Disruptive firms and technological change

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ABSTRACT
The fundamental question in the economics of innovation is how technological change is generated in competitive markets. This study confronts this question here by developing the concept of disruptive firms that deliberate introduce new and improved generations of durable goods that destroy, directly or indirectly, similar products and competencies present in markets in order to support their competitive advantage and/or market leadership. In fact, this concept of disruptive firms endeavours to explain firm success in a Schumpeterian world of innovation-based competition, performance rivalry, increasing returns, and the destructive creation of existing competences and products. If correct, the framework suggests that rapid technological change depends in large measure on disruptive firms (subjects), rather than disruptive technologies (objects) and it extends the existing literature to provide a more complete picture of how technological and industrial change evolves. Hence, this theoretical framework can be useful for bringing a new perspective to explain and generalize, whenever possible one of the drivers that generates technological and industrial change in modern economies.

KEYWORDS
Disruptive Firms; Technological Change; Disruptive Technologies; Incumbent Firms; Radical Innovations; R&D Management; Competitive Advantage; Economic Change.

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1. INTRODUCTION

Current economies show the advent of many technological advances in information technology, biotechnology, nanotechnology, etc. that generate corporate, industrial and economic change (Arora *et al.*, 2001; Henderson and Clark, 1990; Nicholson *et al.*, 1990; Teece *et al.*, 1997; Van de Ven at al., 2008; von Hippel, 1988)[1]. The literature in these research fields has suggested several approaches to explain the technological and industrial change, such as the theory by Christensen (1997, 2006) that introduces the concept of disruptive technologies of new entrants that disrupt the competitive advantage of incumbents in the presence market dynamisms. This theory explains the industrial change with the interplay between incumbent and entrant firms that can generate path-breaking technologies[2]. While the validity of certain of these studies may be debated, it is clear that there are at least some facts about industrial change that theory of disruptive technologies has trouble explaining. As a matter of fact, current dynamics of industries shows that new entrants can generate disruptive technologies but their development and diffusion between markets have more and more economic barriers (Coccia, 2016; 2017).

This paper suggests that industrial and technological change is driven by specific subjects - disruptive firms, rather than disruptive technologies *per se*. This study can be useful for bringing a new perspective to explain and generalize one of the sources of technological change that is represented by specific firms that have the potential to generate and/or to develop radical innovations that disrupt current products in markets and support industrial, economic and social change.

In order to position this study in existing approaches, the paper develops the theoretical framework in next section.

2. THEORETICAL FRAMEWORK

One of the fundamental problems in economics of innovation is to explain how industry emerges from a technological or market discontinuity that triggers the creation of multiple new technological designs (Anderson and Tushman, 1990). Scholars of technological evolution agree that the emergence of new industries is due to a technological or market discontinuity that stimulates the creation of new designs in a period of technological variation (Utterback and Abernathy, 1975).

Grodal *et al.* (2015, p. 426) suggest that technological evolution within industries is generated by:

a) *Period of technological divergence* with design recombination that is the creative synthesis of two or more previously separate designs that generate a new design to address human needs and problems.
b) *Period of technological convergence* driven by path dependence (the mechanism through which the cumulative effects of prior technological design choices increasingly determine and constrain subsequent design recombinations) and design competition that is the mechanism by which producers and users make design investment choices about which designs to retain and which to abandon.

[1] Coccia, 2004, 2006, 2009, 2012a, 2013, 2013a, 2015a; Coccia and Finardi, 2012; Coccia and Rolfo, 2000; Coccia and Wang, 2015, 2016.

[2] *Cf.* Ansari *et al.*, 2016; King and Baatartogtokh, 2015; Chesbrough and Rosenbloom, 2002; Christensen, 1997, 2006; Christensen *et al.*, 2015; Danneels, 2004, 2006; Gilbert and Bower, 2002; Hill and Rothaermel, 2003; Jenkins, 2010; Ryan and Tipu, 2013; Tellis, 2006; Wessel and Christensen, 2012; Cavallo et al., 2014, 2015; Ferrari et al., 2013; Calabrese et al., 2005.

In general, the period of divergence supports the emergence of a dominant design within industry (Abernathy and Utterback, 1978). Designs, in some cases, are completely new, but often new industries emerge from innovations that are due to discontinuous recombination of pre-existing technological designs (Abernathy and Utterback, 1978; Anderson and Tushman, 1990). In short, design recombination is the synthesis of two or more different designs that create a new design to address a human needs or problems (Hargadon, 2003).

Grodal *et al.* (2015) also suggest that convergence on a dominant design is due to design competition and path dependence in markets (Clark, 1985). An implication of this theory is that categories can change the dynamics of competition within industry. This theoretical model, within literature on industry evolution, also emphasizes the dynamics taking place prior to the launch of the first design in an industry (i.e., during the time to market when R&D process shapes design creation). Rosenbloom and Cusumano (1987) suggested that firms investing in R&D during the pre-commercialization phase are more likely to be leader and dominate the industry.

The literature in these research fields has suggested other approaches to explain the technological and industrial change. One of these alternative approaches is the theory of disruptive technologies by Christensen (1997, 2006) that argues how many industries are characterized by incumbents that focus mainly on improving their products and services (usually most profitable), and entrants that endeavour to develop new technologies in market segments, delivering market performance that incumbents' mainstream customers require (Christensen *et al.*, 2015; Christensen, 1997). In this context, Christensen (1997) argues that disruptive innovations generate significant shifts in markets (*cf.* Henderson, 2006). In particular, disruptive innovations are generated by small firms with fewer resources that successfully challenge established incumbent businesses (Christensen *et al.*, 2015). New firms can generate competence-destroying discontinuities that increase the environmental turbulence, whereas incumbents focus mainly on competence-enhancing discontinuities that decrease the turbulence in markets (*cf.* Tushman and Anderson, 1986).

Scholars also argue that the ability of incumbents to develop and to market disruptive innovations is due to their specific ambidexterity: competence-destroying and competence-enhancing based on simultaneous exploratory and exploitative activities to support both incremental and radical innovations (Danneels, 2006; Durisin and Todorova, 2012; Lin and McDonough III, 2014; O'Reilly III and Tushman, 2004, 2008; *cf.* Henderson, 2006; Madsen and Leiblein, 2015). Disruptive innovations generate main effects both for consumers and producers in markets and society (Markides, 2006, pp. 22-23; Markides and Geroski, 2005). In general, disruptive innovations change habits of consumers in markets and undermine the competences and complementary assets of existing producers. Calvano (2007) argues that: "we highlight the role of destruction rather than creation in driving innovative activity.

The formal analysis shows that destructive creation unambiguously leads to higher profits whatever the innovation cost". In particular, disruptive innovations disturb the business models of incumbents that have to counter mobilize resources to sustain their competitive advantage in the presence of market change (Garud *et al.*, 2002; Markman and Waldron, 2014). In fact, new radical technologies in markets require that incumbents undertake specific R&D investments and strategic change to support competitive advantage (Christensen and Raynor, 2003; *cf.* Gioia and Chittipeddi, 1991; Teece *et al.*, 1997). Current R&D management of incumbents, to support innovation processes, is more and more based on network organizations to build research alliances and strategic partnerships for increasing the access to external knowledge from new firms and/or research organizations (*cf.* Coccia, 2016b; Nicholls-Nixon and Woo, 2003). Kapoor and Klueter (2015) argue that incumbents tend to not invest in disruptive technological regimes and maintain a competence-enhancing approach. In some industries, such as biopharmaceutical sector, current wave of research alliances and acquisitions may help incumbents to overcome this "inertia" both in the initial stage of research and in the later stage of development. Other studies show that R&D investments of innovative enterprises in

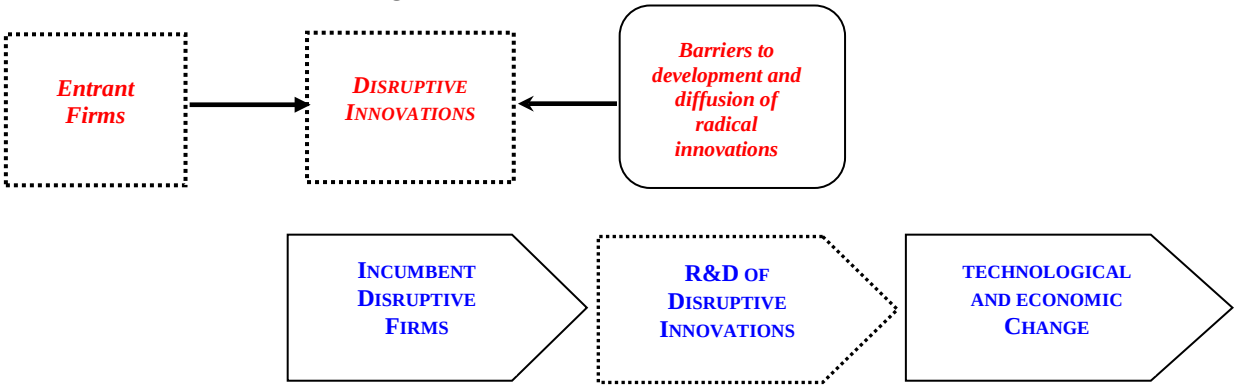
pharmaceutical industry are directed towards both internal research units and strategic alliances to accelerate the drug discovery process (Coccia, 2014).

However, theoretical framework of disruptive technologies suffers of some limitations, such as the ambiguity in the definition of disruptive innovations that considers technologies but also products and business models (*cf.* Christensen and Raynor, 2003; Tellis, 2006). Strictly speaking, a disruptive technological innovation is fundamentally a different phenomenon from a disruptive business-model innovation. Disruptive innovations arise in different ways, have different competitive effects, and require different responses into the organizational behaviour of incumbents and entrants (Markides, 2006, p. 19). This diversity can be due to a variation in the sources of innovation, such as in some industries, users develop innovation, in other sectors, innovations are due to suppliers of related components and product manufactures (von Hippel, 1988). A vital factor in the development of innovations is also played by the coevolution of technical and institutional events (Van de Ven and Garud, 1994). The theory of disruptive technologies also seems to show some inconsistencies in many markets because new small entrants can generate new technology and innovations but their development and diffusion in markets present many economic barriers, such as within biopharmaceutical industry (Coccia, 2014; 2016). In short, the theory of disruptive technologies presents some difficulties to explain the general drivers of technological and economic change.

This study here suggests the vital role of specific firms, called *disruptive firms* that in the ecosystems can generate and spread new technologies with market shifts within and between industries. The study proposes some characteristics of these disruptive firms that can clarify, as far as possible, a main source of innovation to explain drivers of technological change and, as a consequence, industrial, economic and social change.

The model of this study is in Figure 1. Unlike theoretical framework of disruptive innovation (Christensen, 1997), the theoretical framework here suggests that, leading firms – called disruptive firms – support the emergence and diffusion of new technology and radical innovations that generate market shifts, technological and economic change.

Figure 1: Disruptive firms sustain technological and economic change with the introduction and diffusion of technical breakthroughs.



Source: Adapted from Coccia (2017b).

The purpose of the present study is to see whether case study research supports the hypothesis that one of the general sources of technological change is due to disruptive firms (subjects) that generate market shifts, rather than disruptive technologies (objects) *per se*.

3. METHODS: CASE STUDY RESEARCH

The methodology is based on an inductive analysis of case study research (Eisenhardt, 1989; Eisenhardt and Graebner, 2007).

The study analyses the managerial and organizational behaviour of specific leading enterprises (disruptive firms) to explain one of the general sources of technological and economic change. The firms under study are:

- Apple Inc. for Information and Communication Technologies (ICTs);
- AstraZeneca for biopharmaceutical industry.

In particular, the hypothesis of this study is that specific and distinct firms, called disruptive firms, are the driving force of market shift in industries by introducing new products, standard and/or components in markets with new technology and innovation, generating technological and socioeconomic change. Of course, the emergence of a disruptive technology is a necessary but not sufficient condition for the development and diffusion of new technology in markets that generate industrial change. Manifold factors also create important conditions for supporting technical breakthroughs. This study here focuses on specific subjects, the disruptive firms that play a vital role in competitive markets. In order to support the theoretical framework, firstly, the study analyses shortly these firms and then we contextualized the theory with some examples of new technology and the organizational and managerial behaviour of disruptive firms that generate market shift, technological and economic change.

4. INDUCTIVE ANALYSIS

Apple Inc. is a high-tech firm headquartered in California (USA) that designs, develops, and sells consumer electronics, computer software, and online services. Apple was founded in 1976 to develop and sell personal computers (Apple Computer Inc. Historical Information, 1976). It was incorporated as Apple Computer Inc. in 1977, and was renamed as Apple Inc. in 2007 to reflect its shifted focus toward consumer electronics (Wozniak, 2007). Number of employees as of October 2016 is about 116,000 units.

Apple Inc. has been a disruptive firm of storage devices. A simple storage device was the floppy disk: a disk storage medium composed of a disk of thin and flexible magnetic storage medium encased in a rectangular plastic carrier. Sony introduced, in 1983, 90 mm micro diskettes (known as 3.5-inch -89 mm-floppy disks), which it had developed at a time when there were 4" floppy disks, and a lot of variations from different companies, to replace on-going 5.25" floppy disks (Coccia, 2017b). Apple Computer, a market leader in ICTs, decided to use in 1984 the 3½-inch drives produced by Sony in the Macintosh 128K model. This firm strategy effectively makes the 3½-inch drive a *de-facto* standard in markets. This Apples' decision generated a main market shift and the format 3.5" floppy disks became dominant. Floppy disks 3.5" remained a popular medium for nearly 40 years, but their use was declining by the mid-1990s (Mee and Daniel, 1996).

In 1998, Apple Inc. released the iMac G3 with a new store device, called USB because it considered the floppy disk an old technology. USB – or Universal Serial Bus – is a protocol for connecting peripherals to a computer. The development of the first USB technology began in 1994 by Intel and the USB-IF (USB Implementers Forum, Inc., formed with industry leaders like Intel, Microsoft, Compaq, LSI, Apple and Hewlett-Packard). USB was designed to standardize the connection of computer peripherals (Cunningham, 2014). The USB 1.0 debuted in late 1995 and transferred data at a rate of 12 megabits per second. This parasitic technology is associated to other host technologies, such as PCs. Interaction between these high-tech devices and a host computer without the need to disconnect or restart the computer also enables USB technology to render more efficient operation. As just mentioned, in 1998, the iMac G3 was the first consumer computer to discontinue legacy ports (serial and parallel) in favour of USB. This implementation helped to pave the way for a market of solely USB peripherals rather than those using other ports for devices. The combination of the ease of use, self-powering capabilities and technical specifications offered by USB technology and related devices helped this new technology to triumph over other port options (Au Yong, 2006; Tham, 2011). This decision of Apple generated a market shift and industrial change. In the presence of this technological

change generated by a market leader, the ICT industry's reaction is to follow Apple's technological pathway, such as Dell, Hewlett-Packard, etc. that dumped the floppy drivers from their standard PCs. Trek Technology and IBM began selling the first USB flash drives commercially in 2000 (Trek 2000 International Ltd., 2011).

IBM's USB flash drive had a storage capacity of 8 MB, more than five times the capacity of the then-common 3½-inch floppy disks (of 1440 KB). Similar pathway is with the Compact Disc (CD), a digital optical disc data storage format released in 1982 and co-developed by Philips and Sony (BBC News, 2007). The format was originally developed to store and play only sound recordings but was later adapted for storage of data (CD-ROM). Apple Inc. released the third generation of MacBook Pro in 2012 with a 15-inch screen that was a quarter thinner than its predecessor and the Retina Display with a much higher screen resolution. The MacBook Pro with Retina Display does not have an optical drive and to play discs, it is necessary to have an external Super Drive. This decision of a market leader generated a further market shift and industrial change towards new storage devices with the USB port, micro-USB or USBType-C (Hruska, 2015; Mee and Daniel, 1996; Goda and Kitsuregawa, 2012; USB, 2005).

Apple Inc. is also a disruptive firm of wired headphones. Headphones are pair of small listening devices that are electroacoustic transducers, which convert an electrical signal to a corresponding sound in the user's ear (cf., Fastcompany, 2018). They are designed to allow a single user to listen to an audio source privately. Firstly, the headphone with jack was created in the period 1890-1910 and with several generations is still used in many electronic devices. The study here focuses on a critical period associated to Bluetooth technology (a wireless technology standard for exchanging data over short distances from fixed and mobile devices, and building personal area networks-PANs). In fact, the revolution of ICT has generated several innovations such as the Bluetooth technology in 1999 (Bluetooth, 2017). The evolution of this technology has generated in 2004 the Bluetooth 2.0 with an Enhanced Data Rate for rapid data transfer, in 2010 Bluetooth 4.0 with low energy and so on (Bluetooth, 2017). The interaction between Bluetooth and mobile phone has generated in 2002 the first mobile phone with integrated Bluetooth by Nokia, whereas the interaction between Bluetooth and headphones has also generated in 2003 the first Nokia headset, which was sold to end-users (Windows, 2012). The 29 June, 2007 Apple Inc. launched the 1st generation of *i*Phone with Bluetooth 2.0; the diffusion of the *i*Phone worldwide plays a main role in the evolution of several ICTs, driven by Apple Inc., which is one of the market leaders in smartphones and other mobile devices. In 2011, Apple Inc. has announced that new *i*Phone 4S supports Bluetooth 4.0 with low energy phone. In September 2016, the *i*Phone 7 of Generation 10th is launched without headphone jack 3.5mm. This strategic decision by Apple Inc. has a main impact for the evolution of new generations of headphones that will be more and more wireless to function, interact and survive with mobile devices (Coccia, 2017a). This decision of Apple Inc. to produce a new *i*Phone 7 without jack 3.5mm for headphone generates a selection pressure on manufacturers of these technologies that are focusing on new technological directions of headphones with Bluetooth™ technology (wireless) generating an on-going technological substitution and "Destructive creation" (Calvano, 2007) of current headphones with wire. In short, this case study seems to confirm that new technologies and technological trajectories are driven by specific firms that play a role of destruction of current technologies in favour of the creation of new technology and technological standards. Other organizational behaviour of Apple Inc. as disruptive firm in markets is the destruction of the physical keyboard in smartphones with the creation of virtual keyboards in the iPhone of 1st generation in 2007. In general, disruptive firms have the market power to support new technological trajectories and industrial change. In short, the innovative behaviour of market leaders can be a main driving force of technological, industrial and economic change. Moreover, market shifts are due to leader firms of host technologies, such as PC or smartphones, rather than leader firms of parasitic technologies, such as headphones, storage devices, etc. (*cf.* Coccia, 2017a).

AstraZeneca (AZ) is a British–Swedish research-based biopharmaceutical company (AstraZeneca, 2018). It is originated by a merger in 1999 of the Astra AB company formed in 1913 (Sweden) and British Zeneca Group formed in 1993. AstraZeneca (AZ) is a large corporation that has a net income of US$3.406 billion (AstraZeneca, 2016), total assets for US$60.12 billion (Forbes, 2016) and total number of employees for about 50,000 (AstraZeneca, 2015). The human and economic resources invested in R&D by AstraZeneca are about 15,000 units of personnel and over US$4 billion in eight countries (AstraZeneca, 2015). One of the research fields of AZ is anticancer treatments, such as for lung cancer. The current therapeutic treatments (technology) for advanced non-small cell lung cancer (NSCLC) are again mainly based on chemotherapy agents.

However, this technology has low efficacy for lung cancer treatment since the mortality rate is still high (Coccia, 2014). AstraZeneca as incumbent firm in drug discovery industry has generated a main radical innovation to treat lung cancer: the target therapy Iressa® that is based on the blocking agent Gefitinib. These path-breaking anticancer drugs are generating a revolution in therapeutic treatments of lung cancer with mutation Epidermal Growth Factor Receptor (EGFR) because they block specific enzymes and growth factor receptors involved in cancer cell proliferation (Coccia, 2012, 2014, 2016). Studies in the biology show that lung cancer can become resistant to these new drugs because of a secondary mutation (T790M) that generates a progression of the cancer with several metastases and, as a consequence, high mortality within five years (Coccia, 2012a). Clovis Oncology is a small pharmaceutical company, which is generating innovative products for new treatments in oncology. Clovis was founded in 2009 and is headquartered in Boulder, Colorado. This small pharmaceutical firm, Clovis oncology, has generated a new technology to treat lung cancer with mutation T790M: a new target therapy for EGFR-mutant lung cancer (Clovis Oncology, 2015). However, this small firm has difficulties in the development of this radical innovation in a sector with high capital intensity for R&D. This problem has induced Clovis oncology to enter in the stock exchange to gather financial resources directed to support R&D of several innovative products in its pipeline. The structure of the sector based on larger corporation has induced the biopharmaceutical company AstraZeneca (2015) to introduce a similar innovation for mutant lung cancers, called Tagrisso™ (AZD9291), that it was approved by US Food and Drug Administration in 2015 (AstraZeneca, 2016; Coccia, 2017b). This case study also confirms the vital role of large and leader firms, in competitive markets based on high intensity of R&D, that have the power to generate and/or to spread path-breaking innovations in order to achieve and sustain competitive advantage, as well as the goal of a (temporary) profit monopoly to support their market shares and industrial leadership.

Next section endeavours to detect the general characteristics of these disruptive firms that generate technological, industrial and economic change.

5. DISCUSSION

A main goal of this study is the concept of disruptive firms and how these firms sustain technological change: they are firms with market leadership that deliberate introduce new and improved generations of durable goods that destroy, directly or indirectly, similar products present in markets in order to support their competitive advantage and/or market leadership (*cf.* Calvano, 2007). These disruptive firms support technological and industrial change and induce consumers to repeat their purchase in order to adapt to new socioeconomic environment. Firm strategy of these leading firms is directed to support innovation and market leadership with new technology. An example of disruptive firms is Apple Inc. that has the following organizational behaviour (*cf.* Backer, 2013; Barney, 1986; Fogliasso and Williams, 2014; Heracleous, 2013; O'Reilly *et al.*, 1991; Schein, 2010).

- A main and central leader in the organization, represented in the past by the founder Steve Jobs and subsequently by the CEO Tim Cook (Apple Inc., 2017). The hierarchy in Apple's

organizational structure supports strong control over the organization that empowers top leader to control everything in the organization. This organizational behaviour generates limited flexibility of lower levels of the hierarchy to respond to custom needs and market demand but it provides a clear leadership for R&D and strategic management of innovative products.

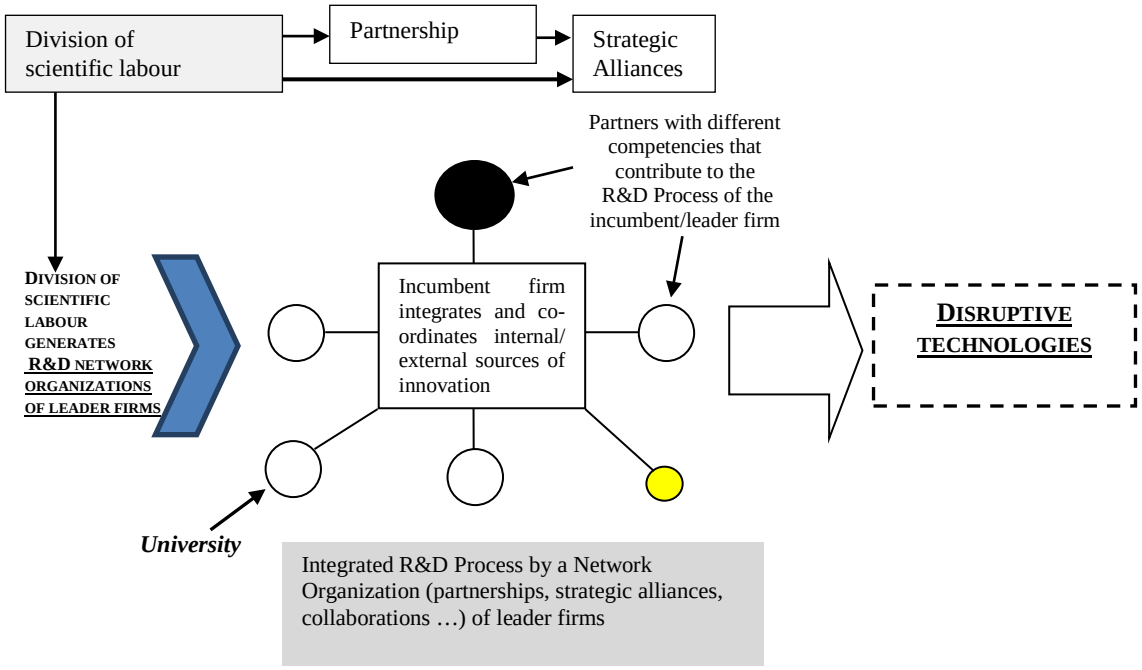
- A large market share in mobile technology and associated industrial leadership. Samsung is the largest vendor in smartphones but it only captured 14% of smartphone profits, while Apple Inc. gathered 91% of them in 2015. Apple holds nearly 45% of the U.S. OEM (Original Equipment Manufacturer) market, and in a distant second is Samsung Electronics with 28% of the market (Kilhefner, 2017). Notably, Apple is one of the only companies to actually advance its market share (from October through January), from 42.3% to 44.6%, for a 2.3% gain. Samsung's market share declined 2% from 30% in late 2016. Apple's *i*Phone accounted for 34% of all smartphone activations in the U.S. last quarter, leading all other smartphone brands. Samsung was just behind the *i*Phone at 33%, followed by LG at 14% share of activations (Kilhefner, 2017).
- Founded in 1976, more than 40 years ago. The firm has a long presence and experience in the sector of computer hardware, software and electronics.
- Headquarters is localized in a high-tech region, California, of a powerful country with socioeconomic influence on wide geoeconomic areas.
- Apple's organizational culture is also highly innovative to support firm's product development processes and firm's industry leadership. Creativity and excellence are especially important in Apple's rapid innovation processes. Moreover, secrecy is part of the company's strategy to minimize theft of proprietary information or intellectual property. Apple employees agree to this organizational culture of secrecy, which is reflected in the firm's policies, rules and employment contracts. This aspect of Apple's organizational culture helps protect the business from corporate espionage and the negative effects of employee poaching. These characteristics of the company's organizational culture are key factors that enable success and competitive advantage (*cf.* also Csaszar, 2013; Damanpour and Aravind, 2012, Lehman and Haslam, 2013).

Some characteristics of the organizational behaviour of AstraZeneca (AZ) are (Coccia, 2014a, 2015, 2016a):

- A characteristic similar to previous firm is a long experience in the market and leadership position in specific segments of the biopharmaceutical sector. In fact, Astra AB formed in 1913 (Sweden) and British Zeneca Group formed in 1993. Moreover, AstraZeneca is a large corporation in industry.
- Higher specialization of technological capability in new research fields of genetics, genomics and proteomics to support drug discovery process.
- Another characteristic of AZ is a division of scientific labour (*cf.* 'division of innovative labour' by Arora and Gambardella 1995; Coccia, 2014a). R&D strategy of this incumbent firm is to create strategic alliances with emerging firms for a division of scientific labour directed to reinforce and accelerate discovery process. In fact, AZ has strategic partnerships with organizations to complement in-house technological and scientific capabilities. In this manner, AZ supports rational modes of drug discoveries by integrative capabilities developed in collaboration with biotechnology firms (*cf.* Coccia, 2016b; Henderson 1994, pp. 607ff; Paruchuri and Eisenman, 2012). In particular, AZ builds and reinforces the scientific capabilities by strategic alliances with external sources of innovation: i.e., partnership with academic institutions, biotechs and other pharmaceutical companies to share skills, knowledge and resources through all phases of R&D process. In addition, the acquisition of the biotechnology firm MedImmune has improved and enlarged the R&D function and technological capabilities (AstraZeneca, 2015). This R&D management of AZ

organizes the R&D labs with a network structure based on strategic alliances for supporting the process of disruptive innovations (figure 2). Network R&D organization reinforces the integrative capabilities in scientific fields, collective and cumulative learning between in-house R&D and external sources of innovation. Moreover, network structure of R&D generates a multiplicity of scientific stimuli and the adoption of different and complementary R&D management approaches (*cf.* Coccia, 2014a, 2016b; Henderson, 1994; Jenkins, 2010).

Figure 2: Network of R&D function of disruptive firms to support new technologies in innovative industries.



Source: adapted from Coccia (2014a).

6. GENERALIZATION OF CHARACTERISTICS OF DISRUPTIVE FIRMS THAT GENERATE TECHNOLOGICAL AND INDUSTRIAL CHANGE

The industrial dynamics shows that the theory of disruptive technology seems to be not consistent for explaining the R&D and diffusion of major innovations in main sectors such as ICTs and biopharmaceuticals. The inductive study here suggests that patterns of technological innovations in markets are dominated by incumbents rather than entrant firms, which have not the market power and structure to support path-breaking innovations across markets (Coccia, 2012a, 2014a, 2015, 2015a, 2016b; Daidj, 2016; Liao, 2011). In short, this study proposes the shift of the locus of one of basic causes of technological change, from disruptive technologies to disruptive firms that support path-breaking innovations and market shifts.

The case study research here reveals some general characteristics of disruptive firms that generate technological change. In particular,

– Large size, associated to a strong market power that supports an industrial leadership.
– Disruptive firms can or cannot generate radical and/or incremental innovations but they have the market power to spread and support new technology in markets generating industrial change.
– Forward-looking executives seeking to pioneer radical innovations in competitive markets.

– High R&D investments to lead the markets towards new technological trajectories, sustain competitive advantage, the goal of a (temporary) profit monopoly and industrial leadership.
– A long historical presence and expertise in the industry for many years (e.g., more than 40 years). The historical development path in industries supports the accumulation of technological knowledge, technical expertise and experience in the sector, more and more important for R&D and strategic management.
– Organizational and managerial behaviour based on competence-destroying and competence-enhancing.
– Strong dynamic capabilities based on combinations of competences and resources that can be developed, deployed, and protected in order to stress exploiting existing internal and external firm specific competences and to address changing environments.
– R&D organization of disruptive firms is more and more based on a division of scientific labour. Network R&D organizations reinforce integrative capabilities, collective and cumulative learning between in-house R&D and external sources of innovation. Moreover, strategic alliances and partnership with innovative firms, university labs and suppliers support learning processes, accumulation of new knowledge and acceleration of innovation processes.

7. CONCLUDING OBSERVATIONS

The theoretical framework of disruptive technologies seems that does not explain the dynamics of technological and economic change (*cf.* Christensen, 1997). The study here endeavours to clarify, whenever possible, one of driving forces of technological change based on the role of leader firms, called *disruptive firms*. The central contribution of this work is an approach that integrates current frameworks in management and industrial organization to explain the sources of industrial and technological change (Cooper 1990; Dosi, 1988; O'Reilly III and Tushman, 2004; 2008).

In general, firms have goals, such as achieve and sustain competitive advantage (Teece *et al.*, 1997).

One of the main organizational drivers of disruptive firms is the incentive to find and/or to introduce innovative solutions in new products, using new technology, in order to reduce costs, achieve and support the goal of a (temporary) profit monopoly and market (industrial) leadership. Case study research here also shows that R&D management of leading firms has more and more a division of scientific labour directed to accelerate innovation process and develop new technology. Disruptive firms generate significant shifts in markets with an ambidexterity strategy based on competence-destroying and competence-enhancing (*cf.* Danneels, 2006; Henderson, 2006; Hill and Rothaermel, 2003; Tushman and Anderson, 1986). Moreover, a main role in disruptive firms is also played by "forward-looking executives seeking to pioneer radical or disruptive innovations while pursuing incremental gains" (O'Reilly III and Tushman, 2004, p. 76). In general, disruptive firms, generating path-breaking innovations, grow more rapidly than other ones (Tushman and Anderson, 1986, p. 439).

On the basis of the argument presented in this paper, based on a case study research, we can therefore conclude that one of principal sources of technological and economic change is due to leading subjects, disruptive firms, which can be the distal sources of disruptive innovations in competitive markets, *ceteris paribus*. Disruptive firms have specific dynamic capabilities that generate learning processes, a vital cumulative change and path dependence in innovative industries (*cf.* Garud *et al.*, 2010, 2015; Teece *et al.*, 1997).

The results of the analysis here are that:

(1) The conceptual framework here assigns a central role to leading firms (subjects) – disruptive firms – rather than disruptive technologies (objects) to sustain technological and economic change.

(2) *Disruptive firms* are firms with market leadership that deliberate introduce new and improved generations of durable goods that destroy, directly or indirectly, similar products

present in markets in order to support their competitive advantage and/or market leadership. These disruptive firms support technological and industrial change and induce consumers to buy new products to adapt to new socioeconomic environment.

(3) The establishment and diffusion of disruptive technologies in markets are mainly driven by incumbent (large) firms with a strong market power. However, small (entrant) firms can generate radical innovations but they have to cope with high economic resources needed for developing new technology (*cf.* Caner *et al.*, 2016). This financial issue explains the strategic alliances and partnerships between some incumbent and entrant firms to develop disruptive technologies. These collaborations mark a new phase in business development of innovations.

(4) Finally, the conceptual framework here also shows that R&D management of disruptive firms is more and more based on a division of scientific labour directed to reinforcing the integrative capabilities and collective learning between internal and external sources of innovation in order to accelerate discovery process.

Overall, then, the conceptual framework here, has several components of generalization that could easily be extended to explain the source of technological and economic change. To conclude, this study suggests that one of principal sources of industrial change is due to disruptive firms in competitive markets. To put it differently, this study provides a preliminary analysis of driving forces of technological change based on disruptive firms rather than disruptive technologies *per se*. However, the conclusions of this study are of course tentative. Most of the focus here is based on a case study research, clearly important but not sufficient for broader understanding of the complex and manifold sources of technological change. Moreover, the evidentiary basis of this paper is also weak, but this study may form a ground work for development of more sophisticated theoretical and empirical analyses to explain, whenever possible general causes of the technological and economic change. Hence, there is need for much more detailed research to explain the reasons for technological change in industries because we know that, in competitive markets with market dynamism, other things are often not equal over time and space. In fact, Wright (1997, p. 1562) properly claims: "In the world of technological change, bounded rationality is the rule".

8. REFERENCES

Abernathy W. J., Utterback J.M., 1978. "Patterns of innovation in technology". *Technology Review*, vol. 80, pp. 40-47.

Anderson P., Tushman M. L., 1990. "Technological discontinuities and dominant designs: A cyclical model of technological change", *Administrative Science Quarterly*, vol. 35, pp. 604-633.

Ansari S., Garud R., Kumaraswamy A., 2016. "The Disruptor's Dilemma: Tivo and The U.S. Television Ecosystem", *Strategic Management Journal*, vol. 37, pp. 1829-1853.

Apple Inc., 2017. https://www.apple.com/leadership/ (accessed 16th June 2017).

Apple Computer Inc. Historical Information, 1976. Apple Computer Company Partnership Agreement, 1 April 1976, Documents online. https://en.wikipedia.org/wiki/History_of_Apple_Inc. (Accessed January 2018).

Arora A., Fosfuri A., Gambardella A., 2001. *Markets for technology: The economics of innovation and corporate strategy*, Cambridge (MA), MIT Press.

Arora A., Gambardella A., 1995. *The division of innovative labour in biotechnology, Sources of medical technology: Universities and industry*, ed. by N. Rosenberg, A.C. Gelijns and H. Dawkins, ch. 8. Washington DC, National Academy Press. Inductive.

AstraZeneca, 2015. Annual Report 2015. Retrieved May 2016.

AstraZeneca, 2016. https://www.astrazeneca.com/media-centre/press-releases/2015/TAGRISSO-AZD9291-approved-by-the-US-FDA-for-patients-with-EGFR-T790M-mutation-positive-metastatic-non-small-cell-lung-cancer-13112015.html (accessed December 2016).

AstraZeneca, 2018. AstraZeneca - Research-Based BioPharmaceutical Company, https://www.astrazeneca.com/ (accessed 9th January 2018).

Au Yong J., 2006. "The drive to succeed", *The Straits Times*, p. 7, retrieved from NewspaperSG January 8.

Backer L. C., 2013. "Transnational Corporations' Outward Expression of Inward Self-Constitution: The Enforcement of Human Rights by Apple, Inc.", *Indiana Journal of Global Legal Studies*, Vol. 20, n. 2, pp. 805-879.

Barney J. B., 1986. "Organizational culture: can it be a source of sustained competitive advantage?", *Academy of Management Review*, Vol. 11, n. 3, pp. 656-665.

BBC News, 2007. Compact Disc Hits 25th birthday, 17 August 2007, http://news.bbc.co.uk/2/hi/technology/6950845.stm, retrieved 18 June 2017.

Bluetooth, 2017. https://www.bluetooth.com/about-us/our-history (accessed January 2016).

Calabrese G., Coccia M., Rolfo S., 2005. "Strategy and market management of new product development: evidence from Italian SMEs". *International Journal of Product Development*, Vol. 2, nos. 1-2, pp. 170-189.

Calvano E., 2007. "Destructive Creation". *SSE/EFI Working Paper Series in Economics and Finance*, n. 653, December 2007.

Caner T., Bruyaka O., Prescott J. E., 2016. "Flow signals: Evidence from patent and alliance portfolios in the US biopharmaceutical industry", *Journal of Management Studies*, DOI: 10.1111/joms.12217.

Cavallo E., Ferrari E., Bollani L., Coccia M., 2014. "Strategic management implications for the adoption of technological innovations in agricultural tractor: the role of scale factors and environmental attitude", *Technology Analysis & Strategic Management*, Vol. 26, n. 7, pp. 765-779.

Cavallo, E., Ferrari E., Coccia M. 2015. "Likely technological trajectories in agricultural tractors by analysing innovative attitudes of farmers, International Journal of Technology", *Policy and Management*, Vol. 15, n. 2, pp. 158-177, DOI: 10.1504/IJTPM.2015.069203.

Chesbrough H., Rosenbloom R. S., 2002. "The role of the business model in capturing value from innovation: Evidence from Xerox Corporation's technology spinoff companies", *Industrial and Corporate Change*, Vol. 11, pp. 529-555.

Christensen C., 1997. *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Cambridge (MA), Harvard Business School Press.

Christensen C., 2006. "The ongoing process of building a theory of disruption", *Journal of Product Innovation Management*, Vol. 23, pp. 39-55.

Christensen C., Raynor M. and McDonald R., 2015. "What is disruptive innovation?", *Harvard Business Review*, December, pp. 44-53.

Christensen C., Raynor M., 2003. *The Innovator's Solution*, Boston, Harvard Business School Press.

Clark K. B., 1985. "The interaction of design hierarchies and market concepts in technological evolution", *Research Policy*, Vol. 14, pp. 235-251.

ClovisxOncology,x2015.xhttp://www.clovisoncology.com/products-companion-diagnostics/rociletinib/, accessed February 2015.

Coccia M., 2004. "Analisi della diffusione delle innovazioni: scala della magnitudo del trasferimento tecnologico", *Economia e Politica Industriale*, n. 123, September, pp. 109-131.

Coccia M., 2006. "Classifications of innovations: survey and future directions". *Working Paper Ceris del Consiglio Nazionale delle Ricerche*, Vol. 8, n. 2, pp. 1-19, ISSN: 1591-0709.

Coccia M., 2009. "A new approach for measuring and analyzing patterns of regional economic growth: empirical analysis in Italy", *Italian Journal of Regional Science – Scienze Regionali*, Vol. 8, n. 2, pp. 71-95.

Coccia M., 2012. "Converging genetics, genomics and nanotechnologies for groundbreaking pathways in biomedicine and nanomedicine", *International Journal of Healthcare Technology and Management*, Vol. 13, n. 4, pp. 184-197.

Coccia M., 2012a. “Evolutionary growth of knowledge in path-breaking targeted therapies for lung cancer: radical innovations and structure of the new technological paradigm”, *International Journal of Behavioural and Healthcare Research*, Vol. 3, nos. 3-4, pp. 273-290, https://doi.org/10.1504/IJBHR.2012.051406.

Coccia M., 2013. “What are the likely interactions among innovation, government debt, and employment?” *Innovation: The European Journal of Social Science Research*, Vol. 26, n. 4, pp. 456-471.

Coccia M., 2013a. “The effect of country wealth on incidence of breast cancer”, *Breast Cancer Research and Treatment*, Vol. 141, n. 2, pp. 225-229, DOI: 10.1007/s10549-013-2683-y.

Coccia M., 2014. “Path-breaking target therapies for lung cancer and a far-sighted health policy to support clinical and cost effectiveness”, *Health Policy and Technology*, Vol. 1, n. 3, pp. 74-82, DOI: 10.1016/j.hlpt.2013.09.007.

Coccia M., 2014a. “Converging scientific fields and new technological paradigms as main drivers of the division of scientific labour in drug discovery process: the effects on strategic management of the R&D corporate change”. *Technology Analysis & Strategic Management*, Vol. 26, n. 7, pp. 733-749, DOI: 10.1080/09537325.2014.882501.

Coccia M., 2015. “General sources of General Purpose Technologies in complex societies: Theory of global leadership-driven innovation, warfare and human development”, *Technology in Society*, Vol. 42, pp. 199-226.

Coccia M., 2015a. “Technological paradigms and trajectories as determinants of the R&D corporate change in drug discovery industry”, *Int. J. Knowledge and Learning*, Vol. 10, n. 1, pp. 29-43. DOI: 10.1504/IJKL.2015.071052.

Coccia M., 2016. “Problem-driven innovations in drug discovery: co-evolution of the patterns of radical innovation with the evolution of problems”, *Health Policy and Technology*, Vol. 5, n. 2, pp. 143-155. DOI: 10.1016/j.hlpt.2016.02.003.

Coccia M., 2016a. “Sources of technological innovation: Radical and incremental innovation problem-driven to support competitive advantage of firms”, *Technology Analysis & Strategic Management*, DOI: 10.1080/09537325.2016.1268682.

Coccia M., 2016b. “Radical innovations as drivers of breakthroughs: characteristics and properties of the management of technology leading to superior organizational performance in the discovery process of R&D labs”, *Technology Analysis & Strategic Management*, Vol. 28, n. 4, pp. 381-395, DOI: 10.1080/09537325.2015.1095287.

Coccia M., 2017. “The source and nature of general purpose technologies for supporting next K-waves: Global leadership and the case study of the U.S. Navy’s Mobile User Objective System”, *Technological Forecasting and Social Change*, Vol. 116 (March), pp. 331-339, DOI: 10.1016/j.techfore.2016.05.019.

Coccia M., 2017a. “Fundamental Interactions as Sources of the Evolution of Technology (May 25, 2017)”, *Working Paper CocciaLab* n. 23, Arizona State University (USA), Available at: Electronic Library SSRN: https://ssrn.com/abstract=2974043.

Coccia M., Finardi U., 2012. “Emerging nanotechnological research for future pathway of biomedicine”. *International Journal of Biomedical nanoscience and nanotechnology*, Vol. 2, nos 3-4, pp. 299-317, DOI: 10.1504/IJBNN.2012.051223.

Coccia M., Rolfo S., 2000. “Ricerca pubblica e trasferimento tecnologico: il caso della regione Piemonte”, In Rolfo S. (eds) *Innovazione e piccole imprese in Piemonte*, Franco Angeli Editore, Milano (Italy), ISBN: 9788846418784.

Coccia M., Wang L., 2015. “Path-breaking directions of nanotechnology-based chemotherapy and molecular cancer therapy”, *Technological Forecasting & Social Change*, Vol. 94, May, pp. 155-169.

Coccia M., Wang L., 2016. “Evolution and convergence of the patterns of international scientific collaboration”. *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 113, n. 8, pp. 2057-2061.

Coccia, M. 2017b. "Disruptive Firms", *Working Paper CocciaLab* n. 24, Arizona State University (USA). Available at permanent arXiv.org e-Print archive: http://arxiv.org/abs/1710.06132.

Cooper R. G., 1990. "Stage-gate systems: a new tool for managing new products", *Business Horizons*, Vol. 33, n. 3, pp. 44-54.

Csaszar F. A., 2013. "An efficient frontier in organization design: Organizational structure as a determinant of exploration and exploitation", *Organization Science*, Vol. 24, n. 4, pp. 1083-1101.

Cunningham A., 2014. A brief history of USB, what it replaced, and what has failed to replace it. arsTECHNICA - 8/18/2014. https://arstechnica.com/gadgets/2014/08/a-brief-history-of-usb-what-it-replaced-and-what-has-failed-to-replace-it/ (accessed June 2017).

Daidj N. 2016. *Strategy, Structure and Corporate Governance: Expressing Inter-firm Networks and Group-affiliated Companies*, Oxford, Routledge.

Damanpour F., Aravind D., 2012. "Organizational structure and innovation revisited: From organic to ambidextrous structure", in Michael D. Mumford (Ed.), *Handbook of Organizational Creativity*, Elsevier, pp. 502-503.

Danneels E., 2004. "Disruptive Technology Reconsidered A Critique and Research Agenda", *Journal of Product Innovation Management*, Vol. 21, n. 4, pp. 246-258.

Danneels E., 2006. "Dialogue on the Effects of Disruptive Technology on Firms and Industries", *Journal of Product Innovation Management*, Vol. 23, n. 1, pp. 2-4.

Dosi G., 1988. "Sources procedures and microeconomic effects of innovation", *Journal of Economic Literature*, Vol. 26, n. 3, pp. 1120-1171.

Durisin B., Todorova G., 2012. "A Study of the Performativity of the «Ambidextrous Organizations» Theory: Neither Lost in nor Lost before Translation", *The Journal of Product Innovation Management*, Vol. 29, n. S1, pp. 53-75.

Eisenhardt K. M., Graebner M. E., 2007. "Theory Building from cases: opportunities and challenges", *The Academy of Management Review*, Vol. 50, n. 1, pp. 25-32.

Eisenhardt K.M., 1989. "Building theories from case study research", *The Academy of Management Review*, Vol. 14, n. 4, pp. 532-550.

Fastcompany, 2018. It's True: Apple Will Drop Headphone Jack To Make The iPhone 7 Slimmer, Says Source. https://www.fastcompany.com/3055208/its-true-apple-will-drop-the-headphone-jack-to-make-the-iphone-7-slimmer-and-simpler (accessed 9th January 2018).

Ferrari E., Bollani L., Coccia M., Cavallo E. (2013) "Technological Innovations in Agricultural Tractors: Adopters' Behaviour Towards New Technological Trajectories and Future Directions", *Working Paper Ceris del Consiglio Nazionale delle Ricerche*, Vol. 15, n. 5 - ISSN (Print): 1591-0709.

Fogliasso C. E., Williams A., 2014. "Analysis of the Business, Societal and Governmental Relationships of Apple Inc.", *Leadership & Organizational Management Journal*, n. 1, pp. 161-175.

Forbes, 2016. http://www.forbes.com/companies/astrazeneca/ (accessed November 2016).

Garud R., Jain S., Kumaraswamy A., 2002. "Orchestrating institutional processes for technology sponsorship: the case of Sun Microsystems and Java", *Academy of Management Journal*, Vol. 45, pp. 196-214.

Garud R., Kumaraswamy A., Karnøe P., 2010. "Path dependence or path creation?", *Journal of Management Studies*, Vol. 47, pp. 760-774.

Garud R., Simpson B., Langley A., Tsoukas H. (Eds), 2015. *The Emergence of Novelty in Organizations*, Oxford University Press.

Gilbert C., Bower J., 2002. "Disruptive Change: When Trying Harder Is Part of the Problem", *Harvard Business Review*, Vol. 80, n. 5, pp. 94-102.

Gioia D. A., Chittipeddi K., 1991. "Sensemaking and sensegiving in strategic change initiation", *Strategic Management Journal*, Vol. 12, n. 6, pp. 433-448.

Goda K., Kitsuregawa M., 2012. "The History of Storage Systems", *Proceedings of the IEEE*, Vol. 100, May 13th, pp. 1433-1440, DOI: 10.1109/JPROC.2012.2189787.

Grodal S., Gotsopoulos A., Suarez F. F., 2015. "The coevolution of technologies and categories during industry emergence", *Academy of Management Review*, Vol. 40, n. 3, pp. 423-445, http://dx.doi.org/10.5465/amr.2013.0359.

Hargadon A., 2003. *How breakthroughs happen: The surprising truth about how companies innovate*, Cambridge (MA), Harvard Business School Press.

Henderson R., 1994. "The evolution of integrative capability: Innovation in cardiovascular drug discovery", *Industrial and Corporate Change*, Vol. 3, n. 3, pp. 607-630.

Henderson R., 2006. "The Innovator's Dilemma as a Problem of Organizational Competence", *Journal of Product Innovation Management*, Vol. 23, pp. 5-11.

Henderson R., Clark K.B. 1990. "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", *Administrative Science Quarterly*, Vol. 35, n. 1, pp. 9-30.

Heracleous L., 2013. "Quantum Strategy at Apple Inc.", *Organizational Dynamics*, Vol. 42, n. 2, pp. 92-99.

Hill C., Rothaermel F., 2003. "The performance of incumbent firms in the face of radical technological innovation2", *Academy of Management Review*, Vol. 28, pp. 257-274.

Hruska J., 2015. USB-C vs. USB 3.1: "What's the difference?", *ExtremeTech*, http://www.extremetech.com/computing/197145-reversible-usb-type-c-finally-on-its-way-alongside-usb-3-1s-10gbit-performance, March 13, (accessed June 2017). http://xinkaishi.typepad.com/a_new_start/2011/06/st-thumbdrive-founders-crusade-against-copycats.html (accessed June 2017).

Jenkins M., 2010. "Technological Discontinuities and Competitive Advantage: A Historical Perspective on Formula 1 Motor Racing 1950-2006", *Journal of Management Studies*, Vol. 47, n. 5, pp. 884-910.

Kapoor R., Klueter T. 2015. "Decoding the adaptability-rigidity puzzle: Evidence from pharmaceutical incumbents' pursuit of gene therapy and monoclonal antibodies", *Academy of Management Journal*, Vol. 58, pp. 1180-1207.

Kilhefner J., 2017. "Apple Inc. iPhone Grabs Even More Market Share – Apple's iPhone keeps gobbling up market share, despite competition", *InvestorPlace*, http://investorplace.com/2017/03/apple-inc-iphone-grabs-even-more-market-share/#.WUedUE0Unmc (accessed June 2017).

King A., Baatartogtokh B., 2015. "How useful is the theory of disruptive innovation", *MIT Sloan Management Review*, Vol. 57, pp. 77-90.

Lehman G., Haslam C., 2013. "Accounting for the Apple Inc. business model: Corporate value capture and dysfunctional economic and social consequences", *Accounting Forum*, Vol. 37, n. 4, pp. 245-248.

Liao C., Chuang S. H., To P. L., 2011. "How knowledge management mediates the relationship between environment and organizational structure", *Journal of Business Research*, Vol. 64, n. 7, pp. 728-736.

Lin H.-E., McDonough III E. F., 2014. "Cognitive Frames, Learning Mechanisms, and Innovation Ambidexterity", *Journal of Product Innovation Management*, Vol. 3, n. S1, pp. 170-188.

Madsen T. L., Leiblein M. J., 2015. « What Factors Affect the Persistence of an Innovation Advantage?", *Journal of Management Studies*, Vol. 52, n. 8, pp. 1097-1127.

Markides C., 2006. "Disruptive innovation: In need of better theory", *Journal of Product Innovation Management*, Vol. 23, pp. 19-25.

Markides C., Geroski P., 2005. *Fast Second: How Smart Companies Bypass Radical Innovation to Enter and Dominate New Markets*, San Francisco, Jossey-Bass.

Markman G. D., Waldron T. L., 2014. "Small entrants and large incumbents: a framework of micro entry", *Academy of Management Perspectives*, Vol. 28, n. 2, pp. 179-197.

Mee C. D., Daniel E. D., 1996. *Magnetic storage handbook*, McGraw Hill.
Nicholls-Nixon, C. L., Woo C. Y., 2003. "Technology sourcing and output of established firms in a regime of encompassing technological change", *Strategic Management Journal*, Vol. 24, pp. 651-666.
Nicholson N., Rees A., Brooks-Rooney A., 1990. "Strategy, Innovation and Performance", *Journal of Management Studies*, Vol. 27, n. 5, pp. 511-534.
O'Reilly III C. A., Chatman J., Caldwell D. F., 1991. "People and organizational culture: A profile comparison approach to assessing person-organization fit", *Academy of management journal*, Vol. 34, n. 3, pp. 487-516.
O'Reilly III C. A., Tushman M. L., 2004. "The ambidextrous organization", *Harvard Business Review*, Vol. 82, n. 4, pp. 74-81.
O'Reilly III C. A., Tushman M. L., 2008. "Ambidexterity as a dynamic capability: Resolving the innovator's dilemma", *Research in Organization Behavior*, Vol. 28, pp. 185-206.
Paruchuri S., Eisenman M., 2012. "Microfoundations of Firm R&D Capabilities: A Study of Inventor Networks in a Merger", *Journal of Management Studies*, Vol. 49, n. 8, pp. 1509-1535.
Rosenbloom R., Cusumano M., 1987. "Technological pioneering and competitive advantage: The birth of the VCR industry", *California Management Review*, Vol. 29, n. 4, pp. 51-76.
Ryan J. C., Tipu S. A. A., 2013. « Leadership effects on innovation propensity: A two-factor full range leadership model", *Journal of Business Research*, Vol. 66, n. 10, pp. 2116-2129.
Schein E. H., 2010. *Organizational culture and leadership*, San Francisco, Jossey-Bass.
Teece D. J., Pisano G., Shuen A., 1997. "Dynamic capabilities and strategic management", *Strategic Management Journal*, Vol. 18, n. 7, pp. 509-533.
Tellis G. J., 2006. "Disruptive Technology or Visionary Leadership?", *Journal of Product Innovation Management*, Vol. 23, pp. 34-38.
Tham I., 2011. "ThumbDrive founder's crusade against copycats", *The Straits Times*, p. 8, retrieved from NewspaperSG, June 19, cf. also National Library Board Singapore (http://eresources.nlb.gov.sg/infopedia/articles/SIP_1071_2010-03-23.html, accessed January 2018).
Trek 2000 International Ltd. 2011. Annual report 2011. Retrieved June 08, 2012, from http://trek2000.listedcompany.com/misc/ar2011.pdf
Tushman M., Anderson P., 1986. "Technological Discontinuities and Organizational Environments", *Administrative Science Quarterly*, Vol. 31, n. 3, pp. 439-465.
USB, 2005. USB 'A' Plug Form Factor Revision 1.0, USB Implementers Forum, Inc. (USB-IF).
Utterback J. M., Abernathy W., 1975. "A dynamic model of product and process innovation", *Omega*, Vol. 3: pp. 639-656.
Van de Ven A., Garud R., 1994. "The coevolution of technical and institutional events in the development of an innovation", in: Baum JA, Singh JV (eds) *Evolutionary dynamics of organizations*, New York - Oxford, Oxford University Press, pp. 425-443.
Van de Ven A., Polley D., Garud R., Venkataraman S., 2008. *The Innovation Journey*, New York - Oxford, Oxford University Press.
Von Hippel E., 1988. *The Sources of Innovation*, New York - Oxford, Oxford University Press.
Wessel M., Christensen C. M., 2012. "Surviving disruption. It's not enough to know that a threat is coming. You need to know whether it's coming right for you", *Harvard Business Review*, Vol. 90, n. 12, pp. 56-65.
Windows, 2012. All ears! A pictorial history of Bluetooth headsets. Part 1, https://blogs.windows.com/devices/2012/02/03/all-ears-a-pictorial-history-of-bluetooth-headsets-part-1.
Wozniak S., 2007. "Homebrew and How the Apple Came to Be", *Digital Deli*, Retrieved June 16, 2017.
Wright G., 1997. "Towards A More Historical Approach to Technological Change", *The Economic Journal*, Vol. 107, September, pp. 1560-1566.