Industrial Evolution and Disruptive Innovation: Theories, Evidence and Perspectives

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Abstract

The notion of disruptive technologies has become in recent years a prominent concept in industrial dynamics and strategy. Yet, we still know too little about the frequency, intensity and modalities of this crucial phenomenon, let alone about the implications for strategy and policy making. There are indeed various meanings and interpretations of this concept, in the literature and in practice, but they often lack generality and in most instances theories rely on a quite narrow set of specific cases of particular firms, products and industries. This paper will not review the details of this debate. Rather, some more basic issues are discussed about the intensity and forms of disruptive innovation and the strategies and reactions of incumbents to the threats presented by new technologies. The paper presents and discusses the various meanings and forms of this concept as well as the conflicting evidence coming from different sources and methodologies in order to clarify its relevance and the differentiated ways in which it appears (or it doesn't appear), thus providing very preliminary and basic indications for analysis and action. The paper concludes that in the aggregate and over time what we observe is a puzzling co-existence and turbulence and stability in industrial dynamics, which appears to be driven by the complex interplay of differentiated processes of market selection and – above all – learning within firms. The specific characteristics of the relevant technologies, markets and firms are fundamental determinants of the patterns of competition and industrial change and they have to be considered carefully in the development of theories, strategies and policies.

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22.1 Introduction: From Creative Destruction to Disruptive Innovation

The idea of disruptive innovation has at the same time a very long and a very short history. Yet, we still know too little about the frequency, intensity and modalities of this crucial phenomenon, let alone about the implications for strategy and policy making. There are indeed various meanings and interpretations of this concept, in the literature and in practice, but they often lack generality and in most instances theories rely on a quite narrow set of specific cases of particular firms, products and industries. This paper will not review the details of this debate. Rather, some more basic issues are discussed about the intensity and forms of disruptive innovation and the strategies and reactions of incumbents to the threats presented by new technologies. Thus, this paper aims at locating the concept of disruptive innovation into a broader context in order to clarify its relevance and the differentiated ways in which it appears (or it doesn't appear), thus providing very preliminary and basic indications for analysis and action.

The long part of the story can be traced back to the Classical economists. The notion that markets and market leadership are constantly changing through the appearance and introduction of new technologies and more generally innovations was forcefully advanced by Marx, who wrote almost poetic pages describing the hectic and irresistible pace of capitalism driven by continuous technological change: "*All that is solid melts into the air*" [1].

Yet, the idea that innovation was the hallmark of economic competition and growth was only systematically introduced in 1911 by Josef A. Schumpeter [2]. He advanced the concept that new firms – the heroic entrepreneur – would continuously threaten and then substitute old incumbents by introducing new processes, new products, new markets and new "combinations of factors". Yet, 30 years later he partly changed his mind. In "Capitalism, Socialism and Democracy" [3], while still maintaining that "*the process of creative destruction is the essential fact about capitalism*", (p. 83), he also suggested that entrepreneurial innovation was being replaced by the routinized activity of R&D labs within large corporations enjoying long lasting monopoly power: in his view, these developments were doomed to bring capitalism to an end.

The shorter part of the story begins in the last three decades of the XX century, when economists began to study innovation in earnest, realizing that technological progress was the single most important source of growth. The advent of the information and communication technologies (ICT) revolution and the emergence of the Silicon Valley prompted an enormous amount of empirical and theoretical research on innovation and entrepreneurship, which became important autonomous fields in economics and management. In the eyes of the larger public, innovation became the "new industrial religion" (as the title of an issue of "The Economist" declared in 1999) and the new mantra for strategy and organization studies in business schools as well as in public policies.

This body of studies produced invaluable knowledge into the sources, patterns and consequences of innovation. Of course, it is impossible to review these findings here (For

a recent survey, see [4]). However, a few main broad results can be emphasized here at the very beginning to set the stage for the following discussion.

First, there is little question that technological innovation is the single major engine of economic growth and of industrial change. Major episodes of industrial transformation, with dramatic reshuffling of dominant positions, are typically associated to the appearance of new technologies. The introduction of new technologies brings about the emergence of new products, processes, markets, firms, organizational forms and business models, etc. Some of these technological innovations are so pervasive and revolutionary – sometimes called General Purpose Technologies or Techno-Economic Paradigms – to produce structural transformations in the economy, in the institutions and in the society at large: steam power, electricity, information technologies, etc. [5, 6].

Second, the development and diffusion of new technologies takes time and requires a multitude of incremental and cumulative innovations. But these processes are not smooth: turbulence and ultimately disruption occurs by impulses, which are typically industry-specific [7].

Third, however, that there is no such thing as "technological innovation", but diverse and variegated forms of innovation in different industries according to the specific nature and characteristics of the relevant technologies and markets.

Thus, it should come as no surprise that many representations of the innovative process have been proposed, sometimes complementary to and sometimes conflicting with each other. Against this background, the concept of disruptive innovation was introduced by Clayton Christensen in 1995 [8] and received quickly an enormous popularity. This idea adds significant nuances and try at the same time to generalize older insights about "creative destruction". A widely used and workable definition can be found in Wikipedia: an innovation that creates a new market and value network and eventually disrupts an existing market and value/support network, displacing established market leaders and alliances. This definition highlights the main substantial features of the concept. First, the adjective "disruptive" is applied to innovations rather than to technologies, because few technologies are intrinsically disruptive (or sustaining); rather, the disruptive character of the innovation is linked to the business model that the new technology enables. Second, emphasis is attributed to the disruption of the value/support network of a company or an industry, that is to say to the set of relationships with customers and suppliers, rather than to the ability of extant market leaders to absorb and master the new required technological capabilities. Thus, "…, *disruptive innovations were technologically straightforward, consisting of off-the-shelf components put together in a product architecture that was often simpler than prior approaches. They offered less of what customers in established markets wanted and so could rarely be initially employed there. They offered a different package of attributes valued only in emerging markets remote from, and unimportant to, the mainstream*." (Christensen 1997, p. 15). In particular, disruption is more likely to occur starting from market niches where customers do not need the full performance valued by customers at the high end of the market and/or in new markets previously unserved by the products supplied by existing incumbents Hence, third, disruptive innovations tend to

be introduced by outsiders and entrepreneurs, because market leaders downplay the potential threat of these innovations, considering them less profitable than current products and absorbing resources from the current businesses.

Unsurprisingly, the notion of disruptive innovation triggered controversies and debates. Some criticism claims that there is nothing inherently new in the concept or that it is only a refinement or a particular case of broader processes of creative destruction. Others have pointed that the evidence on which the theory is based is actually made out of a few, debatable case studies (For reviews, see [9] and [10–13]).

In what follows, this article will not review the details of this debate. Rather, some more basic issues are discussed about the intensity and forms of and the strategies and reactions of incumbents to the threats presented by new technologies. Different explanations are available but they often lack generality and in most instances theories rely on a quite narrow set of specific cases of particular firms, products and industries.

In effect, our knowledge of how creative destruction/disruptive innovation[1] occurs is still limited: it is possible to cite many examples of disruption, where industry leaders were actually swiped away by new competitors (Kodak in digital photography, Nokia for a while in cellular phones, etc.) as well as many cases where industry leaders were able to maintain or even increase their dominance (Fuji in digital photography, big pharma companies vs. new biotechnology firms, etc.). Sweeping generalizations are hard to make in this context, much depending on the industry as well as on the specific characteristics of individual firms. To be sure, the destruction of dominant positions – especially by new entrants – is a much less frequent and in any case a much more nuanced phenomenon than is often assumed.

Indeed, some very basic questions remain open and difficult to resolve, due both to limitations in the data and sometimes in less than robust conceptual clarity about the specific phenomena that are analyzed.

For example:

(i) How frequent and how strong is actually "creative destruction", and how long does it take? How often do we observe dramatic changes in industry leadership? Is disruption a continuous, systematic process? Or is it a punctuation over the history of any one industry or product?
(ii) Where does creative destruction come from and where does it occur? Are always (or most of the time) new firms that introduce disruptive innovations?
(iii) How does disruption occur? Through direct competition and head-on attack on the products of industry leaders or indirectly, via the introduction of products, processes or business models in different market segments that progressively weaken dominant positions?

[1] In this article, the terms "creative destruction" and "disruptive innovation" will be used – somewhat in an undisciplined way – almost interchangeably.

(iv) When and how industry leaders able to maintain their leadership despite the appearance of potentially disruptive innovations?

22.2 The Aggregate Background

To begin with, it might be useful to recall a few important and robust aggregate results that have been emerging from empirical studies made possible from the growing availability of data at the firm level for sufficiently long periods of time. These results help in providing a broader perspective to the analysis of creative destruction/disruptive innovation (see [14] for a survey).

First, relatively high rates of entry of new firms are seen in virtually all industries, even those marked by high capital intensity and other apparent barriers to entry. Further, and contrary to what standard economic textbooks would suggest, rates of entry do not appear to be particularly sensitive to the average rate of profit in an industry. And in most industries there is considerable exit as well as entry. Indeed, exit and entry rates tend to be strongly correlated. Both entry and exit tend to be significantly higher in new industries, and to decline somewhat as the industry matures. However, even relatively mature industries often are marked by continuing entry and exit.

Second, the vast majority of entrants are small firms, and most of them exit the industry within a few years: 20–40% of entrants die in the first two years and only 40–50% survive beyond the seventh year in a given cohort. Survivors grow faster but more erratically than incumbents and they reach average levels of productivity only gradually and slowly over time (around a decade). Only a few outliers in an entry cohort are able to attain superior performances, but, especially in the presence of significant technological and market discontinuities, they sometimes displace the incumbents and become the new industry leaders. Even in relatively mature industries one often observes persistent turbulence and churning in the profile of industrial evolution, due not only to continuous entry and exit flows but also to changes in the incumbents' market shares.

Third, even in mature industries there tends to be persistent heterogeneity among firms regarding any available measure of firms' traits and performance: size, age, productivity, profitability, innovativeness, etc. (For an overview, see [15]). The distributions of these variables tend to be highly asymmetric, and often display fat tails in their rates of change. What is even more interesting though, is that heterogeneity is persistent: more efficient firms at time t have a high probability to be highly efficient also at time t+T, and the same applies for size, profitability, and (more controversially) innovation. The degree of persistence tends to decline the longer the time span considered. However, this tendency is weak and thus heterogeneity decays slowly and it is still present in the limit.

Fourth, positive relationships are typically found among these variables: more efficient firms tend to be also more innovative and profitable and to gain market shares as time goes by. The magnitude of these relationships, however, is extremely variable across samples and across industries. Thus, most studies find only weak or no relationship at all between

productivity and profitability on the one hand, and growth on the other. Firms' expansion appears to be independent from size, possibly with smaller companies exhibiting higher but more variable growth rates. And in general, firms' growth remains very hard to explain. While some studies describe it as driven by small, idiosyncratic, and independently distributed shocks – and therefore as essentially erratic – others find highly complex underlying structures. If anything, the evidence would seem to suggest that firms grow and decline by relatively lumpy jumps which cannot be accounted by the accumulation of small, "atom-less", independent shocks. Rather "big" episodes of expansion and contraction are relatively frequent. (For an overview, see [14].)

Sixth, further important results are offered by studies which decompose aggregate (sectoral or economy-wide) productivity growth, separating (i) idiosyncratic changes in firm/plant productivity levels – the so called within component – that broadly captures improvements occurring within incumbent firms; (ii) changes in average productivity due to reallocation of output or employment shares across firms – the between component – that imperfectly measures the impact of market selection in shifting resources to the more efficient firms; and (iii) the contribution thereof due to entry into and exit from the market. Summarizing heroically, most studies do indeed find further evidence of a steady process of creative destruction involving significant rates of input and output reallocation even within 4-digit industries. Again these studies confirm that the process is accompanied by a good deal of "churning" with relatively high flows of entry and exit. However, the most interesting finding is that the largest contribution to productivity growth comes by far from the within component, that is to say from the learning processes of existing firms. The role of the between component – market selection – is much smaller and in some cases it has even a negative sign. Last, as already mentioned above, the contribution of net entry is highly variable, possibly with exit rather than entry showing a larger impact.

These findings suggest that heterogeneous processes of learning and selection drive industry dynamics, generating a puzzling coexistence of remarkable stability and drastic change. Moreover, continuous change and turbulence and permanent differences among firms coexist with the emergence of remarkably stable structures at higher levels of aggregation. However, the strength, speed and directions of these processes vary significantly across sectors and countries.

22.3 Sectoral Patterns of Innovation and Industrial Dynamics

Indeed, while some of these aggregate properties of the processes of industrial evolution are common to most industries, still fundamental differences appear across sectors. Thus, for example, [16] found that while innovative firms are likely to be rather small in industrial machinery, big companies prevail in chemicals, metal working, aerospace and electrical equipment, and many "science-based" sectors (such as electronics and pharmaceuticals) tend to display a bimodal distribution with high rates of innovativeness associated to small and very large firms.

Analyses have increasingly emphasized the relevance of various factors that impact the patterns of innovation and industrial dynamics. To begin with, it is now acknowledged that technology often develops according to its own internal logic, following trajectories that are only partially responsive to market signals [17]. Moreover, there is no such thing as "technology in general" but rather an array of different technologies, with different properties and characteristics, yielding different patterns of technological advance [18]. Technologies differ in terms of opportunities for innovation, and in terms of the degree of appropriability of its benefits. Including measures of these variables in the analysis (either statistical or qualitative) almost always improves results. Typically technological change proceeds cumulatively: creative accumulation rather than creative destruction is the norm in many industries and over relatively long periods of time. Yet, in some technologies and industries – pharmaceuticals being a clear example – it is harder to use cumulated knowledge to develop new products and processes. This difference has implications for the evolution of industry structure. In some industries, largely public or semi-public organizations produce much of the relevant knowledge base on which innovation depends, which is in principle available to everybody who has the requisite scientific and technological absorptive capabilities. In other cases, technological advances do not rely much on publicly available knowledge, but on private and firm-specific know-how and expertise. Clearly, innovation can arise in and impact on very different industry structures.

The well-known taxonomy by Keith Pavitt [18] was a first and still invaluable attempt at mapping 'industry types' and industry dynamics. Pavitt taxonomy comprises four groups of sectors, namely:

(i) 'supplier dominated', sectors whose innovative opportunities mostly come through the acquisition of new pieces of machinery and new intermediate inputs (textile, clothing, metal products belong to this category);
(ii) 'specialized suppliers', including producers of industrial machinery and equipment;
(iii) 'scale intensive' sectors, wherein the sheer scale of production influence the ability to exploit innovative opportunities partly endogenously generated and partly stemming from science based inputs;
(iv) 'science based' industries, whose innovative opportunities co-evolve, especially in the early stage of their life with advances in pure and applied sciences (microelectronics, informatics, drugs and bioengineering are good examples).

Other, rather complementary, taxonomic exercises have focused primarily on some characteristics of the innovation process, distinguishing between a 'Schumpeter Mark I' and a 'Schumpeter Mark II' regime, dramatizing the difference between the views of innovative activities from Schumpeter (1911) and Schumpeter (1942): see [19–21].

As mentioned previously, Schumpeter himself distinguished two (extreme) patterns of innovation. In the first one, as theorized in *The Theory of Economic Development* (1911) and often labeled as Schumpeter Mark I [22], innovation is created by the bold efforts of new entrepreneurs, who are able and lucky enough to displace incumbents, only to be

challenged themselves by imitative entrants. At the other extreme, as described in *Capitalism, Socialism and Democracy* (1942) and often referred to as Schumpeter Mark II, the main sources of innovation are instead large corporations, which accumulate difficult-to-imitate knowledge in specific domains, and are therefore able to gain long-lasting and self-reproducing technological advantages (and economic leadership). Following this intuition, the notion has been developed that innovation and market structure evolve according to different technological regimes [23]. distinguished between science-based vs. cumulative regimes [24]. Further developed this concept by modeling the different evolution of industries under an "entrepreneurial" as opposed to a "routinized" regime [25] and [20]. provided further empirical evidence concerning the relationships between the properties of technologies, the patterns of innovation, and market structure.

More specifically, a technological regime may be defined by the combination of some fundamental properties of the relevant technology, namely the degree of opportunities for innovating; the degree of appropriability, i. e. the ease and the instruments by which innovators are able to appropriate the economic benefits stemming from innovation; the degree of cumulativeness of innovation, i. e. the extent to which innovators today enjoy cognitive and/or economic advantages vis-a-vis competitors that make it more likely to innovate again the future.

Thus, the Mark I regime is characterized by high opportunities, low appropriability conditions and low cumulativeness: innovations are therefore carried out to a good extent by innovative entrants who continuously challenge incumbents. Market structure is highly unstable, with leadership changing frequently. Examples might be biotechnology, mechanical engineering, furniture, etc.. Conversely, at the other extreme, under the Mark II regime innovative activities are much more cumulative and imitation is difficult. Innovation is therefore undertaken to a greater extent by a few incumbents which turn out to be 'serial innovators': chemical engineering, semiconductors, aerospace, etc..

The structure of the demand side of the market – the demand regime – plays also an important role in shaping the patterns of industrial dynamics. In particular, when the aggregate market is actually composed by a large number of (actual and potential) almost independent niches, it is more difficult for any one firm to build a dominant and persistent leadership in the aggregate market: pharmaceuticals is a classic example (see [21]).

Different technological regimes are also supported by distinct institutions governing public research and training and, at the market end, the interactions among producers. Such institutions, together with the corporate actors involved contribute to define distinct sectoral systems of innovation and production: see [26] and [27].

22.4 Innovation, Dominance and the Reasons for Disruption at the Firm Level

The aggregate and sectoral evidence provides precious insights into the broad patterns of creative destruction/disruption. Innovation, industrial change and turbulence are system-

atic features of industrial dynamics. The timing and the specific features of these processes vary substantially over time and across technologies and industries. Creative destruction and disruptive innovations are more likely to occur – but not exclusively – in Schumpeter Mark I sectors or in the early stages of the life cycle of a new industry. Yet, evidence shows at the same time aspects of remarkable stability, with incremental, path-dependent innovation and persistence of firms' traits and performances.

At the level of individual firms the picture remains however much less clear, to say the least.

This observation should not be surprising. It is intuitive and should be almost common sense (although not always recognized in standard economic textbooks and literature) that firms simply differ widely from each other. The empirical evidence cited previously confirm that heterogeneity in firms' characteristics, behavior and performances is strikingly high. There are obviously good reasons for this observations. Indeed, a large stream of literature in management (more than in economics) has emphasized that firms are to be conceived as bundles of idiosyncratic resources and capabilities, which are built over time, are highly contextual and difficult to change quickly. In this view, the competitive advantages of any one company derive precisely from the specific combination of resources that are uniquely controlled by the firm and even more importantly for the competences and capabilities that have been acquired over time through processes of technological and organizational learning. Such learning processes are typically cumulative and path-dependent: what a firm is and does now is the outcome of its past history and such history heavily constrains what it will possible to do in the future. Moreover, facing an uncertain future, companies place different bets on the perceived opportunities and threats: diversity is therefore a systematic aspect of economic life, even in extremely narrowly defined business lines [28, 29].

Thus, individual firm would typically react differently to the threats coming from new technologies and innovations. Indeed, coming back to the broad questions raised in Sect. 22.1, it is not clear at all that incumbents are always doomed to fail when confronted with disruptive innovation, nor that new firms are always the winners. Even more difficult it is to identify robust regularities about the strategies which lead to success or failure.

An immense literature – mainly based on case studies – provides however a few important suggestions.

First, disruption in almost by definition hard to predict and it is to a large extent an ex-post phenomenon. When new technologies appear, uncertainty is the name of the game and firms – both incumbents and new entrants – experiment with different visions and approaches. As mentioned previously, most of them will fail and turn out as dead ends. Prediction is almost impossible, unless perhaps is too late, and often nothing more than an educated guess.

Second, disruption does not always come from new firms, but also from existing organizations diversifying into new business lines and products: IBM from punching cards to mainframe computers is only a prominent example among many others. Similarly, disruption seldom occurs through head-on, direct confrontation with extant products and

industry leaders. Much more often, it happens through the development of initially small and unprofitable market niches at the flanks of the main product. An iconic example is personal computers (PC), which created a new mass market for computers whereas previously expensive mainframe computers were sold only to large organizations. Another example is given by mini-mills vs. integrated steel mills. Mini-mills used scrap to make cheap, low quality steel of it and the integrated steel companies were not interested at all in this low margin business. However, slowly but steadily, the quality of the mini-mills steel improved and gained systematically new market segments.

The attack to dominant positions comes from multiple directions and potential competitors, who encircle and put under siege the current leader, often for prolonged periods of time. In this respect, the popular representation of disruption as a cruel frontal battle could be better understood – if it ever happens – as the final episode of a longer war, in which it is not clear who the enemy is – a heterogeneous and constantly changing army of autonomous tribes – and where the battlefield is actually located and how it looks like.

But when and why dominant positions are severely challenged or even destroyed?

There are entirely rational reasons why an incumbent may decide not to invest in innovation threatening to displace them or to delay such investment (e. g. cannibalization of current products), but the managerial literature does not seem to attribute a fundamental role to them. When clear incentives motivations are absent, the literature remains underdeveloped [30].

A first natural candidate for explanation is that new technologies may turn out to be "competence destroying" [31]: that is to say, they overturn and render obsolete existing competencies, skills and know-how (e. g. transistors and vacuum tubes, quartz and mechanical watches, etc.). In this respect, the very factors that made a firm dominant – the core capabilities – may become "core rigidities" in a new, different technological environment [32].

In more recent interpretations, however, the main cause of "competence destruction" is not the inability to master the new technology as such, but rather the difficulty established firms encounter in responding to shifts in the market place [33], the challenges that innovation poses to their value and support network [34] and in the larger institutional and social regime [35]: again, the PC was directed to groups of customers (individuals) which had never been the focus of mainframe producers.

It has to be stressed that competence destruction in this wider interpretation does not simply or mainly depends on mistakes in decision making at the most senior levels. Certainly, senior teams are likely to be captured by their largest, most profitable customers, making it difficult to allocate resources to initiatives that serve new customers at (initially) lower margins. But such emphasis might be too simplistic or potentially misleading. Recent studies suggest that organizational competences, in the sense of the embedded organizational routines of established companies, may be much more central to established firm failure in the face of disruptive innovation than is generally acknowledged [36]. Organizational capabilities are almost inherently inertial as they based on and expressed by routines which have been learned and developed over time. They are robust

and provide stability to the organization and become deeply embedded cognitive models, shared systems of understanding and of incentives that reinforce, and are in turn reinforced by, the local experience of the firm [37]. Thus, they are path-dependent and rigid. Exploring a new, possibly disruptive, market thus requires major and difficult changes in patterns of behavior and search that may look unprofitable in the face of deep uncertainty or, even more so, may be not even conceived given the current organizational architecture.

A further important interpretation recently provided by [30], suggests that incumbents failure reflect diseconomies of scope rooted in assets that are necessarily shared across both businesses. Specifically, they show that both Microsoft and IBM were initially very successful in creating free standing business units that could compete with entrants on their own terms, but that as the new businesses grew, the need to share key firm level assets imposed significant costs on both businesses and created severe organizational conflict. In IBM and Microsoft's case this conflict eventually led to control over the new business being given to the old and that in both cases effectively crippled the new business.

22.5 Survival and Persistent Leadership

Defeat of the incumbent and victory for the attacker, however, is not the only or even more frequent outcome. In many occasions, dominant firms retreat and diversify into related but different lucrative business. Once again IBM provides an example: it succeeded in entering the new market for personal computers, obtaining a good, but not dominant position. When profit margins fell into that segment, IBM left the PC market and transformed itself into an immensely successful organization selling services and consultancy. In this respect, it remains also to clarify what exactly is destroyed, when disruption occurs: firms, products, business models?

In many other instances, current leaders are able to win, let alone survive. So, what are the capabilities and strategies that allow for maintaining persistent leadership in markets undergoing technological change and potential disruption?

First, it has been long recognized that technological change as such needs not to be destructive for market leaders. In these cases, technological change is defined as "competence enhancing", meaning that the new technology strengthens rather than weaken the core competences and capabilities of incumbents. The ability of (some) companies to innovate cumulatively and systematically is actually a fundamental source of sustained leadership. But, more than this, in many instances, major – and not simply incremental – innovations, new products and markets have been created by established firms: chemicals, pharmaceuticals, oil, important segments of the "information technology" industry.

Second, incumbents are able to defend their leadership by relying on their big pockets, by imposing their standards, by forging alliances with new firms and maintaining the control of crucial complementary assets, i. e. the upstream and downstream assets necessary to successfully commercialize an invention, like marketing, sales forces, experience and

influence with regulatory issues [38]: pharmaceuticals and biotechnology are a textbook example.

More generally, some basic concepts have been proposed as essential strategic and organizational components for sustained leadership in environments characterized by continuous and sometimes disruptive technological change.

Absorptive capacities, i. e. a firm's "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" is the first on the list [39] and [40]. Absorptive capacities are strongly cumulative, as they are built on previous knowledge and continuous research and development (R&D) investment aiming not only at discovering and developing innovations but, even more importantly to create the competences needed to perceive potential threats and opportunities, to effectively absorb the new relevant knowledge and to put it into use within the organization.

More generally, the notion of dynamic capabilities [38] provides an important framework for devising sustaining strategies. Dynamic capabilities are defined as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments." They are actually composed by a combination of multiple capabilities: "the capacity (1) to sense and shape opportunities and threats, (2) to seize opportunities, and (3) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets." The dynamic capabilities theory provides an important intellectual structure for businesspeople to start thinking systematically about why companies succeed—or fail. It is not a recipe, however: it must be made operational case by case considering the specific attributes of the company, of the technology and of the competitive cont*ext.*

22.6 Conclusion and Ways Forward

Clearly, much more research – both at the empirical and at the theoretical level – is needed in order to grasp some better understanding of the pace and properties of creative destruction and of disruptive innovation. Better and deeper knowledge of these phenomena must be gained by looking at the same time at different but complementary levels: the broad aggregate properties of the patterns of industrial dynamics, the diversity across sectors, the specificities of individual firms.

Here, only a couple of remarks may be proposed in the view of suggesting avenues of future research. First, almost all of the available research relates to threats to existing products/business models of a company. Much less is known about the behavior and performance of industry leaders when the threat is not directly to their core product(s), but to the business models and products of its customers and suppliers, thereby forcing upstream and downstream incumbents to adapt to those changes. Examples might be the oil industry facing the advent of electric cars or insurance companies having to devise new strategies, products and organizational changes in the light of the diffusion of autonomous driving, robotics or next generation genomics. Analysis of industrial change in interde-

pendent industries is notoriously difficult: it implies the study of complex dynamics and co-evolutionary processes that may entail a variety of direct and indirect feedbacks as well as unintended consequences. Some work in this direction has been developed but a lot remains to be done [41]. Yet, this is a crucial source of challenges for both incumbents and potential competitors.

A second important area of research concerns the role of regulation and standards in the processes of creative destruction and innovative competition. They clearly play a major role in shaping the evolution of the industries and the fate of the companies involved. The case of the Internet is an excellent example and recent studies show how important and complex are the processes that lead to the development of those rules, standards and laws [42]. Here again, much remains to be understood.

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