Epigenetic Economics Dynamics in the Internet Ecosystem

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1 Introduction

We are witnessing a very rapid development of mobile telephone-related sectors, firms, and technologies on the Internet. The changes being perceived at the present time are characterized by their high speed, giving rise to high velocity markets and high velocity environments (Eisenhardt and Martin 2000). In such environments, a number of dynamics are not explained by evolutionary principles. This chapter focuses on the dynamics observed in the Internet ecosystem as an illustration of the abrupt changes occurring in these high velocity environments (Fransman 2014).

Apart from well-known, established firms like Google, Apple, Facebook, Amazon, Samsung, Microsoft, IBM, Intel, Twitter, or Yahoo, new arrivals are increasingly occupying leading positions in the market. In particular, Chinese software firms like Baidu (the Chinese Google), Alibaba (the Chinese Amazon), Tencent (the Chinese Facebook), Weibo (the Chinese Twitter), and telecom providers like

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China Mobile, Huawei, Xiaomi, or ZTE are challenging the global leaders. In this chapter, and following Miguel and Casado (see Chapter "GAFAnomy (Google, Amazon, Facebook and Apple): The Big Four and the b-ecosystem"), these few but large business groups will be described as the GAFAs (an acronym formed from the initials of Google, Apple, Facebook, Amazon, etc.) In short, the software ecosystem and the Internet ecosystem are particularly characterized as being small worlds led by few actors (Iyer et al. 2006). Most of these companies are very young, with a clear entrepreneurial origin. However, their short lives did not prevent them from being among the companies with the highest market capitalization at the end of 2014.

The fierce competition amongst these groups forces them to innovate in a continuous, systematic and particularly agile and quick manner. They are thus not only able to anticipate their rivals, but also to change—quasi endogenously—the ecosystem they compete in. Each company's staggering rhythms of innovation not only seek to change their own business ecosystem and the overall Internet ecosystem, but also to rapidly adapt their own ecosystem to the latter.

The goal of this chapter is to analyze the evolution and dynamics observed in the GAFAs, determining how these firms expand and diversify their activities, in what we refer to as epigenetic dynamics. Our aim is to understand how epigenetic dynamics of the business groups mentioned above address change in response to variations in their environments.

To a great extent, the evolution and speed of the dynamics in the Internet ecosystem are being affected and determined, among other factors, by[1]:

- An exponential reduction in the costs of means, infrastructures, equipment and tools used by users and developers, which together allow for improvements in delivery times and connection speeds.
- New materials that can replace those in use to date in key elements such as processors, devices or power supplies.
- The speed at which certain services such as mobile payment, e-commerce, etc., are being deployed on networks.
- Competition among multiple and diverse actors, especially among "big business groups," for the control of global markets and technologies. It is also worth highlighting the new race between large Internet companies (i.e., the GAFAs) on the one hand, and large telecom operators (e.g., Verizon, AT&T, Deutsche Telekom, Vodafone, Telefonica, and Orange) on the other.[2]
- The development of the Internet is also associated with certain challenges, which can compromise its potential advance and introduce uncertainties in relation to its development speed. In particular, we are referring here to the dangers associated to cyberattacks and the lack of security for information circulating on the Internet, which threaten each and every one of the actors engaged in the production and use of the Internet.

[1]See also Frey (2015).

[2]With respect to the above-mentioned determinants it is not possible to know in advance the speed and intensity with which they may occur.

However, it is not a matter of falling prey to fatalism that denies any reasonable progress, since organizations (public and private) can find ways to face the risks associated with attacks that afflict players participating in open networks. Following the Epigenetic Economic Dynamics (EED) approach described in Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups" of this book, all trends mentioned thus far will be explored as variations of the environment and the subsequent economic, social, political, ethical, etc., consequences, derived from the risks that individuals, business groups, and countries are plagued by.

We have discussed how adaptation to rapid changes in business environments gives rise to epigenetic dynamics. A large part of epigenetic dynamics is due to the groups' external relations, such as purchasing external assets, like small start-ups created by developers. Patents are the other key determinant of the epigenetic dynamics observed in the case of the GAFAs. This chapter on the dynamics of the large Internet industry groups therefore focuses on their patenting behavior and the mergers and acquisitions (M&As) completed.

The diversification paths followed by the GAFAs illustrate that most of these paths go against all odds or predictability. This makes prediction of the GAFAs' dynamics almost impossible ex-ante, because despite these business groups having an original and dominant specialization (i.e., DNA), they become active in areas that are unrelated to their original specialization. Accordingly, all groups become involved in the dynamics of the other groups, so "everyone does everything" and therefore "competes with everybody." This behavior finds its rationale in the fact that all the firms in the Internet ecosystem are interested in pursuing and positioning themselves in every dominant vector, because they cannot leave areas or segments to one side or unattended. Even if due to the specialization of each company their presence in every dominant vector may not be efficient from an economic point of view (i.e., they do not master the required skills or have the necessary competences internally), they must cover these segments to avoid being relegated or removed from the competition due to the dominance of the other actors in these segments. As a result, instead of talking about competing firms, large industrial groups on the Internet are regarded as "business ecosystems" (Moore 2005; Jing and Xiong-Jian 2011).

Patents are one of the aspects that best characterizes the epigenetic dynamics of the Internet business groups we address in this chapter.[3] The GAFAs need to acquire large portfolios of thousands of patents not only to protect those areas that represent their core capabilities (e.g. Google with its Android and the acquisition of Motorola's patent portfolio), but also to gain access to those areas where they do not have particular strengths. Such convulsive patent purchasing is known as the patent war (Carrier 2012; Paik and Zhu 2013; Lim 2014; Cass 2015), which is particularly relevant in the context of the GAFAs (Gómez-Uranga et al. 2014). Thus, an exacerbated patenting behavior can be observed, particularly as regards the increase in the number of patent applications (voluminosity) in recent years

[3]We are very much aware of the bias in using patents as a proxy for innovativeness. However, given the remarkably high patenting in the industry, we believe this indicator can provide an accurate picture of the dynamics within it.

(van Zeebroeck et al. 2009). The same outcome can also be observed regarding the acquisition of patent portfolios and business groups that initially were not involved in areas related to the Internet ecosystem (e.g., health).

The purpose of this chapter is to analyze the extent to which the GAFAs' dynamics are more or less disruptive, and therefore closer to or further from the original DNA of these groups. In this regard, we pose the following hypothesis in relation to the EED approach outlined in Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups": the further from a given branch of activity a firm is, the more disruptive their epigenetic dynamics will necessarily be, as this distance forces the firm to take fast and radical measures to get into these new branches. To test this hypothesis, we first describe some of the GAFAs' dynamics during the last 3 years (2012–2015). We then analyze whether the observed epigenetic dynamics can be explained by the patenting behavior of these business groups. To achieve this goal, we study the patents granted to these groups at the USPTO. Our study is focused on the USPTO instead of on the EPO or the PCT patents because the patenting of software, which is one of the central elements that helps characterize and explain the GAFAs' evolution, is permitted in the US (Chingale 2015; Useche 2015). Our aim is thus to analyze the behavior of the groups in their patent portfolios to illustrate the EED approach. In this way, we aim to provide an answer to the following research questions (RQ) in relation to patents:

- RQ1: What technological areas are the GAFAs moving into over time? Are they related to these groups' DNAs?
- RQ2: Are these diversification dynamics similar across the GAFAs?

The next aspect that we focus on in order to explain the epigenetic dynamics identified is that of the M&As carried out by these groups. In this regard, the number of M&As completed by each of the GAFAs, and the amount of investment required are discussed. As with the case of patents, in the case of M&As we also aim to analyze whether the newly acquired companies are related to the original and dominant specialization of each business group or if, on the contrary, the M&As are carried out in a defensive mode so as to guarantee a fast adaptation to the new environment. The research questions we aim to address in relation to the M&As can be formulated in the following way:

- RQ3: What is the amount of investment required?
- RQ4: Are there different strategies among the firms or do they follow similar paths?

The relevance of external sources of knowledge as determinants of innovation has been emphasized in the literature from a wide variety of approaches. The literature on innovation systems highlights innovation as being the result of dynamic social and economic processes based on learning and interaction among actors (Lundvall 1992). Network theories (Håkansson 1987) also maintain that companies rarely innovate individually and that the introduction of new products or processes in the market depends on their ability to cooperate with external agents. Similar arguments are also posed from strategic management perspectives, which note that the

search for new ideas, new organizational forms, etc., surpasses the boundaries of the organization (March 1991). Chesbrough (2003) describes this phenomenon as the rise of open innovation modes (Huizingh 2011; Mortara and Minshall 2011; van de Brande et al. 2009).

However, the concept of absorptive capacity (Cohen and Levinthal 1990; Zahra and George 2002; Engelen et al. 2014) suggests that internal capacities can only be improved in the knowledge bases that are relatively close to those available into the firm. In other words, a company will be able to exploit external knowledge as long as this knowledge can be identified and assimilated. This has led some scholars to introduce the concept of "related variety" (Frenken et al. 2007). As Asheim et al. (2011) discuss related variety refers to a set of complementary sectors that share capabilities and competences so that it becomes easier to understand and absorb each other's knowledge. The underlying idea is that "a region specializing in a particular composition of complementary sectors will experience higher growth rates than a region specializing in sectors that do not complement each other" (Frenken et al. 2007: 686). Consequently, related variety-driven firms, entrepreneurial ventures, territories, etc., reduce the risk of selecting "wrong" activities since the existing competences are taken as the point of departure in order to broaden the economic base.

Specialization in certain fields tends to increase the risks associated to potential external shocks due to a lack of diversity. In contrast, it can also be argued that the wider the sectoral variety, the higher the probability of promoting economic growth. Accordingly, it should also be noted that although these variety-driven spillovers can lead to risk reduction, they may also reduce the probability of obtaining higher profits. This is what is often known as the "unrelated variety" phenomenon. According to this, when one sector is hit by an economic downturn in a territory with a high degree of unrelated variety, this will not negatively affect the other sectors. In sum, while unrelated variety safeguards against external shocks, related variety is expected to be beneficial for Jacobs externalities in the form of knowledge spillovers (ibid: 688).

Several studies have been conducted on these two concepts (see Parrilli and Zabala-Iturriagagoitia 2014), studying whether territories specialized in certain activities, industries or products (i.e., where related variety is in place) are more conducive to innovation and growth as compared to other locations that have more diversified industrial structures (i.e., unrelated variety). In this case, this chapter examines the diversification paths followed by the GAFAs through an analysis of their patenting strategies and their M&As, in order to determine whether their strategies are related or unrelated varieties.

Finally, and following the methodology outlined in Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups" in this book, we also analyze the consequences of these epigenetic dynamics. This analysis of consequences is mainly limited to the patent system, although other dimensions are also discussed. Intellectual property has become one of the main pillars of the economic dynamics of Internet industry groups. Patent lawsuits for infringements and violations are quite common (Cunningham 2011). The biggest disputes have taken

place in the mobile phone business and have even affected consumers. In turn, these lawsuits create a large number of ad hoc alliances out of sheer self-interest, thus distorting the original defining features of each group and, above all, hindering possible innovations, competition and progress for users. Sometimes companies seriously damage the competition with lawsuits, asking courts to stop the sale of their rivals' products. In this regard, a distortion in the rationale for patenting, excessive transaction (and litigation) costs, high entry barriers to SME patenting, problems in the definition and development of standards and an overload in patent offices and regulating agencies are regarded as the main consequences or malfunctions.

The large amounts of financial and human resources that must be devoted to patenting and patenting litigations also become key entry barriers for small developers and start-ups. All these consequences ultimately create disincentives or anomalies for many innovative firms and entrepreneurs, which contrasts with the rationale of the patenting system for supporting the development of further innovations.

The rest of this chapter is structured as follows. Section 2 introduces the concept of business ecosystem and its usefulness in understanding the dynamics of the large Internet industry groups. In addition, it discusses some of the characteristics that define the Internet ecosystem. Section 3 provides some of the main structural characteristics of the firms under study, and illustrates the business ecosystems of the GAFAs under study. Section 4 provides a preliminary introduction to the epigenetic dynamics that we have observed in the evolution of the GAFAs. It helps understand their expansive strategies, the new industry segments they are active in and how patents and M&As become essential in explaining these moves. Section 5 provides the main patenting dynamics that are observed, while Sect. 6 does so with the M&As. In both cases, firms are analyzed separately since each of them covers different periods due to the differences in their year of constitution. Understanding what these consequences are opens the way for the definition of more effective policies in a variety of domains, such as science, technology, and innovation policy (both from the side of supply and demand-side instruments), industrial policy, entrepreneurship policy, employment generation, regional development, education, the institutional environment (i.e., regulations), the patent system, etc. Finally, Sect. 7 concludes by discussing some of the most relevant consequences of the previous epigenetic dynamics.

2 The Internet as a Business Ecosystem

The EED approach is the main focus of this book. However, in this chapter the study of the GAFAs' dynamics is approached not only from an epigenetic perspective but also from that of the business ecosystem. In this way, we intend to bring together two streams of literature (one proceeding from molecular biology and the other from industrial systems) that each have their own logic (Herstatt and Kalogerakis 2005; Cordes 2006).

Referring to the main differences between biological and industrial ecosystems, Daidj (2011) highlights that the evolution of a business ecosystem depends on the decisions made by firms and the institutional and regulatory framework around them. These decisions are intentionally made by the firms themselves,[4] in the sense that they use them to achieve a certain goal or move in a certain direction. However, such intentionality is not found in biological ecosystems.

The business ecosystem approach helps us explain how business groups are being structured with regard to their respective stakeholder groups (e.g., customers, users, suppliers, investors, institutions, regulatory authorities, standard-setting bodies, etc.), the relationships with these and the overlaps and/or conflicts that may emerge with other business ecosystems (Teece 2007). However, it does not make it possible to reach a comprehensive understanding of their evolution, although like any ecosystem they are undergoing continuous evolution (Gueguen and Isckia 2011). To address this gap, we rely on the use of the EED approach. Therefore, in this chapter, we intend to make the two approaches complementary, as they allow us to study the same units of analysis but from two different angles.

But what is an ecosystem? There are many scholars who have tried to incorporate the concept of ecosystems into different streams of the literature (Bijker et al. 2012; Autio and Thomas 2013; Clarysse et al. 2014). The concept of industrial ecosystem was first introduced by Frosch and Gallopoulos (1989). From their view, an industrial ecosystem functions as an analog of biological ecosystems. Their reflection dealt with the impact and consequences of technology on industry and society at large. Their main interest revolved around the optimum consumption of energy and materials, minimization of waste generation and the maximization of material reutilization (i.e., recycling).

The economy as an ecosystem was first introduced by Rothschild (1995), for whom a capitalist economy should be understood as a living ecosystem in which competition, specialization, cooperation and growth should be regarded as determinants of economic behavior. Rothschild equated firms with biological organisms and industries with species. Firms and industries also have their own genes, which, in part, determine their behavior; and, like living organisms, firms also relate to other actors in the ecosystem, where other predators and prey also coexist.

The concept of business ecosystem was first suggested by Moore (1996), who considered that biological metaphors could be useful when understanding economic and industrial processes. Moore initially defined a business ecosystem as an

[4]We will not engage in a discussion here on whether these decisions are voluntarily made by the firms because they are part of their strategic reflections or because the environment somehow "forces" them to do so. Nor will we focus on how these decisions are made, namely: individually or collectively; fast or slowly; following systematic, routinized and structured processes, or chaotic and improvised ones instead; and adopting a heuristic approach or a strategic one, in which information is gathered to form a comprehensive picture of the environment and the firm's relative competitive position in it (Bourgeois and Eisenhardt 1988; Eisenhardt 1989, 2001, 2013; Judge and Zeithaml 1992; Clark and Collins 2002; Hernández-Martínez 2006; Bingham et al. 2007; Christiansen and Varnes 2007; Davis et al. 2009; Hadida et al. 2015; Palmié et al. 2015).

economic community based on a set of interacting individuals and organizations (Moore 1996: 26). In his work, market leaders were characterized as keystones that had a fundamental influence on the coevolution processes of the ecosystem (also see Jansen et al. 2013). However, in his later work he moved on to consider many other types of stakeholders, which were considered "mutually supportive organizations" as agents that could be encompassed within a single business ecosystem: "Business ecosystems are communities of customers, suppliers, lead producers, and other stakeholders—interacting with one another to produce goods and services. We should also include in the business ecosystem those who provide financing, as well as relevant trade associations, standards bodies, labor unions, governmental and quasigovernmental institutions, and other interested parties. These communities come together in a partially intentional, highly self-organizing, and even somewhat accidental manner. But the result is that the members provide contributions that fill out and complement those of the others" (Moore 1998: 1681–69). Finally, Moore (2005) considered that the agents in an ecosystem and the decisions they make are influenced by those of all the other actors in the same ecosystem. Business ecosystems would thus "refer to intentional communities of economic actors whose individual business activities share in some large measure the fate of the whole community" (Moore 2005: 3). In this manner, the members of an ecosystem may form a broad system of organisations that support each other mutually: communities of customers, suppliers, leading producers, business associations, standardization bodies, etc., which are interested in joint work and cooperation for the good of the community. This is the way in which the concept of business ecosystem is understood in this chapter.

For Iansiti and Levien (2004), the concept of business ecosystem is worth considering for analysis of the structure of large business groups, because, as in the case of biology, in the economy there is also a wide variety of agents (i.e., individuals, organizations, institutions) in continuous interaction and which are mutually dependent for their respective survival. As a result, Iansiti and Levien discuss how robust organizations are and whether or not these are able to adapt, and therefore survive, vis a vis internal and/or external changes.

According to Iansiti and Richards (2006) and Gueguen and Isckia (2011), the concept of ecosystem reaches its maximum expression in ecosystems such as those of Apple, Amazon, Google, or Facebook.[5] These groups are characterized by their high and rapid innovativeness and the large number of actors that are embedded in their respective ecosystems. In this regard, after a careful review of the literature, Autio and Thomas (2013: 205) conclude that an innovation ecosystem can be defined as "a network of interconnected organizations, connected to a focal firm or a platform, that incorporates both production and use side participants and creates and appropriates new value through innovation."

[5]Autio and Thomas (2013: 208) also consider the adequacy of the concept of ecosystem when applied to organizations (i.e. hubs) like eBay or platforms like Android.

The concept of business ecosystem is increasingly being applied in the context of the Internet (Nachira 2002; Fransman 2014). Numerous studies can be found in the framework of business ecosystems (Corallo et al. 2007). To mention a few, Razavi et al. (2010) discuss how digital business ecosystems are based on loosely coupled interactions and have demand-driven properties and self-organizing characteristics, which may help small and entrepreneurial firms to constitute new networks and/or become embedded in already existing ones. A similar approach is followed by Ndou et al. (2010), who introduced a dynamic integrated focus based on the modularity concept, which shows several value creation potentialities within the context of digital business ecosystems. Karakas (2009) also considers that the web has become a digital ecosystem, which is characterized by creativity, community, connectivity, cooperation, and convergence.

Moore (2005) proposes that companies manufacturing Apple's iPod belong to the iPod business ecosystem. Basole (2009) analyses the interrelationship between device manufacturers, telephone operators, and platforms (Symbian and Windows). Jing and Xiong-Jian (2011) analyze the strategies of mobile network operators in China. Wan et al. (2011) approach the analysis of the Chinese software ecosystem according to stability factors (e.g., diversity, resilience) and sustainability factors (productivity, vitality, creativity). Similarly, based on the Italian context, Battistella et al. (2013) introduced a model to systematically study the structure and fluxes of the networks in a business ecosystem. Han and Park (2010) have mapped the relationships between the technology, products, and services they produce. Li (2009) explains how Cisco Systems has deployed an intentional M&A strategy to sustain its corporate growth, by means of the analysis of Cisco's technological roadmap according to their patents in the USPTO.

The business ecosystem approach assumes that there is in fact interdependence between the agents within an ecosystem (Adner and Kapoor 2010). However, the role and importance of each one varies, not only over time, but also within the multiple projects that may be underway at the same time within a particular ecosystem (Fig. 1). As an example, application developers are found in the area of software, and although some work with Android, others interact with Apple, others with Symbian, and many with all of them at the same time, meaning competition takes place in different ways in the ecosystem (OECD 2013). In other words, companies compete and cooperate with each other within an ecosystem (Gueguen and Isckia 2011).

Changes in ecosystems come from changes within, although they are influenced and sometimes determined, as in epigenetics, by what is happening around them (i.e., selection environment). Setting clear boundaries on where a certain ecosystem ends is a hard task due to their openness and permeability. The defining element of an innovation ecosystem is not a given product, but rather a coherent set of interrelated technologies and associated organizational competences that bind a variety of participants together to coproduce a set of offerings for different user groups and uses (Autio and Thomas 2013: 208; Geels 2014).

Competition and collaboration sometimes coexist, so it is often difficult to separate the two. Applications and content from a multitude of providers are supplied

Fig. 1 The map of the Internet. *Source* http://orig01.deviantart.net/91af/f/2014/070/a/5/map_of_the_internet_2_0__by_jaysimons-d781bst.jpg. Accessed 19 December 2015

through most of the GAFAs' platforms (e.g., their APIs[6]). These platforms are understood as the coordinating artifact that the firm at the center of the business ecosystem (i.e., each of the GAFAs) "uses, or the services, tools, and technologies that other members of the ecosystem can use to enhance their own performance" (Autio and Thomas 2013: 208). Platforms are also often associated with network or spillover effects, so that the more users adopt the platform, the more valuable this becomes to the owner and to the users, because of growing access to the network of users and often to a set of complementary innovations (Gawer and Cusumano 2012: 1; Gueguen and Isckia 2011).[7] Logic, in terms of market size, also merits a closer look in the case of the GAFAs. As a greater number of applications become available in their platforms, developers show a greater interest in creating new ones and the GAFAs in providing them. These applications form the foundations of the GAFAs' ecosystems because they are constantly increasing the platform's usefulness and value.

[6]In computer programming, an Application Programming Interface (API) is a set of routines, protocols and tools for building software applications. An API expresses a software component in terms of its operations, inputs, outputs, and underlying types. An API defines functionalities that are independent of their respective implementations, which allows definitions and implementations to vary without compromising the interface. A good API makes it easier to develop a program by providing all the building blocks. A programmer then puts the blocks together (Wikipedia, 2015—https://en.wikipedia.org/wiki/Application_programming_interface).

[7]In biology, these phenomena in which some species' actions help others is referred to as mutualism.

Software and application developers, for example, can be considered collaborators since they are embedded in the ecosystems of most GAFAs. They do not exclusively provide content for Apple, but also offer their services through other systems such as Google's Android. Competition in the ecosystem is thus not divided into separate activities but takes place within the whole, meaning that if another group wanted to compete with Apple (or any of the GAFAs), it would not only have to offer a better device than the iPhone, iTunes or the iCloud (the products/services of the other GAFAs), but an entire ecosystem of applications and content. Eaton et al. (2011) consider that in the particular case of Apple, the radical innovation that was produced with the introduction of the iPhone cannot only be explained by the device itself or the applications that can be installed in it, but rather by the platform around the phone itself, which is cocreated by Apple, the developers and other stakeholders.[8]

In biology, the concept of coevolution is used to illustrate the reciprocity of changes (Peltoniemi and Vuori 2004). Coevolution thus implies that when changes in a certain species are produced, these also induce changes in others (i.e., variation). Besides coevolution, other terms such as coexistence, predation, symbiosis, or parasitism could also be used to illustrate this phenomenon (i.e., in evolutionary terms we would talk about variation, retention and selection, changing routines, learning, developing absorptive capacity, and dynamic capabilities). In fact, for Gueguen et al. (2006), when a large firm acquires another and integrates it within its structure (i.e., vertical integration), this could be seen as a symbiotic or predatory process. Another example of symbiosis can be seen in Facebook's partnership with Netflix or Spotify.

Platforms, which support collaboration and relationships, are the mechanism that makes it possible to enlarge and organize an ecosystem. Platforms appear in different ways in information and communication ecosystems, whether they are operating systems (e.g., Microsoft, Linux), APIs (e.g., Google, Facebook) or the like. As we discussed earlier, even devices such as the iPhone or iPad could be considered platforms due to the multiple activities, actions, and services that can be used on them.

2.1 Characterizing the Internet Ecosystem

Having discussed some of the different views on ecosystems, our intention is now to stress some of the underlying features that help characterize the Internet as a business ecosystem (also see Rong et al. 2015).

(a) Competition takes place among ecosystems

During the past two decades of the twentieth century, vertical integration began to characterize the dynamics of large business groups globally. This increased the

[8]Eaton et al. (2011: 2) use the term generativity, which refers to "the ability of a self-contained system to create, generate, or produce new content, structure, or behavior without additional help or input from the original creators".

complexity of their strategies, because their movements (i.e., acquisitions, mergers, takeovers or alliances) could not be analyzed from a single point of view. In the case of GAFAs, their strategies are also becoming increasingly complex because different movements coexist in space and time, making it impossible to establish regulations a priori, as vertical integration strategies can only be analyzed retrospectively and on a case-by-case basis. This also applies to Internet regulation and hinders the implementation of industrial or competition policies.

The analysis of vertical integration already considered the existence of different industries that were related to the original activity of the company or group that was seeking integration (i.e., related variety). The concept of ecosystem allows competition to be understood in a more comprehensive way, as it makes it possible to consider not only the existing concentration in a specific industry but in the ecosystem. The fact that ecosystems are continuously undergoing rapid growth makes it impossible to control the whole ecosystem, leading to systemic failures that have a significant economic and social impact.

(b) The layers of the Internet ecosystem

As Barua et al. (1999) observe, the Internet economy can be characterized by its four-layer model (Table 1). Barua et al. (1999) first classify the Internet economy into two broad categories: infrastructure and economic activity. The infrastructure category is then broken down further into two distinct but related layers. The Internet infrastructure layer provides the physical infrastructure for electronic commerce, while the applications infrastructure layer includes software applications, consultancy, training, and integration services. In turn, the economic activity category is divided into two other layers: online transaction and electronic intermediaries. The transaction layer involves the ability to guarantee the development of direct transactions between buyers and sellers. Finally, the intermediary layer involves a variety of parties providing capacities such as certification, search and retrieval of services that reduce transaction costs, etc. (ibid).

The GAFAs are mainly located in layers 3 and 4. However, much of the software they use to manage their databases (e.g., Amazon) or to build-up their software (e.g., Google), together with the central role of the network infrastructure, are activities located in layer 2.

(c) The coexistence of competition and collaboration

As we discussed earlier, it is sometimes hard to draw a clear line between cooperation and competition when considering the GAFAs' ecosystems (Brandenburger and Nalebuff 1996; Daidj 2011; Gueguen and Isckia 2011). For example, applications (i.e., apps) and contents made by a huge range of providers (i.e., from individual developers to large firms) are offered through the iTunes platform by Apple or the Google Play platform.[9] These content providers (e.g., King, Gameloft, Electronic Arts, Rovio, Disney, Supercell, Tencent, Line), as part of the Apple

[9]For a review of the top app trends, see App Annie (2015).

Table 1 A conceptualization of the Internet economy

Category 1: Infrastructure		
Layer 1: Internet infrastructure	Includes companies with products and services that help create an IP-based network infrastructure	– Internet backbone providers – Internet service providers – IP Networking hardware and software companies – PC and Server manufacturers – Fiber optics – Line acceleration hardware manufacturers
Layer 2: Internet applications infrastructure	In addition to software applications includes the human capital involved in the deployment of e-commerce and e-business applications	– Internet consultants – Internet commerce applications – Multimedia applications – Web development software – Search engine software – Online training – Web-enabled databases – Security products and services
Category 2: Economic activity		
Layer 3: Transactions	Increase the efficiency of electronic markets by facilitating the meeting and interaction of buyers and sellers	– Market makers in vertical industries – Online travel agents – Online brokerages – Content aggregators – Portals/Content providers – Internet ad brokers – Online advertising
Layer 4: Electronic intermediaries	Involves the sales of products and services to consumers or businesses	– E-tailers – Manufacturers selling online – Fee/Subscription-based companies – Airlines selling online tickets – Online entertainment and professional services

Source Adapted from Barua et al. (1999)

ecosystem, could be regarded as Apple's partners, or elements providing the ecosystem with a large variety. However, these same partners are not offering their products/services exclusively through Apple's platform, but also on many others like Android or Facebook.[10] For example, in the particular case of the media and music industries, the number of suppliers is very limited, as it is a highly consolidated segment. Thus, these large actors are not interested in offering their products exclusively to one of these platforms, which would imply that a particular ecosystem (e.g., Apple) sells the content of providers A and B, and another (e.g., Amazon) sells that of C and D. In fact, the opposite is the case.

This leads us to introduce what might be referred to as the "perimeter of innovation." Google, or any of the GAFAs, can develop their own hardware, software,

[10]Spencer (2015) provides evidence of the number of apps developed by Google, Facebook, Microsoft and Adobe, which are provided through the Apple's iOS app store.

APIs, apps, platforms, etc., in-house, taking into consideration the inputs provided by their strategic partners, and/or organizing and promoting events (e.g., hackathons, Kickstarter competitions, Techcrunch events, web summits, code events, Startup battlefields) they may consider strategic for such purposes. However, as more organizations and actors are being embedded in the respective ecosystems, the management of their innovation processes becomes more complex, as the GAFAs need to show the ability to develop and maintain multiple partnerships at the same time with content providers, app developers, etc., each of which also has their own innovation strategies. By the term perimeter we mean that it is often not possible to manage the entire ecosystem and the multiple innovation processes/projects co-existing within it (i.e., retention). Each actor within the ecosystem has its own timing, pace and orientation. Thus, as we move toward the perimeter of the ecosystem, that is, as we draw away from the center of the ecosystem (i.e., the DNA of the firm), managing the innovation and the required partnerships becomes more complex.

(d) The leadership and the dominant vectors

As Autio and Thomas (2013: 208) observe, "while the number of digital services grow in a linear fashion, the distribution of complementors to hub firms [i.e. the GAFAs] tends to follow a power law, implying that a small number of hub firms provided for a majority of complementors." As we mentioned in the introduction, the software ecosystem, and the Internet ecosystem in particular, are characterized by being small worlds led by few actors (Iyer et al. 2006). The leaders (i.e., "keystone organizations" in the words of Iansiti and Levien 2004 or Jansen et al. 2013) in each dominant vector can have a relevant influence not only on their ecosystem but also on that of their competitors (Pellegrin-Boucher and Gueguen 2004; Moore 2005). A change in Apple's ecosystem may induce changes in the rest of the big Internet industry groups. Each of these business groups is a leader in its main field, which means they set the patterns for others, although this is mutual. Google+ copied Facebook, which in turn took many ideas from Google+. Apple first supplied content download and later integrated the applications. In each case, these activities were initially complementary, which gave Apple a slight edge. These business moves were later copied, to varying degrees, by the rest of the groups.

Despite all the big players in the Internet ecosystem being forced to perform the same activities, as already indicated, the original DNA in each group means that each has a leading position in particular dominant vector. As a result, some of the activities performed by each of these business groups are more central to their evolutionary dynamics than to those of others. This can be either because these activities are those central to its own ecosystem or because they provide the group with some kind of competitive advantage. In the case of Apple, for example, it could be considered that its leadership is in its original DNA, namely, the design and manufacture of hardware and software. However, having its own platform for downloading content and applications like iTunes and a platform for contents and software on the cloud like iCloud, which allows users to keep all synchronized content available at any time, gives it a competitive advantage over the rest. On the other hand, the fact that certain activities are not central to the other groups means

that they need to carry out certain dynamics in order to follow the patterns established by the previous group. As previously discussed, the further from a given branch of activity a firm is, the more disruptive its epigenetic dynamics will necessarily be, as this distance forces the firm to take fast and radical measures to enter these new branches. Subsequently, as we will demonstrate in Sect. 4 of this chapter, the leaders transmit their DNA in the Internet ecosystem through the activities they perform, so that these are copied, to a greater or lesser extent, through epigenetic moves made by the rest of the GAFAs (i.e., related to the retention and selection mechanisms in the evolutionary realm).

(e) The environment

As explained earlier in the book (see Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups"), the environment is one of the key elements for understanding epigenetic dynamics. Like genetic contexts, the DNA can be a central element in explaining certain diseases, although epigenetic factors are often as important, or even more so. In the context of the Internet ecosystem, one of the determining aspects of the environment are the institutions around it, which are increasing the number of regulations that drive the dynamics and evolution of the GAFAs and their respective ecosystems. One example of these institutions is the decisions that different competition courts have handed down in the USA and Europe concerning the mergers and acquisitions of some of these groups. Other more recent examples could be those related to network neutrality, which may modify some of the current practices of the GAFAs and may even hinder the survival of some of them in the medium term. Finally, we can also refer to the regulations that frame the activities of certain industries. For example, the provision of physical infrastructures by telecom providers (see Chapters "Future Paths of Evolution in the Digital Ecosystem" and "4G Technology: The Role of Telecom Carriers" in this book) is a key determinant of the current dynamics of the Internet ecosystem and of the GAFAs in particular. However, the provision of telecom services is a highly regulated industry while, to date, the Internet has lacked (almost) any regulation, or it has not even been possible to regulate it. As the 2013 report to the United States Securities and Exchange Commission on Twitter states "… these laws and regulations may involve privacy, rights of publicity, data protection, content regulation, intellectual property, competition, protection of minors, consumer protection, taxation… many of these laws and regulations are still evolving and being tested in courts and could be interpreted in ways that could harm our business. In addition, the application and interpretation of these laws and regulations are often uncertain, particularly in the new and rapidly evolving industry in which we operate" (SEC 2013). As the penetration of the GAFAs into other (often unrelated) industries is becoming increasingly consistent over time as a result of their expansive and defensive strategies, it is possible to observe how many of these are moves into industries that are very highly regulated, such as the provision of telecom services, the health industry, human mobility, education or banking. In Sect. 4 of this chapter, we examine these moves more closely, which, as indicated, in the context of this book we refer to as epigenetic

dynamics, due to the fact that they frequently have no relationship with the business groups' original DNA.

The increasing number of reflections on the role use and often misuse of copyrights, and particularly patents, could also be included in these environmental institutions (see Sect. 5 in this chapter). Despite the number of devices that are constantly being connected to the Internet and the continuous increase in Internet traffic (which may increase even further with the advent of the Internet of things), these go hand in hand with a reduction in the openness of the Internet. In fact, the increasing number of apps could be regarded as activities that skip the "open" Internet searches as we have known them to date. As a result, in the short-term, online Internet search engines may become entirely different from today's; with such changes including app searches and allowing apps to be installed in the corresponding devices. However, it might also be the case that the app developers themselves could be interested in providing this app search service. Social networks also provide a good example of the reduction in the open space of the Internet, as their content is often not included in open searches. Here, too, the decision about which platform to use very much depends on the number of contacts, information and applications that can be accessed within them.

(f) Phenotypic and genotypic changes and the impossibility of making predictions

In Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups" of this book, we introduced the differences between the genotype and the phenotype. We discussed how the plasticity of the genome enables it to adapt to the environment resulting in the formation of different phenotypes determined by the environment the organism is exposed to.

The ability to make predictions, which we are so used to (particularly in economics), on the future development of firms, ecosystems, countries, etc., is only possible in those cases where the variables considered conform to certain previously established and known guidelines and patterns. This would be the case of disciplines such as micro and macroeconomics. An example of this logic is provided by many of the reports that some of the most well-known consulting firms and supranational bodies prepare with a certain periodicity, and which often contribute to expanding the notion that the future is, to a great extent known and predictable. In the case of the Internet ecosystem in particular, the Global Entertainment and Media Outlook by Pricewaterhouse Coopers,[11] the Internet of Things Outlook report,[12] the OECD Digital Economy Outlook,[13] the report on the

[11]The Global Entertainment and Media Outlook 2015–2019 is available: http://www.pwc.com/gx/en/global-entertainment-media-outlook/. Accessed 15 August 2015.

[12]The Internet of Things Outlook report 2015 is available: http://telecoms.com/intelligence/iot-outlook-2015/. Accessed 15 August 2015.

[13]The OECD digital economy outlook 2015 is available: http://www.oecd.org/internet/oecd-digital-economy-outlook-2015-9789264232440-en.htm. Accessed 15 August 2015.

future of the Internet by the World Economic Forum,[14] or the IPG Media Lab' Outlook Report[15] could be highlighted.

However, in the Internet ecosystem, as is also the case in many other high-velocity environments, prediction loses much of its meaning, since it is clear that the rates of change are proving to be much faster than originally expected. Using a metaphor, we could think of the GAFAs as a landscape of dunes, changing constantly, hence capturing their features in snapshots would not make much sense. We therefore agree that the dynamics we intend to observe in the GAFAs in this chapter are far more complex than what we are capable of studying. However, with this book in general, and this chapter in particular, we want to take a first step in this direction. One of the defining characteristics of every ecosystem, like any living organism, is its ability to adapt and evolve (Basole 2009), either due to genetic evolution or to epigenetic transformation. Some of these recent changes, the consequences of which are still unknown, could be as follows:

- Growth of the immaterial (software, content, platforms): this does not imply that hardware and physical infrastructures are forgotten. In fact, software is being increasingly embedded in them.
- Technical convergence: different types of services (e.g., voice, text, code, data, image, video, or a mix of them) are bypassing the physical infrastructure (i.e., cables) available to date, which is also undergoing very large changes (see Chapter "4G Technology: The Role of Telecom Carriers" on telecom carriers and the deployment of 4G technologies and infrastructures). In turn, these services can pass through multiple devices (e.g., PC, laptop, smartphones, iPad, online TV, etc.) and multiple distribution and transmission technologies (e.g., satellite, air, cable, etc.).
- Functional convergence: for example, in the information contained in an online newspaper there is a convergence of text, images, videos, social networks, etc. In turn, televisions use the same basic information, so the different media are increasingly looking more alike and competing not only among themselves, but also with the GAFAs (i.e., Google news, Yahoo news, etc.).
- Corporate convergence: nowadays the same companies are operating in sectors that were previously separate. Thus, a firm participates in many industries, and the boundaries across sectors are becoming increasingly blurred (Gueguen and Isckia 2011).
- Ecosystemic convergence: this last type of convergence is related to the fact that, as we will see in the course of this chapter, each of the GAFAs is increasingly integrating more activities that are not related to its core or original DNA but rather to the original activities of its competitors.

[14]The report on the future of the Internet is available: http://reports.weforum.org/outlook-global-agenda-2015/future-agenda/mapping-the-future-the-future-of-the-internet/. Accessed 15 August 2015.

[15]The IPG Media Lab' Outlook Report 2015 is available: http://ipglab.com/outlook2015/. Accessed 15 August 2015.

(g) The consequentialist change

Changes are evolutionary and constant, influencing not only further development of the business ecosystem itself but also having an indirect impact on the dynamics and paths followed by other ecosystems which, initially, are not directly related to the GAFAs' ecosystems. This has become evident recently, as the actions undertaken by the GAFAs are having a direct influence on other "offline" industries, such as taxis, accommodation, mobility, retailing, health, etc. (Evans et al. 2008).

It can be said that the dynamics of the business ecosystems (concerning the GAFAs) are endogenous to and consciously developed within the Internet ecosystem. The leaders in the respective dominant vectors develop their strategies, involving other stakeholders in their respective ecosystems, and the competing firms are obliged to follow those paths, requiring that they undergo disruptive dynamics due to the changes in the environment. It could even be said that the dynamics of the Internet ecosystem are produced in response to the changes within each of the business ecosystems of which it is formed (i.e., genetic evolution in a Darwinian sense). Each of these business ecosystems is also influenced by its respective (direct) environments (i.e., epigenetic evolution). However, it also has a direct impact on the behavior of the latter (Breslin 2011; Breslin et al. 2015), in the sense that the dynamics of the business groups and their ecosystems also constitute the dynamics of the global Internet ecosystem as a whole. In this regard, when dealing with a high velocity market such as that observed on the Internet, it is not enough to consider the evolution of firms as mere adaptation in response to the changing conditions of the environment (first step of the EED approach). In addition, the dynamics of the firms in the Internet ecosystem should also be taken into consideration (second step of the EED approach), as their strategies are often not only seeking to survive in the selection environment, but also to move ahead of the changes observed in it by making fast and disruptive moves. But even then, in consequentialist logic, they have an indirect impact on the performance and evolution of many other ecosystems; a global impact that has economic, social, institutional, regulatory and even moral consequences (third stage of the EED approach). Thus, with the methodology outlined in Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups," we aim to provide a comprehensive view of the trends and dynamics observed in the Internet ecosystem.

3 Identifying the Genomic Instructions of the GAFAs

The goal of this section is to characterize the business groups we are interested in exploring. Applying the three-stage EED approach outlined in Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups," in this section we identify the business groups' original DNA. Namely, their

original genomic instructions and the products/services that characterized their constitution and consolidation (i.e., the first stage of the EED approach). The first innovative products that are most closely identified with the business groups' initial activities are those forming the essence of each company (e.g., Google's search engine, Microsoft's operating system (OS), Apple's software and design, the social network concept developed by Facebook). Next, the focus moves to the structural characteristics of the ecosystem in which these firms operate and which may lead to changes in their DNA. Some of these characteristics are: intense inter-group competition, exponential growth of markets and users, high demand for innovation, expansion in the number of applications and their content, fast multivectorial technological change and planned obsolescence, modularity in the behavior of business ecosystems, etc. The previous dimensions are due to the high variability of these big groups' environments (Wirtz et al. 2007). Then, in Sect. 4, we move on to the second stage of the EED approach, where an analysis of their epigenetic dynamics is undertaken. Thus, with this section we aim to frame the overall structural characteristics of the GAFAs. In this chapter, the firms that we consider within our group of GAFAs are the following: Google, Apple, Facebook, Amazon, Samsung Electronics, Microsoft, Nokia, Twitter, eBay, and Yahoo.

Before starting with the characterization of the GAFAs, two issues should be noted. One of them is rather simple or even anecdotal, while the other is essential. The first is that there seems to be no other industry that is followed to the same extent by users themselves, followers and the media in general. The names of Bill Gates (Microsoft), Steve Jobs (Apple), Mark Zuckerberg (Facebook), Larry Page (Google), Jeff Bezos (Amazon), etc., are probably familiar to everyone. However, this cannot be said for most of the other major companies worldwide. The second point to stress is that we are currently witnessing many changes in the global order of most industries. We will only mention one of these changes here, which, from our point of view, constitutes a fundamental institutional change, namely the coexistence of two modes of appropriation. On the one hand, the classic mode is to pay for the permanent possession of a good (e.g., an iPhone, a physical book, etc.) On the other, the emerging mode is related to provision (i.e., access in the case of applications such as email, content, YouTube, or payment in cases of Spotify and Netflix). Currently, there is a certain balance between the two modes, but it is foreseeable that provision will become increasingly relevant as opposed to ownership.

As we indicated earlier, even if all groups are competing among themselves, they originally started from some particular or unique competences (i.e., DNA). In the case of Google and Yahoo, they were characterized by their search engines, Facebook and Twitter by their social networking services, Amazon and eBay by their provision of electronic commerce, while Apple, Samsung Electronics and Microsoft were originally concerned about the manufacture of consumer electronics. Finally, Nokia is a company that was initially engaged in the provision of telecommunication infrastructures. Table 2 provides some of the characteristics that identify the origins of the GAFAs.

Table 2 The origins of the GAFAs

	Year founded	Location	Founders	Current CEO	Original DNA (core business)
Google	1998	Mountain View, CA	Larry Page, Sergey Brin	Larry Page	Development of a search engine
Apple	1976	Cupertino, CA	Steve Jobs, Ronald Wayne, Steve Wozniak	Tim Cook	Designing and manufacturing consumer electronics, PCs and related software and peripheral products and networking solutions
Facebook	2004	Menlo Park, CA	Mark Zuckerberg, Eduardo Saverin, Andrew McCollum, Dustin Moskovitz, Chris Hughes	Mark Zuckerberg	Development of a social networking service
Amazon	1994	Seattle, WA	Jeff Bezos	Jeff Bezos	Electronic commerce and cloud computing
Samsung Electronics	1988	Suwon, South Korea	Lee Byung-chull	Kwon Oh-hyun	Manufacturing of electronic components and consumer electronics
Microsoft	1975	Redmond, WA	Paul Allen and Bill Gates	Satya Nadella	Development, manufacturing, licensing and supporting software products
Nokia	1871	Espoo, Finland	Fredrik Idestam, Leo Mechelin	Rajeev Suri	Telecommunications infrastructures, information technology, technology development
Twitter	2006	San Francisco, CA	Jack Dorsey, Noah Glass, Biz Stone, Evan Williams	Jack Dorsey	Online social networking to send and read short messages
eBay Inc.	1995	San Jose, CA	Pierre Omidyar	Devin Wenig	E-commerce company, providing consumer to consumer & business to consumer sales services
Yahoo	1995	Sunnyvale, CA	Jerry Yang, David Filo	Marissa Mayer	Development of a search engine

Source Own elaboration based on de Agonia et al. (2013), and Daidj (2011)

Most of these firms were created in the late 1990s or early 2000s in the US, and are at present determining the direction and intensity of global innovation dynamics to a great extent. However, European firms are underrepresented in this Internet ecosystem, Nokia being the only European group, although nowadays it is basically related to the supply of telecom access. The reality is that few European entrepreneurial firms succeed in this turbulent market. Understanding the diversification and growth strategies of the GAFAs and the high-growth start-ups, as well as their economic effects, is therefore considered crucial if Europe is to support high-growth entrepreneurship oriented toward higher innovation outputs.

Next, we provide a set of figures that give some statistics on certain structural characteristics of the groups under study for the period 2007–2014, such as the number of employees, the revenues and gross profit obtained, the value of R&D investments, the number of USPTO patents granted yearly, etc. The first indicator we will focus on is the number of employees (Fig. 2), measured in terms of Full Time Equivalence (FTE). This is a relevant indicator, not only because it allows us to see the concentration of highly skilled individuals in these organizations, but also because it provides a clear figure on their expansive and diversification strategies. It also allows us to obtain relative measures for some of the indicators we will be considering next, such as revenues, gross profit or number of patents granted. As could be expected, Samsung Electronics is certainly the largest firm, with 326,000 employees in 2014. Nokia's evolution is particularly striking, as it was the largest firm (among those considered in this chapter) in 2007 with 112,662 employees, while in 2014 this figure was halved to 61,656 people. Amazon is the second largest group with 154,100 employees in 2014, followed by Microsoft with 128,000 and Apple with 92,600. Despite Google being one of the companies that has diversified most of its activities in recent years, the number of its employees has not increased to the same extent. In fact, the major increase in the number of employees in Google can be observed between 2007 and 2011, while the figures between 2012 and 2014 basically remained constant. eBay is the next company according to size with 34,600 employees in 2014. Finally, Yahoo with 12,500 employees, Facebook with 9199 and Twitter with 3638 employees close the ranking for this particular indicator.

Next, we will provide some figures on the values observed for the revenues obtained by the GAFAs as a result of the sales of their activities, products, services, etc. As can be observed in Fig. 3, Samsung electronics dominated in this indicator during the period studied, mainly due to the broad portfolio of products manufactured, which include lithium-ion batteries, semiconductors, chips, flash memories, hard drive devices, smart phones, tablet computers, phablets, LCD and LED panels, and televisions, among others. However, according to the data for the year 2014, the sales of Apple (US$182,795 million) overtook those of Samsung electronics (US$174,883 million) for the first time. Apple showed an exponential increase in its sales, particularly following the release of the first generation of iPhones in 2007. Microsoft and Amazon rank next, with sales close to US$90 billion (in 2014 Microsoft had sales of US$86,833 million, while Amazon achieved US$88,988 million). In turn, for the year 2014 Google showed

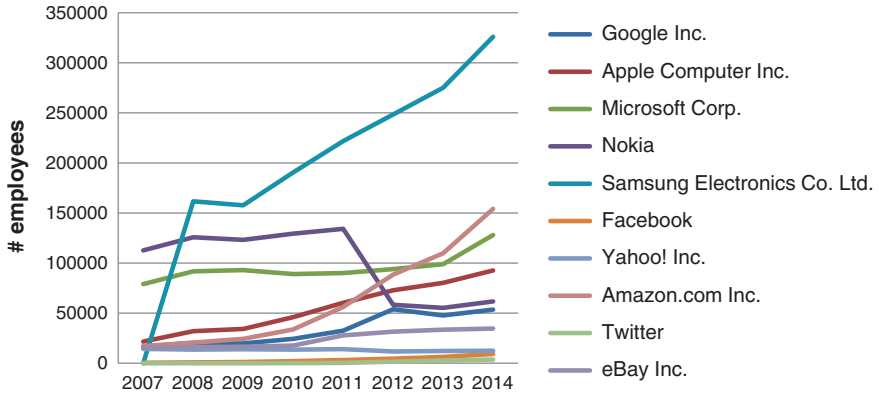

Fig. 2 Number of employees (FTE). *Source* Own elaboration

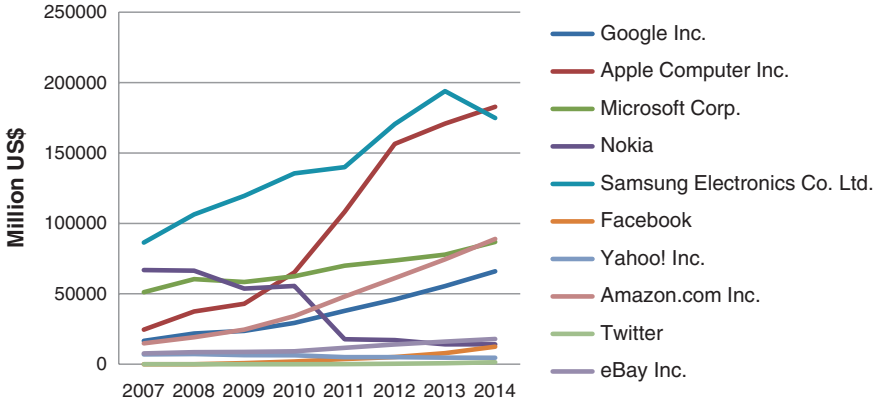

Fig. 3 Sales (revenues)—Million US$. *Source* Own elaboration

sales of US$66,001 million. Nokia's dramatic decrease in sales is also worth noting, with figures in 2007 that reached US$66,871 million, while in 2014 these only amounted to US$14,144 million. The remaining business groups showed the following figures for the year 2014: eBay—US$17,902 million, Facebook—US$12,466 million, Yahoo—US$4618 million, and Twitter—US$1403 million.

However, if we divide the values of the revenues by the number of employees, we obtain a radically different picture as compared to the previous one (Fig. 4). Apple is the company with the largest "productivity" per employee. In 2014, each employee achieved a revenue of US$1.97 million as a result of the sales of Apple goods and services. Facebook and Google are the second and third most efficient firms with US$1.35 million and US$1.23 million per employee, respectively.

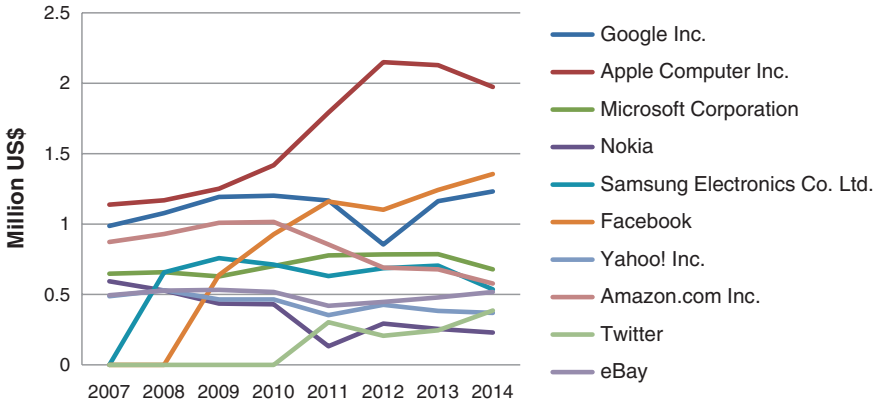

Fig. 4 Sales (revenue) per employee—Million US$. *Source* Own elaboration

The figures for gross profit (Fig. 5) show very similar patterns to those discussed previously for sales, though with some very illustrative differences for some of the business groups. While Apple (US$70,537 million) and Samsung (US$66,090 million) still lead, Microsoft is much closer to them in this indicator (US$59,755 million) than in the one concerning sales. The relative position of Google and Amazon is also worth highlighting, both of which show a very high profits (Google—US$40,688 million, Amazon—US$26,236 million) in relation to their sales. eBay (US$12,170 million) and Facebook (US$10,404 million) come next. Nokia's poorer performance can also be clearly observed in this indicator (US$6263 million). Finally, the ranking for this indicator is closed by Yahoo (US$3320 million) and Twitter (US$957 million).

However, when we analyze the figures for gross profit in relation to the number of employees in each firm (Fig. 6), the results are also rather surprising. According to this indicator, Facebook is the company that obtains the largest profits for each of their employees, with US$1.13 million/employee. In 2014 the figures for Apple and Google were rather similar (US$0.76 million), although each of these firms showed substantially different evolution as far as this indicator is concerned. In turn, Samsung, which had the second largest value for gross profit, obtained US$0.2 million per employee.

The software industry is typically regarded as R&D intensive. However, these firms do not invest much in R&D (Edquist and Zabala-Iturriagagoitia 2012). New entrepreneurial firms are not oriented toward developing long-term applications and technologies (exploration), but are instead more involved in the short-term exploitation of their competitive advantages. The latter are mostly related to the stage of the technological trajectory that the industry is currently involved in. This is a high-velocity market in which new technologies are constantly emerging and where companies must address a high degree of uncertainty. The absolute measurements of these large players' R&D investments are, however, enormous (Fig. 7). Samsung Electronics is the company with the largest investments in R&D activities

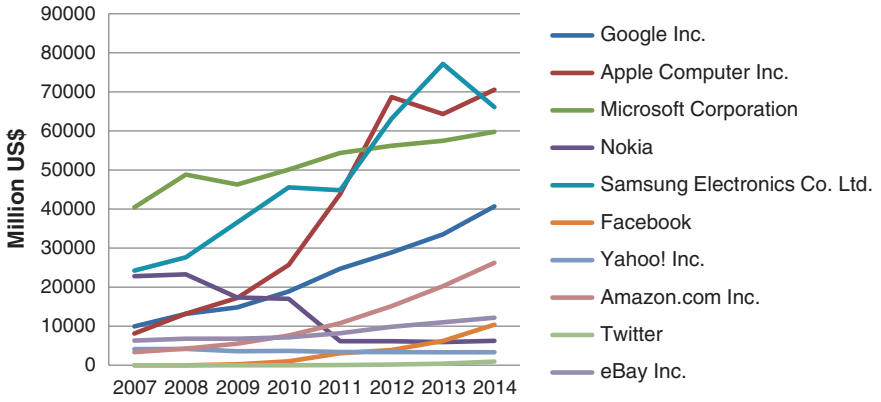

Fig. 5 Gross profit—Million US$. *Source* Own elaboration

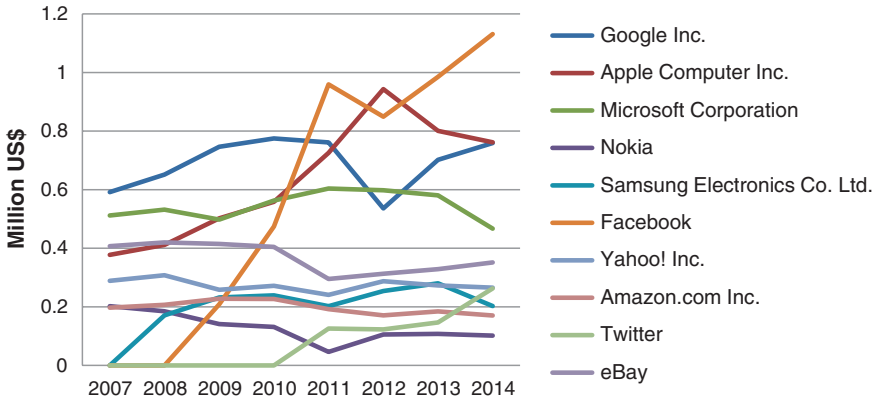

Fig. 6 Gross profit per employee—Million US$. *Source* Own elaboration

with US$12,200 million, closely followed by Microsoft with US$11,381 million. Google and Amazon also show similar patterns over time with US$9832 million and US$9275 million in 2014, respectively. However, despite the similarities that Apple often shares with Samsung, it only invests half as much, registering US$6041 million in 2014. Nokia's evolution for this particular indicator is also very similar to that already noted in relation to the number of employees. In 2007, Nokia was also the player that invested the most in R&D (US$7657 million), while in 2014 its investments amounted to US$2769 million. Finally, we would also like to stress Facebook's evolution. While in 2009, Facebook only invested US$84 million, in 2014 this figure rose to US$2644 million, after having remained constant between 2012 and 2013.

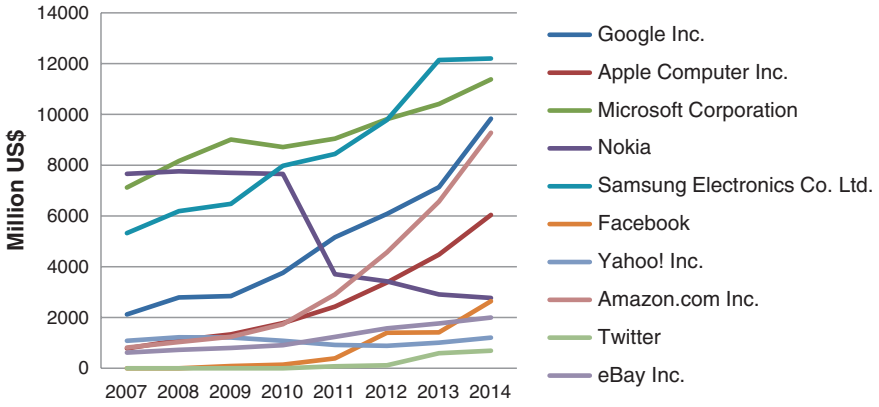

Fig. 7 R&D investments—Million US$. *Source* Own elaboration

However, as is also the case with R&D investments at the country level, we need to provide a relative figure, usually compared to the level of the gross domestic product to obtain conclusive insights about its relevance in the economy. Given that we cannot talk about gross domestic products in the case of firms, we will provide this relative figure as a ratio of the GAFAs' R&D investments over sales. As was the case with the previous relative figures, here too the patterns noted for each of the business groups also show a radical change. In this case, it is Yahoo where R&D investments played the most central role in the firm's strategy in 2014 with 26.14 % of the sales being devoted to R&D activities, although these figures have undergone an important change since 2012, the year that Marissa Mayer was appointed as the CEO of the firm. Facebook is ranked second with 21.21 %. The relative position of Nokia is also worth highlighting here. As we discussed earlier, Nokia has undergone a dramatic reconversion, particularly since 2007. However, as can be observed in Fig. 8, and against all expectations, Nokia continuously increased its share of R&D investments, in particular between 2010 and 2011, years when the company was considered to be bankrupt, out of the smartphone race and when the deal with Microsoft was about to be signed. Google and Microsoft have followed parallel paths, particularly since 2011, with shares close to 15 %. The same can also be said regarding eBay and Amazon, which converged in 2014 around 11 % after embarking on quite different paths.

As we discussed earlier, one of the elements that best characterizes the GAFAs is patents, particularly those granted at the USPTO due to the possibility of patenting software. Figure 9 provides evidence of the number of patents granted per year at the USPTO to the GAFAs between 2007 and 2014. Here again, when we observe the gross value for the patents granted yearly, it is Samsung Electronics which undoubtedly leads (5794 patents in 2014), outperforming the values of Microsoft (3161 patents), Google (2659 patents) or Apple (2195 patents). Nokia's performance has remained somewhat constant over these last years, with values close to 900 patents, while Amazon has significantly increased the number of patents granted on a yearly basis, particularly since 2010, reaching 751 patents in 2014.

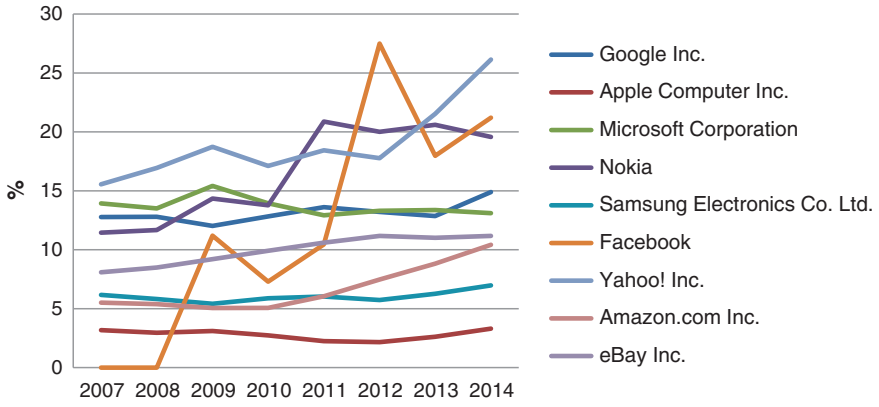

Fig. 8 Share of R&D investments on sales. *Source* Own elaboration

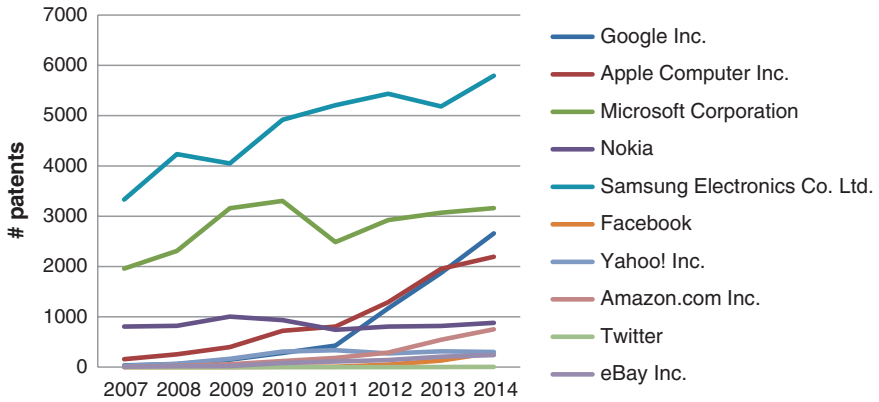

Fig. 9 Number of USPTO patents granted. *Source* Own elaboration

In order to provide evidence of the relevance that patents have in these business groups' strategies, we next provide relative figures for the number of USPTO patents granted per billion US$ invested in R&D (Fig. 10) and the number of USPTO patents granted per thousand employees (Fig. 11). With these measurements we intend to provide a relative view of the efficiency of R&D investments in relation to patents on the one hand, and on the productivity of employees on the other. In the former case, it can be observed that in 2014 Samsung Electronics was the company with the highest efficiency in its R&D processes, as it obtained 475 patents per billion US$ invested in R&D. However, the evolution is quite negative when compared to the firm's performance in 2008, where it achieved 684 patents per billion US$. The opposite is the case for Apple, which doubled its efficiency in the period under analysis, going from 200 to 363 patents/billion. Similarly, Nokia tripled the efficiency of its R&D investments. While in 2007, 105 patents were obtained for each billion US$ invested in R&D, in 2014 this measure rose to 317, overtaking Microsoft, Yahoo, and Google.

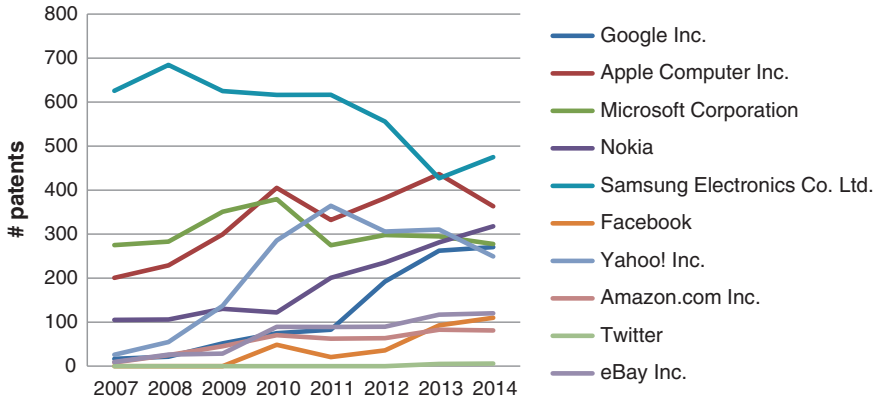

Fig. 10 USPTO patents granted per billion US$ invested on R&D. *Source* Own elaboration

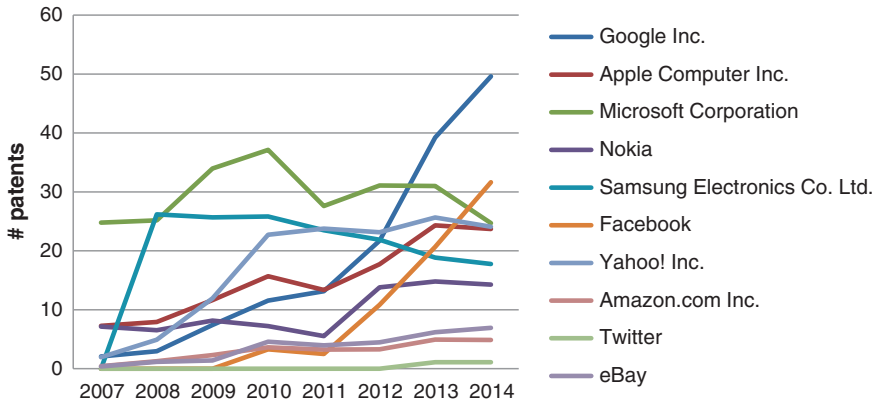

Fig. 11 USPTO patents granted per 1000 employees. *Source* Own elaboration

As for the productivity of the labor force in relation to patents, it was Google that led in 2014 with 50 patents granted per thousand employees. Facebook was the second company in this respect with 31 patents/thousand employees, although the significant gains in productivity since 2011 must be noted. Microsoft, Yahoo, and Apple were granted 25 patents/1000 employees. However, while Microsoft returned to the same productivity registered in the year 2007, Apple, and particularly Yahoo, more than tripled theirs. In this case, due to the large size of the company in terms of employees, the relative performance of Samsung Electronics was quite modest (18 patents/thousand employees in 2014) as compared to its counterparts. Nokia's good performance was also remarkable; in 2014 it doubled its figures from 2007.

The final indicator we focus on here is these firms' market capitalization (Fig. 12). With this figure we aim to determine public opinion regarding the net worth of these companies. In this case, it is Apple that leads by an astonishing difference. In 2012 Apple's shares had the highest value on the stock market with an average

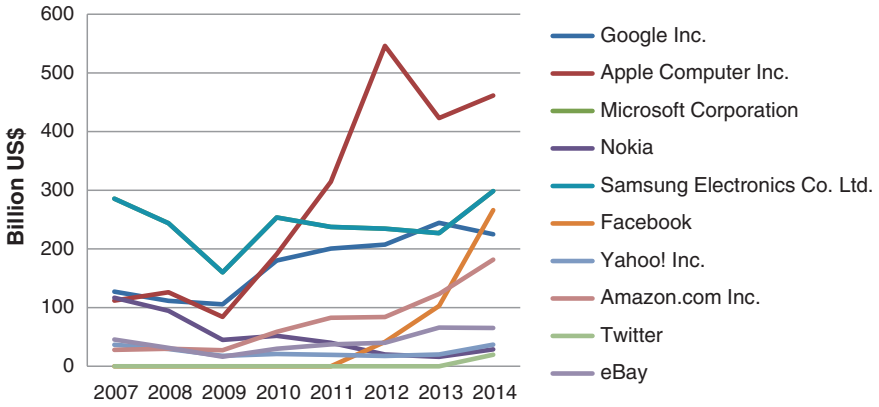

Fig. 12 Market capitalization (billion US$). *Source* Own elaboration

capitalization of US$546 billion. Samsung is the second most valuable company according to this indicator with a market capitalization of nearly US$300 billion, while Google ranks fourth with US$225 billion. The most significant trends are those exemplified by Facebook and Amazon. While the former has become one of the major players on the stock market since its initial public offer in 2011, Amazon showed an interesting trend resulting in a market value of US$182 billion in 2014.

3.1 Illustrating the Business Ecosystems of the GAFAs

As we discussed in Sect. 2.1, the GAFAs can be regarded as business ecosystems rather than mere business groups, due to the large diversity of players embedded in their environments, processes, value chains, goods, and/or services. Next, we will introduce graphic illustrations of the business ecosystems of some of the firms we are interested in.[16] Although they may not represent the current state of their respective ecosystems, due to their high variability and patterns of change, we consider them useful for obtaining an initial picture of their original activities, products and processes, which will help us to better understand their epigenetic moves in the next sections. For example, Google and Amazon are not heavily involved in hardware, although Google is indirectly involved in hardware through its Android mobile operating system. Amazon rules when it comes to retailing, particularly regarding books. Apple and Microsoft are relatively weaker in shopping, but Microsoft is strong in gaming. Apple is hardware-centric. Contents and applications available on iTunes produce revenue and profit, but are all oriented to providing services for the hardware. In a sense, Apple is a counterpart of Amazon,

[16]No graphical evidence could be found for Yahoo, Samsung Electronics, Nokia and eBay's business ecosystems.

as the latter's business is the sale of content. Thus, Apple and Amazon have a business model in which the key is the sale of goods or content. Facebook and Google mainly obtain their income from advertising. Facebook and Google are data-centric. However, one way or another, they are all locked in a death match (de Agonia et al. 2013), particularly concerning dimensions such as books, gaming, music, video, and online shopping, although the boundaries between each of them are hard to define.

As comprehensively evidenced by de Agonia et al. (2013), "during its first decade, Google made massive headway in the field of Internet search, an area that had remained relatively stagnant until its arrival" (de Agonia et al. 2013), and which had been dominated by the search engines of Altavista and Yahoo. Google's first steps in the media world were taken in the fall of 2006, when the firm announced it was acquiring YouTube. The company released its plans for the Android mobile operating system in 2007, a year later launching the first generation of phones that incorporated Android software. Google also unveiled a web-centric operating system called Chrome OS in 2009, a television platform called Google TV in 2010 and services for online movie and music streaming in 2011 (ibid). However, other platforms such as Google Ads, Google+, Google Play Store, Google Books, Google Maps, Google Drive or Google Wallet are also part of Google's ecosystem (Fig. 13). With each move, the simple search box moved further, although search itself remained at the core of the company's business.

The Google Play Store has robust sections devoted to book, magazine, and music related content (i.e., Google Play Music All Access).[17] As of July 2015, the Google Play Store included more than 1,600,000 apps (Statista 2015). In 2014, the top five categories of apps by revenue at the Google Play Store were: gaming, communication, social, tools, and travel (App Annie 2015). Google also has a separate service named Google Books, which makes it possible to search for content within actual books and magazines.[18] However, one of the pivotal elements of the current Google ecosystem is the Android OS. Since it is an open-source platform, anyone (be they a large established organization, an entrepreneur, a developer, etc.) can use the software in any potential device (i.e., already existing or not) and modify it in any way. As a result, despite Google not being explicitly present in gaming (yet), a number of manufacturers offer Android-based devices made specifically for entertainment purposes (e.g., Sony's Xperia Play phone, Nvidia). In this regard, the Google Play Store offers a large collection of apps, some developed by Google, and most of them developed by the millions of developers worldwide that use the Android platform to develop games.

[17]As explained by de Agonia et al. (2013), "Google Play grew out of the former Android Market, which was essentially an app store for Android-based phones and tablets. As the market expanded to include more types of content, Google wanted a name that'd fit the broader focus and emphasize the fact that the store wasn't limited just to Android users".

[18]As de Agonia et al. (2013) note, "Google Books has been the subject of much controversy within the publishing world because of the complex rights issues related to Google's scanning of older print editions".

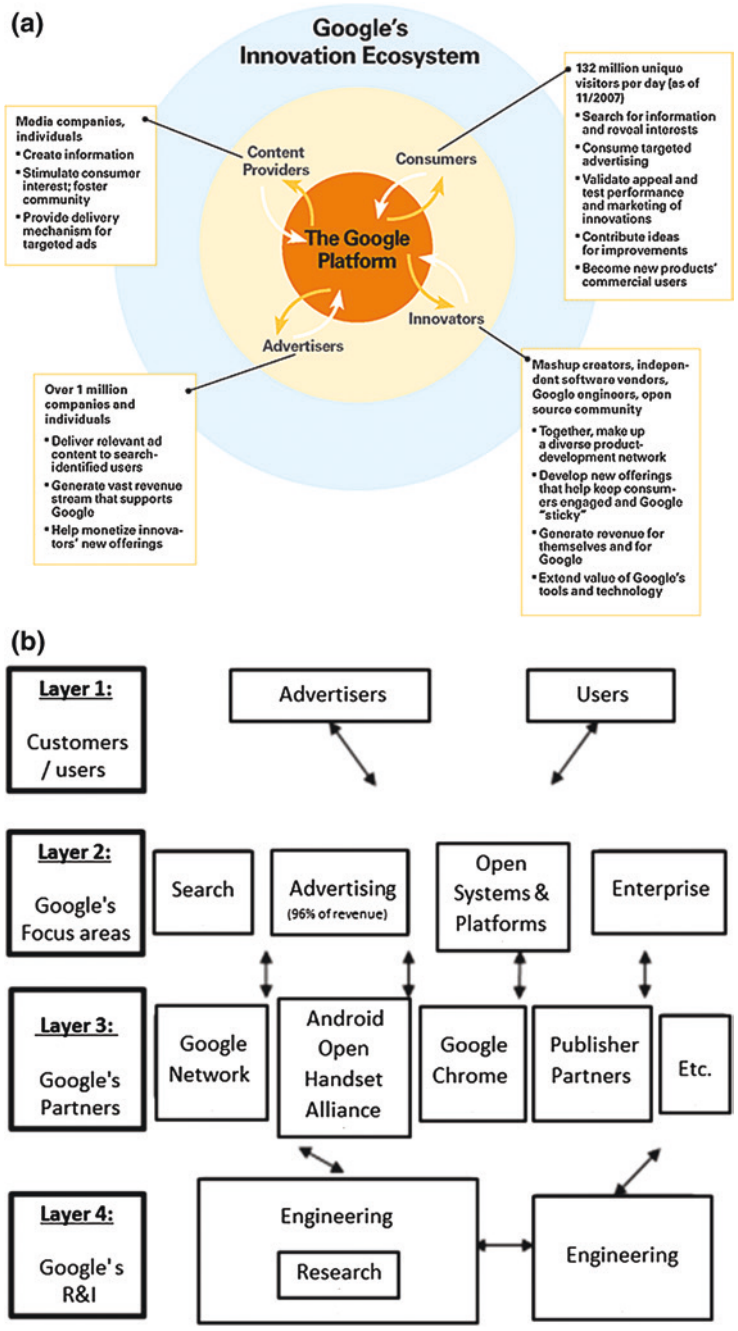

Fig. 13 **a** Google's ecosystem (2008). *Source* Iyer and Davenport (2008). **b** The core of Google's Global Innovation Ecosystem (2014). *Source* Fransman (2014: 24)

In 2009, Google announced the launch of the Chrome OS, a platform in which applications and user data are stored in the cloud. The most common products that use the Chrome OS are Chromebooks, which run on web-based applications. YouTube has become the key source for searching web-based video, which ranges from entertainment videos produced by big-name studios (e.g., movie producers) to homemade clips from individuals across the world, many of whom use the platform to become worldwide "stars" (e.g., Smosh, The Fine Bros, Ryan Higa). In parallel, Google Play offers a variety of possibilities for renting and/or purchasing movies and TV shows (e.g., full seasons or specific episodes).

The cross-platform nature of Google's ecosystem allows the company and its users to gain access to any content from any connected devices at any place and any time, a competitive advantage that many other GAFAs are also putting into practice.

In the case of Apple, the devices (i.e., all mobile hardware) they manufacture are the key to understanding its "digital hub" ecosystem (de Agonia et al. 2013). In 1984, Apple's Macintosh was the first mass market computer that incorporated a graphical user interface and a mouse. After that, a flurry of technology initiatives (e.g., iMovie, iTunes, iPhoto) have emphasized Apple's intentions to bring computerized media to users (ibid). In this regard, Apple's ecosystem cannot be understood without its first digital player, the iPod (2001), that shortly afterwards was accompanied by the release of iTunes (2003), which later entered the current App store. In 2007, with the announcement of the iPhone, Apple created a disruption that radically changed the way telephony (i.e., communication, mobility, and social relations) was understood. This breakthrough was followed by the release of the Apple TV and the iPad. Finally, the last of Apple's products to date has been the iWatch (2015) after a long period of development and maturation.

Each of these devices could be understood as platforms, which provide access to a large variety of online content and services (i.e., music, video, TV shows, games, mobility, banking, health, sports, retailing, software, etc.). It is in these platforms that the actors in the Apple ecosystem (e.g., developers, telecom providers, other large firms Apple cooperates with such as Nike) can introduce their new ideas, projects, services, developments and thereby "co-evolve" and "co-shape" the ecosystem they are part of (Fig. 14).

Apple entered the world of digital books in 2010, when the iBooks app was introduced as a gateway for the iBookstore (de Agonia et al. 2013). However, within the App Store there are thousands of apps listed under the books category, which also provide support for competing services, like Amazon's Kindle, and many other e-book readers.[19]

At the moment of writing this chapter (August 2015), Apple's app store included more than 1,500,000 apps (Statista 2015). In 2014, the top 5 iOS App Store categories by revenue were: gaming, social networking, music, education

[19]As discussed by de Agonia et al. (2013), back in 2012 Apple was having "some trouble with the government for alleged antitrust actions having to do with e-books… the U.S. Justice Department charged that Apple spearheaded a scheme with book publishers to keep the prices of e-books artificially high; on July 10, Apple was found guilty of violating antitrust laws".

and entertainment (App Anie 2015). The number of apps available at the App Store and the Google Store and the repercussion that both OS (iOS vs. Android) have on the smartphone industry lead us to consider that there is battle between the Apple and Google app stores (OECD 2013).

However, in spite of the clear success of mobile gaming, the same cannot be said about Apple's desktop-based gaming, where Apple does not have a console to compete against Microsoft's Xbox, or Sony's Play Station (de Agonia et al. 2013). Similarly, Apple does not yet have a central place where users can buy whatever they may be interested in, as is the case with Amazon and Google. Finally, iCloud is the platform used by Apple to allow for online storage of content (e.g., music, video, books, podcasts, apps). In addition, it also allows all Apple devices to be synchronized so that changes made on one device are automatically transferred to all the other devices belonging to the same user.

These strong innovation capabilities have a massive influence not only on Apple's evolution, but also on its competitors' strategies, which are in some way obliged to follow Apple's logic. However, as we will see, the evolution of these global business ecosystems also has a profound influence on, and causes severe consequences for, many other industries (Evans et al. 2008).

Figure 15 provides an illustration of Facebook's ecosystem, where each icon represents a specific area or action that users can take on Facebook, ranging from apps to photos and events (Trewe 2011). In this way, Trewe provides evidence of the variety of actions users take on their social platforms. However, it should be noted that this version of the Facebook ecosystem is not complete as the network is intricate and changing rapidly.

Facebook began as an online social networking service in 2006, mainly accessible by computers, although it was soon adapted to the changing characteristics of mobile devices as well. As of August 2015, 1490 million accounts were available on Facebook, while Google+ only reached 300 million users and Twitter 316 million (Statista 2015). In 2012, Facebook announced App Center, a store selling applications that operate via the site. Facebook's ecosystem encompasses users, advertisers, other social networks, developers, suppliers, and operating systems (Bonde 2013). However, advertising is pivotal in Facebook's business ecosystem. In fact, both Facebook and Google compete in this advertising market, the two of them accounting for the most significant share of online advertising space. In the fourth quarter of the year 2012, more than US$1.3 billion of Facebook's revenues came from ads.

Facebook is capable of showing the right commercial and noncommercial content to the right person, at the right time and location (ibid: 31). Facebook is capable of adapting to the content distribution method that best suits users and advertisers. Thus, Facebook's data analytic capabilities are at the core of the company. According to Bonde, in 2013 there were more than one million active advertisers on Facebook. Advertising on Facebook is valuable not only for direct sales, but also for creating brand effects and for data creation (Bonde 2013). In this regard, the largest advertisers in social media are financial services, travel and leisure, consumer packaged goods, information, computing, electronics, and retail (ibid).

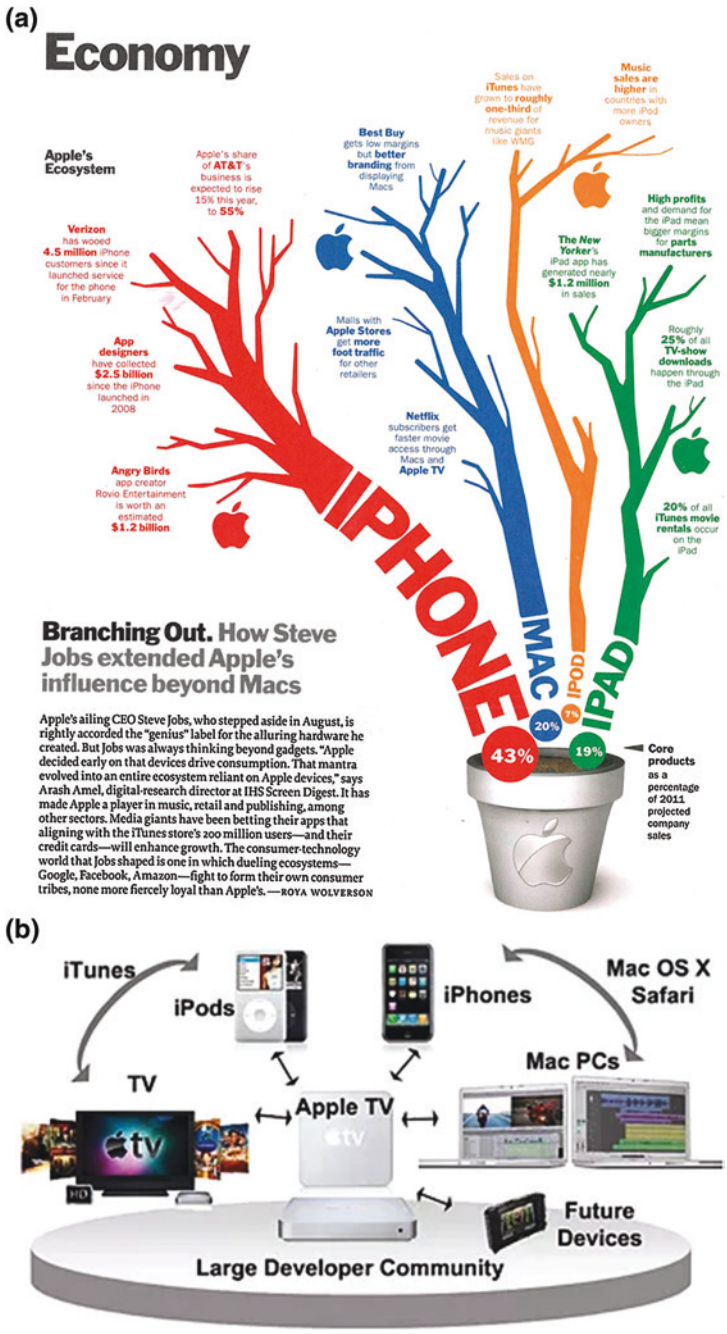

Fig. 14 **a** Apple's ecosystem (2011). *Source* TIME, September 12, 2011. Available: http://obamapacman.com/2011/09/time-magazine-apple-ecosystem-infographic/. **b** Apple's innovation ecosystem (2014). *Source* Nielson (2014)

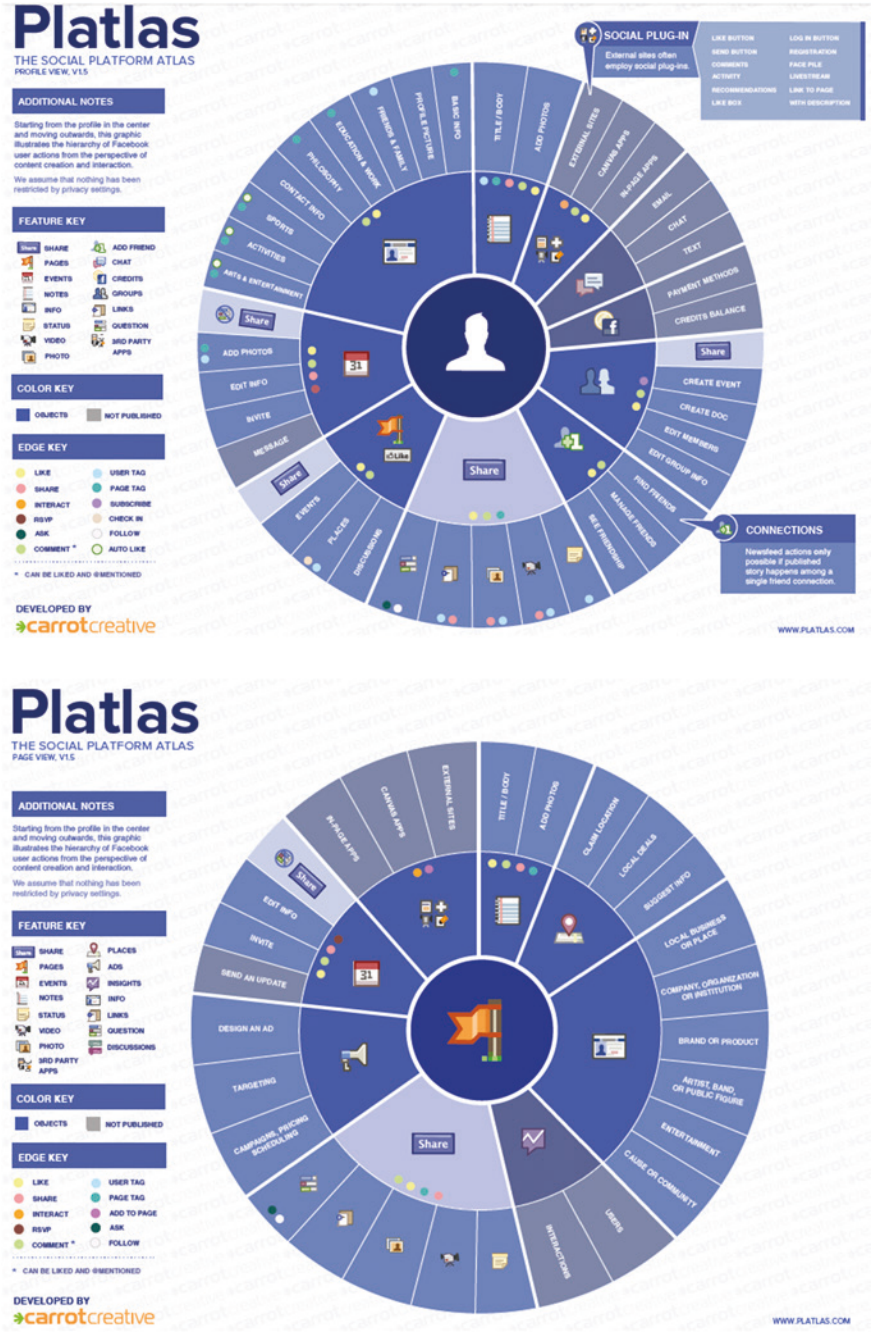

Fig. 15 Facebook's ecosystem (2011). *Source* Trewe (2011)

As discussed by Cocotas (2013: 6), social advertising runs on a freemium model, so that users can join for free and then only pay for premium services. In this regard, a consensus seems to be forming around in-stream advertising as the most promising social advertising format (ibid).

Facebook offers several ways to advertise in its platform: brand pages, display ads, sponsored stories, promoted posts, page post ads, mobile app install ads, and log-out screen ads. In addition, it has introduced a series of tools that brands can use to obtain data on their target customers' uses and habits, such as custom audiences, partner categories, cost-per-action or the Facebook exchange system (see Cocotas 2013: 16).

Entertainment media is part of Amazon's basic DNA (de Agonia et al. 2013). Amazon was founded as a book-selling site, to then branch out into other products such as CDs, DVDs, videogames, electronics, apparel, baby products, consumer electronics, beauty products, gourmet food, groceries, health and personal-care items, industrial and scientific supplies, kitchen items, jewelry and watches, lawn and garden items, musical instruments, sporting goods, tools, automotive items, and toys and games. M&As are one of the means that Amazon has used in its diversification strategy. Today, Amazon is a retail behemoth, but media remain its core business. For example, the Kindle, one of its key products, is designed to make it easier to buy not only books, which it was originally designed for, but also movies, TV shows or music through the Amazon platform (de Agonia et al. 2013). So, it can be said that its media ecosystem is powerful, well-integrated, and possibly the largest in the world (ibid).

Amazon is more than just a retailer of physical products (e.g., books) or downloadable ones (e.g., games). Its ecosystem (Fig. 16) also offers several imprints, tools to help musicians create their own music, and it is producing its own TV shows as a way to attract people to its streaming video service (de Agonia et al. 2013). Since 2000, it has also included Amazon Marketplace, a platform that lets customers sell used products alongside new items. In 2011, Amazon announced its entry into the tablet computer market by introducing the Kindle Fire. Besides, in 2014 Amazon announced its Amazon Fire TV and the Fire Phone, thus entering the TV and smartphone markets, respectively, essentially following in the steps of Apple.

In 2011, Amazon launched the Amazon Appstore, which in August 2015 included more than 400,000 apps (Statista 2015). In 2013, the company announced its Mobile Ads API for developers, which can be used on apps distributed on any Android platform as long as the app is also available in Amazon's Appstore. However, gaming is not one of the key streams of activity Amazon aims to pursue with its ecosystem, in contrast to Apple, Google, or Microsoft.

To date, besides selling, which still remains at the core of Amazon's ecosystem, one of its pivotal elements is cloud computing, a market that the firm first entered in 2002 with the launch of Amazon Web Services (see Case Publisher 2008). Since then, Amazon's cloud computing platform includes services such as the Elastic Compute Cloud or the Simple Storage Service, which are used by organizations worldwide in need of heavy computing resources such as banks.

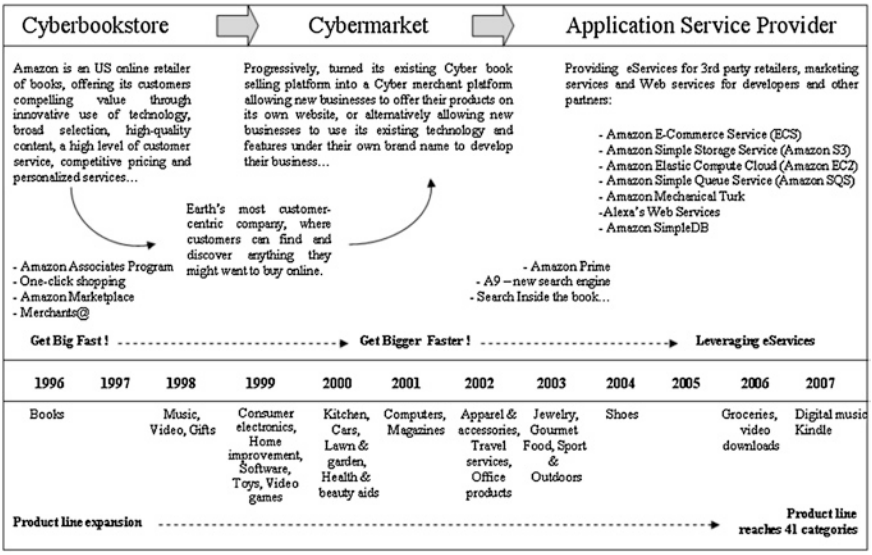

Fig. 16 The evolution of Amazon's business model. *Source* Isckia and Lescop (2009: 45)

Together with Apple (1976) and Nokia (1871), Microsoft is the oldest of all the GAFAs we consider in this chapter, as its creation dates back to 1975. The original purpose of the company was far from being entertainment-oriented, but instead was focused on "products such as a BASIC programming language interpreter, and then (with a contract in late 1980 with IBM) on operating systems like PC-DOS" (de Agonia et al. 2013). Microsoft, which was regarded by many as the evil to be fought against (which gave rise to the entire open-source movement, originally with Linux),[20] has had both major successes and failures. For example, "the Xbox 360 video game platform and community have become a rousing success, along with the Halo and Age of Empires series of games. Microsoft seems to be holding its own with its Windows Phone mobile devices, but there are a lot of people wondering whether its Surface tablets are innovative or a mistake. Still, Microsoft's media system is a work in progress, being very strong in some areas such as gaming, and very weak in others, such as shopping and books" (ibid).

Similar to the App Store and Google play, in 2004 Windows launched the Windows Marketplace, a platform for the delivery of software electronically rather than physically as was previously the case with the Windows OS. In 2012, it was replaced by the Windows Store, an application store for Microsoft Windows and other types of apps. As of August 2015, there were 340,000 apps available in the Windows phone store (Statista 2015). Besides the apps, Microsoft has also put considerable effort into developing cloud computing capabilities in-house. In this regard, the company released the Microsoft Azure platform in 2010.

[20] Also note Google's corporate moto: "Don't be evil".

Microsoft's gaming platform, anchored by the Xbox 360 console, is certainly the most comprehensive of all the GAFAs. Microsoft has put considerable effort into making its Xbox 360 the center of its business ecosystem, integrating it with other Windows-operating devices (Fig. 17). This was the goal sought with the launch of the Xbox One in 2013, which not only allowed for gaming, but also for interacting with other media content such as music or video. From being a company that mainly ran on licensing proprietary OS, Windows has become a big game platform (de Agonia et al. 2013).

Microsoft has also included a powerful search engine in its ecosystem: Bing. Besides carrying out Internet searches, it also includes the Bing's Shopping feature and the Wallet technology, the latter resembling the characteristics previously discussed on Google or Amazon's ecosystems. The company has also engaged in communication activities through Skype, its voice and video communications tool, which could at some point play an important role in Microsoft's entertainment/gameplay platform (de Agonia et al. 2013). Finally, the acquisition of Nokia's Devices and Services business unit by Microsoft in 2014 has enabled the firm to become an important player in the smartphone industry, mainly through the Windows Phone and Surface tablets (Risku 2012).[21]

Twitter was founded as an online social networking service and micro-blogging platform that enables users to send and read short 140-character messages called "tweets." One of the central elements for Twitter's success is its ability to track tweets in real time. In this sense, tracking the ten most-talked-about topics at a given moment has been labeled as "trending topics," making it possible to follow such topics in different geographical zones (i.e., worldwide, a particular country).

Registered users can read and post tweets, but unregistered users can only read them. Users can access Twitter through the website interface, SMS or the apps for most mobile devices available on the market. As Bmimatters (2012) states, "content and media companies are using Twitter to drive traffic to their websites. It is being used by e-commerce and local businesses for deal promotions. Some businesses are using it as a customer service channel; while some are using it to increase their brand awareness and monitor their brand perception. Some non-profits are using Twitter as a fund-raising channel as well" (Fig. 18).

In August 2015, Twitter had 316 million users (Statista 2015), thus becoming an attractive destination for advertisers. Primarily, the efforts of Twitter are oriented to establishing partnerships with search vendors, device vendors, media and telecom providers (Bmimatters 2012). In fact, Twitter's business model also runs on the advertising market.[22] Twitter's advertising efforts are analogous to Facebook's efforts, and it could be said that, to a certain extent, Twitter's ad products mirror Facebook's. Twitter has three primary ad formats: promoted trends, promoted accounts, promoted tweets and keyword targeting (see Cocotas 2013).

[21]When the deal between Microsoft and Nokia was reached (US$7.2 billion acquisition), Microsoft acquired a patent portfolio of up to 8500 design patents, but not the many other thousands of the Finnish company's utility patents, which were licensed to Microsoft for 10 years.

[22]For more details on the economics behind Twitter's business model see Levy (2015).

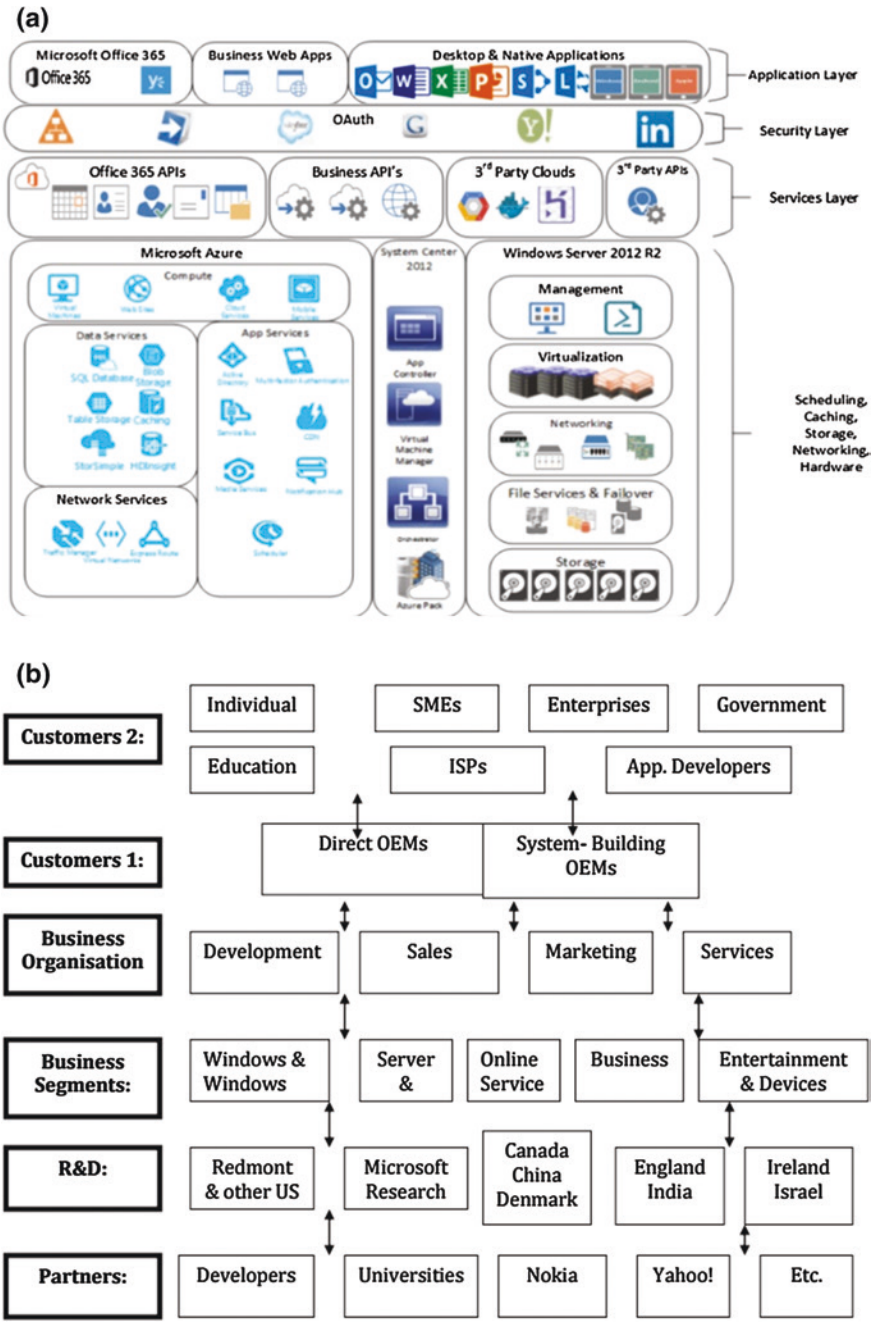

Fig. 17 **a** Microsoft's business ecosystem. *Source* Skelly (2014). **b** The core of Microsoft's Global Innovation Ecosystem. *Source* Fransman (2014: 27)

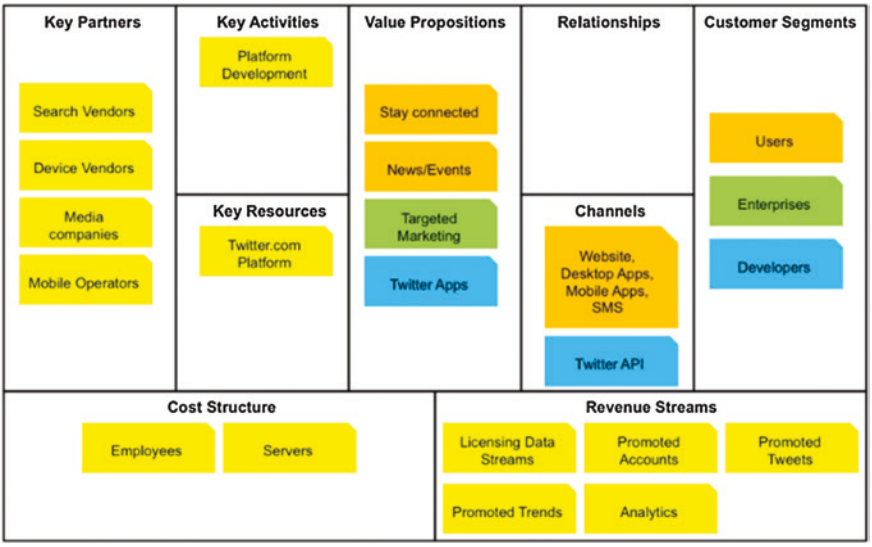

Fig. 18 Twitter's business ecosystem. *Source* Bmimatters (2012)

According to Cocotas (2013: 31), video ads would be a natural expansion for Twitter. This is an area where Twitter is already being challenged by Meerkat, so it seems plausible Twitter will engage in this stream of activity in the short-term in order to defend itself from this increasing competition.

Twitter has also built an app ecosystem, offering APIs that help developers build third party apps. As the Twitter official blog indicated on July the 11th 2011, "As an ecosystem, we've just crossed one million registered applications, built by more than 750,000 developers around the world… A new app is registered every 1.5s, fueling a spike in ecosystem growth in the areas of analytics, curation and publisher tools."

4 Epigenetic Dynamics

Every day we hear about a new business activity in one (if not more) of the GAFAs, which was already carried out by another group. As discussed, we believe they will gradually reach the point where they are all doing the same business activities, although with varying degrees of penetration (and success), and always keeping to a main activity or function (i.e., original DNA). However, this business convergence is at the same time leading them to diversify to new sources of income and risks. They are increasingly being keen to enter fields that do not depend on their original activities. When one group starts up a new business venture or starts exploring a new direction (i.e., what in the context of this chapter we refer to as dominant vector), the others imitate and follow (Daidj 2011).

One example of this convergence would be the availability of social networks. Part of the business groups we are aiming at studying are present in the field of social networks. Facebook, because it is the group's DNA. Google, because it improves and complements user data in searches. Amazon, by using sales data mining and recommender systems. Kindle also enables users to contact with people who read the same book, and Apple integrated Twitter into its new devices. Although Amazon and Apple cannot equal Facebook's social power, they could set up agreements with the firm or, even more easily, with some competitor like Twitter. Other examples (among many) of this convergence could also be the provision of videophone services, or the increasing proliferation of eBooks some years ago and of tablets in more recent times.

This is the goal of this section. To illustrate the epigenetic dynamics of the GAFAs over the past years, providing evidence of the extent to which the moves by some of them are also followed by the others. This section thus responds to the second stage of the EED approach, which focuses on analysing the dynamics in response to influences from the environment, as a result of which "genetic disorders" may be created. These deliberate changes occur abruptly rather than gradually. In other words, epigenetic dynamics follow an economic rationality. They do not happen by chance as it might be deduced from the Darwinism that has dominated evolutionary thought. We would like to stress here the need to constantly follow up these moves so as to get a comprehensive and updated view of the strategy and dynamics of each of these firms. This is particularly central in the analysis of the digital ecosystem. Thus, it might be the case that the dynamics we are analysing in this section become obsolete in a short period of time, and that the dominant vectors in which the GAFAs (or those which still remain solid in the marketplace) are putting their efforts into in say 3–5 years time are radically different from those discussed here. This is why the book is trying to balance the conceptual and empirical parts in the book, contributing with an analytical framework that allows interpreting these dynamics, no matter which these are, in the light of the literature on evolutionary economics.

Entry of these big business groups in other corporations' fields may though be seen as a defensive rather than offensive move. On the one hand, they are looking to diversify, because as Manjoo (2011) pointed out, "You never know what's going to hit big in tech. So if you can, why wouldn't you try everything?" Furthermore, Google may be concerned because some analysts like Vincent Cerf, one of the so-called fathers of the Internet pointed out that the firm's essence, the search engine, may be overtaken by another, just as Altavista, the best engine in its time, was displaced by Yahoo, which was then surpassed by Google. As we have indicated in Sect. 2 in this chapter, due to the increasing proliferation of applications in the Internet ecosystem (i.e., particularly concerning mobile) search engines could suffer a major disruption in the short run.

Iansiti and Richards (2006) make an analogy between competition and evolution in the sense that some animal species "run a race" of adaptation in their evolution. This enables them to defend themselves from their predators to avoid their extinction as a species. From an evolutionary perspective, competition for the

GAFAs implies permanently resizing and readapting to maintain an identity and a place on the market, which requires aggressive strategies (Mortara and Minshall 2011). Some of the characteristics of these epigenetic dynamics are included in Block B of Table 3. These dynamics are produced, among others, as a response to the characteristics of the environment mentioned which these firms operate, namely, the digital ecosystem: Intense increase in inter-group competition.

Innovation becomes an asset and a key activity. This has been true for a long time now. What is new is the difficulty companies experience keeping up with the extremely fast pace of innovation for long periods of time. Companies like Nokia or RIM (Blackberry) that were leaders just a short time ago have been displaced by others such as Samsung, Apple, or Google, and their respective business ecosystems, which have drastically changed the mobile telephone landscape and the overall Internet panorama. Nokia has not been overtaken by another mobile telephone company but by an ecosystem in which the device is merely a part of it (Gruman 2012; Thomas and Autio 2012). Accordingly, as previously discussed, the companies we are interested in need to define and deploy comprehensive, intense, and complex innovation strategies (Iyer and Davenport 2008). Even so, they are not enough to manage innovation of the entire ecosystem, especially as the business groups move away from the main function of the ecosystem (i.e., the perimeter of innovation).

Table 3 An epigenetic understanding of the economic impact of big internet business ecosystems' dynamics

A. Analysis of the environment	B. Identification of epigenetic dynamics
Intense increase in inter-group competition	Massive acquisition of small firms and/or their intellectual property (i.e. patent portfolio) to block potential structural changes and to defend from competition
Exponential growth of the markets and users in other (related) business areas	Aggressive acquisition strategies to sustain profit growth
Expansion in the number of applications and their content	Presence in global markets and gain access to new technologies and innovations
Fast multivectorial technological change and planned obsolescence	Asymmetric negotiations between large business groups, application developers and content providers
Modularity in the behavior of business ecosystems	Entry of large business groups in activities not related to their original purpose (DNA)
Exponential increase in advertising as a share of turnover	High entry barriers posed by large incumbents
Exponential increase in the patent portfolio	Risk-averse industrial strategies played by large companies
Dominance by large companies that are increasingly being delocalized	Use of the financial strength as the main protective industrial instrument
Industry, market and institutional structures	

Source Own elaboration based on Gómez-Uranga et al. (2014)

Mobile telephones are essential to all the groups we are interested in analysing, due to the possibilities of future expansion. For Facebook and Google in the field of advertising; for Apple, because it is the firm's key business, needed to maintain its leadership in a wide range of innovative products and discover new sources of income (amplified iTunes, iCloud, etc.). In fact, big changes in business organizations' environments have been observed with the arrival of the new 4G technology as it marks a qualitative break for mobile telephones. The promising future of mobile phones prompted Amazon to consider launching Kindle, which, of course, made it easier to sell their goods to users who purchased it. It is also a support device that could be used for other activities, such as advertising. Google and Amazon had also launched their own replicas of iTunes and more recently of the iCloud (Shearman 2012). Television may also be a dominant growth vector in the future, although at current times the main dominant vector is that related to cloud computing.

When observing the activities of big Internet industry groups it can be noticed that their development does not conform to the natural/gradual processes that evolutionary economics would predict (see Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups"). These large groups were originally distinctive for know-how that resulted in some "initial business routines" as well as certain products that fit into their "original activity." However, these groups suddenly and rather abruptly took on new routines and entered fields that initially had nothing to do with their businesses. Table 4 illustrates the convergence observed in the direction and intensity of the dynamics of some of the leading Internet business groups between 2012 and 2013.

More recently though, these dynamics have even become more disruptive, as the business groups have started to penetrate other domains which are not that close to the software industry as Table 4 illustrated. As we can observe in Table 5, some examples of these radical and abrupt economic dynamics are represented by the increasing moves toward health and genetics, self-driving cars, augmented reality, higher education, or finance and banking to mention a few. As discussed earlier, the presence of these large business groups in these sectors cannot be explained or expected according to their original activities or DNAs, but rather from the pressure introduced by competing firms and the environment in which these operate.

Internet firms are obliged to follow these dominant vectors because they cannot leave areas or segments outside their organizational routines if they are to survive in the marketplace. Even if that behavior leads them to have an inefficient behavior, they need to penetrate other (often unrelated) sectors of activity because in their absence they would be relegated from other areas where rival groups dominate.

The previous diversification strategies have been motivated by the convergence context (Daidj 2011). Apple has always adopted an "original" Internet pay model (subscription model for content in iTunes) compared to its competitors. Between 2011 and 2012, Apple released the iPhone 4S, iPhone 5, Siri, cloud-sourced data services with iCloud, the third and fourth generation iPads, the iPad MiniIn, iBooks Textbooks for iOS and iBook Author for Mac OS X, a third-generation MacBook Pro and new iMac and Mac Mini computers. In 2013, Apple got deeply involved in the development of augmented reality systems, following the steps by

Table 4 The companies' activities in different fields (market shares and ranking by activities or products) between 2012 and 2013

Business Groups	Hardware		Software	Contents	
	Mobile /Smart phones[a]	Tablets	Op. System—also for smart phones	Search engines	Social networks
GOOGLE	Nexus	Nexus	Bada 5th	**	65 m
			0.7 %	1st	
	Smart Phone		Android 1st	88.8 %	
			74.4 %		
APPLE	**		IOS		
	3rd	1st	2nd		
	9.0 %	39.6 %	18.2 %		
MICROSOFT	Expected Smart Phone with Nokia	Surface,os:rt	**	Bing	
		5th	4th	2nd	
		1.8 %	2.9 %	4.2 %	
FACEBOOK	Expected Smart Phone with HTC			*4th in the US*	**
					1st
					750 m
					72.4 %
AMAZON	Expected	4th			
		3.7 %			
SAMSUNG	1st	2nd	Android		
	23.6 %	17.9 %	1st		
			72.4 %		
NOKIA	**	Expected	Symbian		
	2nd		6th		
	14.8 %		0.6 %		
HTC	8th				
	2.3 %				
MOTOROLA	9th				
	2.1 %				

Convergence in the direction and intensity across Internet Business Groups

[a]The figures included in the first column refer to the Worldwide Mobile Phone Sales to End Users by Vendor in the first quarter of 2013. For the Worldwide Smartphone Sales to End Users by Vendor see Gartner (2013)

**Activity/Routine within the DNA of the business group. The first "innovative" products that best identify with the Internet industry groups' DNA would be those that form the essence (i.e., products that each company has been distinctive for since its beginnings)

Source Own elaboration from Gartner (2013), Alexa Global traffic Rank (2013), IDC (2013) and Gómez-Uranga et al. (2014)

the other GAFAs, particularly Google and Facebook, and more recently wearables. More recently, the company is getting into the manufacture of smart electric cars and the production of green energy, and getting serious about video games through the new developments carried out in the new Apple TV.

Table 5 Economic dynamics in some of the leading Internet business groups in 2014

Business groups	Sectors						
GOOGLE	The cloud	Wearables, health and genetics	Self-driving car	Connected homes and societies	Digital ads	Augmented reality	Higher education (udacity), Finance and banking
APPLE	The cloud	Wearables and health	Third-party Digital content (music, movies, games, podcasts)	Apple Smart TV			
MICROSOFT	The cloud		Gaming	Social networks		Augmented reality	
FACEBOOK	The cloud	Wearables (Fitness)	Private social networks	Connected homes and societies	Digital ads	Press and media	
AMAZON	The cloud	Online payment systems	3D printing	Amazon TV and Amazon Studios	Digital ads		
SAMSUNG		Wearables and health	Samsung Bikes	Connected homes Smart TV	Microchips for smartphones	Augmented reality	Wi-Fi standards
TWITTER			Finance and banking	Video communication			

For a more detailed analysis of the most recent dynamics included in Table 5, see Chapter "GAFAnomy (Google, Amazon, Facebook and Apple): The Big Four and the b-ecosystem"
Source Own elaboration

Google has adopted a diversification strategy of nonrelated media products and services in such a way that hardware and software have become more inextricably linked at the company (Finkle 2011). Google has also employed the Web Search technology into other search services, including Image Search, Google News, the price comparison site Google Product Search, the interactive Usenet archive Google Groups, Google Maps, Picasa, Orkut, Youtube, Google books, Google Scholar, Google Patent search, Google Docs, Google Chrome, and Chromebook. In 2013, the company announced the launch of Calico, a firm focused on the challenge of aging and associated diseases in a clear move toward the health sector and the pharmaceutical industry (i.e., Google X project, Google Fit). A first step in this direction has been the development of wearables by Google, following the steps

undertaken by Apple and Samsung among others (see also Peeble).[23] In 2014 the firm announced the acquisition of Nest in order to more into the Internet of Things and the connected house. The more recent moves of the firm into the higher education (i.e., university education) and academic research segment should not be overlooked, due to the follower effects it can create in the other GAFAs. Partly derived from the previous epigenetic dynamics during the past years, in 2015, Google announced plans to reorganize its various interests in a holding company called Alphabet Inc. give operating divisions more leeway in making their own decisions and keep the businesses more nimble (Dougherty 2015). From our EED approach, this corporate reorganization can be regarded as one of the most significant epigenetic dynamics that may occur. This reorganization in holdings undertaken by Google may generate some potential consequences such as: the existence of a magma business with different yields and expectations; a difficulty to identify and separate each product complexity and therefore to calculate the actual value of each business by investors; regulatory problems. One of the dominant vectors that may guide the future of Google, together with Facebook, is the development of systems that allow satellite Internet connection (i.e., Space X and Project Loon). Another is Kobalt, with the one the company is intending to disrupt the music industry. The other, namely, the development of driverless cars is also being fostered by the investments Google has carried out in building artificial intelligence systems (i.e., TensorFlow) that can learn from video games.

As early as 2002, Microsoft decided to be the first mover in the promising online game sector, developing a specific OS for the Xbox 360. This led the firm to the development of Kinect. It is expected that Microsoft might use Kinect to penetrate in the TV industry as Amazon and Google are increasingly doing. In this sense, in 2014 Microsoft acquired the video game development company Mojang (i.e., Minecraft) for $2.5 billion. Following the release of Windows Phone, Microsoft underwent a gradual rebranding of its product range throughout 2011 and 2012. In 2012, Microsoft unveiled the Surface, the first computer in the company's history to have its hardware made in-house. At the same time, Microsoft was buying the social network Yammer to compete with Facebook, launching the Outlook.com webmail service to compete with Gmail, and releasing Windows Server 2012 to compete with Amazon. In 2013 Microsoft agreed to buy Nokia's mobile unit for $7 billion, which was then followed in 2014 by the acquisition of Nokia Devices and Services, forming Microsoft Mobile Oy, and the acquisition of Skype. The Alliance for Affordable Internet was also launched in 2013, with

[23]In this sense, it should be emphasized the partnership Google keeps with Tag Heuer in the development of high quality smart watches and wearables in order to be able to compete with Apple's range of high quality goods.

Microsoft as part of a coalition of public and private organizations that also includes Facebook, Intel and Google, and aims to make Internet access more affordable so that access is broadened in the developing world.[24]

Yahoo has various other services besides the original search engine and Email (e.g., Yahoo News, Yahoo Mobile, Yahoo Messenger; Yahoo Music, Yahoo Finance, Yahoo! 360°, Flickr).[25] Yahoo has also signed partnership deals with different broadband providers such as AT&T, Verizon Communications, Rogers Communications and British Telecom, offering a range of free and premium Yahoo content and services to subscribers. In 2013 Yahoo purchased the blogging site Tumblr for US$1.1 billion, which led to a significant shift in the activities of the firm, targeting to get into the social network activities already in place in the other GAFAs. In 2014, the firm announced its partnership with Yelp Inc. and the acquisition of BrightRoll so as to compete with Google.

Amazon product lines include a terrific diversity of goods and services, from media to baby products, and jewelries to groceries. Being mostly recognized as a book retailer, it has to be said that the firm also counts with its own publishing unit. In 2011, Amazon announced its entry into the tablet computer segment in a move to get closer to the activities of the other GAFAs, who as discussed were already present in this segment. This launch was followed by the Amazon Appstore for Android devices. In 2012, Amazon announced it would be adding a gaming department (i.e., Amazon Game Studios) to get into the entertainment and gaming industry. In 2014 Amazon announced its Amazon Fire TV set-top box system, a device targeted to compete with such systems like Apple TV or Google's Chromecast device. On the one hand it allows for streaming videos from sites like Amazon's own streaming service as well as others such as Netflix or Hulu, while it also supports voice search for movies and games on the other. This should be interpreted as part of the interest of the firm in its Amazon Studios, a division focused on the development of TV shows, movies and comics. Next, the company entered the smartphone market with the release of the Fire Phone. Amazon has also carried out significant moves in the so-called Amazon Web Services (AWS), particularly as regards cloud computing and storage. In the past years, the company is also investing in the use of unmanned drones to deliver small packages and also 3D printing.

Facebook filed for an initial public offering in 2012, getting the largest valuation to date for a newly listed public company. At the same time, Facebook announced App Center, a store selling applications that operate via the site. Besides, it also acquired the firm Instagram and entered cloud storage. In its move toward the search engine business, in 2013 Facebook announced Facebook

[24]We should not overlook the fact that in August 2015, a consortium of major German automotive business (including Daimler, BMW and the luxury division of Audi and Volkswagen) has agreed to buy maps of the Finnish company Nokia for a value of €2500 million, in an attempt to expand the participation of auto manufacturers in digital online services. It is expected that these systems will have a key collision detection and other functions in driverless vehicles.

[25]See: http://www.diffen.com/difference/Google_vs_Yahoo. Accessed 10 August 2015.

Graph Search. Facebook also unveiled Facebook Home, a user-interface layer for Android devices, which were first made available in smartphones by HTC. In February 2014, Facebook announced the acquisition of the mobile messaging company Whatsapp for US$19 billion, which was followed by the acquisition of Pryte, a Finnish mobile data-plan firm that aims to make it easier for mobile phone users in underdeveloped parts of the world to use wireless Internet apps (see The Alliance for Affordable Internet above), the investment in the future of wearables through the acquisition of Fitness App, and the acquisition of LiveRail, an online video advertising company.

Samsung Electronics has emphasized innovation in its management strategy since the early 2000s. In the first quarter of 2012 the company became the highest selling mobile and smartphone company. These large earnings allowed the firm to (radically) get into different streams of activity (e.g. LCD and LEDs, semiconductors, Wi-Fi standards, Internet TV, connected housed and Internet of Things, wearables, virtual and augmented reality). In part, the fact that Samsung has become the world's biggest semiconductor chip supplier can be attributed to this financial success. In 2014, Samsung partnered with Amazon to introduce the Kindle for Samsung app. As most of the previous GAFAs, Samsung also counts with its own app store. While many other handset makers tended to focus on supporting one or two OS, Samsung kept supporting a wider range, like Symbian, Windows Phone, Linux-based LiMo, and Samsung's proprietary Bada.

Despite Twitter is one of the smallest of these Internet Giants, it has experienced very rapid growth. In 2012, Twitter acquired Vine, a video clip company that allowed users to create and share six-second looping video clips. In 2013, Twitter launched a music app called Twitter Music for the iPhone. In 2014, the firm announced the acquisition of Namo Media, a technology firm specializing in native advertising for mobile devices. This was followed by the acquisition of SnappyTV, a service that helps edit and share video from television broadcasts, and the acquisition of CardSpring, which enables retailers to offer online shoppers coupons that they can automatically sync to their credit cards in order to receive discounts when they shop in physical stores. More recently, and due to the increasing relevance gained by Meerkat, Twitter announced its acquisition of Periscope, an app which allows live streaming of video. Twitter is also increasingly used for making TV more interactive and social, not only for the audience but also for the TV companies themselves. In May 2013, it launched Twitter Amplify—an advertising product for media and consumer brands, and more recently it is also engaging into financing and banking. In an attempt to compete with Twitter's leadership in TV, Facebook introduced a number of features in 2013 to drive conversation around TV including hashtags, verified profiles, and embeddable posts.[26]

[26]This competition between Facebook and Twitter is increasingly being regarded as the "news war" (Holmes 2015).

So, which are the dominant vectors that the GAFAs are engaged in and which could reach mass consumer markets in the next years to come? Improving the efficiency of the terminals and devices implies accelerating the diffusion of the technologies and the devices that make up the Internet universe. However, it is hard to know with certainty what the dynamics in the efficiency improvements of these devices might be, and the timing in which these can be achieved. Computers and mobile devices (e.g., smartphones, tablets) are progressively introducing technological improvements in the new generations through advances in batteries (i.e., improving battery life and speed of connection), efficiency gains and price. For example, screens, larger and with much better definition, are demanding more energy and requiring superior performance, so it is necessary to adjust battery consumption. In this regard, graphene presents ideal properties, with respect to silicon, ceramics and plastics, to manufacture components that can later be incorporated into the devices of the future. In fact, Asian firms Moxi and Galapad have already announced their idea to launch in short 30,000 devices in which graphene is used in batteries, screens and power systems.

Competition between the various agents that form the Internet constellation, also results in the development of time-varying dynamics. As we have earlier discussed, it is unpredictable to know in advance and with certainty the evolution that the different groups and actors may have, due to the clashes and conflicts among them.[27]

Wearables and smart watches have significantly grown in these past years, which have not only become an important market for the GAFAs, but are also transforming sectors such as health or sports. The so-called "phablets" (i.e., a hybrid between smartphones and tablets) are also growing rapidly. Although this can be regarded as an incremental move, according to the forecasts made by Business Insider (Danova 2014), sales of phablets in 2019 will triple that of tablets. The increase in the demand of these phablets is due to the expected increase in the generation and further use of services and content, together with the and growth in advertising investment in mobile devices.

The level reached by the technology, the ability to connect appliances, and particularly the progress made in human-machine interaction makes it possible to contemplate the potential of the Internet of Things. The development, deployment, and distribution of Internet of Things requires a very important network of telecom support and infrastructure. This explains the introduction of telecom operators in areas such as 4G and 5G (see Chapter "4G Technology: The Role of Telecom Carriers" by Araujo and Urizar), what in turn leads to joint ventures and mergers or acquisitions. As with mobile payment, new alliances and partnerships are being established among different players like General Motors with AT&T, or Sprint Nextel with Chrysler. But as it is the case with any connection, the Internet of Things is still vulnerable and subject to risks of cyberattacks, so here too, it is not easy to accurately assess the speed of this phenomenon.

[27]For example, competition between providers of processors and chips (key components of smartphones and wearables) is becoming increasingly noticeable.

The Internet of Things is conducive to several global trends; for example in relation to the consumption of food, health and fitness, besides the already mentioned wearables. While the arrival of driverless cars is still pending, we are witnessing a race to connect cars and other physical objects to the Internet and integrate apps services in these. Manufacturers, operators and technology companies have started the conquest of this new market, but, again, there are still major obstacles to overcome.

Mobile payments are still modest, but it is estimated that we are close to reaching a context in which cash money ceases to have relevance, and economic transactions can be made through mobile terminals safely.[28] Technically, there are different solutions available; but this has not yet being enough for a sharp growth in mobile payments due to the different and sometimes conflicting interests of the various stakeholders involved: telecom operators, mobile device manufacturers, banks, etc. In this regard, the entry of Google, Amazon, Apple, Twitter, or Facebook, in mobile payment is becoming an important competition for traditional banks.

Partly due to the increase in online shopping, there is a trend in many cities to a gradual disappearance of the traditional shops and local commerce. Globalization trends and the potential of the information made available through the Internet are posing a major challenge to these small and much localized actors. In this sense, large groups are increasingly offering these small businesses the opportunity to be visible through marketing techniques on the net (see the Ads provided by many of the GAFAs), so their scope of activity can adapt to the new globalization requirements. The universe of the Internet is in present times characterized by the existence of massive or big data. As we have discussed earlier, Amazon was the first among the GAFAs to get into the big data through the Amazon Web Services. The analysis of this massive data requires the involvement of specialized service companies, what explains the increasing moves of the GAFAs toward cloud computing activities and services (see also Chapter "The Digital Ecosystem: An "Inherit" Disruption for Developers?" by Vega et al.). The advice to local companies and ships is thus regarded crucial so these can benefit from the opportunities that arise from the big data. As a result, large business groups must be able to provide customers with services that adhere to their main specialty. For example, large groups such as the Spanish bank BBVA are redefining their strategies toward the provision of software services and the transmission of data (Gallego 2015). Competition between the GAFAs groups is occurring particularly between Microsoft, Facebook, Amazon, and Google, with unpredictable results in the medium term.

Increasingly, companies and countries are in an international context of cyber-attacks, in which every organization can be subject to being attacked. Table 6 offers an illustration, though not exhaustive, of the cyber dangers affecting the potential GAFAs' dynamics in the short term.

[28]Mobile payment requires the deployment of Near Field Communication technology, which is still widespread in very few countries.

Table 6 Cyber challenges and dangers faced by the GAFAs and other SMEs

Malware	Short for "malicious software" is any type of program designed or used for unauthorized access to a computer system
	It can be used to access data, control a targeted system, or to do both. Malware used to access data ranges from simple programs that track keystrokes and copy screenshots to sophisticated programs that can search through a users files and browser history to steal passwords and bank data
	While malware has historically targeted only computers, "mobile malware" that targets tablets and smartphones is an increasing threat
	Terms often used in security news stories like viruses, worms, Trojans and spyware describe specific types of malware
Phishing	Phishing attacks have become more sophisticated in recent years as the online footprints of individuals have grown. Social networks have given phishers access to a treasure trove of personal information they can use to customize their attacks and increase their likelihood of success
Phishing scams	Phishing Scams may use email, text messages, Facebook or Twitter to distribute links to malicious webpages designed to trick you into providing information like passwords or account numbers
Advanced persistent threats	Are systematic, long-term attacks against technology systems. They seek to create situations for very complex malware programs to be introduced or permitted access to critical systems or information. They involve the accumulation of several strategies, including: phishing, social engineering, waterholes, or exploratory hacking to mention a few
Unsecured internet connections	Businesses do not have direct control over these wireless access points like they do in the workplace, and these unsecured connections risk exposing company data when security measures are not taken to protect the transmission of data
Cloud computing	In spite of the risks associated to cloud computing, the resources devoted to this area on cyber security are still quite low
Passwords and encryptions	Hackers can use special software to "guess" passwords or they can trick unsuspecting employees into turning over their login credentials by directing them to seemingly legitimate login pages
Application-based threats	So-called "malicious apps" may look fine on the surface, but they are specifically designed to commit fraud or cause disruption to devices. They may come in the form of malware, but also include privacy threats and vulnerable apps
Phishing scams	May use email, text messages, Facebook or Twitter to distribute links to malicious webpages designed to trick you into providing information like passwords or account numbers

Source Own elaboration based on Harris (2014) and Hobby et al. (2014)

Table 7 Possible measures to face the cyber risks

The "Leaders"	Understand and be conscious about the company's current exposure to cyber-threats and its effectiveness in managing the risk
Employees and managers	Should follow good practices of cybersecurity, and define crisis plans against possible attacks
Predefining recovery point objectives	They represent the maximum acceptable data loss, the maximum tolerable time data, services, and operations can be unavailable, as the result of an incident
	Since an attack transforms the environment, it would be possible to assess the resilience to these drastic events
Firms	For more details on the 21 guidelines organizations may follow to protect their core business, see Hobby et al. (2014: 12)
Prevention systems	More comprehensive encryption systems should be implemented, together with antivirus programs and appropriate firewalls, by specialized suppliers
Cloud computing service providers, contract compliance providers, and mobile application providers	Firms should negotiate with these the potential problems and security risks to be faces, so as to choose the best supplier
Services provided by telecom operators	Besides providing access to high speed capacity (4G, 5G), they should also guarantee security in their networks

Source Own elaboration based on Harris (2014) and Hobby et al. (2014)

Epigenetic dynamics are directly influenced by the dangers outlined in Table 6. This implies that the evolution of these dynamics might be faster (i.e., more disruptive) or slower (i.e., more incremental and progressive). Thus, a high degree of uncertainty and unpredictability is introduced into the system to predict how and to what extent (i.e., speed) nuclear technologies to the further development of the Internet ecosystem can spread, what affects both the GAFAs and their users. Next, we present some of the practical steps or roads organizations and individuals may follow to minimize cyber vulnerabilities, and defend from possible attacks and the challenges associated to them as discussed earlier. The result of the possible ways to meet the challenges below by companies is not predictable. In certain contexts, the difficulty of overcoming these challenges will be greater and in others instead easier to address. Therefore, anticipating and predicting the speed of certain evolutionary dynamics is not possible, unless the characteristics of the environment in which the organizations under analysis are embedded are known (i.e., stage one of the EED approach). However, what it can be concluded is that without the measures outlined in Table 7, any change in the environment (e.g., changes associated to the growth in demand for Internet users) would be more constrained, and even canceled, and therefore any potential path resulting from the new epigenetic dynamics may vanish.

5 Patenting Dynamics

As we have earlier discussed, patents are one of the strongest environmental properties in of the Internet ecosystem. The field of patents shows just how fierce the competition is. The main reason is the high knowledge content in these groups' business activities. When the GAFAs enter new fields, they embark on out-of-control patent purchasing (a scenario known as the "patent war"). Examples of the increased dynamics of acquisition and penetration in new fields can be the seventeen thousand Motorola patents bought by Google, the CPTN Holding, formed by Microsoft, Apple and other companies, which acquired six thousand patents auctioned by the bankrupt company Nortel, or Facebook's patent acquisitions from IBM and AOL (Gómez-Uranga et al. 2014). As a result, the groups get involved in an enormous amount of cross litigation, to support their business strategies aimed at "doing new business" or protecting themselves. However, we have not included here the analysis of the patents acquired as a result of the joint ventures or acquisitions of other firms, as the analysis of the M&As is carried out in the next section.

In this section, we will illustrate whether the previously observed epigenetic dynamics can be explained by the patenting behavior of these business groups. The goal is to analyze the evolution and dynamics observed in the GAFAs, determining how these firms expand and diversify their activities. With it, we aim to analyze the behavior of the groups in their patent portfolios to illustrate the EED approach.

Figure 19 illustrates the total number of USPTO patents granted to each of the GAFAs under study between 1984 and 2014. Naturally, the exponential differences among these can be partially explained by the age of the firm. While Twitter, the youngest firm among all, was born in 2006, Microsoft and Samsung Electronics go back to 1975 and 1988, respectively. However, the voluminosity of the patents also provides explanations for the epigenetic dynamics discussed above.

In Sect. 3 (see Fig. 9), we provided evidence of the number of patents granted per year at the USPTO to the GAFAs between 2007 and 2014. Here, we will go back to this figure so as to analyze more in-depth the voluminosity of the patenting activities in the GAFAs. As the reader may observe, we have divided Fig. 20 into two blocks. Part a focuses on the evolution shown by the five business groups with the largest amount of patents granted in the past 7 years (i.e., Google, Apple, Microsoft, Nokia and Samsung Electronics), while part b focuses on the five groups with the smallest number of granted patents (i.e., Facebook, Yahoo, Amazon, Twitter, and eBay). The first conclusion that can be obtained from the figures below is that Samsung Electronics is the company that a priori, has the strongest technological capabilities to lead potential epigenetic dynamics in the next years. The 5794 USPTO patents granted in 2014 provided the firm with a large technological advantage in the development of LCDs and LEDs, semiconductors, Wi-Fi standards, Internet TV, connected housed and Internet of Things, wearables, and virtual and augmented reality products. Samsung is also the firm that counts with the largest accumulative knowledge in the protection of

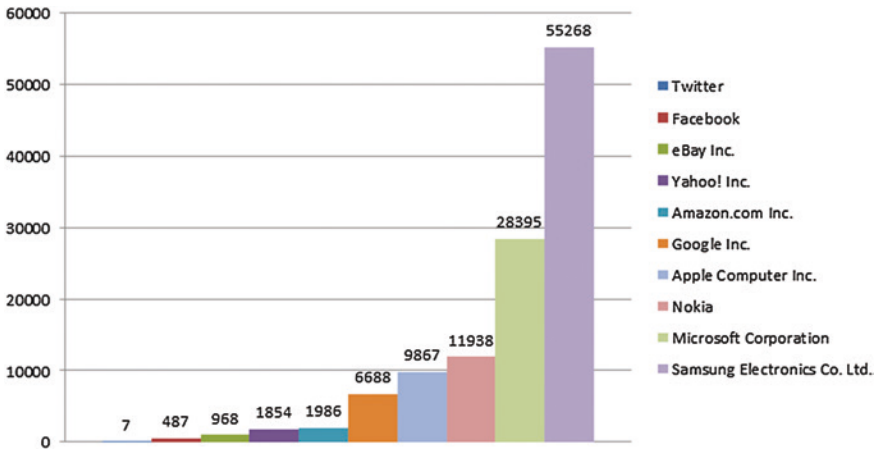

Fig. 19 Number of USPTO patents granted between 1984 and 2014. *Source* Own elaboration based on USPTO

its know-how as the 55,269 USPTO patents granted between 1984 and 2014 evidence. Besides, it should be stressed the evolution shown by the company in this very matter in the past 7 years. While in 2007 the firm was granted 3332 patents at the USPTO, this amount was almost doubles in 2014, an evolution that only Apple and Google seem to be able to follow. Microsoft and Nokia have on the other hand remained somewhat constant over these past years, with values close to 3000 and 900 patents, respectively.

When we move the analysis to the remaining five GAFAs, the first thing to note is the difference in the values observed in the vertical axis. Where in Fig. 20a, we were close to 6000 patents per year, in here it is Amazon the one that shows the largest number of patents granted per year, with 751 patents in 2014. The second aspect that should be noted, though in different scales, is the parallel path followed by Amazon and Facebook. Facebook got its first patents granted ($n = 7$) in 2010. The numbers were kept constant in 2011 with eight patents, but since then the evolution has been explosive with 50, 131, and 291 patents in the years 2012, 2013, and 2014, respectively. As it was the case with Microsoft and Nokia above, the path followed by Yahoo since 2010 can also be regarded as stable, with around 300 patents per year. Finally, eBay has also shown progressive growth rates since 2010 in particular, while the very low values achieved by Twitter to date, with three patents in 2013 and four in 2014 do not allow reaching any solid conclusions.

In order to analyze to what extent the dynamics followed by the GAFAs are more or less disruptive, and therefore more toward or away from the original DNA of these groups, we have next conducted a partial analysis of the diversification paths followed by the GAFAs in their patenting strategies. In order to achieve this goal, we have gathered all the (CPC—cooperative patent classification) technology classes included in the patents granted to the GAFAs at the

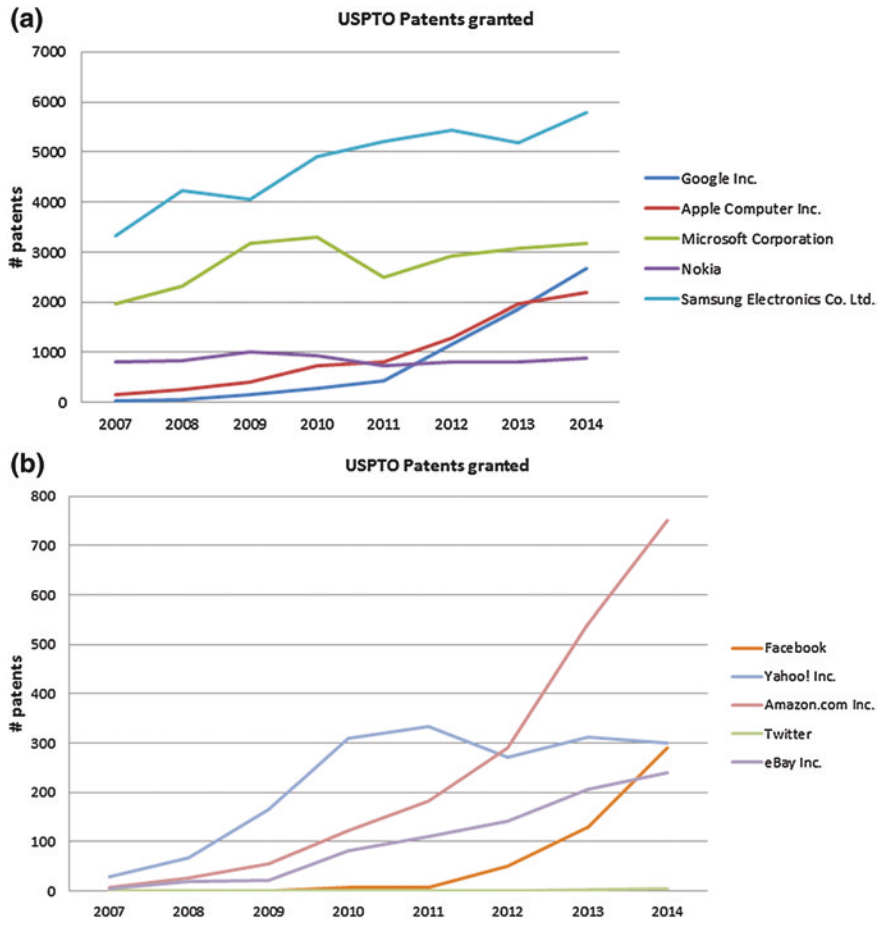

Fig. 20 **a** Number of yearly USPTO patents granted to some of the large business groups operating on the Internet (2007–2014). *Source* Own elaboration based on USPTO. **b** Number of yearly USPTO patents granted to some of the large business groups operating on the Internet (2007–2014). *Source* Own elaboration based on USPTO

USPTO. In each case, this analysis has been carried out since the year in which the first patent was granted to each of the 10 GAFAs included in the chapter. Once all technology classes covered by the patents granted each year are known, then we have assessed which is their share in relation to the total number of patents for that year.[29] In other words, we measure which is the number of times a certain technology class is repeated as compared to the total number of patents

[29]The technological domain covered by each technology class can be observed at the World International Patent Office (WIPO). See: http://web2.wipo.int/classifications/ipc/ipcpub/#refresh=page&notion=scheme&version=20150101&symbol=G06F0017300000. Accessed 19 December 2015.

Table 8 Methodology followed to assess the technological diversification of the GAFAs. *Source* Own elaboration

Year 1		
Tech class (CPC)	# patents	%
	2	3
G06	3	100.00
Y10	2	66.67

in that particular year. Let us assume a company has been granted 3 patents in a year, and these three patents include two technology classes. We observe the number of times each technology class is being included in the 3 patents and from there we are able to assess the relative weight of each technology class. This operation is then repeated for all the 10 GAFAs and for all years in which they have been granted patents at the USPTO. However, in order to provide a preliminary analysis of the results obtained so far, we will only represent below the diversification paths followed by three of these firms, namely, Twitter, eBay, and Amazon.[30] The vertical axis represents the different technology classes in which each of the groups has obtained patents in their evolutionary paths. In turn, the size of the bubble represent the share of each technology class in relation to the total number of patents (i.e., the % as outlined in Table 8), so that the larger the share, the bigger the size of the bubble.

As indicated above, Twitter got their first three patents granted in 2013, to reach a total of seven patents to date. These seven patents only include two CPC technology classes, G06 and H04. As Fig. 21 shows, the relative weight of the technology class G06 has remained constant over time, while the weight associated to H04 has increased from 33.33 % in 2013 to a 50 % in 2014.

In the case of eBay, the company got its first patent granted in year 2000, so in order to gain some conclusions about its technological diversification, the time window is much larger in this case. As Fig. 22 shows, eBay too started patenting two technology classes (i.e., G06 and Y10), a situation that remained constant until the year 2004 when a third technology class was included (i.e., H04). These three technology classes have ever since remained in eBay's patent portfolio. It is noteworthy signaling year 2009 as the year in which more technology classes started being included in the know-how of the firm. Since then, the diversification has continued including more classes to the technological capabilities of the firm. Even if this diversification is clearly observed, however, the relative weight of these classes in the whole portfolio of patents has remained fairly constant, with three technology classes dominating above the others (i.e., G06, H04, and Y10).

[30]Another reason for not including here the evolution of the other firms is visibility. As the reader may expect, the larger the voluminosity of patents, there bigger also the number of technology classes covered. For example, Samsung Electronics had 77 different technology classes only in year 2014, Nokia and Microsoft 31, Apple 54 and Google 39. If we add these numbers to the values for the technology classes in the rest of the years, we end up in situations where more than 200 classes need to be visualized, which we deem not sensible to provide in one single figure.

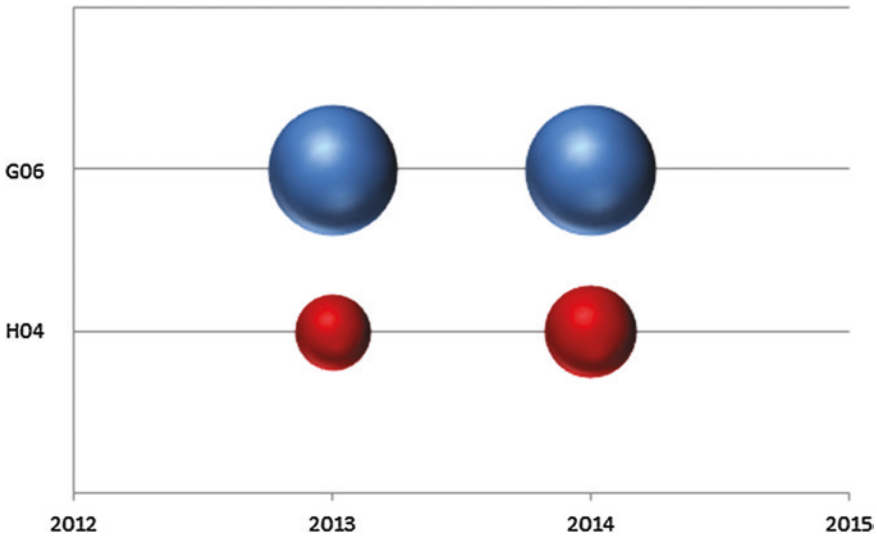

Fig. 21 Technological diversification path followed by Twitter (2013–2014). *Source* Own elaboration based on USPTO

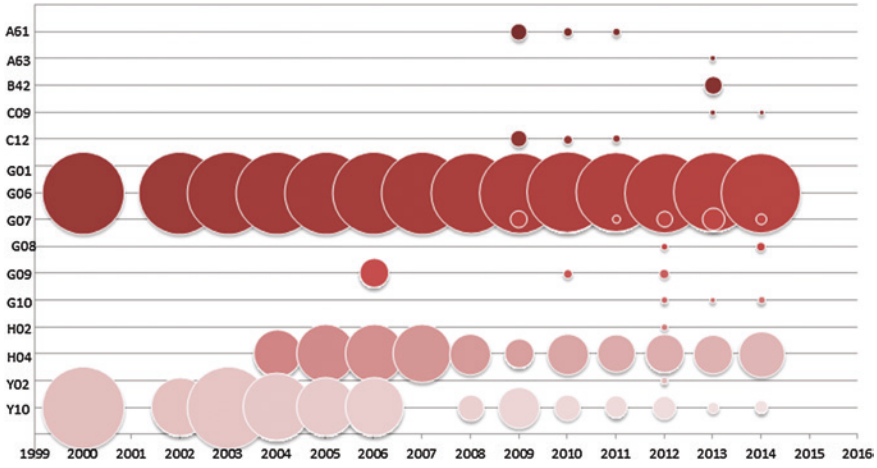

Fig. 22 Technological diversification path followed by eBay (2000–2014). *Source* Own elaboration based on USPTO

The previous dynamics are also replicated in the case of Amazon but to a much larger extent. In other words, the dynamics are more disruptive. As Fig. 23 shows, Amazon's portfolio of patents incorporates many additional technology classes than in the previous two cases. Besides, the relative weights of these additional classes are also much larger than in the previous cases. We can for example refer

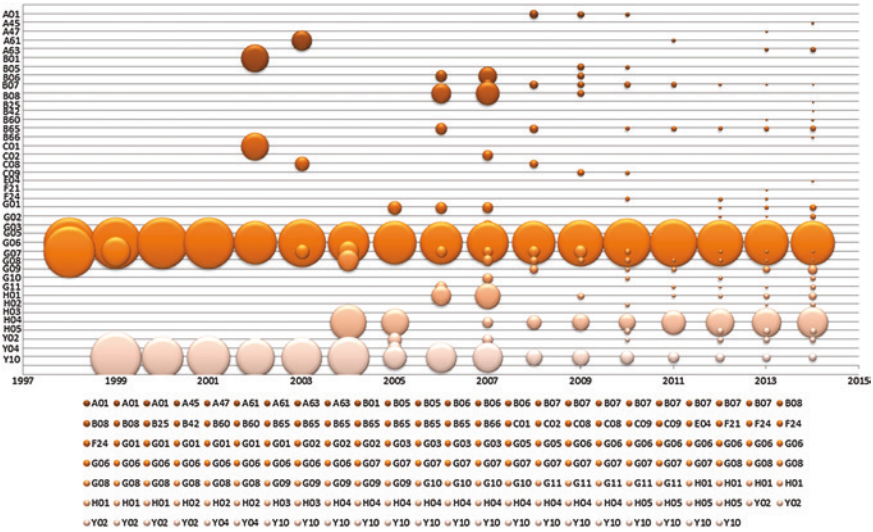

Fig. 23 Technological diversification path followed by Amazon (1998–2014). *Source* Own elaboration based on USPTO

to classes such as A61, B01, B06, B08, C01, G01, G07, and H01 which are also representative of the dynamics followed by Amazon in recent years.

So, what can we say about the research questions posed at the beginning of this chapter? In relation to what technological areas are the GAFAs moving into overtime, the previous analysis shows that the high velocity of the Internet ecosystem is making the analyzed firms move into other technological classes which were not at the core of their organizational routines. Some of these are: A63, B41, B60, B82, G01, G08, G09, G11, H01, H03, and H05. Are they related to these groups' DNAs? Addressing this research question is a bit more complex, since the technological capabilities of each firm varies, and therefore it is not possible to provide a unique answer. In order to be able to comprehensively assess this question, it would be necessary to carry out an analysis of the technological distances among technology classes, similar to these introduced by the scholars in the field of economic geography as regards related variety studies (see Sect. 1). However, what it can be confirmed is that fact that these diversification dynamics are similar across the GAFAs. Even if the intensity of the multiple technology classes across firms varies, when we observe the diversification paths followed by all GAFAs is parallel. Thus, as we have discussed in the book, the environment is forcing all the firms to go through similar paths. This causes contexts in which all go against all, as previously discussed in the chapter. The main rationale for this patenting war is that as Malik (2015) evidences, and as Abba would sing, in the context of the Internet ecosystem, the winner almost always takes it all.

This analysis has also driven us to suggest the following research avenues and pursue the following research goals. Given the large amounts of patents granted to

the GAFAS, we believe it would be very enlightening to apply the latest methodological approaches developed in the scientometric and technology mining communities (van Eck et al. 2013; Leydesdorff et al. 2014; Kay et al. 2014) to gain new insights on their dynamics and their diversification strategies. This would pursue the following goals:

– The analysis of the patents granted to the GAFAs will allow us to bundle all the patent information into clusters of activity, so that the main dominant vectors in which the GAFAs diversity their portfolio of activities are identified. With it we will be able to determine which are the key milestones (back in time) that set the ground for the diversification that we are witnessing at present times. The previous analysis will also allow us to determine whether the GAFAs are following related variety or unrelated variety strategies in their diversification processes. This analysis may provide crucial information not only for other established firms in a large variety of industry segments who want to supply these large players into their diversification strategies (e.g., security, health, financing), but also for new ventures (i.e., entrepreneurs) who are identifying technological and market opportunities.
– The analysis of the citations of the granted patents (backward and forward citation) can help us understand which firms cite the patents of the GAFAs and which patents are cited by the patents granted to them. Similarly, we will also be able to examine the extent to which the GAFAs cite each other's patents or not.
– The analysis of the citations of the patents granted to the GAFAs can also provide relevant information for the identification of which the standard essential patents are (Gómez-Uranga et al. 2014). By studying the forward and backward citations of the patents granted to the GAFAs we would be able to observe whether there are certain patents that play a central role in opening new technological domains. Besides, once these "essential" patents are identified, then it will be possible also to track who their inventors are as well as their affiliation and location (at the moment of patenting).
– As regards the analysis of the key inventors, we could also identify whether these only cooperate with one company or whether they patent for many companies at the same time. Inventors can also provide relevant information as to the extent to which they are present in many different communities at the same time, so the radical innovations are produced as a result of multidisciplinarity. In this regard, some of the questions that could be addressed from the perspective of the inventors are: Which are the communities these lead inventors are present in at each moment in time? And how many communities are they present in at the same time? Why do researchers/inventors move between often unrelated communities? How distant are these communities?

In order to achieve the previous research purposes, it would be possible to rely on two well established methodologies in the innovation studies community. On the one hand, social network analysis methods are applied (Granovetter 1973; Håkansson 1987; Ahuja and Katila 2001). Given the large amounts of patents to be analyzed, by studying the forward and backward citations it is also be possible

to answer identify those patents that act as standards in the mobile and software industries. By identifying the patents that act as standard essential patents, it would also possible to understand the reasons for the GAFAs to engage in patent lawsuits one another.

6 Merger and Acquisition Dynamics

In this section, we will focus on the number of M&As completed by each of the GAFAs, and the amount of investment required in order to explain the identified epigenetic dynamics. As Daidj (2011) discusses, the motivations for carrying out M&A include achieving growth by opening up to market opportunities in domestic and foreign markets; having a better access to capital, intangible assets of other firms such as managerial skills and knowledge of markets and customers, etc. In the context of high velocity environments as the one we are interested in, firms pursue M&A to renew their technical capabilities and products. However, M&As are regarded as one of the most effective ways to spur innovation and change the markets in which the firm is either competing or aims to compete.

The GAFAs have for long signed agreements with different partners belonging to the ICT sector but also to the automotive, banking industry, etc., particularly in these past years where their number and intensity has bubbled. To a certain extent, we could make a metaphor here with the GAFAs and the pirates. Pirates were looking for the best of the best anytime and anywhere, and similarly, the GAFAs are very much aware of their antennas in order to capture the innovations available worldwide and bring them to their own "castles." Figure 24 shows the total number of M&As completed by the GAFAs between 1987 and 2015. As it can be

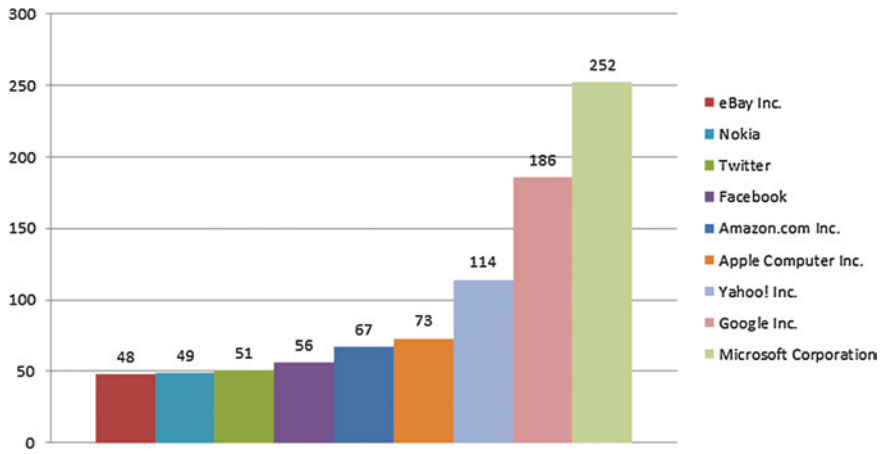

Fig. 24 Number of M&As completed (1987–2015) (We could not find any evidence of the M&As completed by Samsung.). *Source* Own elaboration

observed, according to the total number of M&As, Microsoft is the one that counts with the largest portfolio of firms with 252. However, the case by Google deserves special attention, because despite it is a much younger firm than Microsoft outperforms all the other organizations in this dimension. In this particular case, M&As are without doubt one of the main factors explaining the epigenetic dynamics and hence, the high adaptability shown by Google.

Next, we plot the total accumulated value (in million US$) of the M&As completed by the previous firms over time. In this case too, the company that has invested the most in the acquisition of firms is Microsoft with US$52,124 million, followed in the distance by Google with US$27,789 million. If we compare the two figures, the reader may note that Facebook and eBay have increased its relative position with regard to the value invested in the acquisition of other firms. On the contrary, the case by Apple is worth stressing as it is one of the firms that has invested the least in acquiring new firms (US$6211 million). It has to be noted that the values represented below, only include those acquisitions whose value has been reported and does not remain undisclosed. As a result, due to the large number of acquisitions for which we could not find information, Fig. 25 should be interpreted with caution.

Figure 26a, b we represent the evolution shown by the GAFAs with regard to the number of M&As. As we did in the case of the analysis of the patents in the previous section, here too, we divide Fig. 26 into two blocks. Part a focuses on the evolution shown by the five business groups with the largest number of M&As (i.e., Google, Apple, Microsoft, Nokia, and Yahoo). In the case of Google, the number of acquisitions, taking into account the evolution of the firm, shows peaks in 2007 with 15 acquisitions, 2010 with 27 acquisitions, and 2014 with 32 acquisitions, respectively. Microsoft also shows various peaks in years 1999, 2006 and 2008, and 2015 with 32, 18 and 19 acquisitions, respectively. As discussed earlier, Apple is not characterized by the completing a significant number of M&As. The

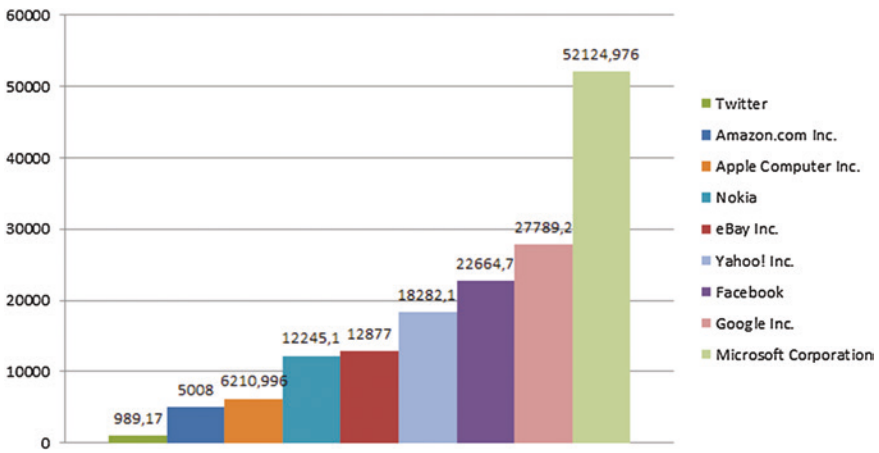

Fig. 25 Value of the completed M&As (1987–2015) (Million US$). *Source* Own elaboration

number of M&As has been kept rather stable between 3 and 4 yearly, until year 2013 when the company acquired up to 14 firms. Finally, Yahoo also shows two peaks in the number of MA&s, the first in 2005 with 10 M&As and the second in 2013, just one year after Marissa Mayer was appointed as the CEO of the firm, with 27 firms acquired. In turn, part b of the figure focuses on the 4 groups with the smallest number of acquisitions (i.e., Facebook, Amazon, Twitter and eBay). As can be observed, these four firms start conducting M&As later in time as compared to the other five cases. Amazon and eBay conducted their first M&As in 1998, while Facebook completed its first acquisition in the year 2005 and Twitter in the year 2008. Among these, the case of Amazon is quite illustrative of a first mover. The company, born in 1994, started acquiring other firms just 4 years after

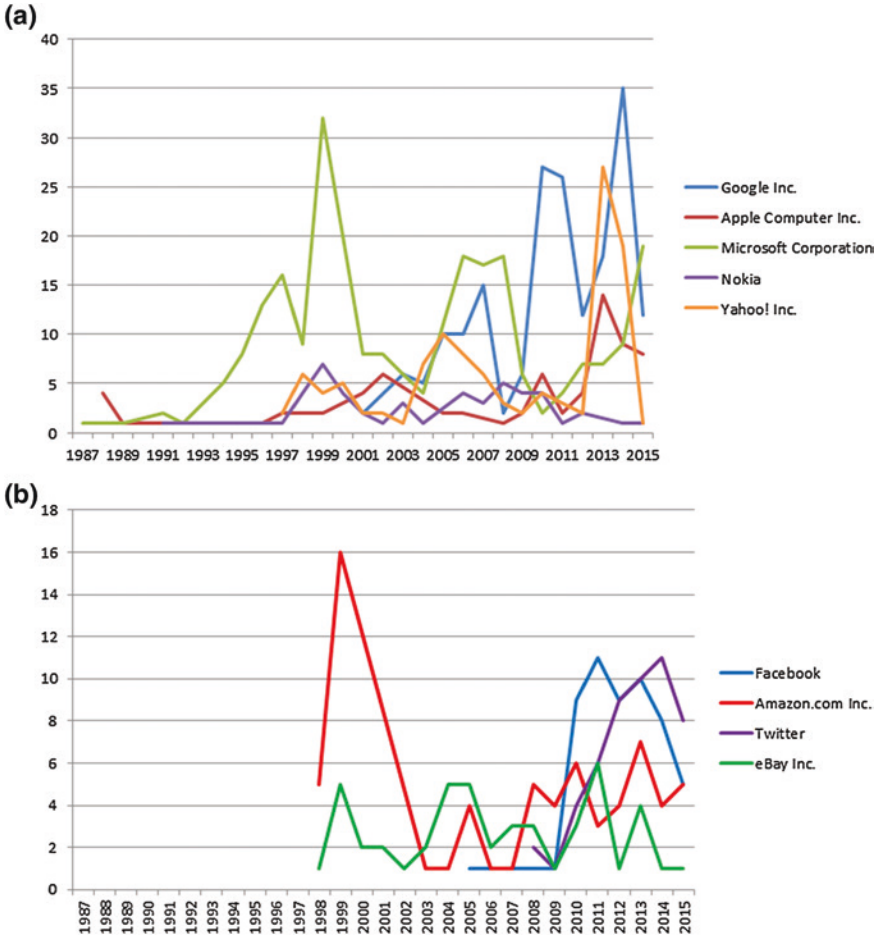

Fig. 26 **a** Number of M&As completed (1987–2015) by some of the large business groups operating on the Internet. *Source* Own elaboration. **b** Number of M&As completed (1987–2015) by some of the large business groups operating on the Internet. *Source* Own elaboration

its existence, and in fact, the largest volume of acquisitions was observed in 1999 ($n = 16$). In the case of eBay, the number of acquisitions shows ups and downs with values in between 3 and 6 firms acquired yearly. Finally, both Facebook and Twitter show a parallel path with an exponential increase in the number of firms acquired.

In Fig. 27, we replicate the previous analysis but this time with the value invested in the M&As instead. Here too, we divide the figure into two blocks. Part a focuses on the evolution shown by the five business groups with the largest investments devoted to the acquisition of new firms (i.e., Google, Microsoft, Nokia, Facebook, and Yahoo), while part b focuses on the 4 groups with the smallest number of granted patents (i.e., Apple, Amazon, Twitter, and eBay).

As to the former, the most illustrative cases are the peaks observed for Yahoo in 1999, Nokia in 2008, Google in 2011 and Facebook in 2011. In the case of Yahoo, the company invested in 1999 a total amount of US$9510 million in the acquisition of four firms, the most significant of which were Broadcast.com for a value of US$5700 million, and Geocities for US$3600 million. In the case of Nokia, the Finnish company invested US$8517 million in year 2008 in the acquisition of five firms, from which the acquisition of the American company Navteq is to be stressed with a value of US$81,000 million. In 2011, Google devoted US$13,265 million to acquire 26 firms. Among these firms, the most significant ones were Motorola for a value of US$12,500 million, a case that has already been discussed in Gómez-Uranga et al. (2014). In turn, Facebook invested in year 2014 US$21,500 million in the acquisition of 35 firms, the most relevant of which were well-known cases of Whatssap for US$19,000 million and Oculus VR for US$2000 million. Finally, and for Microsoft five peaks can be observed in years 1999 (32 firms for US$7116 million), 2005 (11 firms and US$3175 million), 2007 (17 firms and US$6793 million), 2011 (US$8600 million in four firms) and 2013 (US$7200 million in seven firms). Among these, the most significant acquisitions were the ones of AQuantive, a digital marketing firm in 2007 for a value of US$6333 million, the acquisition of Skype in 2011 for US$8500 million, and the previously discussed acquisition of Nokia mobile phones unit in 2013 for US$7200 million.

In the case of Apple, the most substantial acquisitions were completed in year 2014, when a total amount of US$3030 million were invested in nine firms, the most significant of which was the music streaming company Beats Electronics (US$3000 million). In the case of eBay, there are four years which deserve attention, 2002 (US$1500 million in one firm, Paypal), 2005 (US$3220 million in five firms), 2008 (US$1759 million in three firms) and 2011 (US$2825 million in six firms). In Amazon, there are three peaks that deserve some attention in years 2009 (US$1200 million in four firms), 2012 (US$1087 million in four firms) and 2014 (US$970 million in four firms). Among these, the most significant one was the acquisition of the online shoe and apparel retailer Zappos in 2009 for US$1200 million.

Here too, there are several further research avenues to be conducted in order to better understand the role M&As play in explaining the epigenetic dynamics of

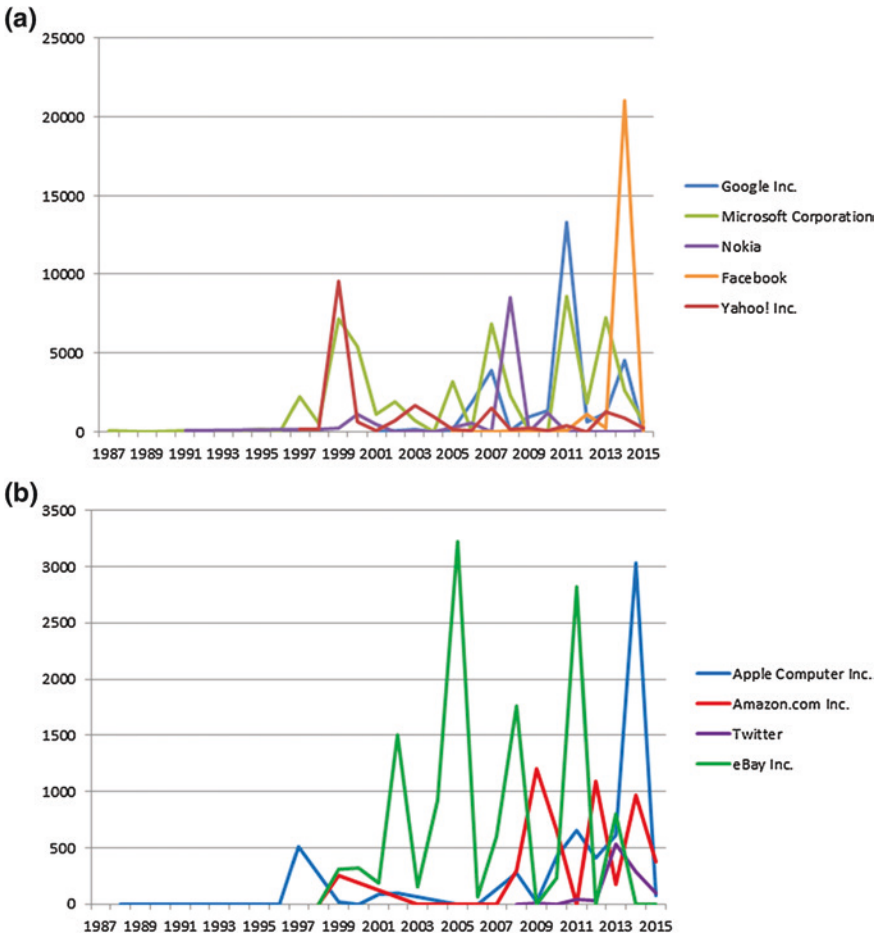

Fig. 27 **a** Value of the completed M&As (1987–2015) by some of the large business groups operating on the Internet (Million US$). *Source* Own elaboration. **b** Value of the completed M&As (1987–2015) by some of the large business groups operating on the Internet (Million US$). *Source* Own elaboration

the GAFAs. Which domains of activity do the acquired start-up firms belong to? Does the diversification strategy, through the acquisition of new firms, respond to a related or an unrelated variety? What is their geographical location? Are they located close to the GAFAs (i.e., hot spots) or are they dispersed? How old are these firms? There are still many open questions to be addressed and that we have not yet been able to respond in a comprehensive manner.

The analysis of the age, size of the acquired firm, its geographical location, and the sector it belongs to will allow us to conclude whether the GAFAs are following related or unrelated variety strategies. Besides, since many of the entrepreneurial

firms that are acquired by the GAFAs also count with an important patent portfolio, the questions formulated above for the case of the GAFAs could also be pursued, but in relation to the acquired entrepreneurial firms created by developers.

One of the characteristics of modern developers is the speed at which they can create new applications, programs, etc. In this regard, the cloud, the use of automation tools, collaborative methodologies, ready-made components, the availability of open software and code and the large number of developers facilitate their diffusion into the Internet ecosystem. Developers get adapted instantaneously to:

- The relationship with other companies which either absorb their applications (e.g., the GAFAs) or use them in their respective markets and sectors (e.g., machine tools).
- The requirements and limitations of the hardware through the development of new programs (software) or changing and improving existing ones.
- The areas (i.e., dominant vectors) where a higher demand for applications exist, such as the sustainability of the environment, health, human mobility, massive online shopping, videogames, etc.

However, in spite of the relevance of developers, there is certainly no evidence to date on their evolution, the dominant vectors that guide their actions, the reasons for the developers to orient toward certain industries ignoring others, etc.[31]

Building upon the data gathered in relation to patents and M&As, it would be possible to build a model that helps determine which are the key structural characteristics that explain: (i) the revenues achieved by the GAFAs, and (ii) their market capitalization. In this regard, a longitudinal model could be built, which would use panel data from a large variety of indicators characterizing the GAFAs, including: number of employees, gross profit, R&D investments, number of USPTO granted yearly, etc. As a result, we could identify which are the key variables that help statistically explain the limitless performance of the GAFAs.

7 Discussing Some of the Consequences as a Result of Epigenetic Factors

As Gómez-Uranga et al. have discussed in Chapter "Introducing an Epigenetic Approach for the Study of Internet Industry Groups" in this book, the third stage deals with the abnormalities, malfunctions or obstacles to innovation, and/or blockage to developing competition that may arise as a result of the influence of epigenetic factors (Lehman and Haslam 2013). Some of these implications include (see Gómez-Uranga et al. 2014): existence of a gap between R&D investments and patenting results; patenting rationale distorted; excessive transaction (and

[31]See Chapter "The Digital Ecosystem: An "Inherit" Disruption for Developers?" by Vega et al. for a methodological proposal on how to address the study of the dynamics of developers.

litigation) costs; high entry barriers to SME patenting; problems in the definition and development of standards; overload in patent offices and regulating agencies. Other potential consequences also include: economic consequences, institutional consequences, regulatory consequences, social consequences, moral and ethical consequences, with their subsequent implications in terms of policy and social dynamics (Dutton 2013). An example, currently under discussion in Europe, is the increasing tax engineering practices of the GAFAS (Corkery et al. 2015).

Patents are one of the strongest environmental properties in the field where the business groups examined in this book operate. In theory, patents ensure progress and technology advances. In practice, they have become a battlefield for cross-claims which questions one of the key objectives of patents systems. Patents are now being used to hinder competitors' growth. The meaning of patents has changed (Bessen and Meurer 2008): they used to be the result of innovation and companies could pay for the use of license rights, but now they seek exclusive rights so as to include them in their ecosystems and thus hinder rivals companies' growth (i.e., blocking the potential innovation capacity of competitors rather than creating the necessary incentives to innovate).

Companies sometimes seriously alter competition through their lawsuits, asking the court to stop the sale of their rivals' products (Fischer and Henkel 2012; Knable Gotts and Sher 2012). These business groups devote large amounts of their resources to patents, above all, human resources. Swarms of engineers and attorneys work constantly on companies' legal claims and law suits. Maintaining a patent portfolio and licenses on the basis of lawsuits involves enormous costs (Gómez-Uranga et al. 2014). Lawsuits and legal disputes not only involve high costs but also create disincentives for innovators. Bessen and Meurer (2008), state that the intellectual property rights system has failed as a means of protection and information for companies in the U.S. Lawsuits for infringement of intellectual property may even be affecting different business groups' share prices. Although the situation of patents and incentives for innovation varies according to the industry, software patents are very abstract and poorly defined. This makes it much more complicated to achieve reasonably efficient market contracts (Bessen and Meurer 2008). Therefore, we could say that market failure is due to poorly defined property rights. All of these issues lead us to ask if patents systems can no longer fulfill their primary objectives.

Business groups have a distorted view of the competition's conditions as a result of the turbulence in these environments. Companies may block or have their innovation paths blocked. Their competitive conditions may vary radically due to changes in the environment. The environment is at the mercy of whatever company is the biggest at a given time (Gómez-Uranga et al. 2014).

As we have seen, patent applications for operating systems and programs used in all types of computation, internet and telephone devices and gadgets have increased sharply in the past years. This has led to a considerable increase in the amount as well as the voluminosity of patents. This growth in the voluminosity (size and scope of patents applications) may be a necessary condition for companies to adapt their business models to changes in technology, legal systems and market conditions (van Zeebroeck et al. 2009).

Furthermore, it is important to take into account the impact caused by inefficiencies in the patent system in regard to the high price of the end product/service as well as higher "transaction costs" resulting from patenting expenses and related lawsuits (Gómez-Uranga et al. 2014). This inefficiency also means that products/services take longer to reach the market because of the time involved in patenting and the lawsuits which may result. The inability to control planned obsolescence is another aspect related to patents systems. This is due to overprotection of previously patented products and the strong deterrent posed by a lawsuit on behalf of the owners of the intellectual property concerned. Finally, we have to take into account the regulations and laws protecting possible violations of free competition resulting from predatory business practices when companies, etc., use their power to gain control of large amounts of intellectual production (i.e., patents).

Understanding the consequences that result from the discussed epigenetic dynamics of the GAFAs requires a dialectical vision in which there are sets of consequences that go in different directions but exist simultaneously. One of the positive consequences of the evolution of the Internet phenomenon (based on the evolutionary dynamics of the large groups) would be the increase of individuals to access new information, what can potentially lead to new paths that make these individuals better off. These could be called as "user-centric epigenetic dynamics." Other positive consequences could also include: (i) the increase of relationships among individuals; (ii) these connections and relationships are reinforced regardless their training and education levels; (iii) cultural and language barriers that impeded relationships are broken down; (iv) the possibilities of promoting extensively and intensively leisure activities are increased (e.g., music); (v) individuals can get rid of corsets and restrictions in their respective environments, and gain access to different universes elsewhere.

Meanwhile, one of the main negative consequences of the evolution of the Internet phenomenon (based on evolutionary dynamics of the large groups) refers to the increasing disintegration of privacy (Dutton 2013). In this regard, an example of direct user privacy attack is illustrated by Max Schrems, whose lawsuit against Facebook has recently been resolved by European courts. However, the most important and significant risks, both due to their size and their subtlety, are generated by the use Internet groups make of users and their information (i.e., personal data) for economic and commercial purposes. Other potential negative consequences include: (a) changes in human relationships, what results in an impoverishment of these, despite their exponential increase; (b) relationships in the Internet world, even when they have a more horizontal character, pose no greater democratization of these; On the contrary, they often imply maintaining and reinforcing the status quo of the establishment, which are mainly represented by the interests of the large Internet groups; (c) a distortion of world economic resources, whose fate is not devoted to the improvement of the living standards of the general population; (d) a greater capacity to generate high risk situations, due to the possible loss of control over potential cyberattacks that could have devastating effects on economies, populations, etc.

European Commissioner Oettinger (Digital Economy Society) has as main responsibilities, among others, to take steps toward a connected digital single Europe and to achieve a comprehensive protection of data and copyright. The

Commissioner noted that Europe must force business groups to comply with the rules issued in Europe. Clearly the past stances of European Commissioners during the past years open a particular conflict, not without tensions between the U.S. and European governments (Leyden and Dolmans 2014; Wiethaus 2015).

In any case, in recent years, we are witnessing the existence of a gap between the evolution of technologies on the one hand, and the activities and practices of Internet groups and the adequacy of regulations and laws to these changes on the other. The latter always move with a delay. One of the latest examples in this regard is the regulation on network neutrality issued by the Federal Communications Commission in February 2015 in order to guarantee the promotion of the quality of Internet service (Tardiff 2015). Against radical solutions such as the rejection or the submissive acceptance of judicial decisions, or the very high fines, other intermediate areas, based on negotiation and consensus, and in finding policy approaches that may better suit to a situation of conflicting interests are imposed (Nazzini 2015).

The dominant discourse on technology provides the latter with an almost total autonomy on issues such as culture and society. In this "standard" understanding of technology, this plays a deterministic role exclusively subject to the laws of nature, and related to the applied sciences. Against this dominance of technology, the role of culture and society would be regarded as simple derivatives. The so-called classical model of technology assessment (Shrader-Frechette 1985; Westrum 1991), focuses primarily on highlighting the negative effects of the implementation and development of technologies. It would be centered in applying a consistent logic in which technology has effects on other (mainly social) systems.

Against the previous deterministic conceptions of technologies, there are also approaches that intend to integrate the implementation and development of technologies in the "social" dimension. This would, for example, be the case of the literature on constructive technology assessment (Wynne 1975). Table 9 presents the main features of this constructive evaluation of technologies, which are then compared with the classic one.

This alternative constructive perspective, more centered on the social dimension, is incorporated in a functionalist logic. This implies that the economic feasibility of the technologies, the development of real markets, efficiency criteria, the effects created by the diffusion of technologies and equity are also considered. Moreover, we believe that technology, in addition to its technical and organizational dimensions, must also be understood as being immersed in values, ideas, and beliefs.

Table 9 Classic and constructive assessment of technologies

Classic assessment of technologies	Constructive evaluation of technologies
Elitist character (centered on scientific knowledge)	Participatory character
Focused on the regulation of the products of technological activity	Focused on the processes by which technologies are created
Reactive approach (impact assessment)	Proactive approach (ex-ante evaluation)
Economic and probabilistic approach	Interdisciplinary and comprehensive approach

Source López Cerezo and Martín Gordillo (2002: 341)

Table 10 Standard and constructivist view on technology

Standard view on technology	Constructivist view on technology
Clear separation between technology and society	The border between society and technology is diffuse
Technological development is autonomous from social and cultural changes	Technology is socially shaped
Technological changes determine sociocultural changes	Technology and society are co-produced
Technology is applied science	The relationship between science and technology is not unidirectional
Technology is neutral	Technology can be inherently political
Technological development follows an internal logic based on technical efficiency criteria and scientific principles	Technological development is the product of diverse cultural forces
Linear model of technological development: design-development-dissemination	Multidirectional model of technological development
Emphasis on the social impacts of technology	Emphasis on processes of social shaping of technology
Clear distinction between the development of technology and its effects	The development and dissemination phases overlap

Source Aibar (2002: 51)

As part of the EED approach, consequences are enriched from the observation of the dynamics occurring in the Internet universe. Contrary to a deterministic view of the evolution of technology, which seeks to minimize its effects on other systems, consequences, as we understand them in our EED approach, are embodied on the dynamics of the Internet ecosystems and the actors that constitute it. That is, consequences are immersed in the actual epigenetic dynamics, and are not simply effects of dominant and a priori determined dynamics. Thus, it can be concluded that our conception of the consequences is closer to constructive technology assessment and social constructivist approaches (Bijker 1995; Aibar 2002).

In this constructivist understanding, culture and technology move hand in hand, although none is contingent on the other. In both approaches, it is necessary to understand the sociotechnical grids hosting technologies, the properties of evolution associated with irreversibility processes, other evolutionary approaches to understand technical change, and of course regulations by the public sector (Table 10).

In our EED approach, we also distinguish between central and peripheral consequences. The former are those generated from the epigenetic dynamics, in our case, of the large Internet business groups. The latter are related to the evolution of the ecosystem itself, but without being in connection with the decisions made by the big Internet business groups. In this section, we have mainly focused on the central consequences, so the analysis of the peripheral ones also remains to be further studied.

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