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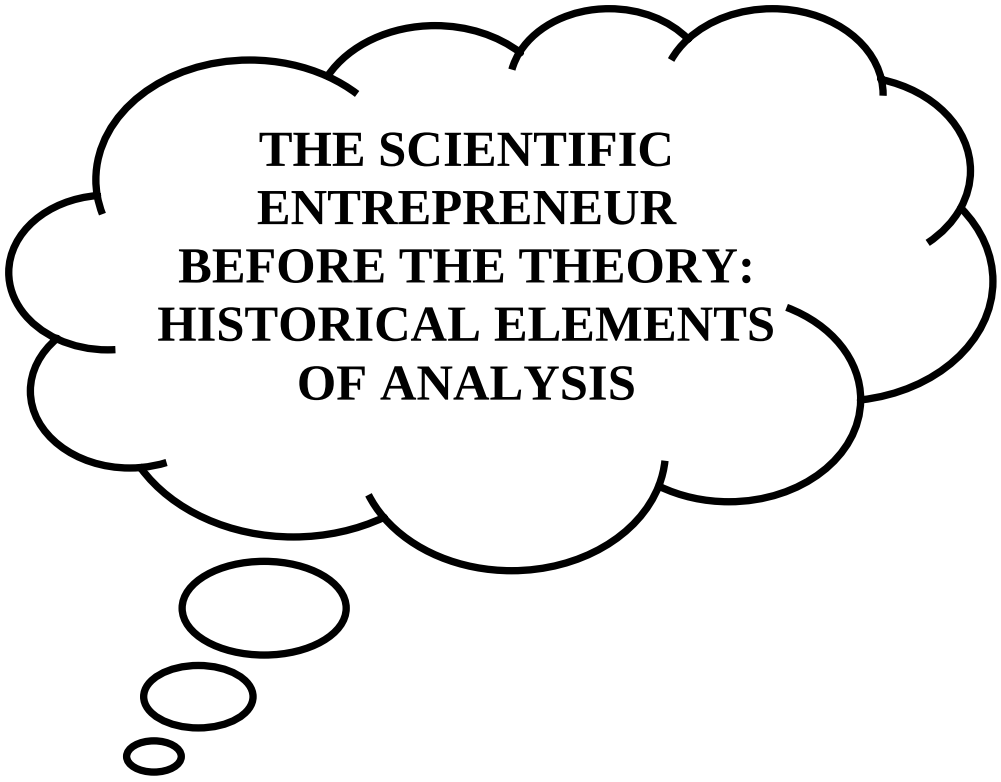

THE SCIENTIFIC ENTREPRENEUR BEFORE THE THEORY: HISTORICAL ELEMENTS OF ANALYSIS

Sophie BOUTILLIER
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Abstract: Since the 1980s, following the law Doyle-Bah in the United States, a large number of papers have been published on the topic of researcher entrepreneur, scientific entrepreneur or academic entrepreneur (definitions are numerous and varied). The initiative was followed in many countries, as in France for example with the Allègre Law at the end of the 1990s. Nevertheless, if the phenomenon and the theories explaining them were developed at the end of the 20th century, the facts that they analyze are not new. From the 17th century, namely at the beginning of the first industrial revolution, scientists – or 'savant' that was the term used at the period – filed patents or even created an enterprise, which some of them are becoming dominating enterprises. This is what we call today the valorization of research. Indeed, this pre-industrial period is fundamental because it is from this period that the scientific method began to be built with Nicolas Copernic (1473-1543), Galileo (1564-1642), René Descartes (1596-1640), Johannes Kepler (1571-1630), Isaac Newton (1643-1727), etc. An institutional framework has been built progressively in different parts in Europe. Some nations, as the Great Britain became the leader of the first industrial revolution and made Newton as a national hero. Nevertheless, Italy declined Galileo who narrowly escaped by a condemnation of pyre.

We will present the analysis of the trajectories of fourteen entrepreneurs living in different historical periods between the beginning of the 17th century and the beginning of the 20th century to show the general traits of these scientists and entrepreneurs: Denis Papin (1647-1714), Richard Cantillon (1680-1734), James Watt (1736-1819), Claude-Louis Berthollet (1748-1822), Nicolas Conté (1755-1805), Jean-Baptiste Say (1767-1832), Louis Pasteur (1822-1895), Alfred Nobel (1833-1896), Nicolas Tesla (1856-1943), Guglielmo Marconi (1874-1937), André Citroën (1878-1935), Eugène Schueller (1881-1957), William Hewlett (1913-2001) and David Packard (1912-1996). The aim is to study the common points and the differences and to build a typology to analyze the interactions between these entrepreneurial trajectories and the techno-economic trajectories in which they were inserted.

Key-words: entrepreneur, scientist, university, science, industry, knowledge

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CONTENTS

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INTRODUCTION

Since the 1980s, following the law Doyle-Bah in the United States, a large number of papers have been published on the topic of researcher entrepreneur, scientific entrepreneur or academic entrepreneur (definitions are numerous and varied). The initiative was followed in many countries, as in France for example with the Allègre Law at the end of the 1990's. Nevertheless, if the phenomenon and the theories explaining them were developed at the end of the 20th century, the facts that they analyze are not new. From the 17th century, namely at the beginning of the first industrial revolution, scientists – or 'savant' that was the term used at the period – filed patents or even created an enterprise, which some of them are becoming dominating enterprises. This is what we call today the valorization of research. Indeed this pre-industrial period is fundamental because it is from this period that the scientific method began to be built with Nicolas Copernic (1473-1543), Galileo (1564-1642), René Descartes (1596-1640), Johannes Kepler (1571-1630), Isaac Newton (1643-1727), etc. An institutional framework has been built progressively in different parts in Europe. Some nations, as the Great Britain became the leader of the first industrial revolution and made Newton as a national hero. Nevertheless Italy declined Galileo who narrowly escaped by a condemnation of pyre.

Therefore, the objective of this paper is to explore the long history to studying the trajectory of some scientific entrepreneurs from the 17th century according to the institutional framework where they were inserted. Our objective is to study the dialectic link between the scientific entrepreneur in his institutional framework in a large sense (including the law, the economic and social context as well as the level of scientific and technological development), and to identify the interacting links. In the first place we will present a literature review on the scientific entrepreneur (definitions and origins). Therefore, we will show that the scientific entrepreneur has been existed since long time ago and he has played a fundamental role in the industrial process. If in 2001 Audretsch and Kehmann identified the "knowledge spillover" from the research centers that resulted in creation of innovative enterprises, it is not an exclusive fact of the 21st century. The progress of knowledge in a given field leads to new knowledge; exchanges and interactions between the members of the scientific community feed a long process of production of new knowledge from ancient times that economist does not want to explore. According this objective, we will firstly present the theory of the scientific entrepreneur and how it is different from the general theory of the entrepreneur. To identify the identity of the scientific entrepreneur, we will link the entrepreneurial trajectories of these individuals with the techno-economic trajectories in which they are inserted. The level of the development of technologies, the institutional framework and the market influence closely the emergence of new enterprises. These enterprises created by scientific entrepreneurs will in term introduce new fundamental changes in the technological and scientific development. In a second time, we will present the analysis of the trajectories of fourteen entrepreneurs living in different historical periods between the beginning of the 17th century and the beginning of the 20th century: Denis Papin (1647-1714), Richard Cantillon (1680-1734), James Watt (1736-1819), Claude-Louis Berthollet (1748-1822), Nicolas Conté (1755-1805), Jean-Baptiste Say (1767-1832), Louis Pasteur (1822-1895), Alfred Nobel (1833-1896), Nicolas Tesla (1856-1943), Guglielmo Marconi (1874-1937), André Citroën (1878-1935), Eugène Schueller (1881-1957), William Hewlett (1913-2001) and David Packard (1912-1996). The aim is to study their common points and differences and to build a typology to analyze the interactions between these entrepreneurial trajectories and the techno-economic trajectories in which they were inserted (see table 3 at the end of the article for more details on scientific and entrepreneurial biographies of these scientific entrepreneurs).

1. THE SCIENTIFIC ENTREPRENEUR, TECHNO-ECONOMIC AND ENTREPRENEURIAL TRAJECTORIES

1.1. A new kind of entrepreneur: the scientific/academic entrepreneur

According to the economic theory of the entrepreneur (Aldrich, 2011; Boutillier, Uzunidis, 2016; Boutillier 2017), the entrepreneur is the engine of economic development by his capacity to innovate. So by definition, the entrepreneur is an innovator. For example, according to Jean-Baptiste Say (1803), industrial operations is distributed between three categories of individuals and industrial activities: production of knowledge by the scientist, application of knowledge by the entrepreneur and execution by the worker. So the entrepreneur plays a strategic role between the scientist and the worker. Some years later, Joseph A. Schumpeter (1942) defines the entrepreneur as the individual who executes new combinations of production factors. The Schumpeterian entrepreneur is an economic agent who creates new combinations of production factors and transforms them into investments opportunities: development of a new product, introduction of a new production method, opening of a new market, discover of a new production method, opening of a new market, discover of a source of raw materials or semi-manufactured products, and realization of a new organization. According to Schumpeter, entrepreneur and innovator are tautological terms.

Based on these definitions of the entrepreneur, we will propose our own definition the scientific entrepreneur by taking into account the historical context of the changes of the scientific institutions during the 19th century. During this period, the links between the scientific institutions and enterprises have been developed and the role of scientists in the industrialization process has been clearly established. Therefore, when tracing back to the historical roots of the economic theory of the entrepreneur, one can ask why building a new theory of the entrepreneur, a theory of the scientific entrepreneur or a theory of the researcher entrepreneur. Indeed, we can observe that these theories have been developed since the beginning of the 1990s, a period when various governments (first in industrialized countries) have issued laws to promote creation of enterprises by scientists and to file patents. Moreover, the apprehension of the terms of "academic", "scientific" and "entrepreneur" varies according to different analytical approaches in different periods and under different contexts. So we cannot separate the emergence of the academic (or scientific) entrepreneur without analyzing the economic and social context in which it is embedded.

Dickson, Coles and Smith (1998) use "academic entrepreneur", "entrepreneurial scientist" and "scientific entrepreneur" as three distinctive terms to describe three categories of individuals who involve both in the scientific and business activities.

- The academic entrepreneur is a scientist who engages in the entrepreneurial endeavors, but maintains their identity as an academic scientist.
- The entrepreneurial scientist is a scientist operating full-time in a new business essentially dedicated to scientific interests.
- The scientific entrepreneur combines his/her scientific and business interests by employing a high level of scientific intelligence to identify new business opportunities.

The authors emphasize the main difference between the academic and the scientific entrepreneur. According to them, the academic entrepreneur works mainly in the academic context, while the scientific entrepreneur acts in a business context and identifies easily business opportunities to valorize the product of his (or her) research. If the concept of the scientific entrepreneur could sound paradoxical according to the historical context that we

have presented, it is due to the changing role of university over time and in particular to its new mission of commercialization, as well as the change of the whole economic organization. This reflects the more active role that universities have to take in promoting the direct transfer of academic research.

Viale and Etzkowitz (2010) define the academic entrepreneur as a faculty member, a staff member, or a student who creates an activity on the basis of the results of his/her research, with the purpose to commercialize it within or outside the university. On the other hand, Etzkowitz (2010: 204) writes that the "ideal-typical entrepreneurial scientist holds the constant interaction between the market, the university and the industrial laboratory, carrying the flows of information going back and forth between them. These relationships involve different levels of commitments (financial and otherwise) of industrial sponsors, including their involvement in the selection and research collaboration".

1.2. From the entrepreneurial society to the academic capitalism

Our aim is to present the essential findings of the literature on the scientific (or academic) entrepreneur. We will see that the questioning about the academic or scientific entrepreneur cannot be summarized by one word or sentence. If the scientific entrepreneur can be an individual, it represents also a new industrial and scientific system. Some scholars speak about the "academic capitalism" (Slaughter, Leslie, 1997; Rhoades, Slaughter, 1997) to show that this phenomenon does not concern a small part of the economic system, but that it includes the production of knowledge and the purpose of this production. The fundamental element at the center of this evolution is the enterprise and its new role in the process of innovation. Audretsch and Thurik (2004: 3) highlight that we are now living in an entrepreneurial society in response to the knowledge-based economy and entrepreneurial capital. The entrepreneurial capital is the capacity to join or initiate an entrepreneurial activity. The entrepreneurial society (or economy) is by definition more flexible than the management economy "where the power of 'big business' was balanced by that of 'big labor' and 'big government'. This was the era of the man in the gray flannel suit and the organization, when virtually every major social and economic institution acted to reinforce the stability and predictability needed for mass production (…)". "By contrast, the model of the entrepreneurial economy is the political, social and economic response to an economy dictated not only to the dominance of the production factor of knowledge (…) but also by a very different, but complementary, factor they had overlooked: entrepreneurship capital, or the capacity to engage in and generate entrepreneurial activity." (Audretsch and Thurik, 2004: 2). In the same way, Shane (2004) defines an academic entrepreneur as an institution but not as a person. He focuses on the new role of the university, defining the academic entrepreneur as a university faculty that establishes a spinoff based on their research.

Rhoades and Slaughter (1999) link the development of a new economy (or the entrepreneurial economy described by Audretsch and Thurik) and the "academic capitalism". Research, according to Rhoades and Slaughter (1999) has become less "curiosity-driven" and more "market-driven". The term of "Academic capitalism" describes the phenomenon of universities' increasing attention to market potential as research impetus. They develop a negative analysis of the academic capitalism that they define simply as the involvement of colleges and faculty in market-driven behaviors. They underline that "today, higher education institutions are seeking to generate revenue from their core educational, research and service functions, ranging from the production of knowledge (such as research leading to patents) created by the faculty to the faculty's curriculum and instruction (teaching materials that can

be copyrighted and marketed)". The authors analyze the emergence of an "academic capitalism knowledge/learning/consumption regime" based on a "systematic revision and creation of policies to make these activities possible; a fundamental change in the interconnections between states, their higher education institutions and private-sector organizations to support such activities, blurring the boundaries between the for-profit and not-for-profit sectors; and a basic change in academy practices – changes that prioritize potential revenue generation, rather than the unfettered of knowledge, in policy negotiation and in strategic and academic decision making"[3]. In this context, "universities have created and expanded technology transfer and university-industry relation offices to promote collaborations and the marketing of research discoveries, created or revised policies to enable university professors to form start-up companies, and generally pursued a shift in emphasis to producing research for commercial applications" (Welsh et al., 2008: 1855).

This negative analysis of the academic entrepreneur is not shared by Etzkowitz et al. (2000) in a famous article entitled *The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm*. The authors, as Audretsch and Thurik, place the new role of the university in an historical evolution. It is a "response to the increasing importance of knowledge in national and regional innovation systems and the recognition that the university is a cost effective and creative inventor and transfer agent both knowledge and technology" (Etzkowitz et al., 2000: 314). This logical historical evolution is linked to the model of "triple helix", because "the separation of teaching, research and business activities becomes less sustainable: ironically, some have suggested this is akin to return to the medieval ideal of a common academic format that meets both the cultural and material needs of society." These authors describe the birth of the "entrepreneurial academic paradigm". So for Etzkowitz et al. (2000), it is not the academic entrepreneur itself which is important, but the emergence of a new historical logic based on new interactions between universities-enterprises and governments in a historical context characterized by the emergence of "knowledge-based innovation". They observe "the emergence of new structures such as these with and between universities reflects the changing division of labor in innovation system which encourages new patterns of mobility of both knowledge and researchers" (Etzkowitz et al., 2000: 327).

Martin and Etzkowitz (2000) and Etzkowitz and Leydesdorff (2000) developed their analysis about the triple helix to question the theory of Gibbons et al. (1994) which considered that the history of knowledge production followed basic steps: The Mode 1 and the Mode 2. The Mode 1 is characterized by academic initiated investigation and disciplinary knowledge production: "the term of Mode 1 refers to a form of knowledge production – a complex of ideas, methods, values, norms – that has grown up to control the diffusion of Newtonian model to more and more fields of enquiry and ensure its compliance with what is considered sound scientific practice. Mode 1 is meant to summarize in a single phrase the cognitive and social norms which must be followed in the production, legitimation and diffusion of knowledge of this kind" (Gibbons et al., 1994: 2). While the mode 2 is based on multidisciplinary teams brought together for a short period to work on specific problems in the real world: "by contrast, Mode 2 knowledge is carried out in a context of application. Mode 1 is disciplinary while Mode 2 is transdisciplinary. Mode 1 is characterized by homogeneity, Mode 2 by heterogeneity. In terms of organization, Mode 1 is hierarchical and tends to preserve its form, while Mode 2 is more hierarchical and transient. Each employs a different type of quality control. In comparison with mode 1, mode 2 is more socially

[3] http://firgoa.usc.es/drupal/files/Rhoades.qxp.pdf

accountable and reflexive. It includes a wider, more temporary and heterogeneous set of practitioners, collaborating on a problem defined in a specific and localized context" (Gibbons et al., 1994: 3).

In response to the criticism of the analysis of Modes 1 and 2, Nowotny, Scott and Gibbons (2001) published *Re-thinking science, knowledge and the public in an Age of uncertainly*, in which they underlined that the production of knowledge has changed because the links between knowledge production and the industry are more flexible, in a context characterized by the expansion of higher education accompanied by a culture of accountability that has impacted on both teaching and research. Gibbons explained in an article publish in 1999 that during the 20th century, "universities, government research establishments and industrial laboratories have therefore operated relatively independently, developing their own research practices and modes of behavior. Recently, however, this relative institutional impermeability has gradually become more porous. Privatization policies, for example, have moved many government research establishments into the market place". He also underlined that "there are no longer clear demarcation lines between university science and industrial science, between basic research, applied research and product development, or even between careers in the academic world and in industry. There is a now greater movement across institutional boundaries, a blurring of professional identities and a greater diversity of career patterns", and that "the norms and practices of research in university and industrial laboratories have converged. There are still differences between universities and industry, but these do not impact on what is considered sound scientific practice. Indeed, science and society more generally have each invaded the other's domain, and lines demarcating the one from the other have virtually disappeared" (Gibbons, 1999).

Similarly, Matouk (2011) distinguishes two types of knowledge production in the history of science. The first one is the "era of inventor" when the inventor produces new knowledge by observing the nature or by resolving a technical problem. It is the era of "reactive innovation". The second one is the "era of researcher" in which the researcher works in a laboratory to resolve a technical problem. It is the era of the "proactive innovation", where the research is an activity by it-self. But Matouk argues that these two eras co-exist today in the process of knowledge production. At the beginning of the industrial revolution, the inventor is a craftsman or an industrial worker who resolve a technical problem by their daily practice. Generally, they did not file patents. They fund their research by their own resources. In the other model, fundamental research is the basis of applied research. The researchers can file patents and they are funded by a research institution or by an enterprise.

Nevertheless, Etzkowitz and Leydesdorff (2000: 115-116) criticized that the classification between Mode 1 and mode 2 scientific by quoting various studies that shew "between 40% and 60% of discoveries in the 17th century could be classified as having their origins in trying to solve problems in navigation, mining, etc. Conversely, solution of practical problems through scientific means has been an important factor in scientific development, whether in German pharmaceutical science in the 17th century (…) or in the British-sponsored competition to provide a secure basis for navigation. The so-called Mode 2 is not new; it is the original format of science before its academic institutionalization in the 19th century".

While many scholars link the development of academic entrepreneurs with the development of a new technological-based economy, on the other hand, they also underline the difficulty to combine research and business. Some of them consider the term of academic entrepreneur as an oxymoron (Gee, 2001). Viale and Etzkowitz (2010: 22) underline that the academic

entrepreneur is like a “Janus scientist”. The world of science and business are very different: “in science, it is accepted that the quest for knowledge is valued over the pursuit of profits or capital gain. Because scientists are breaking new ground, the research orientation cannot be narrow, lest they risk missing angles leading to breakthroughs. Planning horizons are distant: how can you time a scientific discovery? In contrast, business objectives are much more focused and can often he expressed in the common denominator of money. Compared to that of the scientist, the planning horizon of the businessman is short, often no longer than a year or two”.

In the same context, Samson and Gurdon (1993: 65) underline the cultural differences between the scientist and the entrepreneur. They explain that “scientists represent a culture which appears substantially different from that of business. Consider the differing occupational environments. Academic scientist lives in a culture which is peer group oriented: peer recognition and tenure provide motivation and security within academic structures in which they function fairly independently. Decision-making processes are based on consensus. In the typical business venture, financial performance principally, influences rewards, a clear hierarchy exists and security is limited at the best of times”.

We can observe that behind these differences of analysis of scholars are the role of the entrepreneur in translating knowledge into economic value creation and the profile of these actors of economic changes at the stake. In the following section we will present our own definition and develop a typology of the academic/scientific entrepreneurs based on the historical analysis of actors during major industrial revolutions.

In the table 1, we present these theories about “entrepreneurial society”, “academic capitalism”, “triple helix”, “entrepreneurial academic paradigm”, “Mode 1 and mode 2”, “Academic entrepreneurship”, “era of inventor/era of researcher”.

Table 1 Theories on entrepreneurial entrepreneurship and knowledge production

Authors	**Main publications**	**Concept**	**Definition**
Audretsch and Thurik (2001, 2004) Audretsch (2007)	Audretsch A., Thurik R., 2001, What's new about the new economy? Sources of growth in the managed and Entrepreneurial economy, *industrial and Corporate Change*, 1(10), pages 267-315. Audretsch A., Thurik R., 2004, A model of the Entrepreneurial economy, Discussion Papers, n° 1204, Max Planck institute for Research into Economic System. Audretsch D.B. (2007), *The entrepreneurial society*, Oxford University Press	Entrepreneurial society Entrepreneurial economy	"In the entrepreneurial society, where workers may rapidly change jobs and employers come and go, (…)" (Audretsch, 2007: 21). The entrepreneurial economy is based on change, competition and cooperation, jobs and high wages
Slaughter and Leslie (1997) Rhoades and Slaughter (1999)	Slaughter S., Leslie L. L., 1997, *Academic Capitalism: Policies, Policies and the Entrepreneurial University*, Johns Hopkins University Press Rhoades G., Slaughter S., Academic Capitalism, Managed Professionals and Supply-side Higher Education, *Social Text*, No. 51, Summer 1997, pages 9-38	Academic capitalism	Research has become less "curiosity-driven" and more "market-driven"
Etzkowitz et al., (2000)	Etzkowitz H., Webster A., Gebhardt C. Terra B. R. C., 2000, The future of the university and the university of the future evolution of ivory tower to entrepreneurial paradigm, *Research policy*, 29, pages 313-330.	Entrepreneurial academic paradigm	"The emergence of new structures such as these with between universities reflects the changing division of labor in innovation system which encourage new patterns of mobility of both knowledge and researchers" (2000: 327)
Leidesdorff and Etzkowitz (1999, 2000)	Etzkowitz H., Leydesdorff L., 1996, Emergence of a triple helix of university-industry-government relations, *Science and Public policy*, n°23, pages 276-286. Etzkowitz H., Leydesdorff L., 2000, The dynamics of innovation: from National systems and "mode 2" to a Triple helix of university-industry-government relations, *Research policy*, 29, pages 109-123.	Triple helix	Relation between universities-Industries and government, and specially the universities: "The Triple Helix thesis states that the university can play an enhanced role in innovation in increas-ingly knowledge-based societies" (2000: 109)

Gibbons et al., 1994 Nowotny, Scott and Gibbons, 2001	Gibbons M., Limoges C., Nowotny H., Schwartzman S., Scott P., Trow M., 1994, *The Dynamics of Science and Research in contemporary Societies*, Sage Publications. Gibbons M., 1999, Science's new social contract with society, *Nature*, Vol 402, sup, 2 December. Nowotny H., Scott P., Gibbons M., 2001, *Re-Thinking Science, Knowledge and the Public in a Age of Uncertainty*, Polity Press.	Mode 1 and Mode 2	Mode 1: academic initiated investigation and disciplinary knowledge production. Mode 2 : multidisciplinary teams brought together for a short period to work on specific problem in the real world
Matouk (2011)	Matouk J., 2011, Le financement de l'innovation : une approche historique, *Innovations*, N°34, pages 13-138.	"Era of inventor" and "era of researcher"	"Era of inventor": when the inventor produces new knowledge by observing the nature or by resolving a technical problem. "Era or researcher": the researcher works in a laboratory to resolve a technical problem.

2. IDENTIFYING THE ACTORS: WHO ARE THE ENTREPRENEURS WHO CONTRIBUTE TO BUILD THE TECHNO-ECONOMIC TRAJECTORIES?

We present in the second part of our article some biographical elements about the scientific and entrepreneurial trajectory of 14 scientific entrepreneurs that we have chosen from the beginning of the first industrial revolution. By this way, we can identify the interactions between the institutional, economic, political, social and technical context where they are embedded (Granovetter, 1985). These entrepreneurs are by nature social agents. They are the result of the social context where they live. Schumpeter (1942) underlined that the entrepreneur is the product of the capitalist economy and the "bourgeoisie society", as before the knight for the medieval times. But, if the entrepreneur is the engine of the technological progress, how can he identify and find the resources that he needs to develop his project? According to Kirzner (1973), the entrepreneur is characterized by his capacity to discover biasness opportunities. But by which means? If Granovetter underlines the social context where social agents are embedded, on the other hand, he does not say anything about entrepreneurs' resources to develop their projects. In a very famous book, Penrose (1959) identified managers' resources in the enterprise. In 1985, the French sociologist, Pierre Bourdieu (1980) identified four types of capital to characterize social actors: economic, social, cultural and symbolic. Our objective is to identify the entrepreneurs' resources in their scientific and entrepreneurial trajectory. We have identified three kinks of resources: knowledge, financial and social networks (Boutillier, Uzunidis, 2017). These different elements are analyzed in the historical context of the entrepreneurs' trajectory.

2.1. A scientific entrepreneur, elements of definition

To link the individual trajectory of the scientific entrepreneur and the institutional context where he/she is embedded, we will define a scientific entrepreneur as an individual, a scientist who creates enterprise, or who files patens based on his (or her) own research. More analytically, an academic entrepreneur has following characteristics:

- He/she acquires scientific knowledge in school and university or through practice in enterprises. Generally, his/her scientific career in a scientific institution is very short. But he/she develops scientific activities in an enterprise.
- He develops during his studies links with enterprises, or financial institutions.
- He creates an enterprise (or another kind of institution as a foundation for example) or filed patents, to valorize the product of his (or her) own research and to increase his/her incomes. In this case, we have two possible situations: the scientist stays in his/her university or his/her research centers, or he/she creates his/her own enterprise to develop his/her activities, because he/she identified a real entrepreneurial opportunity (Kirzner, 1973).
- During all his life, he/she tries to develop a dialectic link between the scientific and entrepreneurial activities, to improve his scientific knowledge and to develop their uses in the industrial activity, or because he/she has difficulties to integrate into a scientific institution and to be recognized as scientist.
- In a lot of cases, the creation of an enterprise or the filling of patents is a solution to funding his (or her) own research in an institutional context characterized by policies in favor of the privatization of scientific research.
- Very well integrated in a scientific institution during his/her studies (Ph. D in sciences or in engineering) and later creates an enterprise with the support of his/her scientific institution which has detected an entrepreneurial opportunity.

We have distinguished three kinds of motivation for a scientist to become an entrepreneur: 1/ by entrepreneurial opportunity, 2/ by necessity or 3/ he/she is supported by the scientific institution where he/she works. But these motivations can differ for a scientific or an entrepreneurial career. If the scientist becomes an entrepreneur by (entrepreneurial) opportunity, it is because he/she catches very early in his/her scientific career to valorize the result of his/her scientific work. He/she quickly quits his/her scientific career in order to develop new innovations and his/her enterprise as entrepreneur. On the contrary, if the scientist creates an enterprise by necessity because he/she fails to integrate into a scientific institution due to for example the lack of a rich social network, he/she would hardly success as entrepreneur mainly for the same reasons (his/her incapacity to develop a strong professional network). In the third case, the scientist, who is very well integrated in the academic institution (for example where he/she prepares his/her Ph.D) is supported by his/her university to create an enterprise. In this last case universities often create incubators to support the technology transfer between the university and enterprises (see table 2).

Table 2: Motivations of the scientific entrepreneur for a scientific or an entrepreneurial career

Scientific entrepreneur			
	By entrepreneurial opportunity	**By necessity**	**Supported by the scientific institution where he/she works**
Scientific career	- Generally short in the research institution - Developing links with enterprises and financial institutions during his/her studies - Developing new scientific and technical knowledge during entrepreneurial career	- Difficulties to integrate into the academic world and to build a scientific career and to be recognize as a scientist - Filing patents but staying in the academic world where he/she succeeds an exemplary scientific career	- Very well integrated into the academic world and supported by it where he/she has successful scientific career
Entrepreneurial career	- Catching very early in the scientific career an entrepreneurial opportunity to valorize his/her scientific results and to increase income -During his/her life, he/she tries to develop a dialectic link between scientific and entrepreneurial activities, to improve his/her scientific knowledge and to develop their use in industrial activity	- Difficulties to develop his/her enterprise (bankruptcy, failure), - Creating an enterprise and filing patents to valorize the product of his/her research to increase his/her incomes	- Supported and encouraged by his/her scientific institution, - Succeeding an exemplary entrepreneurial career

From these elements, we have built a typology of the scientific entrepreneur by combining his motivations on his career as a scientific and as an entrepreneur (table 3). In order to illustrate this typology, we will give some examples of 14 scientific entrepreneurs in the history. Their careers illustrate the three types of scientific entrepreneurs that we have identified according the following criteria:

1/ They are very famous in the scientific field as well as by the public. They are part of the scientific popular culture.

2/ They created a new industrial or intellectual trajectory for major innovation (steam engine, explosive, vaccine, electricity, radio waves, automotive, informatics and bleach), which were the engines of the first industrial revolution. This period is very important to understand the creation of a systemic link between science and industry activities during the 20th century.

3/ The history of the two prominent economists – Richard Cantillon and Jean-Baptiste Say – are very special. We choose Richard Cantillon because he was, before Ricardo and Keynes, the richest economist thanks to his knowledge of market mechanism based on which he wrote a theoretical book – “Essai sur la nature du commerce en général” –, which is considered as

the most important economics book before "The Wealth of Nations" of Adam Smith. In the case of Jean-Baptiste Say, he became an entrepreneur because he was forced to give up his career as journalist after the publication his book "Traité d'économie politique" in 1803 considered by Napoléon as too liberal.

Table 3: Historic scientific/academic entrepreneurs according their motivation to be a scientist of an entrepreneur

Historical academic/scientific entrepreneur		
By entrepreneurial opportunity	**By necessity**	**Supported by the scientific institution where he/she works**
Richard Cantillon (1680-1734) James Watt (1736-1819) Alfred Nobel (1833-1896) Louis Pasteur (1822-1895) Guglielmo Marconi (1874-1937) Nicolas Tesla (1856-1943) Eugène Schueller (1881-1957)	Denis Papin (1647-1714) Jean-Baptiste Say (1767-1832) André Citroën (1878-1935)	Nicolas Conté (1755-1805) Claude-Louis Berthollet (1748-1822) William Hewlett (1913-2001) David Packard (1912-1996)

2.2. Three types of scientific entrepreneur

2.2.1. To be an entrepreneur by entrepreneurial opportunism

We have selected seven entrepreneurs in this first group: Richard Cantillon, James Watt, Alfred Nobel, Louis Pasteur, Guglielmo Marconi, Nicolas Tesla and Eugène Schueller. Most of them lived during the 19th century, at the end of the first industrial revolution. They share following characteristics:

i) They were all successful entrepreneurs and became very rich, except for Nicolas Tesla who had a very irregular entrepreneurial career and died in extremely poverty.
ii) They contributed to the development of new industrial-technological trajectories:

Watt, although he was not the first engineer to invent the steam engine, has improved the technology that had been developed by Denis Papin, Thomas Savery (1698) and Thomas Newcomen (1712, who has become a wealthy man at the end of his life) and has commercialized it successfully.

Richard Cantillon has invented a new banking model with the banker John Law who created the "Banque Générale", which became the Banque Royale. John Law introduced in France paper-money. To develop his banking activity, Law created two trade companies, the "Compagnie d'Occident" and the "Compagnie du Mississippi", to exploit French territories in America (but in fact Law did nothing, and it has run into crash and collapse. Cantillon was Law's partner before fighting against him). Cantillon was the first economist (before Ricardo and Keynes) to build a huge fortune (probably 20 millions of pounds) (Murphy, 1997).

Nobel developed a new industrial-technological trajectory with the Dynamite, Pasteur with vaccination products and the Pasteur Institute, Marconi with the long-distance radio

transmission, Tesla with the electric engine and Schuller with the cosmetic products, which became important industries during the 20th century.

iii)Their scientific career ended shortly or did not exist.

Watt did not attend school regularly. He had been initially mainly educated at home by his mother, although later he attended school. He showed great manual dexterity, engineering skills and an aptitude for mathematics.

Nobel worked in his father's enterprise had never developed a scientific career.

Tesla worked some years in France and in the United States in Continental Edison where he developed his technical knowledge and tested his creative ideas.

Schueller worked in the laboratory of Pierre and Marie Curie at Sorbonne University as researcher in chemical. He was bored by the laboratory life and did not like the work of research. He seized the opportunity offered by a Parisian hairdresser who wanted to create new products to dye hair. He worked in his kitchen to find out the appropriate formulate. Nevertheless, Pasteur is an exemption because he was during all his life a scientist recognized by the scientific institution, even if sometimes he had difficulties to be recognized as a scientist.

iv) All have experienced setbacks in their entrepreneurial ventures except Schueller who developed his enterprises without many difficulties. Pasteur increased substantively his incomes while public findings were very low. Nobel, Marconi and Tesla had a lot of difficulties and collapses.

Schueller has started his career as a mathematical instrument maker. He met a lot of financial difficulties before his partnership with Matthew Boulton.

Marconi has failed to develop his activity in Italy and immigrated to England where he found the Wireless Telegraph & Signal Company (which became the Marconi Company in 1900. His mother was the daughter of Andrew Jameson of Daphne Castle in Ireland, and granddaughter of John Jameson founder of whisky distillers) and later to the United States where he became an entrepreneur and filed patents.

Nobel was ruined after the explosion of his factory and had to face the anger of the people and the government.

v) They all have become the symbol of the industry that they contributed to develop.

It is mainly the case for James Watt (who created the "Watt" or the horsepower), Alfred Nobel (for the dynamite), Louis Pasteur (for the vaccination), Euguène Schueller (for the cosmetics industry), Guglielmo Marconi and Nikola Tesla (for the long-distance radio transmission).

But in 1943, the Supreme Court of the United States handed down a decision on Marconi's radio patents restoring some of the prior patents of Olivier Lodge (English physician-patent on the "syntonic tuning" used by Marconi), John Stone Stone (American mathematician and

physician – patent on the Stone battery system) and Nikola Tesla (the real inventor of the radio).

The case of Nikola Tesla is very particular. Nikola Tesla was an electrical engineer. He worked during a short period for Thomas Alva Edison, but they developed two different electric technologies. Tesla developed the alternating current, which was superior to the Edison's technology, the direct current. A situation that Edison could not accept. Tesla moved to work with George Westinghouse who bought his patents. In 1889 Tesla created a laboratory in New York to develop new inventions. His main objective was to improve human well-being instead of being rich. In 1912, he refused the Nobel Price, which was finally attribute to Gustav Dalen, a Swedish entrepreneur founder of the Enterprise AGA, because he thought that his innovations were technological and that he did not create new scientific knowledge. But it is not the only reason. The Nobel Prize was to be awarded jointly with Thomas Edison with whom he had a very hard relation. Tesla did not agree with this option because he had no consideration for Edison for scientific and technological reasons, but also because when Tesla arrived in the United States he worked for Edison, but who did not pay him…

2.2.2. To be an entrepreneur by necessity because he could not integrate a scientific institution

In this group of scientific entrepreneurs, we have selected three entrepreneurs. The first one is Denis Papin who lived before the first industrial revolution. He invented a primitive form of the steam engine, but he could not develop a scientific career in scientific institutions, even if he worked in France, in Italy, in Germany and in England (where worked with Robert Boyle). He corresponded with Leibniz. He developed social relations to find a place in scientific institutions of these different countries, but only for a short period. In order to make a living, he decided to valorize his scientific knowledge and to use the steam engine to develop new kinds of mobility means on earth and on water. But the European society was not ready to use these new technologies. Denis Papin did not have the entrepreneurial culture and become a rich entrepreneur; instead he wanted to spread his knowledge and discoveries. In 1680, he published in London "*A new Digester or Engine for softening bones, containing the description of its make and use in these particulars",* where he explained all the details of his invention. He was never rich.

Jean-Baptiste Say was a famous liberal economist. He worked in London during some years of which the experiences helped him to become an entrepreneur later. In London, he read Adam Smith and was very interested by his theory of individualism and free competition (the "invisible hand" of Adam Smith). But Jean-Baptiste Say disagreed with Adam Smith in different questions in particular the role of entrepreneur in economic activity. Adam Smith had not a positive opinion about entrepreneur, as he considered them as people who wanted to win a lot of money very quickly. Nevertheless, according to Jean-Baptiste Say, the entrepreneur plays a very important economic role as a link between the scientist who produces new knowledge and the worker who uses this knowledge in the industrial process. But the main difference between Adam Smith and Jean-Baptiste Say is that Adam Smith was never an entrepreneur as in contrary to Jean-Baptiste Say.

Jean-Baptiste Say became an entrepreneur because he could no more be an economist due to his theory book "Traité d'économie politique" published 1803, which was considered to be too liberal by Napoléon. Indeed, according Napoléon, the State must play an important

economic role to control the process of wealth creation and he required that Jean-Baptiste Say corrected his manuscript, which he refused. As a result, Napoléon prohibited Jean-Baptiste to exercise as journalist. In consequence, Jean-Baptiste Say decided to become entrepreneur. He built a spinning mill in the North of France and ran it during eight years. To create this modern factory, Jean-Baptiste Say attended courses at the National Conservatory of Arts and Crafts. The factory expanded quickly, from 67 workers at the beginning to 100 in 1810. After the death of Napoléon, he came back to Paris and became a teacher at the Collège de France and has become a famous economist. In 1819, Jean-Baptiste Say created with a French businessman Vital Roux (who participated in the drafting of the Commercial Code in 1807), the world's first business school – the "Ecole spéciale de commerce et d'industrie" which became the "Ecole supérieure de commerce". This first business school was really an innovation by its pedagogical approach combined academic teaching and practice. "The first curriculum was based on a combined theoretical and practical approach to business education, including pedagogical simulation games" (Kaplan, 2014: 530). This school always exists today under the name: ESCP-Europe. So the entrepreneurial activity of Jean-Baptiste Say is a way to overcome this troubled period during which he could not be a scientist, but he had the will to diffuse entrepreneurial spirit in France by his books, by his teaching and by the creation of this business school which was a major innovation.

André Citroën, the well-known French automobile entrepreneur (with Louis Renault), developed his activity at the beginning of the 20th century. He became entrepreneur by necessity because he had studied at the famous French engineering school, Polytechnique School, but at the end of his studies, failed in integrating into the most prestigious French administration. He thus decided to create an enterprise in automobile industry, which was at that times a new high-tech activity with great potential of growth. During his studies at the Polytechnique School, he was interested in automobile technology and later created his enterprise after the military service, with two engineer friends André Boas and Paul Hinstin in 1912.

2.2.3. To be an entrepreneur with the support of the scientific institution

In the third group of scientific/academic entrepreneurs, we have selected four entrepreneurs: Nicolas Conté and Claude-Louis Berthollet, William Hewlett and David Packard. The first two developed their activities during the beginning of the first industrial revolution and Hewlett and Packard during the 20th century in the new information industry.

Nicolas Conté and Claude-Louis Berthollet lived during the French revolution, a very difficult political period. They were both solicited by the French government (the "Comité de Salut Public") to find a solution to a technical problem. At the beginning of the 19th century, Conté was a member of the "Société d'encouragement", a public institution to support French industry. At that time, the French economy was blocked by British, German and Austrian royalist armies and it was impossible to import graphite from England (which was the only producer in Europe), which was used to make pencils. So Conté invented the crayon-mine and he created an enterprise to produce these pencils. However, Conté was not involved in the management of his enterprise most of the time. Instead, he preferred to work in his laboratory and to develop new inventions (for example airships).

Claude-Louis Berthollet studied medicine and chemistry. He was both a chemist and an entrepreneur. He managed a well-known laboratory of chemistry with very famous chemists (Lavoisier, Monge, etc.). He was also professor at Polytechnique School and created a kind of

think-tank, “La société d’Arceuil” at the end of his life. He was also a manger of a public manufacture (“La manufacture des Gobelins”) where a new product to launder and disinfect laundry (bleach or “eau de Javel”, but the first name was “berthellage”) has been invented. He set up an enterprise thanks to help of Comte d’Artois. But like Denis Papin, he did not want to be rich and gave his invention to entrepreneurs who wanted to exploit it.

Nicolas Conté and Claude-Louis Berthollet were mainly scientist meanwhile inventors. If they created an enterprise, their main objective was not personal enrichment. They made themselves a double mission: to improve human knowledge about nature, and to spread their knowledge.

Table 3: Scientific and entrepreneurial trajectory of 14 famous scientific entrepreneurs

Period	**Major innovation**	**Name**	**Study and scientific career**	**Entrepreneurial trajectory**
Before the beginning of the first industrial revolution during which economic activity was dominated by agriculture The first universities were created in Europe in the 12th century but they studied mainly theology, public law and medicine	Steam engine	Denis Papin 1647-1712	He studied medicine, physic and mathematics Royal Academy of sciences (France) He works with Robert Boyle in London Royal society of London	He invented the first steam engine of the history in 1688, but he could not exploit as entrepreneur the results of his research. His main objective was to be a scientist not an entrepreneur. 6 main inventions: 1679: steam digester 1687: piston steam engine 1689: centrifugal pomp 1690: piston steam 1707: steam boat
Development of scientific academies but scientific institutions were under developed Beginning of industrial progress (steam energy industry) but with low entrepreneurial spirit The intellectual property not yet recognized	One of the first economic theory of market economy	Richard Cantillon 1680-1734	No information	Banker (with John Law) The first economist who accumulated big fortune before Ricardo and Keynes
Period	**Major innovation**	**Name**	**Study and scientific career**	**Entrepreneurial trajectory**
The beginning of the first industrial revolution Development of steam energy industry and new	Steam engine	James Watt 1736-1819	Only within the family (with his mother). He did not attend school regularly	He worked at the university of Glasgow as a mathematical instrument maker where he repaired a Newcomen steam engine. To commercialize his invention he

technical progress in this field Intellectual property recognized (beginning in France in 1791 after "Statues of monopolies" in England in 1623) Universities developed new sciences: physics, chemistry, mechanics				experienced great financial difficulties until he entered a partnership with Matthew Boulton in 1775. He filed six patents: 1769: separate condenser 1780: a new method of copying letters 1782: new methods to produce a continued rotation motion and new improvements upon steam engines-expansive and double acting, and three bar motion and steam carriage 1785: new methods of constructing furnaces. He developed the concept of horsepower (the "Watt") He was wealthy at the end of his life.
	Bleach ("eau de Javel")	Claude-Louis Berthollet 1748-1822	He first studied medicine in Italy then chemistry in Paris. He created a laboratory with other well-known scientists. During the 1st Empire, he became professor at the Polytechnic School and he created a small society of scientists	He took place in the Napoleon campaign in Egypt with other many scientists. 1775: patent of Bleach Manager of the Manufacture des Gobelins (Paris). He refuses the proposition of Watt and Boulton to create an enterprise in England to produce the Bleach, and another proposition from a French entrepreneur. He created himself in 1777 a manufactory to produce Bleach. He did not sell his patent but he gives it to entrepreneurs who wanted to produce it.

	Modern pencil lead	Nicolas Conté 1755-1805	He studied physics and mechanics	He took place in the Napoleon campaign in Egypt with other many scientists. He receive patent for his invention in 1795 and formed the "Société Conté" to make it.
	The economic role of the entrepreneur	Jean-Baptiste Say 1767-1832	His father was entrepreneur with a lot of financial difficulties. He gave him a very liberal education to reduce the influence of the religion and sent him to England to learn modern management methods. Say took part to the French revolution. He had left his career as journalist and founded his enterprise after studying technology of spinning at the National Conservatory in Arts and Crafts.	Founder and manager (during 8 years) of a spinning manufacture in north of France. In 1819, he created the world's first business school in Paris: "The Ecole spéciale du commerce et d'industrie"
Period	**Major innovation**	**Name**	**Study and scientific career**	**Entrepreneurial trajectory**
Beginning of the second industrial revolution New development of industrial activities Development of institutional links between university and industry	Principals of vaccination, microbial fermentation and pasteurization	Louis Pasteur 1822-1895	He studied chemistry, physics and crystallography and worked in the laboratory of Antoine-Jérôme Balard as chemist. Ph.D in 1847, professor in Dijon, Strasbourg, Lille. He was also administrator of the Ecole Normale Supérieure	1865: patent for the pasteurization 1871: patent for making beer 1873: patent for the yeast 1887: Creation of Institute Pasteur

New universities are created in Europe and in the United States Scientific and entrepreneurial spirit	Dynamite and detonator	Alfred Nobel 1833-1896	He studied chemistry during four years in the United States, but mainly learned chemistry by his own professional experience in his father's firm of explosive in Sweden and in Russia. He worked with the French chemist Théophile Jules Pelouze with whom he learned the existence of nitroglycerin invented by one of his student, the Italian chemist Ascanio Sobero.	He developed the father's enterprise when he works as a scientist and as a manager. The first industrial fortune in his lifetime. 1863: patent of the detonator 1879: patent of the dynamite. During his life, Nobel filed around 350 patents.
	Electricity power Alternating current	Nikolas Tesla 1856-1943	He studied mathematics, mechanics and physics at the School of enginery in Graz (Austria)	He worked at the Office telegraph in Budapest as designer. He worked in Paris for the Edison company. In Paris, he worked also with Clément Ader and developed the first engine with alternating current. He went in United-states to work in the Edison Company, but after a disagree; he went to work with George Westinghouse (the Niagara Falls Power Project in 1888) who bought his patents. In 1887, Tesla formed the Tesla Electric company. He refused the Nobel Prize in 1912 for personal and scientific reasons.
	Long-distance radio transmission radio, telegraph	Guglielmo Marconi 1874-1937	When he was child, he did not like studying, except electricity	Founder of the first enterprise of radio diffusion in 1897 in England, the Wireless telegraph & signal Company

	system		He studied physics and chemistry at the Technical Institute of Livorno. He finished his studies without diploma. But he worked on the Hertz's results in the laboratory who has built in the father's home. Nobel Prize in 1909	(which became the Marconi Company in 1900). He had a lot of financial difficulties at the beginning. 1901: first transatlantic link. But in 1943, the Supreme Court of the United States handed down a decision on Marconi's radio patents restoring some of the prior patents of Olivier Lodge (English physician-patent on the "syntonic tuning" used by Marconi), John Stone Stone (American mathematician and physician – patent on the Stone battery system) and Nikola Tesla (the real inventor of the radio)
	Citroën Traction Avant	André Citroën 1878-1935	He studied mechanics in Polytechnics in Paris.	He became director of an automotive enterprise, the Automobile Mors, a very famous enterprise but with important financial difficulties. In 1912, he visited the Ford's factory in Detroit. The same year, he found his own enterprise with two friends, André Boas and Paul Hinstin, "Citorën, Hinstin et Cie", which will become the "Société anonyme des engrenages Citroën"
	Cosmetics	Eugène Schueller 1881-1957	He studied chemistry at the university of Paris. He worked as researcher in the Pierre and Marie Curie.	Founder of the enterprise L'Oréal in 1909.
Period	**Major innovation**	**Name**	**Study and scientific career**	**Entrepreneurial trajectory**
The beginning of the third	Computer and	David	He studied electricity in	Founders of the enterprise Hewlett-

industrial revolution Development of new technologies: electronics and informatics Domination of the United-States as the first world industrial economy	information technology	Packard 1912-1996	Stanford University and got his Ph.D in 1938. He worked the laboratory of F. Terman when W. Hewlett was in General Electric.	Packard (HP) in 1939 thanks to the support of their professor Frederick Terman who helped them to develop the markets, mainly in military industry.
	Computer and information technology	William Hewlett-Packard 1913-2001	He studied electricity in Sanford University Ph.D in1939. He worked in General Electric in New York during three years.	

CONCLUSION

Progressively since the 17th century, links between scientific and industrial activities have been developed as a respond to the new social needs created by the social evolution. These 14 scientific entrepreneurs characterized different steps of this evolution, from to Denis Papin to Louis Pasteur and to William Hewlett and David Packard. Our analysis underlines that the links between entrepreneurs and universities are not new and can be dated back to more than four centuries.

The academic capitalism exists today is the result of this evolution. The golden times of the science activity where the scientists were free to choose what they wanted to study and how they can develop new ideas, theories and technologies does not exist. Some scientific entrepreneurs identify new needs, technologies and markets that they can develop due to the favorable condition created by a capitalist society that promotes entrepreneurial spirit. To become a scientist is not always easy and many scientists become entrepreneurs because they could not find their place in academic institutions. Other scientists are supported by the academic institution to become entrepreneurs and to develop new technologies that enterprises need.

MAIN REFERENCES

Aldrich H., 2011, *An evolutionary Approach to Entrepreneurship,* Edward Elgar.

Audretsch A., Thurik R., 2001, What's new about the new economy? Sources of growth in the managed and Entrepreneurial economy, *industrial and Corporate Change*, 1(10), pages 267-315.

Audretsch A., Thurik R., 2004, A model of the Entrepreneurial economy, Discussion Papers, n° 1204, Max Planck institute for Research into Economic System.

Audretsch D., Lehmann E. E., 2001, Does the knowledge Spillover theory of Entrepreneurship hold for regions?, *Research policy,* n° 34, pages 1191-1202.

Baumol W., 1990, Entrepreneurship: productive, Unproductive and Destructive, *The Journal of Political Economy,* Vol. 98, N) 5, pages 893-924.

Bourdieu P., 1980, Le Capital social. Notes Provisoires, *Actes de la Recherche en sciences sociales,* vol. 31, N°1, pages 2-3.

Boutillier S., 2017, L'entrepreneur académique, un entrepreneur, comme les autres ?, Séminaire du RRI-ULCO, 15 février.

Boutillier S., 2017eds, *Entrepreneuriat et innovation. Contextes et concept,* Peter Lang.

Boutillier S., Uzunidis D., 2017, *The Entrepreneur. The economic Function of Free Entreprise,* ISTE.

Chandler A., 1977, *La main visible des managers*, Economica.

Dickson K., Coles A. M., Smith H. L., 1998, Science in the market place: the role of the scientific entrepreneur, in During W., Oakey R. (eds), *New technology-based firms in the 1990s,* Volume IV, Paul Chapman, pages 27-37.

De Ridder O., 1997, *Alfred Nobel,* Denoël.

Drancourt M., 2002, *Leçons d'histoire sur l'entreprise de l'antiquité à nos jours,* PUF.

Dubos R., 1995, *Louis Pasteur, franc-tireur de la science,* La découverte.

Etzkowitz H., 2010, A company of their own: entrepreneurial scientists and the capitalization of knowledge, in Viale R., Etzkowitz H., 2010dir, *The capitalization of Knowledge. A triple helix of University-Industry-Government*, Edward Elgar, pages 201-217.

Etzkowitz H., Leydesdorff L., 1996, Emergence of a triple helix of university-industry-government relations, *Science and Public policy,* n°23, pages 276-286.
Etzkowitz H., Leydesdorff L., 2000, The dynamics of innovation: from National systems and "mode 2" to a Triple helix of university-industry-government relations, *Research policy,* 29, pages 109-123.
Etzkowitz H., Webster A., Gebhardt C. Terra B. R. C., 2000, The future of the university and the university of the future evolution of ivory tower to entrepreneurial paradigm, *Research policy,* 29, pages 313-330.
Fant K., 2014, *Alfred Nobel. A biography,* Skyhorse Publising.
Freeman C., 2008, *Systems of Innovation: Selected Essays in Evolutionary Economics*, Edward Elgar.
Frèrejean A., 2000, *Terre d'inventeurs,* Tome 1, Tallandier.
Frèrejean A., 2001, *Terre d'inventeurs,* Tome 2, Tallandier.
Galbraith J. K., 1968, *le nouvel état industriel,* Gallimard (édition originale 1967).
Galvez-Behar G., 2005, Le savant, l'inventeur et le politique. Le rôle du sous-secrétariat d'Etat aux inventions durant la première guerre mondiale, *Vingtième Siècle. Revue d'histoire,* n°95, pages 103-117.
Galvez-Behar G.,2016, Louis pasteur, entrepreneur. Pour une histoire économique des mondes savants, HAL, 2 mai : halshs-01267638.
Galvez-Behar G., Hatchuel A., Henry O., O'Connor E. S., Segrestin B., 2016, L'innovation a-t-elle joué un rôle dans la naissance de l'administration de la science ?, *Entreprise et Histoire,* n°83, pages 121-131.
Gaston-Breton T., 2015, Citroën ou la conspiration de Javel, 3th August.
Gaston-Breton T., 2011, Guglielmo Marconi, *Les échos,* 8th August.
Gaston-Breton T., 2003, Claude-Louis Berthollet et l'eau de javel, *Les échos,* 6th July.
Gee K., 2001, Academic entrepreneur – An oxymoron?, Molecular Interventions, vol. 1, issue 4, pages 186-187.
Gibbons M., Limoges C., Nowotny H., Schwartzman S., Scott P., Trow M., 1994, *The Dynamics of Science and Research in contemporary Societies,* Sage Publications.
Gibbons M., 1999, Science's new social contract with society, *Nature,* Vol 402, sup, 2 december.
Gille B., 1978, *Histoire des techniques,* Encyclopédie de la Pléiade
Gingras Y., Keating P., Limoges C., 2000, *Du scribe au savant,* PUF.
Gjerding A. N., Wilderom C., Cameron S., Taylor A., Scheunert K-J., 2006, *L'université entrepreneuriale : vingt pratiques distinctives,* Editions de l'OCDE.
Granovetter M., 1985, Economic Action and Social Structure: The problem of embeddedness, *American Journal of Sociology,* vol.91, N°3, pages 481-510.
Kaplan A., 2014, European Management and European business schools: insights from the hisotry fo business schools, *European management Journal,* 32, pages 529-534.
Kirzner I., 1973, *Competition and Entrepreneurship,* The University of Chicago Press.
Landes D., Mokyr J., Baumol W., 2010eds, *The invention of Enterprise,* Princeton University Press.
Latour B., 2011, *Pasteur, guerre et paix des microbes,* La découverte.
Lira C., 2013, *Biography of James Watt*
https://www.egr.msu.edu/~lira/supp/steam/wattbio.html
Leydesdorff L., Etzkowitz H. 1998, The Triple Helix as a Model for Innovation Studies (Conference Report, Science and Public Policy, Vol.25, n°3 pages 195-203.
Loubet J.-L., 1999, André Citroën, *Les Echos,* 10th August.

Louvel S., Hubert M., 2016, L'usage des exemples étrangers dans les politiques de financement de la recherché. Les nanosciences et nanotechnologies en France, *Revue Française de Sociologie,* vol 57, pages 473-501.
Lucas R. E., 1988, On the mechanics of economic development, *Journal of Monetary Economics,* n°22, pages 3-39.
Lucas R. E., 1993, Making a miracle, *Econometria,* 61(2), pages 251-272.
Martin B. R., Etzkowitz H., 2000, The Origin and evolution of the University Species, Electronic Working Paper series, SPRU, No. 59, December.
Matouk J., 2011, Le financement de l'innovation : une approche historique, *Innovations,* N°34, pages 13-138.
Murphy A. E., 1997, *Richard Cantillon, le rival de Law,* Editeurs des sciences et des arts.
Nelson R. R., Winter S. G., 1982, *An Evolutionary theory of economic change,* the Belknap Press of Harvard University Press.
Nowotny H., Scott P., Gibbons M., 2001, *Re-Thinking Science, Knowledge and the Public in a Age of Uncertainty,* Polity Press.
O'Neill J. J., Herpin C., 2015, *Le génie prodigue, l'incroyable vie de Nikola Tesla,* Independent Publishing Plateforme.
Penrose E., 1959, *The Theory of the Growth of the Firm*, OUP Oxford.
Rhoades G., Slaughter S., 1997, Academic Capitalism, Managed Professionals and Supply-side Higher Education, *Social Text,* No. 51, pages 9-38
Romer P.M, 1986, Endegenous technological change, *journal of Political Economy,* n°98, pages 71-101.
Rosenberg E. S., 2009, Le « modèle américain » de la consommation de masse, *Cahiers d'histoire. Revue d'histoire critique,* n°108, pages 111-142.
Samson J. K., Gurdon A. M., 1993, University scientists as entrepreneurs: a special case of technology transfer and high-tech venturing, *Technovation,* 13, pages 63-71.
Say J.-B., 1803, *Traité d'économie politique,*
http://www.institutcoppet.org/wp-content/uploads/2011/12/Traite-deconomie-politique-Jean-Baptiste-Say.pdf
Schumpeter J., 2005, *The theory of Economic Development,* Transaction Publishers (first edition 1911).
Schumpeter J., 1979, *Capitalisme, socialisme et démocratie,* Payot (first edition 1942).
Shane S., 2004, *Academic entrepreneurship: University Spinoffs and wealth creation,* Edward Elgar.
Slaughter S., Leslie L. L., 1997, *Academic Capitalism: Policies, Policies and the Entrepreneurial University*, Johns Hopkins University Press.
Viale R., Etzkowitz H., 2010dir, *The capitalization of Knowledge. A triple helix of University-Industry-Government,* Edward Elgar.
Weil T., 2010, Des histoires de la Silcon Valley, *Entreprises et histoire,* 58, pages 129-149.
Welsh R., Glenna L., Lacy W., biscotti D., 2008, Close enough not too far: Assessing the effects of university-industry research relationship and the rise of academic capitalism, *Research Policy,* 37, pages 1854-1864.