How Intelligent is Watson?

Enabling Digital Transformation through Artificial Intelligence

Stefano Magistretti
School of Management Politecnico di Milano
Piazza L. da Vinci, 32 20133 Milano Italy Tel: +39 02 2399 4093
stefano.magistretti@polimi.it

Claudio Dell'Era
School of Management Politecnico di Milano
Piazza L. da Vinci, 32 20133 Milano Italy Tel: +39 02 2399 2798
claudio.dellera@polimi.it

Antonio Messeni Petruzzelli
Politecnico di Bari, Department of Mechanics, Mathematics, and Management
Viale Japigia, 186, 70122 Bari, Italy, Tel. +39 080 5962776
antonio.messenipetruzzelli@poliba.it

This is a Post Print version of the paper that has been accepted for publication on *Business Horizons*

DOI 10.1016/j.bushor.2019.08.004

How intelligent is Watson? Enabling digital transformation through artificial intelligence. *Business Horizons*

https://doi.org/10.1016/j.bushor.2019.08.004

Abstract

In this paper, we aim to analyze Artificial Intelligence (AI) that due to its intrinsic characteristics can be considered as a General Purpose Technology (GPT) in the digital era. Most studies in the field focus on the ex-post recognition and classification of GPT, while the present investigation aims to enrich knowledge on the designing ex-ante of a GPT by studying an extreme and inspiring case of AI that IBM developed: Watson. Our objective is to shed lights on how companies can create value through AI. In particular, our longitudinal case study highlights the strategic decisions IBM took on two dimensions to create value: internal development and external collaborations. Our findings offer relevant implications for practitioners and academics eager to know more about AI in the digital world.

Keywords: Developing Artificial Intelligence, Designing General Purpose Technology; Crafting Digital Technology; Unlocking opportunities hidden in digital technolgoies.

ARTIFICIAL INTELLIGENCE TRANSFORMS OUR SOCIETY

We live in a world where digital solutions are widespread, and the distinction between digital and non-digital technologies is somewhat complex. Technologies, and especially digital technologies, influence our behaviors, our way of living, and are adopted differently around the world (Williams & Edge, 1996). Scholars and practitioners define this as digital transformation, consisting in all the initiatives that leverage digital tools (e.g., 3D printing, mobile computing, Artificial Intelligence, etc.) to transform processes and organizations (Nambisan et al., 2017).

Two other dimensions impact the world of digital technologies. The first concerns the input. Due to their constant evolution and adaptation, the processes to develop and sustain digital technologies require the involvement of a dynamic set of actors (Boudreau & Lakhani, 2013) whose different goals and capabilities allow creating diverse solutions. The second concerns the outcome. As digital technologies increase the flexibility in creating end products and services, the outcomes are intentionally incomplete, allowing companies to continuously upgrade their offering even if the solution is already on the market (Garud, Jain & Tuertscher, 2008).

Digital technologies redesign the competitive arena

The abundant scholarly debate around defining what a technology is (Danneels & Frattini, 2018) has led to difficulties in properly framing digital technology. In particular, digital technologies include big data (Kaplan & Haenlein, 2010), information knowledge management systems, cloud computing, artificial intelligence, and rapid prototyping systems (Bughin et al., 2017; Urbinati et al., 2018) that more than others foster the digital transformation of companies and society. Big data, for example, not only reshape the way new products and services are designed (Erevelles, Fukawa & Swayne 2016) (e.g., Netflix creating new series), but have improved the healthcare industry by providing more insights

and information than ever before (O'Donovan, 2015). Furthermore, AI, and especially machine learning, profoundly change the way we create and envision new products. An example is IBM's Watson Chef initiative. Launched in 2016, this digital technology allows screening and mapping more than 10.000 recipes to study the ingredients and propose new combinations.

Digital technologies can change not only the way of creating new products and services, but also generating value. Indeed, people are not always able to perceive the value in all the final solutions proposed. Nokia Lumia is just one of many examples showing that providing too many options is not always positive. Indeed, the real value that digital technologies generate is not always in their essence, but can also be in the actions they enable. For instance, Netflix does not require big data to understand customer behaviors and create new TV series, but what is important is the outcome from the customers' perspective (i.e., new series more aligned with their expectations). When faced with too many options for the same solution, decisions are difficult to make (Verganti, 2017).

Unlock the opportunities hidden in digital technologies

In such an overcrowded and fluid world where the value of technology is more in the benefit generated for adopters than in the technology itself, the discovery of hidden opportunities in digital technologies is crucial (Chesbrough, 2003). The perspective suppliers may adopt is twofold. First, they can develop a unique technology that unveils a new meaning and can be adapted to explore a unique application field (Dell'Era et al., 2017; Magistretti & Dell'Era, 2018), or they can leverage the essence of the digital technology by understanding its intrinsic generalizability. Indeed, digital technologies, such as AI, are intrinsically general-purpose technologies (GPTs). Scholars define GPT as a technology that has a substantial and pervasive effect across the whole society (Youtie, Iacopetta & Graham, 2008). Researchers have always tended to focus on studying and recognizing complex and

relevant technologies ex-post. Numerous studies have been published on the underpinning elements of GPT (Gambardella & Giarratana, 2013), but only few attempts to understand and conceptualize the process that companies should follow to bring such technologies to the market (Gambradella & McGahan, 2010). Indeed, scholars posit that the development of a technology may be scattered and not always linear. The open innovation (Chesbrough, 2006) paradigm affirms that this process has evolved over the last decade, and further research is needed.

Interpret Artificial Intelligence as general purpose technology

Given that digital technologies are reshaping the competitive and social arenas, as well as the increasing attention of tech suppliers on how to create value, this study aims to enrich current knowledge on AI as an enabler of value creation in the digital world (Kaplan & Haenlein, 2018). In particular, the underlying research question concerns the managerial practices that companies might follow to unveil the opportunities AI offers during its development and integration in the market.

To do so, we adopt a case study methodology. The case we investigate is Watson, the cognitive system launched by IBM. The results of our investigations are relevant for practitioners and researchers, providing some managerial implications on how to unveil opportunities hidden in technologies and how to develop AI as a GPT that can better support the digital transformation. In particular, by pointing out how the study proposes unique insights on how to design AI as a GPT, going beyond the existing debate that is more focused on ex-post recognition.

ARITIFICIAL INTELLIGENCE RESHAPES PRODUCT DEVELOPMENT

The literature on technology management is vast, and considering our focus on AI, we pay particular attention to its intrinsic link with the GPT literature stream. As mentioned in

the introduction, studies on the proliferation of digital technologies and their link to value creation indicate that the digital era is profoundly reshaping new product development and the new technology development field (Dobush & Kapeller, 2018).

Digital Transformation is enabled by Artificial Intelligence

Considering the impact of digital technologies in today's society, some scholars (Nambisan et al., 2017) argue that digital technologies favor more dynamic relations between the people involved and the product outcomes. Moreover, they indicate that innovations that leverage digital technologies can cut across industry and sector boundaries. As such, the digital technology and GPT research fields that can benefit from each other. Several studies focus on digital technologies by mapping the specific field of adoption (Yoo et al., 2012; Urbinati et al, 2018), while others attempt to understand specific digital technologies, such as big data, cloud computing, artificial intelligence, or 3D printing, and their impact on creating new strategies and innovations (Wieland, Hartmann & Vargo, 2017).

Technologies, such as big data, require the involvement of different people and various roles in the innovation process (Bharadwaj & Noble, 2017). The vast amount of data allows different paths for designing new solutions and dealing with management problems (George, Haas & Pentland, 2014). Moreover, other digital technologies instead change the way decisions are made to support and complement existing processes (e.g., 3D printing is complementary to additive manufacturing). Finally, digital technology researchers point out the growing role of AI as a complementary strategy and a new way of making decisions. The volume of information available in online repositories and fast access to databases can exponentially increase the speed and efficiency of the decision-making process (Van Knippenberg, Dahlander, Haas & George, 2015). Thus, AI is changing the business models in several industries and reshaping the markets (Nenonen & Storbacka, 2018). Recent examples

of AI adoption in very different contexts include healthcare in India, or the public library system in New York to suggest new readings based on a customer's history.

Digital technologies are deeply redesigning the new product development processes

Our analysis of the literature related to the technology field identified several different studies that deal with the creation of new products and services, and delivering value. On the one hand, some consider the processes of evolution and development (Cuhls, 2003; Thomke & Reinertsen, 2012; Savino, Messeni Petruzzelli & Albino, 2017), others look at the process of unveiling opportunities (Verganti, 2011; Dell'Era et al., 2017). On the other hand, some studies focus on particular technologies aiming to shed light on unusual aspects, such as uncertainty or the possibility of recombining knowledge to generate new technologies (Cohen & Levinthal, 1989; Levinthal, 1998).

Considering the focus of our investigation, the second perspective is more relevant, defining GPT and hence where AI can be theoretically positioned and discussed. Scholars point out that GPTs are a set of core technologies that have the characteristics of generating and spreading incremental or radical innovations in different fields, activities, and sectors. In particular, some define them as technologies characterized by pervasiveness, inherent potential for technical improvements, and innovative complementarities (Bresnahan & Trajtenberg, 1995). In addition, some authors suggest that the first slowdown is caused by the rapid depreciation of skills that are specific to older technologies (Helpman & Rangel, 1999). Numerous scholars discuss the role of technology substitution and how firms usually develop a new version or a new technology just to increase the performance of an existing technology (Smith & Reinertsen, 1992), and not to unveil new opportunities and identify new application fields (Dell'Era et al., 2017).

Notwithstanding this, the literature in the field shows that the prolonged slowdown of GPT in the early phases is usually followed by fast acceleration (Helpman, 1998), and that

GPT commercialization and diffusion is not always linear and straightforward (Ardito, Petruzzelli & Albino, 2016) due to its substantial and pervasive effect across the whole of society (Youtie, Iacopetta & Graham, 2008). Scholars indicate that in the past, the traditional way of developing and integrating GPT was through licensing (Gambardella & Giarratana, 2013). Relevant therefore is not the ex-post recognition of how companies can effectively exploit AI after having adopted it, but enhancing ex-ante development knowledge. Indeed, little is known about how tech suppliers can develop such technologies to foster pervasiveness and adopt them to create value. Second, scholars and practitioners seek to understand how they can create value from GPT beyond licensing, and the management practices concerning knowledge search and recombination, as well as initiatives they can implement to foster the development and commercialization of AI as a GPT.

This brief literature review shows that research on digital technology is evolving, thus this research aims to investigate the methods that companies can put in place to develop and commercialize a digital GPT such as AI to create value. To do so, we formulate the following research question: How can companies create value through adopting AI?

IBM WATSON, AS GENERAL-PURPOSE TECHNOLOGY, OFFERS "INFINITE" OPPORTUNITIES

Considering the multifaceted aspect of this topic, the case study methodology is the most appropriate to explore our research problem, particularly suited to answering "how" questions and investigate complex phenomena (Yin, 2011).

Considering the limitation of the methodology in terms of generalizability (Harrison & Kjellberg 2010), the selection of the case is a crucial aspect. Following prior studies (Yin, 2011), we adopt theoretical and convenience sampling. In particular, considering GPT and its commercialization, and relying on the theoretical definition of GPT, we study a digital

technology case that is facing the integration moment, namely, AI. As reported above, AI respects all the previously defined features (Bresnahan & Trajtenberg, 1995) of pervasiveness and innovation spawning. Given the convenience sampling and difficulties in collecting sufficient relevant data on such an emerging and growing technology, we selected a globally famous case offering a considerable number of articles and records that proved excellent to start the data collection. In addition, due to our connection with the company, we were able to interview key informants in the development of this sophisticated technology. Finally given the complexity of the phenomenon, we selected an extreme case that could simultaneously shed light on the inputs, outcomes, and organizational changes (Pettigrew, 1990) to understand the longitudinal perspective of the development and commercialization of a GPT in the digital era.

These considerations led to selecting IBM Watson as an eye-opening case of an emerging GPT; a technology that meets the aforementioned sampling requirements, both theoretically and empirically. Table 1 summarizes all the main sources of data gathered.

[Insert Table 1 about here]

We analyzed the database adopting an inductive and iterative approach (Strauss & Corbin, 1998). This allowed us to shed light on the phenomenon by building and refining theory from the evidence emerging from the longitudinal case study (Eisenhardt, 1989). In particular, the first step consisted in creating the database by tagging the different data to position them in a longitudinal perspective essential to understanding the technology's development and commercialization. Thereafter, each author individually read through the information to start analyzing the data. We created different visualization schemas, charts, and tables to allow comparing the different information and data sources. We then internally discussed the interpretation of the data and how the data could suggest ways to commercialize and unveil the opportunities within the AI technology.

IBM Watson is everywhere: from 0 to 270 (applications) in 6 years

The origin of Watson dates back to May 1997 when a group of researchers started to develop Deep Blue, an artificial intelligence solution that can solve complex problems, adapt to the context, and analyze new information. From that year on, the development of the AI solution within the company grew and led IBM to introduce the first version of Watson in Jeopardy, an American TV quiz show, in 2011. Through this show, the AI solution showed its potential to the world. In particular, it demonstrated how the machine learning algorithm can search a massive database to find the answer to common questions. The outcome was Watson's victory over the human participants, and this event confirmed that having access to large amounts of data, such as pre-loaded documents, and the ability to make fast enquiries could improve the scouting of relevant information. It also showed the market the initial potential of this technology. Wherever these two aspects are relevant, the technology can play a crucial role in the future decision-making process.

Moreover, one interviewee defined the IBM Watson technology as a combination of different technologies. In particular, the two most important are natural language processing (NLP) and machine learning. NLP is the process that through deconstructing and reconstructing sentences allows a computer to understand and process the information captured by the speakers. Machine learning is a technique in which a machine spots connections between a particular pattern and the most likely outcomes. The system receives feedback from regular use, learning from every interaction. Every prediction it makes, whether right or wrong, is considered for the next prediction, until it can reliably spot the meaningful patterns throughout the massive amount of data it searches. The combination of these two technologies gave rise to the creation of AI and ultimately IBM Watson.

After 2011, IBM started to significantly invest in the research and development of this technology that was then studied by a few employees to learn its potentiality. Today, more

than 12 Watson research centers with more than 100 IBM researchers are present in six continents. In these facilities, employees work on developing and advancing AI technology and supporting firms in adopting this solution.

The technology evolved year after year and now accounts for over 270 different applications across more than 30 industries. This clearly shows the pervasiveness of AI and its innovativeness, critical elements of any GPT. Figure 1 reports the evolution over time of the application fields addressed with a new Watson application since 2011.

[Insert Figure 1 about here]

The figure illustrates that at the beginning, the focus was only on a few application fields, such as healthcare and banks. The analysis of the database created from combining more than 300 web sources shows that the experimentation in these first two fields in 2011 and 2012 allowed the researchers to understand the technology's potential and that Watson was capable of processing a vast amount of data and propose accurate answers. From 2013 onwards, the company started suggesting the technology's adoption in different application fields, exploring the different opportunities offered, such as fast image recognition, sound detection, and text mining. The process IBM adopted to nurture this expansion and exploration followed different initiatives, some internal, others with external partners.

Spreading the solution over different application fields allowed the company to achieve $18 billion in revenues in 2017 from the Watson cognitive solutions (Source IBM Annual Report). In other words, around 22% of IBM's entire revenues and more than 1400 patents awarded in 2017 for artificial intelligence solutions.

As is evident from these numbers and the description, the AI solution is a GPT, and the case is extreme and can provide powerful insights on how opportunities hidden within a technology can be unveiled to create pervasive digital solutions.

HOW CAN YOU CREATE VALUE THROUGH ARTIFICAL INTELLIGENCE?

ELEMENTARY, MY DEAR WATSON

Our aim in studying the evolution of the Watson technology is to depict a familiar path that companies seeking to develop and create value through AI in the digital world can follow.

Our key informants stressed that knowledge of the opportunities the technology offers was not explicit from the beginning. They indicated that the technology was able to grow and expand into different markets by leveraging two aspects: its ability to process and analyze a large amount of data, and the creation of a platform and an Application Programming Interface (API) ecosystem able to share the technology more efficiently.

Initially, the focus was more on internal development, while in later years, they diversified the focus to create a network of external collaborations with different players.

First, understand what you are able to do

The analysis of the documentary data and the interviews indicates that internal development was strategically conducted around two main initiatives: the data and the API. In particular, the use of data is key in the digital world where big data are starting to show their potentiality in terms of enhanced decision-making and better designed products and services. The company understood this importance, convinced that AI would show its greater potential when a considerable amount of data are present, speeding up the search for useful information 60-fold. As the following quotes indicate, this knowledge allowed the company to start developing solutions for an industry where the data repository is enormous and the time for searching is not enough. Strategically, healthcare became the primary industry for the technology.

"... Watson is instrumentally useful when lots of data are available. So, markets where big data are predominant and where this data can provide value to different stakeholders. For example, in healthcare where many studies are published, and doctors do not have time to read all the articles,

Watson is amazing. He can read and process 4 billion pages in a minute, so then he can support doctors in understanding which studies are relevant for the disease they are facing …"

IBM Human-Centric Practice Manager

Thus, the company leveraged some crucial aspects of the technology to better explore the opportunities it offers. By understanding the most essential elements of the technology, they started to adopt it in sectors where these elements - big data, different stakeholders, and time pressure to process a great deal of information - are present. The process of understanding the technology was initially performed internally, and the IBM researchers started to frame the technology's essential features and components to understand the opportunities.

The second element concerning internal development is leveraging the API. IBM employees realized that a multifaceted and powerful technology, such as AI, could not be developed exclusively internally. They therefore decided to build the technology's core to allow others to develop solutions by exploiting the API. This strategic decision was taken to support the technology's growth. The technological feature the researchers introduced through the API led to the protocol to build software programs by adding features and not coding every single end solution from scratch. The underlying assumption is that people can create a software solution by adding different components developed by others and called on demand by the software. To support this, the firm launched the Bluemix platform to allow different adopters to leverage this API repository.

"… Bluemix can be seen as an API marketplace where different companies can buy different features that through Watson can allow them to perform the work they need. I share with you just a quick example. Inside Bluemix we have an API for image recognition. This API is useful for Watson developers when the input of the information is not a voice or a written document but a set of images. This is valuable in the medical industry for analyzing radiographs or in marketing for recognizing products. If you are in a hospital, you can use the same API as a fashion company, reducing the amount of work needed to have a working solution …"

IBM Research Ecosystem Manager

The intuition to leverage the API economy to sustain the technology's development was a way to rapidly and pervasively spread the use of Watson in different application fields. In this sense, players in different markets could use the same piece of code to add the same features to their system and speed up the technology's adoption.

"… the cloud platform and the API enable everyone to adopt a "do it yourself" approach while planning and developing a new application or a new concept. In this direction, IBM can help them by providing software and not always by coding it on demand. This helps the growth of Watson by facilitating its spread …"

IBM Cognitive Solutions Leader

These two strategic decisions exploiting the big data explosion and opening the API led to sustaining the technology's development and commercialization. IBM was able to propose Watson as a general-purpose technology, not only due to its potentiality but also the strategic decisions taken. Indeed, the decision to open the API is counterintuitive for a core business, such as cognitive solutions, due to complexity and data protection issues. All the different solutions use the same technology and the same machine learning algorithm even if owned by different players. Notwithstanding this, IBM considered this as the only way to create a pervasive digital solution.

Second, do not be shy and co-develop with others

In addition to the internal development and allowing Watson to become pervasive and spread its innovativeness, other strategic decisions were taken to support its commercialization.

In particular, the analysis of the database and the insights extrapolated from the interviews show that external collaboration played an essential role in fostering the development and commercialization of the AI technology.

From the in-depth analysis of the data sources, four external collaboration initiatives emerged that IBM adopted: (1) research activities with third parties; (2) partnerships; (3) university programs; and (4) hackathons. In particular, research activities refer to all the initiatives that IBM put in place to find new application fields for the technology based on researching and experimenting the opportunities the technology offers through strong interactions with key players in the field. In the early stage of AI development, due to the complexity and cost, research was undertaken with a few select players, such as hospitals or premium banking institutions, willing to support the research, as they could already envision an opportunity. Driving this initiative was the uncertain results, and the fact that IBM was unsure of the effectiveness of the final solution, thus joint research with other players seemed the best option. Partnerships refer to commercial partnerships with companies to develop Watson-based applications. In this case, the initiative was driven mainly by the exchange of money instead of knowledge. Indeed, the partners were involved as beneficiaries of the final solutions, but given the nature of the technology and the need to explore its opportunities, higher involvement was required. Therefore, a partnership was formed, for example, with an insurance company to better manage road accidents. Partnerships guarantee mutual involvement in exploring opportunities and the higher involvement of the adopters. This was fundamental to foster the discovery of more opportunities and thus envision future application fields. University programs are initiatives to find new uses and deepen the systems' capabilities by collaborating with expert academic researchers in the AI field. This initiative brought IBM to make connections with top universities around the world with the intention of bringing different and more theoretical knowledge to the development. Indeed, it was evident to the managers that the practitioners' perspective alone was not enough to spread AI around the world. Finally, hackathons refer to external calls aimed at start-ups, students, and citizens of the world to unveil potential new users of the Watson technology.

These external collaboration initiatives led to the explosion of the adoption of IBM AI solutions in literally every industry. There were two reasons behind the decision to organize hackathons: first, to envision new opportunities and solutions; second, to communicate the existence and power of the technology to the world.

Figure 2 shows that the first two years of experimentation where mainly dedicated to research activities. The research team in IBM developed AI applications for the health and bank industries together with their research centers. Between 2013 and 2014, other initiatives and activities were adopted to expand the technology's potentiality. Thus IBM launched partnerships, university programs, and hackathons mainly targeting external players for inspiration on the technology's potential further development.

[Insert Figure 2 about here]

ARTIFICIAL INTELLIGENCE CREATES VALUE IN THE DIGITAL WORLD

This longitudinal qualitative analysis sheds light on the way a company can adopt AI to create value in today's digital world. In particular, it shows the relationship between the intrinsic characteristics of AI technology and how these influence the strategic decisions taken to allow innovativeness to spread and its commercialization to become pervasive. In particular, our qualitative study identifies new and thus far unexplored effects of the way a company can commercialize a digital technology in the market with the aim of crafting it as a GPT. In particular, Figure 3 shows the two perspectives companies can adopt to create value through AI. The first is by looking inside the technology to unveil hidden opportunities and its core essence, which is usually an internal activity. Second, a strategy to create value by putting in place interactions with external collaborators to increase the technology's pervasiveness of adoption and the value generated.

[Insert Figure 3 about here]

The main contributions of this study are as follows.

First, it enables better understanding from an ex-ante perspective how companies can experiment and explore AI technology to sustain its pervasiveness as a GPT. Indeed, with digital technology, commercialization in the market is overturned. It is not only a matter of developing the technology internally and then licensing it (Gambardella & McGaham, 2010), but can be co-developed with users through internal development and external collaborations.

Second, the investigation shows that the digital innovation process follows a different path compared to the traditional technology development view (Cooper, 2008). In fact, it is no longer a funnel process where the technology is developed for a single use even if immense, e.g., railway technology, but the opportunity to open the boundaries to several different application fields. This shift of perspective from market to technology has an enormous impact on the way the technology is designed and commercialized. In particular, to create value through the adoption of AI, the exemplary Watson case shows that understanding the core essence of the technology is crucial (Danneels & Frattini, 2018). Indeed, the strategic decision to leverage big data and the API to allow AI to become pervasive was key for the success of the technology itself. This was only possible because the company started to look inside the technology at what it was capable of and not by merely understanding user needs. This is a perspective shared in designing meaningful innovations (Verganti, 2017) but still underexplored on the technological side (Magistretti & Dell'Era, 2018). IBM's intuition to look inside the technology first and then leverage external collaborations to commercialize the technology is one of the most important findings of this research.

Third, our qualitative research aimed to enrich knowledge on technology development, and especially in the designing process of a GPT. In this sense, the evidence previously reported shows that experimentation in different application fields (more than 32 in a six-year

period) allowed IBM to create a very powerful technology and spread it to so many countries and markets, thereby matching all the characteristics of a GPT. This is very important for research in this field. To the best of our knowledge, all current GPT studies help practitioners and academics in recognizing and labeling a technology as a GPT (Gambardella & Giarratana, 2013). This study shares insights on how in the digital era companies can exploit different aspects to increase the probability of creating a GPT through understanding how IBM succeeded in doing so by developing and commercializing AI in a completely different way compared to existing GPT literature. Indeed, by adopting different research, university program, partnership, and hackathon initiatives, IBM was able to address 32 different markets, reaching a very high level of pervasiveness, the first crucial element of a GPT. Emerging from the case analysis is that out of the 270 applications created based on IBM AI, some were downstream, such as image recognition for a fashion player, while others were more upstream and strategic, such as helping a company better frame the machine learning algorithm. Secondly, the use and exploitation of API also allowed performing extremely well on the improvement dimension, the second crucial factor of a GPT. Indeed, IBM's strategic decision to open the technology's development to external players by letting them use the API was counterintuitive for a GPT where firms usually target technology patenting and licensing, attempting to preserve their knowledge from being exploited externally (Youtie, Iacopetta & Graham, 2008). Finally, through the Bluemix solution, the cloud platform where different applications for the Watson technology are made available to users, IBM also pursued the innovation spawning dimension of GPT. Watson embraces the three elements of pervasiveness, improvement, and innovation spawning to sustain the growth and experimentation of this technology to unveil the hidden opportunities and allow it to become a GPT. As evident from the data, the initiatives IBM adopted, such as different activities to experiment the opportunities offered by the technology during commercialization in different

application fields, allowed the company to enhance the improvement and the innovation spawning effects (Bresnahan & Trajtenberg, 1995). Moreover, the inclusion of different APIs in the final solution increased the pervasiveness of the technology in society (Youtie, Iacopetta & Graham, 2008).

[Insert Table 2 about here]

IBM Watson teaches to academics

From a theoretical standpoint, this investigation enriches academic knowledge in different perspectives. First, the study contributes theoretical knowledge of AI in expanding the related literature (Kaplan & Haenlein, 2018). Indeed, it shows that aside from changes in business models (Nenonen & Storbacka, 2018) and the possibility to adopt it to address different markets, better and deeper knowledge of AI can create value for academics. Indeed, by introducing the two dimensions of internal and external exploration, companies that aim to adopt AI can create value in the market. This is an interesting theoretical contribution, pointing out that in digital technologies, understanding the technology (Danneels & Frattini, 2018) is even more difficult due to the different stakeholders involved. Second, this study enhances the GPT literature by shedding light on the designing perspective of the creation of a GPT (Gambardella & Giarratana, 2013). This is a rather neglected aspect of the literature. Third, it shows that companies can commercialize technology differently and particularly that the digital environment sustains such development. The analysis shows that companies should approach technology development from a different perspective compared to the funnel approach and the open innovation paradigm (Chesbrough, 2006). Technology is not channeled into markets thanks to an inbound or outbound perspective (West & Bogers, 2017), but resides within the company, and external stakeholders only develop the features. This enriches the open innovation and big data literature by showing that technology can be crafted to support multi-stakeholder interactions. Indeed, the big data literature argues that the

dynamic involvement of different stakeholders can foster higher innovativeness (Bharadwaj & Noble, 2017). This study shows the importance of stakeholders, academics, partners, and citizens through hackathons. Experimentation and development can steer the technology toward different application fields, opening commercial opportunities for the company as well as potentially interesting modifications that can be introduced to better exploit the technology over different applications (Dell'Era et al., 2017).

IBM Watson teaches to mangers

The investigation also has some interesting practical implications for companies facing technological innovation. The first and most important is that companies seeking to address a wider market should leverage the hidden key elements of the AI technology and explore them by integrating the technology in different application fields. Without exploration and integration, it is difficult to unveil all the potentials of AI. As reported in the IBM Watson case, it is difficult to predict ex-ante where the technology can be applied. Commercializing it in one application field allows managers to explore and understand the opportunities and particularities of the technology to create value and learn where the same key traits are present, and even increase the value created from economies of scale (e.g., big data and relevance of speed in creating connections between them). Second, the overturned traditional funnel approach is relevant for practitioners. Indeed, it suggests that the approach toward AI development as a GPT should follow a different path, not focusing on a single use but on broadening the application scope to a larger set of application fields (see Figure 3). Third, the involvement of different external stakeholders, universities, hackathons, and partners is fundamental to speeding up the integration of AI in different markets.

UNLOCK THE OPPORTUNITIES HIDDEN IN ARTIFICAL INTELLIGENCE IN A NUTSHELL

This study sheds light on how companies can create value through AI technologies. The unique and extreme IBM Watson case offers some insights on how to unveil opportunities hidden in AI. First, based on the digital transformation (Nambisan et al., 2017) and GPT (Youtie, Iacopetta & Graham, 2008) literature, the investigation proposes a different perspective on AI. Indeed, it indicates some theoretical and managerial implications on how to design AI solutions to become a GPT. This will help companies aiming to commercialize these technologies in the future to achieve high pervasiveness in the market. In addition, to our best knowledge, this investigation is one of the few that considers the ex-ante creation rather than the ex-post study of GPT. Moreover, it enriches current knowledge on technology innovation in the complex digital ecosystem. Adopting a longitudinal perspective in the analysis, we show that technology must not only be understood in detail (Danneels & Frattini, 2018), but also crafted and designed to support its continuing evolution. Indeed, this allows opening opportunities while commercializing the technology without focusing on just one application and one product, as is evident in the two main strategies IBM adopted for internal development and external collaboration initiatives.

REFERENCES

Ardito, L., Petruzzelli, A. M., & Albino, V. (2016). Investigating the antecedents of general purpose technologies: A patent perspective in the green energy field. *Journal of Engineering and Technology Management*, *39*, 81-100.

Bharadwaj, N., & Noble, C. (2017). Finding innovation in data rich environments. *Journal of Product Innovation Management*, *34*(5), 560-564.

Boudreau, K. J., & Lakhani, K. R. (2013). Using the crowd as an innovation partner. *Harvard business review*, *91*(4), 60-9.

Bresnahan, T. F., & Trajtenberg, M. (1995). General purpose technologies 'Engines of growth'?. *Journal of econometrics*, *65*(1), 83-108.

Bughin, J., McCarthy, B., & Chui, M. (2017). A Survey of 3,000 Executives Reveal How Businesses Succeed with AI. *Harvard Business Review*.

Chesbrough, H. (2003). The governance and performance of Xerox's technology spin-off companies. *Research Policy*, *32*(3), 403-421.

Chesbrough, H. W. (2006). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business Press.

Cohen, W. M., & Levinthal, D. A. (1989). Innovation and learning: the two faces of R & D. *The economic journal*, *99*(397), 569-596.

Cooper, R. G. (2008). Perspective: The Stage-Gate® idea-to-launch process—Update, what's new, and NexGen systems. *Journal of product innovation management*, *25*(3), 213-232.

Cuhls, K. (2003). From forecasting to foresight processes—new participative foresight activities in Germany. *Journal of forecasting*, *22*(2-3), 93-111.

Danneels, E., & Frattini, F. (2018). Finding Applications for Technologies Beyond the Core Business. *MIT Sloan Management Review*, *59*(3), 73-78.

Dell'Era, C., Altuna, N., Magistretti, S., & Verganti, R. (2017). Discovering quiescent meanings in technologies: Exploring the design management practices that support the development of technology epiphanies. *Technology Analysis & Strategic Management*, *29*(2), 149-166.

Dobusch, L., & Kapeller, J. (2018). Open strategy-making with crowds and communities: Comparing Wikimedia and Creative Commons. *Long Range Planning*, *51*(4), 561-579.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of management review*, *14*(4), 532-550.

Erevelles, S., Fukawa, N., & Swayne, L. (2016). Big Data consumer analytics and the transformation of marketing. *Journal of Business Research*, *69*(2), 897-904.

Gambardella, A., & Giarratana, M. S. (2013). General technological capabilities, product market fragmentation, and markets for technology. *Research Policy*, *42*(2), 315-325.

Gambardella, A., & McGahan, A. M. (2010). Business-model innovation: General purpose technologies and their implications for industry structure. *Long range planning*, *43*(2-3), 262-271.

Garud, R., Jain, S., & Tuertscher, P. (2008). Incomplete by design and designing for incompleteness. *Organization studies*, *29*(3), 351-371.

George, G., Haas, M. R., & Pentland, A. (2014). Big data and management. *Academy of Management Journal, 57 (2),* 321-326.

Harrison, D., & Kjellberg, H. (2010). Segmenting a market in the making: Industrial market segmentation as construction. *Industrial Marketing Management*, *39*(5), 784-792.

Helpman, E. (Ed.). (1998). *General purpose technologies and economic growth*. MIT press.

Helpman, E., & Rangel, A. (1999). Adjusting to a new technology: experience and training. *Journal of Economic Growth*, *4*(4), 359-383.

Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of Social Media. *Business horizons*, *53*(1), 59-68.

Kaplan, A. M., & Haenlein, M. (2018). Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. *Business Horizons*.

Levinthal, D. A. (1998). The slow pace of rapid technological change: gradualism and punctuation in technological change. *Industrial and corporate change*, *7*(2), 217-247.

Magistretti, S., & Dell'Era, C. (2018). Unveiling opportunities afforded by emerging technologies: evidences from the drone industry. *Technology Analysis & Strategic Management*, 1-18.

Nambisan, S., Lyytinen, K., Majchrzak, A., & Song, M. (2017). Digital Innovation Management: Reinventing innovation management research in a digital world. *Mis Quarterly*, *41*(1).

Nenonen, S., & Storbacka, K. (2018). *Smash: using market shaping to design new strategies for innovation, value creation, and growth*. Emerald Publishing Limited.

O'Donovan, P., Leahy, K., Bruton, K., & O'Sullivan, D. T. (2015). Big data in manufacturing: a systematic mapping study. *Journal of Big Data*, *2*(1), 20.
Pettigrew, A. M. (1990). Longitudinal field research on change: Theory and practice. *Organization science*, *1*(3), 267-292.
Savino, T., Messeni Petruzzelli, A., & Albino, V. (2017). Search and recombination process to innovate: a review of the empirical evidence and a research agenda. *International Journal of Management Reviews*, *19*(1), 54-75.
Smith, P. G., & Reinertsen, D. G. (1992). Shortening the product development cycle. *Research-Technology Management*, *35*(3), 44-49.
Strauss, A., & Corbin, J. (1998). Basics of qualitative research: Procedures and techniques for developing grounded theory.
Thomke, S., & Reinertsen, D. (2012). Six myths of product development. *Harvard Business Review*, *90*(5), 84-94.
Urbinati, A., Chiaroni, D., Chiesa, V., & Frattini, F. (2018). The role of digital technologies in open innovation processes: an exploratory multiple case study analysis. *R&D Management*.
Van Knippenberg, D., Dahlander, L., Haas, M. R., & George, G. (2015). Information, attention, and decision making. *Academy of Management Journal, 58 (3),* 649-657.
Verganti, R. (2011). Radical design and technology epiphanies: A new focus for research on design management. *Journal of Product Innovation Management*, *28*(3), 384-388.
Verganti, R. (2017). *Overcrowded: designing meaningful products in a world awash with ideas*. MIT Press.
West, J., & Bogers, M. (2017). Open innovation: current status and research opportunities. *Innovation*, *19*(1), 43-50.
Wieland, H., Hartmann, N. N., & Vargo, S. L. (2017). Business models as service strategy. *Journal of the Academy of Marketing Science*, *45*(6), 925-943.
Williams, R., & Edge, D. (1996). The social shaping of technology. *Research policy*, *25*(6), 865-899.
Yin, R. K. (2011). *Applications of case study research*. Sage.
Yoo, Y., Boland Jr, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization science*, *23*(5), 1398-1408.
Youtie, J., Iacopetta, M., & Graham, S. (2008). Assessing the nature of nanotechnology: can we uncover an emerging general purpose technology?. *The Journal of Technology Transfer*, *33*(3), 315-329.

Figures

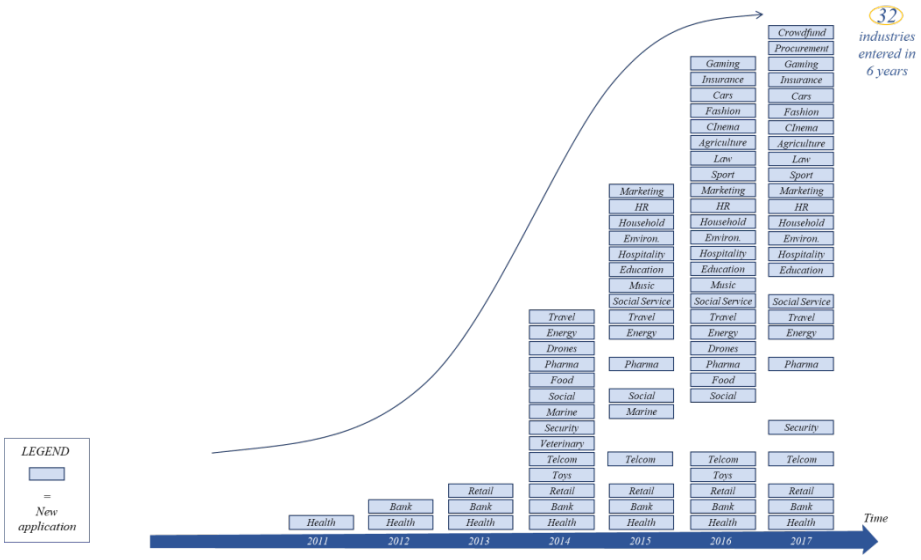


Figure 1. The evolution of the IBM Watson application fields over time

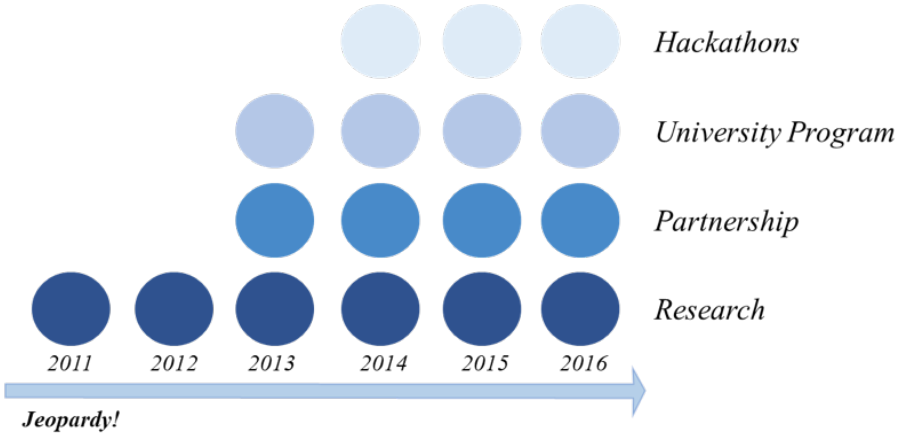


Figure 2. Different initiatives that supported the evolution of IBM Watson over time

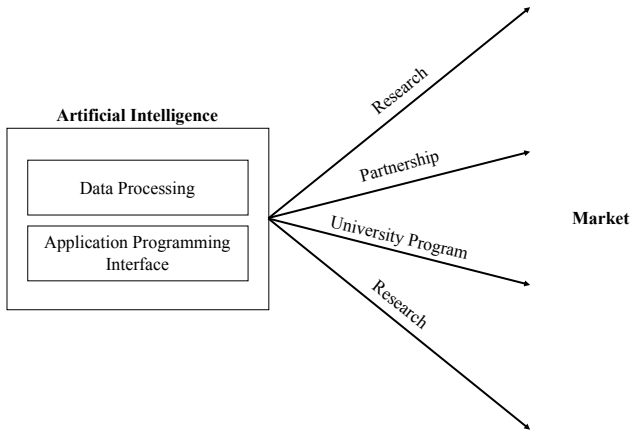


Figure 3. Different strategies that can support companies in creating value through AI

Sources	Description	Details
Interviews (semi-structured)	First wave set with an exploratory perspective Second wave with the aim of triangulating information in order pursue a longitudinal perspective	6 in depth interviews 3 managers 16 hours of recorded materials
Bluemix Platform	Bluemix developers can use IBM services to create, manage, run, and deploy various types of applications for the public cloud, as well as for local or on-premise environments	25 solutions 3 different models: public, dedicated, and hybrid
Videos	Records of events regarding Watson such as World of Watson event that summarizes the initiatives related to the technology and is presented live by the CEO Ginny Rometty	> 100 videos
News	From Websites: New York Times, The Economist, Fortune, and Wired, public press releases, sectorial studies, Gartner, Business Insiders reports and company websites	300 websites 38% IBM press releases, 35% IBM web pages, 27% external sources

Table 1. Data gathering

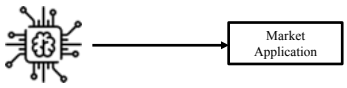
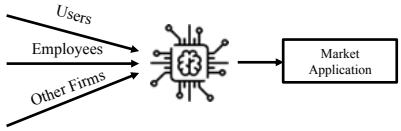
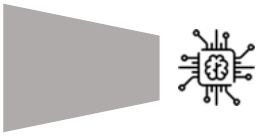
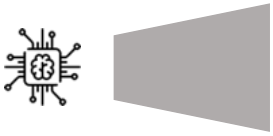
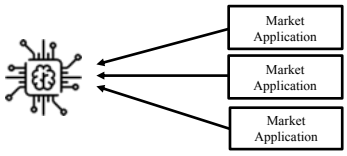
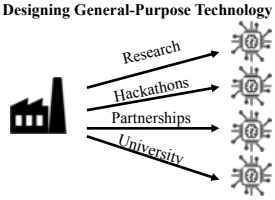
	FROM	TO
Contributions in a nutshell	**Traditional view**	**Evidence from IBM Watson**
The article proposes an ex-ante perspective on **how companies can experiment and explore AI** technology to sustain its pervasiveness as a GPT	**Licensing**  Developers of tech patent the technology and do not propose their own product but they license the usage	**Co-Develop**  Developers together with other players in the market co-develop the solution to unveil more technology opportunities
The investigation shows that the **digital innovation process follows a different path** compared to the traditional technology development view when it comes to technology such as AI	**Funnel Perspective**  Stage gate approach to reach one promising market application. Development driven by the market	**Fan Perspective**  Comprehend the essence of the AI to develop several different market applications. Development driven by the unveil of tech opportunities
The qualitative research enriches the knowledge on **technology development, and especially the ex-ante creation and crafting** of an AI solution	**Recognizing General-Purpose Technology**  Tech developer proposes the technology in several different application fields to pursue pervasiveness and foster improvement by adapting to the different context	**Designing General-Purpose Technology**  Tech developer leverages different knowledge to identify different market application fields to pursue pervasiveness and foster improvement by adapting to the different context

Table 2. Managerial contributions to steer the development of a worldwide impactful digital technology