How are
the digital and environmental transitions
interconnected?

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Abstract:
The digital and environmental transitions are shaping socioeconomic trends during the first half of this new century. The digital transition leaves environmental footprints directly (energy consumption) and indirectly (the stimulus imparted to social practices, such as tourism). But digital technology is a necessary condition for the environmental transition, in particular for managing ever more complex energy systems. Plans for "smart cities" give us a glimpse of the huge potential for innovation at the convergence of these two transitions and, too, of the disruptions in existing organizations. Blockchain technology will stimulate peer-to-peer transactions conducive to the decentralization of energy and the emergence of carbon (or energy) "currencies".

Two transitions, distinct but both technological, …

It is logical to analyze the relations between the digital transition and the environmental transition since both these processes, owing to a historical concourse, are shaping socioeconomic trends during this first half of the 21st century.[1] Before assessing their potential interdependence, let us emphasize how much these two transitions are intrinsically different, each having its own relation to technology.

The digital transition corresponds to a transformation stemming from a combination of advances, at first, in electronics and computer science and, then, in telecommunications. Widespread, fixed and mobile, high-speed connections, the high penetration rate of digital equipment (in particular, mobile telephones) in households in developing as well as developed countries, the service platforms that are upending entire branches of the economy (transportation, the hotel business, etc.) and the ramifications of the Internet for everyday devices (the Internet of things)… these trends have reached maturity or are on the drawing board for a near future. The diffusion of such products and services mainly passes through the usual economic channels (offers of a better combination of features per price than what is being replaced) but at a higher speed owing to network effects and two-sided platforms (with, on the user's side, the possibility of for-free access to a range of services).

[1] This article has been translated from French by Noal Mellott (Omaha Beach, France).

The environmental transition is completely different. It is impelled not by technological progress but by the need to change our model of economic growth. This model, having reigned for two centuries now, produces an excess of negative externalites (above all greenhouse gas emissions, a deterioration of biodiversity and of the quality of air, water, etc.). Nonetheless, the "blamed" forms of technology are not obsolete: coal-fired power plants are still capable of producing electricity, combustion engines are still an efficient means of transportation, etc. But their use is not sustainable in the middle or long run, whence the need for a transition that invents environmentally friendly techniques as substitutes.

The difficulty is enormous: it is necessary to run counter to conventional economic processes — to replace techniques that, still efficient in terms of the services rendered (despite their negative externalities), rely on resources that are often available in abundance at acceptable prices. Coal, oil and gas will still be in supply beyond the end of this century. No do price trends automatically evict them from the energy mix. The objective is, therefore, to replace this technology with another that costs more and/or is less efficient, for example, due to the intermittent supply of electricity from solar or wind energy, or owing to the limited mileage range of electric vehicles. Furthermore, the new technology cannot, during a start-up phase, hold its own in the economy without support from taxes, subsidies, or regulations (incentives or restrictions).

In the fight against climate change, the environmental transition has to be made under the pressure of time, whence complicated questions related to intergenerational choices. People in the first half of the 21st century have to assume the costs of a transition for limiting the (drastic) risks that will peak for the generations living at the end of this century. Such questions do not, of course, crop up in the case of the digital transition.

…That do not naturally converge…

Given the sometimes disruptive implications of digital technology for the organization of society, what are its implications for the environmental transition? In the fight against climate change, will this technology make a breakthrough for meeting the target of 2°C by, we might say, exporting Moore's law to the realm of low-carbon technology? Research of this sort must not be one-sided. How does the digital transition affect the environment both directly (the energy consumed by digital equipment) and indirectly (social practices, such as tourism, fostered by digital technology)?

To be persuaded that the digital transition as such is not a cure for environmental problems, we need but notice that the acceleration in the 1990s of CO_2 emissions coincided with the roll-out of a "bunch of innovations" in electronics and telecommunications. We would be exaggerating, of course, to deduce that information and communications technology (henceforth ICT) has caused climate change. After all, the origin of rising greenhouse gas emissions is multifactorial: burgeoning globalization, emerging economies, ongoing population growth, etc. For all that, digital technology has not been a factor curbing the increase in such emissions.

Let us point to evidence that helps explain why the digital transition is not intrinsically environmentalist:

— The manufacturing of electronic equipment consumes not only energy but also mineral resources. A smartphone, for example, contains tin, copper, cobalt, lithium, etc. Data centers - their proliferation being a good indicator of the diffusion of digital technology - account for 5% of electricity consumption worldwide, electricity mainly used by their cooling systems. However the firms in charge of server farms (GAFA in the lead: Google, Apple, Facebook, Amazon) and the suppliers of digital equipment are reacting. Their efforts to retrieve the heat, use carbon-free electricity and devise algorithms for optimizing energy efficiency are evidence of the priority they have assigned to this problem.

— Environmental assessments of the services offered by digital platforms (even those that seem at first sight to be virtuous) contrast sharply. Car-pooling involves not only sharing rides but also transferring part of the itinerary to another mode of transportation (such as trains), whence a global effect that often turns to be negative for long-distance rides. Websites for rentals between private persons tap an un- or underused stock of housing; but they also boost tourism and, consequently, long-distance trips. Overall, the gains in energy associated with digital technology are not exempt from rebound effects.

— Digital technology is also a tool for optimization in the fossil fuel industry. In response to the falling price of oil in 2014, installations for prospecting and production have been digitized as the price of sensors has fallen; and "data analytics" is now widely used. This accounts for many of the gains in efficiency achieved by the shale gas industry in the United States. By lowering its break-even point, it has staked out a solid position for resisting the collapse in world prices (and, in turn, it has thus shored up the world price of oil).

…But have a large zone of convergence…

Despite these reservations, there is no doubt but that the use of digital technology is a condition underlying the energy transition. Systems relying heavily on digital technology will be required to handle increasingly complex electricity grids, as decentralized means of production (wind farms, photovoltaics, biomass sources, etc.) are massively hooked up, as storage capacities are gradually enlarged, as the need for flexibility increases owing to demand, and as new uses (in particular, electric vehicles) emerge.

Nor is there any doubt but that the zone of convergence for the environmental and digital transitions will be the "smart city", where we most clearly catch sight of the synergy. This convergence is dictated by massive emigration toward urban areas: 52% of the world's population now lives in cities with a surface area covering not more than 2% of the globe. Besides, the percentage of city-dwellers might well rise to 70% by 2050. Urban areas also lead in primary energy consumption (65%) and greenhouse gas emissions (70%). In this context, various plans are being made for smart cities that, despite differences, have in common the attempt to optimize data management for the purpose of improving urban services: transportation, energy, wastes, housing, health, education, culture, etc.

A basic force driving these changes is the determination to curb the pandemic of urban pollution and prevent the thrombosis that the ongoing rural exodus could automatically cause in this 21st century. Developing "smart mobility" is the pivot of predictions. From this abundance of solutions, a city will choose an *ad hoc* local mixture with the objective of making the urban area more compact, managing traffic in real time, expanding multimodal transit systems, etc. Naturally, the place of vehicles with internal combustion engines in urban areas will come under question, as (in the relatively long term) substitutes become more widely available for the motor (electric vehicles), steerage (self-driving cars), method of appropriation (sharing, pooling) or business model (more services), etc. This change will center around players who used to be on the periphery of the automobile industry, such as GAFA, utility companies and local service groups.

Information technology will innerve the smart city through horizontal interconnections via the social media and the proliferation of new interfaces (screens and smart devices of all sorts, starting with telephones), which lend themselves to experiences of enhanced reality. Since this sort of city produces data in abundance, the conditions (open or not) for diffusing them, the ability to process them and the capacity for drawing value from them opens possibilities for new innovations, even disruptive breakthroughs as two-sided platforms (Airbnb and Uber at present) stake out "the" position of intermediary. The potential of smart cities mainly stems from digital technology (and interconnected platforms), but it will be combined with the progress being made in the construction and energy industries. Energy-plus buildings (thermal energy efficiency plus energy from renewable sources plus the capacity for storing electricity) can be designed and interconnected in environmentally friendly neighborhoods (entirely new urban cityscapes).

In this context, the distinction between the suppliers and consumers of services will blur. The application of ICT to cities requires an increased commitment from users, who will be asked to become more closely involved in managing new services. This holds good for the new smart networks for producing and distributing electricity and natural gas. Final users will act on the energy supply (mainly through the production capacity integrated in their homes), modulate their demand (in reaction to price signals, depending on production requirements and, above all, as a function of the need to reduce the CO_2 emitted while generating electricity), and even contribute to the grid's equilibrium (through the capacity of electric vehicles to store electricity: vehicle-to-grid and vehicle-to-home interconnections).

…Even for breakthroughs that eliminate intermediaries

From another angle, we can see blockchain technology as an illustration of the potential breakthroughs to be made at the point of convergence between the environmental and digital transitions. Above all, this new technology suggests that these transitions will not necessarily have platforms as intermediaries.

Blockchain technology is at the origin of bitcoins, the cryptocurrency created without involving central banks. This technology for peer-to-peer transactions establishes a decentralized stock of bitcoins and encrypts transactions through a chaining of blocks of inviolable data. Smart contracts, which contain the rules (volume, quality or price) for a transaction, allow for an autonomous, decentralized matching of buyers and sellers with reduced transaction costs.

Developments using this sort of technology are being worked out for pricing carbon. Blockchain technology can be used to organize local ecosystems in the market for trading allowances (under the European Union Emission Trading Scheme, EUETS). Each tonne of CO_2 emitted can be registered on a blockchain as a token. Primary and secondary markets could then be organized for trading these tokens — a sort of carbon currency with a traceability that prevents fraud. Such a system resembles a self-regulated process for creating a currency for the climate. It could be organized in a demarcated area, such as a local community that wants to be carbon-free or a company that is setting an internal price for carbon. These "archipelagos" of carbon-price zones could then be interconnected. Blockchains provide guarantees for registers of CO_2 emissions in application of the Paris Climate Agreement.

Blockchains can also be used for transactions for supplying energy. Experimental programs are under way, in particular for a decentralized generation of electricity and for transactions among "neighbors" in environmentally friendly neighborhoods or industrial parks. The objective is to set up systems wherein producers and consumers sign contracts for an automated supply of energy without intermediaries. Besides being used to read utility meters (for billing purposes and offsetting operations), blockchains could also serve to authenticate the carbon-free origin of energy, thus giving a boost to a circular economy.

As a machine for manufacturing a consensus from the local to the global levels, blockchain technology suggests breakthroughs that digital technology, as it is deployed, will introduce in the organization of energy systems. More broadly, it lets us glimpse the potential of innovations to be accredited to the environmental transition.