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Digital Revolution or Anthropocenic Feedback?

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Abstract

Digital technologies are shaking the world. They contribute to the emergence of new modes of organisations of our economies, privileging direct horizontal exchanges between ubiquitously connected humans. Although the rise of new technologies and social behaviours may appear coincidental, we investigate whether an anthropocenic feedback may contribute to their current blooming. The profound shift resulting from the flattening of hierarchical structures through algorithmic intermediation suggests that a more essential need is at stake. In the biosphere, horizontal resilience strategies, e.g., sexual vs. asexual reproduction, are promoted when resources become scarce. We investigate the relationships between resource scarcity and horizontal resilience in the technosphere, and the striking similarities with mechanisms of the biosphere, thus suggesting that the rise of the digital layer may have been fuelled by the end of abundance. Following this biological analogy further, we predict that the increasing autonomy of the digital layer might even help achieve global homeostasis in the technosphere.

1 Introduction

As it is not officially a stratigraphic unit yet, the starting date of the Anthropocene is the subject of heated discussions [LM15]. This debate however masks deeper underlying revolutions. The Anthropocene is an age of rapid transformations in all areas, from climate to society. In the present paper, we focus on the technosphere, which emerged in the Anthropocene, and more specifically, on the recent expansion of its digital layer. Given the extent of change that the Internet has brought to our everyday life, there is no doubt that the wording "digital revolution" is fully deserved. Yet, one may question whether we are solely progressing through one scientific breakthrough after another. Here we explore an alternative, yet non exclusive scenario, in which the digital revolution would be more than the simple consequence of technological progress, but instead the result of a deeper path relating to the planet's resources.

Our environment is classically subdivided into "spheres", such as the atmosphere, the lithosphere, or the biosphere. As highlighted by Peter Haff in a seminal paper [Haf14], all these spheres display one common feature: homeostasis through recycling. The cycle of water in the hydrosphere may be the most iconic example in this respect. Such dynamic stability, or to quote Haff "conservative dynamics", is thus a defining feature of the spheres, and explains why spheres are sustainable entities.

In the Anthropocene, and because technology is becoming more and more widespread, the concept of technosphere has emerged, as the intertwined systems of in particular communication, transportation, industry, agriculture, as well as administration. The concept is consistent with its size and global impact on Earth, relying on a strong appropriation of energy as well as other resources, as well as a growing independence. For instance, the amount of solids moved by the technosphere is of the same order of magnitude as that of solids moved on the earth surface by other spheres [Haf12]. However, and as noted by Haff, it strongly differs from the other spheres in that recycling is close to absent in the technosphere.

This provocative, yet elegant, analogy places the technosphere in an odd position. By questioning the very essence of the technosphere's sustainability, the lack of resource homeostasis in the Anthropocene would inevitably condemn the technosphere to collapse. The threat is real, as resource scarcity has indeed led to collapse events in the past. Documenting the path of many civilisations in human history has demonstrated that their extinction often follows a phase of rapid growth and forcing on resources [Dia05]. While other factors are involved in these collapse events, a contribution of resource scarcity in such episodes cannot be ignored.

As noted by Haff, such lack of recycling is not new and has already happened much before the Anthropocene. More specifically, 2.4 billions years ago, large quantities of dioxygene accumulated in the atmosphere [SDW⁺09]. Like the technosphere today, the biosphere in those ages was not recycling its waste, O₂, and this led to a more and more toxic environment for the mostly anaerobic organisms that lived at that time. Yet, geological survey shows that this accumulation stopped and reached a steady state in the following eras. This can be explained by a major shift in the biosphere: recycling mechanisms emerged, now known as respiration. The so called "great oxidative event" is thus a typical example where the lack

of recycling by the biosphere threatened its existence, and where new recycling mechanisms allowed survival.

How is the biosphere adapting to the current threat on resource homeostasis? A large proportion of the biosphere is actually not able to adapt to the pace at which our environment is changing. We are witnessing the sixth extinction of species [BMT⁺11]. The atmospheric balance is also impacted, notably with the steady increase in carbone dioxide over the years. While it is difficult to anticipate how the different spheres are going to adapt to the absence of recycling of the technosphere, one may also question whether this no recycling trend is going to stay steady. The recent aspiration for "greener" societies, as shown by the fast growth of "renewable energies", might result in a new paradigm. One may thus expect that the technosphere, like the biosphere during the great oxidative event, is going to find its own cure and adopt a new balance.

We argue that the collection of solutions for "sustainable development" might in fact overshadow the unique revolution that our era is experiencing, the equivalent of the invention of respiration during the great oxidative event, for the technosphere facing resource scarcity. To explore which type of "metabolism" the technosphere is generating, we first look at biology, where strategies to resource scarcity are numerous and well documented. Sexual reproduction has been correlated to resource scarcity. Some species [Nor03, Kin80] switch from asexual to sexual reproduction when food resources become scarce, thus resulting in a horizontal resilience strategy, with a broader access to resources. Scheu and Drossel [SD07] show that the timing of sexual reproduction can be triggered by resource scarcity.

The development of information and communication technologies has led to a world in which both humans and devices are connected continuously to the network, and can exchange information and access resources, goods or services. As a consequence, the capacity to intermediate between actors offering and consuming services is shifting to high level platforms, often not involved in the physical transactions, but making full use of the data they have acquired, combined with powerful algorithmic techniques.

The resulting algorithmic intermediation is not only a product of communication tools. It has spread to all economic and social interactions extremely rapidly. Exploiting the data deluge, the digital actors are contributing to the emergence of a digital layer of the technosphere, which connects humans as well as devices, and interacts directly with them. As a result, hierarchical structures are flattened. Such a profound shift suggests that it addresses a more essential need than previously anticipated. What could be that need? In the biosphere, horizontal resilience strategies, e.g. sexual vs. asexual reproduction, are promoted when resources become scarce.

Does algorithmic intermediation, and its resulting horizontal organisation, emerge to address the shortage of resources? We observe that algorithmic intermediation allows sharing mechanisms from accommodation to transport, and that this trends now extends to Earth resources, such as energy or crops. These mechanisms are expected to contribute to a more frugal use of resources, thus helping to achieve a more sustainable development. Conversely, this also entails that the digital layer of the technosphere is irreversibly gaining power over humans. Acting more and more independently from Human decisions, this is where the true

power for Anthropocenic Earth transformation resides. Born at an age where the Earth limits were reached, the digital layer may have emerged from the end of abundance, rationalising the use of available resources and driving us from the Anthropocene to the "Algoecene".

2 Ressource scarcity feeds back on the biosphere

As resource scarcity is relatively new to the technosphere, it remains difficult to predict what the future holds. In contrast, the biosphere has been facing variations in resource availability on a regular basis at different time scales and it has selected robust strategies during its evolution. Can we find one common, overarching, trend in these strategies? And if yes, could it apply to the current evolution of the technosphere? Because it is the primary regulator of population growth, because it relates to heredity and the acquisition of new biological functions during evolution, and because it might be the most emblematic defining feature of life, we focus here on reproduction and how it relates to resource availability.

Sexual reproduction has been positively correlated to resource scarcity, when considering living organisms which can shift between asexual and sexual reproduction modes. Phytophagous insects [Nor03] and aquatic filter feeders, such as water fleas and monogonont rotifers [Kin80], switch from asexual to sexual reproduction when food resources become scarce. In fact, resource scarcity can be used to predict the shift to sexual reproduction in most animals and protists that exhibit such intermittent mixes [Bel82, Bel88].

Conversely, asexual reproduction dominates among the soil decomposers, i.e., in an environment that is abundant in resources. Sexual reproduction has even never been reported for some of these soil species [Bel88]. Scheu and Drossel generalize this finding and demonstrate that the timing of sexual reproduction can be triggered by resource scarcity [SD07]. Importantly, the correlation between sexual reproduction and resource scarcity can be extended to most living organisms: when food becomes scarce, animals tend to reproduce earlier [BTH05]. Resource scarcity has even been proposed to be a primary factor in the emergence of sexual reproduction. For most organisms with a determinate development, like humans, sexual maturity occurs when growth terminates.

The selection of such a reproducible strategy suggests that a feedback exists, i.e. that sexual reproduction positively addresses the issue of resource scarcity. By involving the search for sexual partners and by constantly exposing and reshuffling the various genetic alleles in a population over several generations, sexual reproduction contributes to a form of horizontal resilience. The "tangled bank hypothesis" [Koe88, Bel82] points that sexual reproduction leads to the production of a wider variety of organisms that can use a broader spectrum of resources. Sexual reproduction thus leads to the production of offspring that can feed on additional resources. This represents a major advantage when resources are scarce [SD07].

Conversely, and as mentioned above, asexual reproduction can be associated with resource abundance. This also means that horizontal resilience is lost. The production of clones by asexual reproduction indeed entails a vertical form of hierarchy, as all the genetic information is autonomously and conservatively passed on from one parent to the progeny. This strategy

is by far the most efficient way to colonise a site rapidly: because males are not produced, all the offspring are productive, and if the environment features remain stable, this strategy also ensures the production of optimally adapted individuals. However asexual reproduction also generates offspring that compete for the same resources and this has dramatic consequences as "complete competitors cannot coexist" [H⁺60].

It seems therefore that observations, models and evolutionary perspectives converge towards a paradigm in which resource scarcity promotes a form of horizontal resilience in biology, that in turn promotes diversification and adaptation to new resources. We propose that the shift from vertical to horizontal hierarchy is the unifying feature that best qualifies the biosphere strategy to resource scarcity. We also note that while this strategy can be in conflict with short-term benefits of maintaining a vertical form of hierarchy, it has been selected during evolution and it prevails. These biological data thus strongly suggest that the promotion of horizontal resilience strategies do not appear randomly, but can instead be the product of a large scale environmental feedback. It thus seems relevant to investigate whether such mechanisms make sense for the technosphere in the Anthropocene as well.

3 The birth and rise of algorithmic intermediation

If the classical spheres, bio-, hydro-, litho-, etc. have been developed over periods of time orders of magnitude higher, the technosphere has been progressively taking shape in the course of the 19th and 20th centuries, an instant in regards, with the increase of the energy production capacity, the deployment of heavy industries, the construction of increasingly rapid transportation means, the mechanisation and the use of chemicals followed by genetic engineering in agriculture, as well as the development of long distance communications. The technosphere played a crucial role in the increase of the human population, which almost doubled during the 19th century. It has tripled since WWII, an era also coined as "the great acceleration", which corresponds to a period of growth in all sectors. In this respect, the intertwined relationships with the other spheres forms the foundation of the concept of anthropocene.

Communication technologies have played a key role in the expansion of the technosphere. They have evolved from the inception of the telegraph at the beginning of the 19th century, which for the first time allowed high speed point to point long distance communication. In the early 20th century, the development of radio, followed by different type of wireless systems, reinforced vertical communication from a small number of emitters, reaching a progressively increasing part of the global population. For the first time, it offered the possibility to provide synchronised information to large populations.

Information technologies were developed in parallel to communication technologies, at the early stages of the 19th century with the introduction of punch cards by Jacquard, and the programmable mechanical computer by Cabbage. But it is really with the advent of electro-mechanisms in the beginning of the 20th century, which allowed industrial census to be carried on, and then in the years around WWII, with digital signals replacing analogical methods, rapidly followed by the development of transistors, that computers got a real

impetus, and allowed for automatic processing of information. Not only the delivery of information became increasingly fast, but the type of delivered data diversified. This step also marks a stage where complexity and automation dramatically increased the level of abstraction between humans and data.

Production, storage, transmission, and automatic transformation of data were at the verge to revolutionise the world. For the last 50 years, information technologies have evolved under the auspices of Moore's law [Moo75], which predicted in 1965 the doubling of the technical capacities every other year, thus leading to an exponential growth in computing, communication, as well as storage capacity. While Moore's prediction was quantitatively correct, it did not distinguish between a conservative scenario in which the world would count small quantities of supercomputers, and a world with large quantities of small computers.

Technological progress allowed the development of cheap, small, and powerful devices which could be embedded anywhere. At the turn of last century, with the popularisation of mobile devices carried by humans, as well as the embedding of technological means into connected devices, which now outnumber the number of people on earth, the ground was built for a shift from a vertical organisation to a horizontal one.

The miniaturisation and sophistication of devices is only half of the story though and it could have consolidated the vertical organisation. Unquestionably, the development and expansion of the Web in the 1990s led to an alternative path. Knowledge was made accessible to all, thanks to search engines, and online encyclopaedia. In addition horizontal communication grew very fast through various types of online networks. With the advent of the Web 2.0 [O'r07], beyond the simple access, the production of knowledge itself was made possible to all, thus closing the loop: information users also became information providers. The Web 2.0 also gave rise to social networks, and therefore to a horizontal connection between people, devices, as well as immaterial goods, with sophisticated means to find and address individual or groups of people.

Global connection and the positive feedback loop of data, led to the development of a powerful "digital layer" in the technosphere, directly at reach for humans and devices. This layer also displays increasing predictive power because it acts as an integrated mirror view of the physical world, at an extremely fine spatial and temporal granularity, and permanently updated thanks to the continuous flow of data harvested or produced by major online systems. The essence of the formidable development and efficient metabolism of this digital layer can be embedded into a central concept, *algorithmic intermediation*.

Intermediation is the art to connect people to the services they need, or that might be useful to them. Even if intermediation existed in the pre-digital era, it was at a different scale, orders of magnitude more modest. Banks for instance intermediate between lenders and borrowers, while various matching services are offered by organisations that do find adequate answers for their clients among their offering. What has changed in the digital era is the capacity to reach globally both humans and devices, combined with the very fine granularity of the real time knowledge available in the digital layer, which combines global data with the traces of the connected components. Intermediation now constitute the beating heart of digital systems connecting people or devices.

Intermediation also modifies our relation to resources. It arises in two-sided markets [RT03], with essentially two groups, providers and consumers of services, that would benefit from the capacity to get in contact. These groups might be producers and consumers of knowledge, drivers and passengers, patients and physicians, readers and journalists, etc. By exploiting the large amounts of data now available, it is possible to offer personalised services of very high efficiency, thus targeting the right resources.

It also changes human resources, which are increasingly mobile, and can in particular switch from one side of the two-sided market to the other, be consumer or provider of services. Carpooling systems constitute an excellent example of such a phenomenon, impossible in the previous framework. The access to resources becomes much more specific and this opens new economic niches. Conversely, traditional intermediaries with often local range and standardised paths, e.g., newspapers, transportation corporations, etc. are at stake, because their business model is collapsing. Intermediation players thus offer a horizontal deployment, which increases the capacity to reach resources, much like in the biosphere.

4 Horizontalisation through intermediation

Is algorithmic intermediation a passing trend in human history or is it going to stay and further consolidate ? Surveying the invasive nature of the revolution at play, we would rather support the latter scenario. The scale of transformation that algorithmic intermediation induces cannot be underestimated. As illustrated below, its entanglement with all layers of societies, as well as increasingly with the other spheres of earth's organisation is already overwhelming, for it plays now the role of a major command mechanism.

The steady increase in energy consumption of the digital layer demonstrates its growing importance. It is now estimated that information technology exceeds 10% of the world's electricity consumption. Measures have been proposed to evaluate the energy intensity in terms of data volume, showing that at the core network, it is around 0.05 kWh/GB [SP14, SCHP15]. According to Google¹, a query on the engine amounts to 0.0003 kWh, which corresponds to what the human body burns in 10 seconds given that the average adult needs amounts to about 8000 kJ a day of energy from food. Some of the new appliances, such as iPhones, consume more energy than traditional ones, and their needs now compare to that of refrigerators [Wal15].

At the economic level, intermediation actors occupy already a central position. Their role has been rapidly increasing since the beginning of the millennium, after their inception in the late 90's. Their capitalisation grows at unprecedented speed. Uber weights a quarter of IBM, while the front runners are rivalling with the crude oil industry at the top positions. Among the top 5 capitalisations², Apple (\$740 B), Google (\$367 B), Exxon (\$357 B), Berkshire Hathaway (\$354 B), and Microsoft (\$340 B), three are operating global intermediation platforms. It is rather noticeable to see digital corporations challenging the energy industry,

¹<https://googleblog.blogspot.fr/2009/01/powering-google-search.html>

²<http://www.forbes.com/global2000>, September 22, 2015

revealing maybe that their role in the technosphere is on the verge to become as fundamental as energy production. In this context, the recent decision of Rockefeller, famous father of Standard Oil (then Esso, then ExxonMobil) to quit fossil energy to embrace the grid of renewable energy is symptomatic of the revolution at play.

Moreover, this revolution is not restricted to urban environments. The part of land which is not massively inhabited but used for agricultural production is also being increasingly connected. Agriculture is a story of people and land, therefore local. But it is also severely determined by regulations, trade agreements, market conditions, and increasingly by climatic threats, therefore extremely global as well. Furthermore, although it employs a declining part of the population, almost negligible in rich economies, there is no economic sector of greater importance to fulfil our basic needs, and its products reach daily every single person. Its connection to the technosphere might contribute to better face the deepening challenges of feeding the planet.

A powerful company has emerged in the later sector [Gru15], The Climate Corporation, which assimilates meteorological data from the main agencies and uses predictive models to provide services to its customers, through a downstream data flow. It also collects, through an upstream data flow, data produced by sensors installed at its customers location, which allow for better services combining global and local data. Its services address short term issues such as watering and pests, as well as long term issues such as choices of crops. In a recent press release³, The Climate Corporation announced that "farmers have mapped more than 75 million row crop acres in their digital agriculture platform, up from 50 million acres in 2014. This significant acre adoption represents nearly 45 percent of all corn and soybean acres planted in the U.S." therefore an already rather dominant position in that country. The corporation was acquired by Monsanto for around US\$ 1 billion in 2013, raising discussions and controversies in the U.S.⁴

The previous facts demonstrate that algorithmic intermediation truly reshapes our societies and our relation to resources in the long term. Beyond the efficiency that horizontal and personalised services offer, it seems that other factors contribute to make this transition inexorable? Below, we examine two feedback mechanisms that may contribute to the rise of an increasingly powerful digital layer.

First, algorithmic intermediation changes the very nature of data, both quantitatively and qualitatively. One of the most striking consequences of the information and communication technologies is the exponential increase in the production of data. Data has become a fundamental resource, one of the main assets today. We are entering the *zettabyte* era, with volumes of data increasing by orders of magnitude⁵. These data fill the digital layer, which can be seen as some sort of virtual copy of the so-called real world, perceived by humans. Interestingly, we observe that the corporations handling big data that have the largest impact, both economically and socially, are those which not only combine freely available data and data actively provided by users, but also integrate metadata, i.e., data

³<https://www.climate.com/company/press-releases/digital-agronomic-services-platform/>

⁴<http://www.newyorker.com/tech/elements/why-the-climate-corporation-sold-itself-to-monsanto>

⁵http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/VNI_Hyperconnectivity_WP.html

that were not intendedly transmitted, through the traces of their activity on the corporation's platform.

Activity traces have given rise to extremely valuable services, which can either contribute to improve initial services through personalisation, or lead to the development of completely new services, which at first glance might appear very distant from the original services. The increased level of granularity for information access is thus due to the numerous, more personalised, communication paths, but it also emerges from the augmented nature of the information that algorithmic intermediation provides, in a positive feedback loop.

Second, algorithmic intermediation not only allows the identification of complimentary needs in horizontal networks between human and non human component, it also ensures *trust* in the newly established relation, thus making it reliable and efficient. Importantly, trust is a necessary element for exchanges, whether economic or not. Fukuyama [Fuk96] has shown the importance of trust and the cultural variations and their impact on different human groups. A new notion of trust is emerging with intermediation actors, which is based on the recommendation people make of the services and the other users. Carpooling becomes possible because intermediation actors are offering guarantees of both drivers and passengers, which are established on the evaluation of previous users. While trust has been in most cultures ensured by vertical organisations, in the digital world trust is ensured at the horizontal level, by peers evaluating others. Interestingly, like metadata that emerged from personalised intermediation patterns of data exchange and further reinforced the power of algorithmic intermediation, trusting complete strangers is also a side effect of horizontal, personalised intermediation and it is fuelling the development of algorithmic intermediation in a second feedback loop.

Beyond trust, knowledge could result from disruptive paradigm as well. In a provocative tribune [And08], Chris Anderson, asserted that the scientific method was becoming obsolete, and that given the availability of the data, correlations could be found automatically, leaving aside the need for theories. The digital layer thus appears more and more holistic, impacting all sectors of our societies and promoting its own growth by channeling the resources on which it feeds, very much like a living organism constructing its own niche as it colonises it. Are we then leaving the Anthropocene for an era where the power fully shifts to the digital layer?

5 Towards the algocene?

Humans gradually outsource decision-making to algorithmic intermediation platforms, because these systems are more efficient. But this also generates tensions while it reshapes the economy as a whole. The social impact of intermediation platforms working from the virtual digital layer hits now the headlines, for their severe disruption of various traditional economic sectors, raising popular discontent as well as political and judiciary hostile reactions. The creation or the release of data, not accessible before, changes the subtle equilibria between actors in the society.

Newly released data allow the emergence of new sorts of extremely powerful intermedi-

aries, which offer services at a global scale. Although they rely on heavy infrastructure of the technosphere, they often have little if any implication in the physical world with the products or services exchanged, as well as little reliance on local legal constraints. As a result, power is redistributed, with downward empowerment of the users, as well as upward empowerment of the global platforms themselves, while others are weakened if not destroyed, such as legacy intermediaries with local activity.

Because it shakes the ground of our economic models, this new world becomes more and more apparent, as illustrated by the publication of best seller books on the subject. For instance, Jeremy Rifkin announced the emergence of a new society, the zero marginal cost society, and predicted the end of capitalism [Rif14]. More recently Paul Mason⁶ draw similar conclusions. Even the data used by states administration, regarding for instance security or economy figures, more and more originate from the new intermediaries.

While most analyses point the global scale of transformation at play, they mostly consider the horizontalisation as a new dimension of the democratisation of our societies. But a major implication of the current revolution might be that power gradually shifts to algorithms. We might thus be entering a form of "algorocracy".

The virtual world constitutes a new layer of the technosphere, which plays a role of increasing importance, connects most of the human population, and a rapidly increasing number of non human components, mostly devices monitoring human as well as non human activity. Heavily concentrated around a few powerful actors, mostly private, they have a hold on a large share of the personal information which is used for various purposes, including beyond purely commercial activities, security for both human and non human threats.

While one might question the extremely strong concentration of control in this emerging sphere by a few corporations in particular in the Silicon Valley, the real novelty might be that it becomes increasingly autonomous, much like the technosphere itself. One might wonder what the consequences of such an autonomy and a control by algorithms could lead to.

The digital layer has direct access to the current status of our resources, water supply, electricity consumption, as well as meteorological or financial figures for instance. It offers an increasingly accurate view on global resource availability. Resource control is now at a resolution unreachable before, allowing increased efficiency in their management. For instance, home automation will allow the monitoring and reduction of energy consumption in households, connected vehicle will lead to better control of flow and security not to mention energy consumption and particle emission. Smart cities, equipped with sensors in the infrastructure, will lead to more rational governance. Smart grids will help us to shift from a world with few stable producers and numerous consumers, to a more symmetric world with numerous unreliable producers and consumers.

While algorithmic intermediation may first be seen as a way to further promote individualistic, economic liberalism, it also generates alternative economic models, and in particular sharing mechanisms, which were unthinkable in the past. Car pooling is a notable example, which leads to resilience under stress on various types of resources primarily energy and urban space. Altogether, this demonstrates that the digital layer is changing and will further

⁶<http://www.theguardian.com/books/2015/jul/17/postcapitalism-end-of-capitalism-begun>

change human behaviour.

The new norms imposed by the digital layer might serve global objectives, and promote new values, disrupting local rules. They can be banned or considered illegal, but their wide adoption by the population gives them a legitimacy of a new sort, the legitimacy of the technosphere that goes beyond national politics. In biology, horizontal resilience strategies such as sexual reproduction when resources become scarce, are promoted to the detriment of individual benefits. Typically, parents take the risk of having offsprings with disabilities, and thus a lower fit to their current environment. Biology during evolution has selected strategies that allow survival in the long term, not comfort in the short term.

It is thus worth questioning whether the virtual world may increasingly decide for our future sake, and conflict with our short-terms desire. We may thus enter an era where algorithms concentrate the true power of the technosphere, accurately assessing resource availability and feeding back on society more and more independently from human decisions. This age, the "allogocene", can be seen as the era where the virtual world becomes the geological force on Earth. This major shift echoes the current transition of power towards the digital layer, where automation does not only increase calculation speed but completely reshuffles our relation to resources.

6 Conclusion

If the analysis of population growth in biology and evolution tends to suggest that the promotion of horizontal resilience strategies may not appear by accident, but instead result from a feedback on resource scarcity, it is relevant to ask whether similar phenomena could channel the development of horizontal organisations to face resource homeostasis defects. Looking more carefully at the structure and functions of the emerging intermediaries of the technosphere might suggest at least that a feedback from resource scarcity would not have done a better job.

Note that we are not claiming that algorithmic intermediation was created as a deterministic response to resource scarcity. By interfering with the human-information nexus, algorithmic intermediation is progressively changing our relation to resources, and we are thus proposing that its expansion may have been further promoted by resource scarcity. We have seen how new concepts of social trust or scientific discoveries were emerging from the digital layer, potentially replacing legacy ones. The allogocene, which results from the technosphere's increasing autonomy and its unstoppable development could lead to a reduction of the many excess of the Anthropocene to a transient anomaly.

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