Scope and Limitations of the Epigenetic Analogy: An Application to the Digital World

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1 The Digital World

The development of digital ecosystems has undergone growth and an unusual transformation since its origins. This has created new business models, new ways to exchange information and new types of socio-economic relationships, all of which have been based on a core of continuous technological development. It is also important to note that the ecosystem is formed by several dimensions. One is related to communication infrastructures. Another is the network where the information travels. All the devices and/or resources that ensure connectivity and an accessible operating interface function between the two should also be considered. This third factor can be understood as an extension of one of the two previously mentioned dimensions. Besides, a new dimension needs to be included, namely, that which embraces socio-economics, which are global and interdependent, in scales that have never before been seen, going beyond political and geographic barriers, must also be noted. All that is taking shape within fast response times,

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which generate a new tempus for socio-economic actions (i.e. those carried out by companies, countries, organisations) and poses extraordinary innovation demands.

Technological advances coalescing as massive connectivity have enabled the Internet to become an authentically global phenomenon. However, the incessant increase in traffic calls for mobile bandwidth extension which, in turn, depends on the radio electric spectrum, which is a public good. Mobile connectivity (also fostered by the arrival of devices that facilitate it), together with new connections to machine to machine type networks, transport management systems, security systems or Smart grid devices point to an increase in user demand of mobile wideband (see Chapter "Future Paths of Evolution in the Digital Ecosystem" in this book by Pérez Martínez and Serrano Calle, and Chapter "4G Technology: The Role of Telecom Carriers" by Araujo and Urizar). Both the technological limitations and allocation of this public good already indicate a gap between demand and supply possibilities. This gap may create asymmetric geopolitical and socio-economic areas, as per the extent of network expansion and, as a result, may cause digital divides with the consequent inequalities they involve.

Technological and economic feasibility is needed due to dependence on infrastructures. This calls for efficient design and use of the radio electric network and its complementary options, or if applicable, its replacement. As quality differences between fixed and mobile networks diminish, the tension between the two is being resolved in favour of the latter.

It also necessary to note the incessant speed of product and services innovation as well as the constant and abrupt transformations that the various actors in the ecosystems and the ecosystems themselves are undergoing. Intense change and rapid innovation are constants in the digital (i.e. Internet) ecosystem. Partly as a consequence of the latter, new issues, not only institutional, regulatory and normative, but also related to security and privacy arise. They lead to the need to restrict companies' freedom via public regulation to safeguard citizens' freedom and open access to the network. All of these aspects are breaking down traditional business models and creating new models and value chains. The latter is now based on the digital "mode of production" with new parties and activities, content owners, online services, connectivity, etc. In these highly dynamic ecosystems, countries (i.e. environments) and firms interact in an operative manner. It is no coincidence that the USA and Apple and South Korea and Samsung are the global leaders in the digital world. We should not overlook the relationship between Apple and Samsung, which may also be partially explained by the epigenetic dynamics approach, as discussed in Chapter "Epigenetic Economics Dynamics in the Internet Ecosystem" in this book by Zabala-Iturriagagoitia et al. (see also Gómez-Uranga et al. 2014).

This alignment of countries and companies causes a certain amount of tension between agents concerning adequate network neutrality and related conflicts. Public regulation is the generic scope of resolution for these issues (see Chapter "Future Paths of Evolution in the Digital Ecosystem" in this book). From the perspective of globalisation, the digital ecosystem provides clear possibilities for an effective delocalisation at every possible level: operative, financial, commercial and even legal. Their scope goes beyond national States and laws, as they also modify the framework of global relations. Along these same lines of change, it

has also transformed the information failures of traditional markets, shifting from information asymmetries to knowledge asymmetries. Accessibility conditions concerning capital markets or intellectual property protection can neither be overlooked. These aspects play a key role in these ecosystems and initially benefit big business groups.

Strangely enough, user empowerment is increasing in the same ecosystem, what has an important impact on the entire group of system actors. Therefore, gatekeepers generate the main initiatives and control in the configured ecosystems. In other words, they are the agents which determine access and participation in the system. It is the big established business groups (i.e. in this book we have referred to these as the GAFA) which compete to play the role of main gatekeepers and benefit from the corresponding privileges, thus causing problems related to lack of competition or collusion. Therefore, regulations are not only important per se, but their implementation and control have also become essential. Nevertheless, the difficulty involved is also extreme due to the trans-border and globalised nature of the digital ecosystem. These aspects question the freedom and security of countries, companies and citizens, leading to tension between the possibilities of greater freedom and violation of it in that intervention is allowed to an extent that had never before been possible. In short, the diversity of agents and operators, globalisation, regulation and security ultimately underscore the importance of Internet governance.

It is therefore necessary to understand the multi-stakeholder approach and note that an approach based on multilateral cooperation is not entirely valid on its own. For instance, it is not valid inasmuch as it limits the States' role merely to that of any other agent. They are placed on equal footing with the rest of the agents, which makes regulatory responsibility less effective. Nevertheless, there is a common demand for the Internet to be a global 'place' managed in the public interest.

We are ultimately facing a new world, like the discovery of America, where the amount and scope of transactions, as well as their economic value, social potential, the regulatory challenges and the new business models they called for and the global innovation they lead to are totally new to us because of their disruptive nature. The Internet constitutes a digital ecosystem where the pace of change is staggering, which makes the internal dynamic itself disruptive, demanding enormous adaptive capacities at all levels. Furthermore, it is important to understand that the type of knowledge being generated and the way in which it is applied to different realities causes it to change radically. In other words, it invades everything, ranking from traditional business models and industries to long lasting institutions, also causing disruptive changes in all of them. This speed of internal change is then transferred to the exterior (i.e. the environment), creating a rapid and double route of transformation in the economy. Dysfunctions, malfunctions or obstacles (to innovation) which cause different impacts arise when there is an imbalance between the two speeds, what in the context of the EED approach we have referred to as the consequences of epigenetic dynamics (see Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups" in this book by Gómez-Uranga et al.).

When the internal speed is much faster than the external, processes of acceleration may occur which lead to the elimination of certain agents from the ecosystem.

When the external speed matches the internal, traditional industries break down and new activities arise from old ones. These may have very different market valuations, which trigger relevant dysfunctions in the job market, etc. At the present time, health, financing, telecommunications or the higher education are areas that may undergo radical transformations in short as a result of the epigenetic moves of the large firms in the Internet ecosystem.

Nor can we overlook the fact that the digital ecosystem is formed by multiple subsystems, which count with different types and which are in continuous interaction. New phenomena, which need also be analysed, also emerge from these frictions and interrelationships, thus enabling us to understand the evolution of the ecosystem as a whole. More specifically, we might regard the GAFA (see Chapter "Epigenetic Economics Dynamics in the Internet Ecosystem" in this book by Zabala-Iturriagagoitia et al., and Chapter "GAFAnomy (Google, Amazon, Facebook and Apple): The Big Four and the b-Ecosystem" by Miguel and Casado) as two-sided markets; namely, companies that occupy a significant position on both markets and among citizens, with a strong innovation push, a global nature in their activities, all of which systematically influence the everyday activities of citizens, firms and public organisations of all ranges and types. Furthermore, they are the leaders in a complex ecosystem formed by reticular relationships which include different, yet also complementary, industries, activities and agents.

All of these form an ecosystem whose key characteristic is dynamic coexistence of organisations (i.e. the GAFA and their corresponding business ecosystems) engaged in hardware, software and content in varying proportions and in a systemic manner. Put differently, the GAFA function in a global and interdependent way so that they can provide consumers with higher value by offering the sum of the parts as a whole and in context (see Chapter "GAFAnomy (Google, Amazon, Facebook and Apple): The Big Four and the b-Ecosystem").

The conceptual discussion is useful and of interest, due to the implications it carries out. However, although each of the GAFA may be considered a business ecosystem (see Chapter "Epigenetic Economics Dynamics in the Internet Ecosystem"), the fact remains that the entire new digital communication world is a large ecosystem where agents set up as subsystems, which are directly interrelated. Thus, it is not only necessary to study the systemic dynamics of each of the GAFA but those of all of them as a whole, as they also go beyond the global level and overflow into other productive sectors and the entire economy. In this regard, Chapter "Epigenetic Economics Dynamics in the Internet Ecosystem" pointed out some of the consequences (i.e. malfunctions or dysfunctions) that the dynamics observed in the Internet ecosystem in general and on the analysed GAFA in particular have over a set of systemic elements such as fiscal policy, the treatment of intellectual property, competition, as well as social, cultural, or the rights of privacy of individuals.

Proof of this is that the GAFA mutually identify each other as competitors in the 10-K Forms they need to report to the United States Securities and Exchange Commission, and behave in this manner in the market game. They compete against each other for clients but also for sources of funding, or form alliances with other stakeholders to manufacture their devices, they provide incentives for

developers to use their platforms and APIs, etc. Interrelation is thus extremely complex and interdependent, often of a type never seen before and with a high potential to overflow and devour resources, generating a new profile or version of the crowding-out effect (Aschauer 1989) in this case to other productive sectors.

Being a leader in this framework implies high innovation levels, what in turn requires highly dynamic and innovative capacities. To achieve this, and due to the fact that the endogenous rhythms of innovation processes of the GAFA do not happen to be flexible enough or sufficient, these groups are often forced to support their innovation processes and strategies from acquisitions, both from other companies as intellectual property rights of third parties. It should not be overlooked that the developers, a priori outside agents to the GAFA, also constitute one of the core areas on which the latter pivot their innovation strategies and decisions (see Chapter "The Digital Ecosystem: An "Inherit" Disruption for Developers?" in this book by Vega et al.). Finally, we should also mention the integration of new talent and competent human resources incorporated by these large business groups.

The competitive dynamics of the GAFA have some particular characteristics. Each works comes from being specialist in an industry (original routines and competences, which have often been regarded along the book as the original DNA of the business groups) where the others barely have any options to perform and grow. Thus, and to a certain extent, there is monopolistic competition. However, in the system as a whole, these firms hinder each other's mutual growth. Continuing with the epigenetic metaphor, the system is like a forest where each tree competes to have more space to grow. In this case, we might even say that the forest is formed by trees of different species, due to their different DNAs.

In this forest, the GAFA act as platforms where intermediation power becomes the strength to determine the "meeting point" between content providers and customers. As previously discussed, they are two-sided platform markets and as such, provide us with understanding about markets which are affected by global networks. This means an increase in the number of users on one market attracts those from another market. That is to say, the number of users in one group increases as the number in the other group does, creating a great incentive to form the highest concentration of activities (see Chapter "Epigenetic Economics Dynamics in the Internet Ecosystem"). On the other hand, they are complex platforms which, in turn, are connecting and intertwining, creating new ones, undergoing thus modular growth that strengthen the ecosystem rather than challenge it. Limitations derive from the urgent need to differentiate and the capacity and potential for diversification in this same process. The comparison with trees in the forest remains valid.

Competitive tendencies stimulate the closed (self-sufficient) nature of these systems and thus prevent the 'commodity system effect' (see Chapter "GAFAnomy (Google, Amazon, Facebook and Apple): The Big Four and the b-Ecosystem"), but their complexity makes them dependent on resources and therefore partially open. This is the case of developers, and particularly, the case of the Apple–Samsung partnership. The latter provides the former with strategic components and, as a result, has relevant information on innovation, quality and marketing strategies (see Gómez-Uranga et al. 2014). A cooperative and competitive relationship (i.e. often

referred to as 'coopetition', see Brandenburger and Nalebuff 1996) is established between the two which also relates to the characteristics of epigenetic and systemic dynamics, as long as the two of them see themselves obliged to adopt certain decisions due to the pressure from the environment. In the same respect, we also find financial needs being strongly associated to the previous moves. The need for resources is so great that the tension between autonomy and openness is constant and dialectic. This complexity leads us to a context in which multiplier effect economies do not occur. Nor do economies of scale, synergies or cost economies in traditional terms although strong interrelationships and large dimensions do. It could be said these are 'symbiotic economies'.

A highly relevant amount of information is used and handled, knowing that their systematised digital mode management (i.e. the Big Data), leads to positions of knowledge and socio-economic actions which have been completely unknown to date. These have an enormous potential, not only for large public and private organisations, but also for small start-ups, developers and even individuals at large (see Chapter "The Digital Ecosystem: An "Inherit" Disruption for Developers?"). We therefore find ourselves, following our epigenetic approach, in a huge forest which is growing and expanding, in the competitive coexistence of different plant and animal species with their own biological legitimation processes, at least in their initial stages of development. If we would be able to show, with a certain temporal perspective, that this is the case in the Internet ecosystem as a whole, then it could be said that these dynamics would explain the different competitive natures of the epigenetic process in this macro-ecosystem. The macro-ecosystem has factors which are both material and immaterial, located and de-located, which end up creating a typical working space that penetrates the traditional economic space, thus giving it new forms and content.

In the field of telephony, as it has been discussed in Chapters "Future Paths of Evolution in the Digital Ecosystem" and "4G Technology: The Role of Telecom Carriers" in the book, the combination of telecommunications infrastructures and the computer world, which includes mobile network operators on the one hand, and over the top firms on the other, we find that there are truly asymmetric benefits due to positions of power and economic results, with the latter clearly winning out. It should not be overlooked that in addition to the millions invested by mobile network operators, they are subjected to much higher regulatory pressure than over the top firms.

From an epigenetic approach, it seems that the former have not evolved and adapted parallel to the latter. These asymmetries are accelerating with the arrival of 4G technology, which will force mobile network operators to make new moves (i.e. decisions) and adopt new dynamics if they are to avoid being excluded from the value chain, as they are obliged to gain a stronger foothold in the advent of the Internet of Things.

Ultimately, the market structure is far from being perfect competition. There are monopoly areas and many monopolistic competition areas, with the well-known entry barriers that are not only placed on economies of scale, but also reach knowledge agglomerations and the barriers to access resources. Disruptive innovation dynamics and their Schumpeterian relationship with socio-economic progress also arise in this context. Some of the points mentioned can also be illustrated by

planned obsolescence as a strategy to achieve a certain level of innovative tension, which creates demands and excludes potential competitors. Nor can we overlook all the differentiation strategies that aim to create loyalty, which goes beyond the brand to reach operating systems and production logics. Oligopolistic logics are also found on these markets, with their corresponding strategic interdependence, tendencies to collusion and leader–follower dynamics.

The Internet being a business sector with a markedly horizontal activity, which affects many other sectors of activity and even infrastructures and institutions of the public interest, regulatory pressure is particularly high in some fields. In addition to other aspects, this issue creates exit barriers and institutional barriers that make the sector and its expansion even more complex. As per institutional barriers, it is important to note that companies create international environments in the digital world, making regulatory systems highly or even totally inefficient (see Chapter "Epigenetic Economics Dynamics in the Internet Ecosystem").

For all of the above, economic analysis usually falls somewhat short of offering explanations and predictability of the digital world. The epigenetic logic introduced in this book, and ultimately the ecology-biology analogy, may therefore be even more appropriate as a body of knowledge to offer explanations and predictability.

2 The Epigenetic Analogy and Digital Ecosystems

Digital and communication ecosystems form a new scenario on the world socioeconomic panorama. It therefore does not only constitute an area in which the epigenetic analogy can be applied as an illustration of high-velocity markets, but it is also creating a new industrial revolution. In this respect, the environment-business ecosystem relationship, which our epigenetic approach is distinctive for (see Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups"), becomes highly dialectic in this context, and gradual iteratively mutual influencing phenomena occur. That is to say, the Internet ecosystem addresses the evolutionary demands posed by the environment, although in turn, it also creates new environments which call for new evolutionary demands and so on.

In this regard, it can be considered that there is a double creation of environments. On the one hand, there are intrinsic environments (i.e. those occurring within the business ecosystem formed by each firm), which are digital in nature and therefore closely related to the original production mode followed by the firms themselves. This scope would include the dynamics that involve mobile network operators (i.e. telecommunications companies) on the one hand, and digital firms selling telephony equipment, tablets, software firms, etc. on the other.

We also need to consider here the environments created as a result of the cross-cutting nature of the digital world's use or application in other economic sectors or industries. References are being made to the arrival and development of digital technologies in fields such as the manufacturing industry, health, education,

mobility, construction, etc. The qualitative changes caused are usually so large in scale that they may even break down the traditional dynamics of these sectors. Cases in point are the Industry 4.0 and e-health. In this manner, the digital world exports its dynamics to other sectors and, makes them its own to a certain extent. It can thus be said that a third type of environment emerges and establishes the relationship between the two former ones. This third environment would actually form part of digital ecosystem, and therefore it should be included in analysis. In the book, this third environment has been partially included in the analysis of the consequences of epigenetic dynamics. However, as discussed in Chapter "Epigenetic Economics Dynamics in the Internet Ecosystem", the analysis of the consequences is still rather partial, as the consequences are only observed ex-post. Therefore, this remains a matter of further work.

One of the problems encountered in any analysis undertaken within the Internet ecosystem is the definition of the borders. Setting topological markers proves difficult due to the dynamic nature of the ecosystem concerned, its powerful permeability and penetration in other production sectors and its "eagerness" to radically transform these. It is a dynamic with limitless expansion, which means we could consider it as an open growing ecosystem. This is illustrated by the figure below, which follows, reconsiders and further develops the EED approach introduced in Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups".

This topological difficulty is transferred to the core issue of the strategic scope and industry configuration, in other words, the environment-organisation relationship. The environment may thus be considered to play the leading role as the driver of change, or this priority may be given to the substantial capacity of organisations to address or respond to changes in the environment. If the former is considered vital, environmental pressure is then understood to push selection and, as such, evolution (Hannan and Freeman 1977). This approach also implies that survival is based on successfully fighting to obtain the resources available in the environment (McKelvey and Aldrich 1983). In fact, very often the dynamics of the big Internet business groups are regarded as "the winner take it all", due to their enormous economies of scale, scope and network effects.[1] The profile or characteristics of the population under study are highly relevant from this point of view (Salimath and Jones 2011). Thus, one of the key explanatory variables to be considered in relation to the performance of the firms is the size of that population (i.e. number of firms competing in it). Population density and population mass (i.e. weighing each organisation by its size) are used as representative concepts in this regard (Bataglia et al. 2009; Freeman and Anderies 2015).

[1]The software industry in general, and the Internet ecosystem in particular, can be regarded as sectors where the main share of the total cost of the firms operating in them is a fixed cost. Accordingly, as the size of the companies becomes larger, the costs continue dwindling. In fact, since the marginal cost is almost zero, if there were perfect competition, the equilibrium price would also be zero.

When focusing on the population density and applying the density dependence model[2] (Hannan 1989), it can be said that legitimation and competition affect organisational dynamics from the perspective of firm survival. Legitimation is a sociological process which, in our case, confirms a certain type of organisation as the dominant one to face the demands involved in capturing resources in the environment, thus making it possible to take advantage of the opportunities offered. From this perspective, an active environment boosts the creation and proliferation of certain organisations over others. An increase in said organisations, in turn, enables them to capture the necessary resources more efficiently as synergistic effects are generated with the environment.

All of these issues fit squarely into the digital world, its arrival as a sector or industry in itself and as a cross-cutting application. Therefore, in other industries it is generating legitimation processes where organisational types share a minimum of key factors and, on the other hand, the number of organisations that emerge from this scope is also very high. In fact, it is difficult for firms in the digital world to escape from other competitive sectors. In the strictest sense of the digital ecosystem, namely, adopting a narrow view of the ecosystem in which only firms that belong to it are considered, legitimation processes like those described also occur.[3] The competition factor comes into play. In other words, legitimation enables a more efficient resource management. However, once the number of organisations and active players has grown to a certain number, and according to the evidence of the density dependence model, we reach an inflection point after which companies need to compete for the limited resources available (e.g., human, financial, technological). In other words, an U-inverted shape can be observed. We can also observe this aspect in the digital world, where dynamic legitimation processes are being accelerated over time.

The ability to determine the said number of active organisations could help to anticipate and/or understand some competitive dynamics. In this same respect, and simultaneously, organisations undergo concentration processes and make large acquisitions. This process is accelerated insofar as the size of the firm has a direct impact on its competitive strength (Winter 1990). Large acquisitions, either through processes of expansion, diversification, or mergers and acquisitions, create complex dynamics in which expulsion phenomena (i.e. the big fish eats the little fish) and cooperation phenomena occur, in which small organisations (i.e.

[2]This model and the following one are used in the field of Organizational Ecology to establish the competitive atmosphere and explain the mortality rate of organizations (Hannan and Freeman 1977; Hannan et al. 1995; Baum and Shipilov 2006). Organizational ecology is a valuable addition to the repertoire of theories that guide digital innovation policy when extended to community and ecosystem levels (Su 2011). Given the nature of the subject of this book, part of its findings and development may be applied to the EED approach introduced in it.

[3]As discussed in Chapter "Epigenetic Economics Dynamics in the Internet Ecosystem", an additional value of a device (e.g. tablet, Smartphone, etc.) increases the value of the previous device, insomuch as a general service is offered, at the same time, it works to increase the business ecosystem, which provides a substantial value in the product or service being offered. This is what Kelly (1998) labelled as the "fax effect".

start-ups and developers) gravitate, showing a large dependence, to the big ones. This would take us to the population mass scope. At this point, it would also be useful to know the impact of population mass on each sector and its direct relationship with legitimation and competition.[4]

From the organisational ecology perspective (Hannan et al. 1995; Becker 2007), and considering each organisation as a "test" to address the demands in the environment, it seems logical to think that the more tests, in other words, the more organisations there are, the higher the likelihood of successful realities when effectively addressing environmental pressure. To some extent, this is occurring in the digital world and its different "worlds", which would be those created as the digital world is introduced in other sectors. The capacity for success also depends on the extent of its organisational and productive logic. The more organisations and dynamism there are, the higher the probabilities of "finding" the most appropriate organisational types.[5]

An alternative point of view gives higher prevalence to the intrinsic capacity of organisations as competitive strength, rather than to pressure from the environment. This implies that organisations' functions, routines and resources (i.e. dynamic capabilities in the sense of Teece et al. 1997; Teece 2007, 2012) are what make them capable of continuing to properly nourish themselves and form combinations. Within the genetic code expressed in the original routines of the business groups, certain aspects that contribute to a proper evolution may arise, either from a phenotypic or a mutative perspective, with aptitudes for plasticity in rapidly evolving environments (i.e. high-velocity markets), and which allow an adequate relationship with relevant stakeholders (see Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups"). Finally, it cannot be overlooked that this world is party to a new industrial revolution and, as such, creates a new environment. As has been stated in this chapter (see Fig. 1), we are in front of a global and open ecosystem in a continuous expansion.

There are new analytical challenges for the biological analogy in general, upon which the field of evolutionary economics is based, and for the EED approach introduced in this book in particular, that require the construction of models with

[4]In relation to the density dependence model, a mass dependency model can also be found (Barnett and Amburgery 1990). From this point of view, the size or the organizational dimension is understood as the main variable explaining the competitive behavior, so that firm competitiveness is positively related to size. However, far from density and mass being alternative explanations, they may be compatible and can improve our understanding of the sector's behaviour. Along these lines, there are very interesting developments in Moyano and Nuñez (2002, 2004) applied to sectors different to the digital one, which make the two models compatible.

[5]As far as the present study is concerned, the most appropriate focus may be synthetic, in which the external approach (i.e. the environment induces change) can be made compatible with the internal one (i.e. internal capacity determines evolution). Given its complexity, formed by its own cross-cutting dynamics, the digital world creates fields to test the two approaches simultaneously. However, it is more difficult to track the endogenous or internal approach in comparison with the external one. The latter has some quantitative indicators such as density and mass that make it possible to run reasonably accurate analyses.

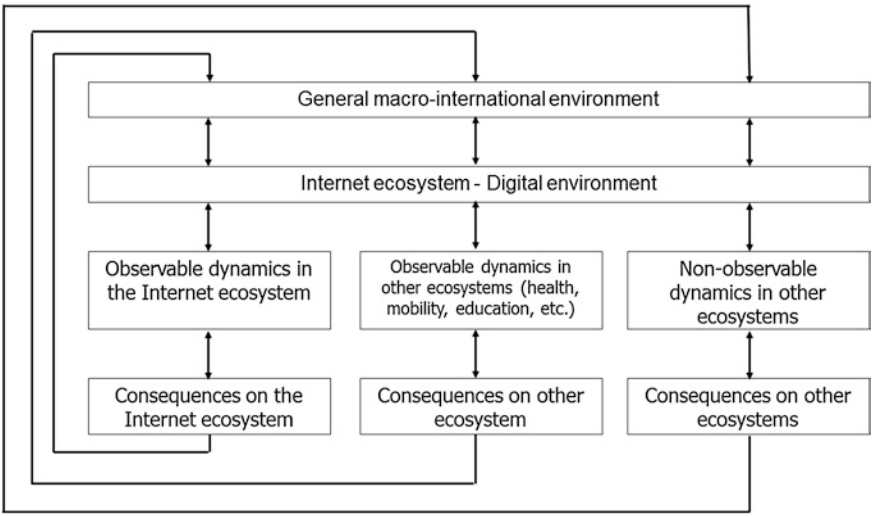

Fig. 1 Reframing the EED approach. *Source* Own elaboration

explanatory and predictability potential so that they can orient policy makers' and business management's decision-making. This last aspect is an even more sensitive subject and calls for further research, which we aim, as a community, to be able to accomplish in the following years to come.

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