerity measures, promote economic recovery plans, and implement unconditional basic income programmes (see points B and C below).

All things considered, the emergence of the new coronavirus pandemic seems to magnify four interrelated geopolitical and techno-economic trends from the past decade:

A. The manufacturing global value chains overly dependent on China became a central target of national policy. When China decided to shut down parts of the country (beginning with Wuhan), and kept its supply of medical equipment - personal protective equipment, pharmaceutical drugs and inputs, mechanical ventilators - for itself, the whole world faced the consequences of the fragile interdependent global system of production. Consequently, many countries began to discuss industrial development (or re-industrialization) as a key goal to achieve in the coming years, as a means for securing national sovereignty and security against other possible shocks to the system. Concerns over China-centred manufacturing chains spilled over into the electronic and digital value networks and the central role of China in setting standards for the digital economy. As Li (2020) has pointed out, decoupling production chains from the Chinese economy is already a reality. However, decoupling is easier for some value chains, and very difficult for others, and we shall not see a full decoupling for certain sectors with complex value chains. On the other hand, the decoupling between advanced economies and China could open up new opportunities for development in other geographical areas, as argued by Breznitz (2020), just like it happened at the height of the Cold War between the US and the then USSR in the 1960s. However, Salerno (2020) counterargues that whether this opportunity will mean anything more than "maquila-type" industrialization[5] is still to be seen, as historically activities such as design, research and development have always remained at home (i.e., in the original countries of the transnational corporations), even if transnational continue to engage with open innovation. Yet, when faced with disruptive innovation, companies close themselves. While they may still promote open innovation, control remains with the headquarters of the transnational corporation.

B. Upgrading industrial structures and reshoring of value chains are now "the flavour of the month" in the policymakers' menu of measures – calls for new "Marshall Plans" to reconstruct economies abound. The wave of national industrial and innovation strategies, which surged after the 2008 GFC and gained pace with the widespread diffusion of digital technologies, was further accelerated with the pandemic. It is also worth mentioning that, in itself, the adoption of digital technologies, in areas such as e-commerce and remote work, gained momentum and became a key strategy for survival during the SARS-CoV-19 pandemic. As discussed in section 2, recent industrial and innovation strategy plans present several common characteristics (Labrunie, Penna and Kupfer, in press). Two of these characteristics are particularly relevant: they are conceived as a means to seize technological opportunities, and not just upgrade industrial structures and value chains; and, secondly, they address persistent economic consequences of the current societal challenges of sustainability and demographic change. Kattel (2020) argues that the consolidation of active industrial policy by nation states is the key outcome of the current pandemic, resulting from three converging drivers: renewed geopolitical aspirations; the climate and environmental emergency; and a growing understanding of a holistic approach to economic policies (giving coherence to policies implemented by finance ministries and science and technology ministries).

C. Industrial and innovation policies became key national concerns and increasingly "mission oriented". Using innovation policy to resolve societal challenges is what observers like economist Mariana Mazzucato call "mission-oriented" innovation policies (Mazzucato, 2018a; Mazzucato, 2018b). The global race for a SARS-CoV-19 vaccine could be seen from this perspective as a key example of mission-oriented initiative. Regions (such as the European Union), individual countries (Peru and Spain) and cities (Manchester, Valencia and Medellin) are currently developing their own mission-oriented innovation strategies, in which the missions *are innovation driven* and related to environmental and health issues. The German Environmental Agency has recently published a study "based on the evaluation of 130 scientific studies and relevant statements that deal with the design and effectiveness of green economic recovery programmes" which reveals a yet positive effect of the pandemic: a "broad consensus" that "the only way to overcome the economic crisis is with green recovery programmes and structural reforms" (Umweltbundesamt, 2020).

D. In what concerns the digital economy, the US-China competition sharpens the differences in technology strategies while creating divides between business models and firm choices making more difficult an agreement over standards and practices. As a consequence, the policy space for multilateral governance is diminished. The widespread diffusion of digital technologies brings about the prospects of disruption of established structures – work relations, business models, trade patterns – all of which call for a realignment of institutions and the establishment of a new governance system. Historical observation shows that technological innovations also bring about negative externalities. Digital technologies create different regulatory problems (IEL *et al,* 2017):

- **Ethical:**
  right to privacy and data confidentiality
- **Proprietary:**
  ownership and access to data
- **Industrial design:**
  degree of autonomy of the machines, which could become an issue of economic and political power
- **Normative:**
  establishment of open vs. proprietary standards and of technical standards for tracking decisions, securing compatibility and retrofitting legacy systems

5. The term refers to "maquiladoras", companies that only assemble products, importing more sophisticated parts and technology developed elsewhere, usually operating in tariff and duty-free zones (like Brazil's *Zona Franca de Manaus*).

- **Techno-economic:**
  support for the development of technical and organizational skills adapted to each production system
- **Socio-environmental:**
  rising unemployment due to robotization or the disposal of digital equipment, supplies and goods

All such problems call for regulations, and some of them may not be amenable to national regulations – they need a global framework if the problems are to be effectively addressed. However, current discourse of distrust over the action and mandates of existing multilateral institutions (the US pulling out of the WHO and WTO, for instance) is at odds with the prospects of international agreements in the regulation of the digital economy. Furthermore, we can trace a parallel with the regulation of problems associated with the paradigm carrying industry of the fourth technological revolution (Perez, 2001): the automobile industry (Box 1).

Box 1: The regulation of the automobile industry

The automobile industry is what Perez (2002; 2010) calls a "paradigm carrying industry" (PCI) of a technological revolution, as it epitomizes the best practice model for the most effective use of the new technologies of the revolution. Together with the oil industry, the automobile industry was the PCI of the fourth technological revolution, which she calls "the age of the automobile, oil and petrochemicals" (see table 1). In the current "age of information and telecommunications", digital technology industries are the ones that carry the paradigm. In this sense, looking at how the automobile was regulated (Penna and Geels, 2012; Geels and Penna, 2015; Penna and Geels, 2015) may hold lessons for the regulation of digital technologies. In particular, the issue of regulating automobile and highway safety seems to hold parallels with the issue of regulating internet privacy and security. Automobile safety emerged as a public issue in the early decades of the 20th century; by then, it received a behavioural framing: to address the problem, the driver should be educated to change its behaviour and drive safely. This soon became the official framing in national regulations being enacted in the US (the leading country of the fourth technological revolution). Currently, the internet privacy also receives a behavioural framing: it is up to the user to change her behaviour and protect its own privacy. This framing also enters national regulatory frameworks, which calls for companies to give users the option to "opt in or out" data sharing accords and to accept or not tracking "cookies" (text files shared with websites to identify users and which track their behaviour). An alternative, technological framing only emerged in the 1950s, as a result of a growing understanding (fruits of military R&D) that the automobiles could be designed for the protection of occupants. But such design was not advanced by manufacturers, which instead promoted style and gadgets that could boost sales. "Safety doesn't sell" was the motto in the American automobile industry. It was only in 1966 that this technical framing became official through the enactment of the *National Traffic and Motor Vehicle Safety Act*, which empowered the US federal government to set uniform safety standards for automobiles, ranging from crash-avoidance standards (e.g. controls, display and brakes) through crashworthiness (e.g. occupant protection, seat belts, airbags) to post-crash survivability standards (e.g. fuel system integrity). Currently, designing algorithms for promoting individual privacy (and not for increasing sales and user engagement) is off the table of internet corporations, but is starting to receive attention via the works of nonprofit organizations like the Center for Humane Technology, focused on the 'realignment of consumer digital technology with humanity's interests'. In the history of automobile safety, it were the actions of activists – initially medical doctors who witnessed the tragedy of car crashes and later consumer groups led by the first consumer activist Ralph Nader – who managed to promote the technological framing until it entered official regulation. Different framings do not only affect the types of regulations, but also the technologies that are developed (Penna, 2014): the behavioural framing led to a surge in patenting that would help drivers drive safely, while the technological framing led to patents that would protect the integrity of the car and of the occupants. But the regulation of automobile safety holds another lesson for the regulation of digital technology: despite the surge in fatalities due to highway crashes in all countries that saw a widespread diffusion of automobiles, an international regulatory policy framework for cars was never established by multilateral organizations. Instead, what did emerge were shared technical standards promoted by technical associations like the Society of Automotive Engineers. In this sense, if the parallel with automobile safety holds for digital technologies, we may not see the emergence of an international regulatory policy framework but witness the creation of technical standards in professional and industry associations. Indeed, these fora should become the arena for the new rounds of regulatory battles around the paradigm carrying industry of the fifth technological revolution.

As it currently looks, however, the promotion of sustainability and green new deals seem to be one of the few areas open for global alliances and multilateral collaboration. While the US-China conflict was gestated already during the Obama administration, in 2014 the United States and China jointly pledged to reduce carbon emissions by 2030. While environmental issues lost momentum with the Trump administration and any "green" motivations behind the American official industrial and innovation strategy disappeared, it remains a key commitment of civil society and corporate social responsibility, which recognizes the economic importance of a sustainability agenda born and consolidated as a multilateral task. National climate and sustainability agendas were and are built directly linked to the multilateral one, and parameters and instruments for monitoring and evaluating these agendas are "multilateral" in their roots.

The widespread recognition of the 2030 Agenda and its 17 Sustainable Development Goals (SDGs) is part of this trend. If, on the one hand, the main low carbon technologies (solar and wind energy, electric cars) are concentrated in a few agents (and countries) – in fact, the green energy supply chain is concentrated in China (Ladislaw and Tsafos, 2020) – and may create a problem of access; on the other, it is increasingly clear that low-tech solutions are also important and perhaps of greatest impact from the point of view of developing countries with critical technological gaps in sanitation, waste management of solids, and public transportation.

It follows that while policy spaces for regulation of the digital economy are diminished by conflict and competition, the advent of the SARS-CoV-19 pandemic does not seem to have shut the window of opportunity for multilateral collaboration for innovations in the area of climate and sustainability, especially when considering the economic and social benefits of access to health services, sanitation or pharmaceutical drugs and vaccines.

5 Implications for Brazil and emerging economies

No capitalist country has ever developed without manufacturing industries and technological innovation (Reinert, 2016). The current pandemic has shown that having manufacturing and innovative capacities are key not only for economic growth, but for sovereignty and security. The fact that Brazil has a network of top-level health research institutions (Federal public universities, the Fiocruz and official pharmaceutical labs) highlights this. Without this network, it is not unwarranted to speculate that the country would be in an even worse position in dealing with the Covid-19 pandemic.

The development of a strong scientific system (as Brazil experienced since the 1970s) is however not enough to seize the opportunities created by digital innovations. While the recent increase in innovative entrepreneurial activity in Brazil, beyond the São Paulo-Rio de Janeiro axis (to include states like Pernambuco, Santa Catarina and Goiás) has been fundamental, it is not economically sufficient or sustainable. There needs to be a vector that directs investments and technological development towards high value-added areas.

What Brazil and other developing countries lack is an explicit industrial and innovation strategy that establishes a long-term development vision that recognizes its potential place in the global arena. Such strategy must contemplate the key role of public procurement for innovation and mission-oriented innovation programs as policy tools: as means to direct technological development towards digital transformation while addressing pressing environmental and social challenges that the country's society faces. It is only thus that developing countries may combine the opportunities of the digital economy to complete their development project.

The current US-China conflict diminishes the policy playing field for developing countries. Choosing sides risks limiting technology strategies and adopting technical standards that may not become dominant in the long run. Avoiding this divide is key for preparing institutions, the infrastructural base – and workers – for the adoption of what emerges as the de facto technical standard, e.g. for 5G technologies. While the policy space is diminished for multilateral negotiations, it is collectively that developing countries may secure more bargaining power. Furthermore, explicit attention for technological aspects of trade agreements is key in this era of uncertainty regarding technological governance and regulations.

"What Brazil and other developing countries lack is an explicit industrial and innovation strategy that establishes a long-term development vision that recognizes its potential place in the global arena."

6 Concluding remarks

This chapter discussed the relationship between technological dynamics, the economics of innovation and geopolitics. Despite being a relatively neglected topic in mainstream and Neo-Schumpeterian economics, geopolitics is at the root of technology development strategies.

In particular, the chapter examined the trends of offshoring manufacturing capacity from the West to the East and of the re-emergence of active industrial and innovation policies (section 2). Industrial policies from different countries present similar characteristics, with some also seeking to address societal challenges, in what has been dubbed "mission-oriented policies". In the case of the US and China, their plans have geopolitical motives and ambitions, which contributed to the trade and technological conflict between them, exacerbated in the past few years (discussed in section 3).

Section 4 argued that the current SARS-CoV-19 pandemic has worked as a magnifying glass for such trends with important implications for the governance of the trade system, of digital technologies, as well as for the prospects for an innovation based sustainable global development path. In this respect, the chapter offered a brief parallel between the regulation of the automobile industry and of the digital technology industries: if the parallel holds, we may see disputes around technical standards not in multilateral policy fora but in international professional and industry associations.

In the fifth section, the chapter offered reflections on the repercussions for developing countries in general, and for Brazil in particular, of the examined dynamics and the prospects of autonomous socioeconomic development based on technological innovation.

As a final remark, it may be added that windows of opportunity for technological innovation and socioeconomic development are moving targets shifting with political and economic dynamics. To seize the opportunity created by digital technologies, developing countries need to understand the recurrent and unique patterns of each technological cycle (Perez, 2001). Current disruptive digital innovations are characterised by the abundant use of data and the convergence of different fields of knowledge. Their diffusion to the global periphery is accelerated as a result of increasing production capacity and decreasing adoption prices (amidst exponential growth of technological performance and decreasing size of components). Such trends are aggravated by the threat of obsolescence not only for old technologies and firms with sunk investments in them, but also – and maybe more importantly – to workers and certain geographic areas, amidst the process of globalization of value chains. Confronted with the threat of disruption, nation-states turn back to active industrial and innovation policies. These dynamics exacerbate conflicts (not only between US and China) over trade and technological issues. For the global south, taking sides in this conflict is unwarranted, while promoting new avenues for redirecting multilateral collaboration – also in alternative international fora – is increasingly vital.

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