Input paper for the Euro-CASE annual conference "Boosting Innovation in Europe: USA-EU - Why the innovation gap? Horizon 2020, How to boost Innovation?"

Introduction[1]

In his controversial and mediatized 1989 essay, *The End of History*, Francis Fukuyama claimed that society had reached the final stage of its evolutionary process, by crystallizing itself in the so-called liberal democracies. Twelve years later, in 2002, Fukuyama wrote another essay entitled *Our Post Human Future: Consequences of the Biotechnology Revolution* in which he presented technological evolution, notably the area at the crossroads of bio/nanotechnologies and artificial intelligence, as the most substantial risk to 21st century society. He brought to social analysis John von Neumann's concept of *technological singularity* – meanwhile popularized by science fiction authors such as the mathematician Vernor Vinge –, that is, techno-scientific change with such a deep impact as to transform not only our habitat, but also ourselves. The concept of *technological singularity* enlarges the former concept of *Anthropocene,* coined by ecologist Eugene F. Stoermer and popularized by the Nobel Prize, Paul Crutzen, to describe a new geologic era (that began with the Industrial Revolution and speeded up during the 20th century) shaped by human activities that have had a significant global impact on the Earth's ecosystems.

Although often evading one's perception, since the second half of the 20th century we live times of revolution, which has changed in unprecedented ways, the world around us by instilling in it an eminently technological nature.[2] Today's natural world has such a deep technological structure that one does not even realize it when using technical devices and apparatuses as "naturally" as we breathe. This change has been so radical and "surreptitious" that the world before World War II became a distant memory, almost bucolic, with which we can hardly identify. Writing an e-mail or texting a message in a mobile phone, downloading a film or searching for a street in Google maps have become so natural, not in the general sense of the term, but in that it became part of our identity as human beings.

In our days, words like change, innovation, entrepreneurship, became omnipresent worldwide not only in political discourse, but also in daily routines. The use one

[1] This paper was originally written by Maria Paula Diogo and Fernando Santana (Faculty of Science and Technology, NOVA – New University of Lisbon). The present version includes the suggestions and comments raised during the discussion of this position paper by the members of the Euro-CASE innovation platform.

[2] Rosalind Williams, *Retooling: A Historian Confronts Technological Change*, Cambridge (Mass.):MIT Press,

makes of these expressions, however, is often abstract and simplistic, ignoring the density of their interrelationships in different geographic, historical and civilizational contexts, and the *boomerang* character of today's world.[3]

In order to address the topic of this conference – *Boosting Innovation in Europe: USA-EU Why the innovation gap? Horizon 2020, How to boost Innovation* – we suggest a brief albeit deeper reflection on the meaning of these words, which have become common currency in meetings, lectures and seminars, and on how engineering may contribute to a new European research agenda.

In 2000, when confronted with complaints on gender discrimination in MIT, Provost Robert Brown, professor of chemical engineering responded: "But (…) this is the MIT. We are engineers. Engineers solve problems." These words are not that different from those of Sheldon Cooper, Doctor in theoretical physics at Caltech, a character of the TV series *The Big Bang Theory*, who while conversing with his friend Howard, precisely a MIT mechanical engineer working for a NASA project, described the engineers as "So, this is engineering, huh?" Engineering where the noble semi-skilled labourers execute the vision of those who think and dream.

In completely different contexts, these two sentences synthesize the distinctive essence of engineering: the importance of doing and intervening in the world of things. It is the very identity of engineering, which determines its relationships with the knowledge of nature. On this account, one should recall the old Baconian idea "knowledge is power" – in the sense of a capacity of transforming, changing and manipulating – or the Cartesian concept "knowing nature to dominate it", which substantiate engineering's close relationship with invention and innovation.

Although distinct, but traditionally used together, the concepts of inventions and innovation have drifted apart from one another. Today one mostly hears about innovation and for the lay public this means basically new technical solutions available in the marketplace. The reasons behind this perception of innovation are simple: the social character of innovation and the fact that it is deeply linked both to the markets and a measurable concept of success, which feeds itself in a vicious circle, since market-driven innovation imposes its own continuation. This weight of the market has narrowed the concept of innovation to the universe of entrepreneurship, innovation's cognitive dimension being lost on the way. One often recalls Steve Jobs and Bill Gates, first as young men inventing personal computers in a garage and subsequently tycoons in the world of computing, but one easily forgets John Bardeen, William Shockley and Walter Brattain inventing the transistor in the Bell Labs.

However, the concept of innovation is much broader broad encompassing both breakthroughs and incremental changes and covering a diversity of areas, such as technical, marketing, operational, and organizational. At its core lies the ability of thinking differently while approaching a set of problems or needs, the capacity of being a "wild spirit", as used by Schumpeter.

[3]Ulrich Beck, *World Risk Society*, Cambridge: Polity Press, 1998.

In 2000, precisely inspired in Schumpeter's ideas, the Lisbon Agenda devised a ten years plan for the European Union's economy aiming at making the EU "the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion."[4] The topic of this conference shows that most of the Lisbon Agenda goals were not achieved. Our contribution thus follows the Europe 2020 initiative that aims at "smart, sustainable, inclusive growth"[5] taking as a benchmark the United States of America and the BRICS, particularly China.

USA-EU Why the innovation gap?

The reasons for the innovation gap between the USA and Europe are multiple starting with the fact that the US are a federal republic and Europe is a space dominated by Nation-States each staunchly defending its specific interests: (1) the total value of the investment in R&D; (2) the organization of research; (3) education system; (4) cultural values concerning risk and citizenship.

Up to the 1930s, the USA mainly adapted inventions, but with World War II, and later the Cold War with its spatial programme and military interventions, investments grew substantially, above 3% of the GDP. The American government, in particular its military sector, joined forces with universities and companies in order to make the USA the world leader in techno scientific innovation, in the context of the country's affirmation as one of the main world superpowers.

A key-factor was the immigration and settlement of European scientists, who were organized in innovative ways around specific research objectives and had at their disposal considerable private and public funds, the so-called research-oriented projects such as the Manhattan project; synthetic rubber GRS; the trilogy Mercury, Gemini and Apollo; Star Wars and Arpanet; the transistor of the Bell Laboratories or the IBM computers. They were all linked to the military-industrial complex with massive investments in research carried out in universities such as the MIT, Caltech and Columbia, and in corporate laboratories of which the government was the main customer.

On the other hand, also after the World War II, a new type of investment was created in America – the venture capital - to support at an early-stage high-potential and high-risk start-up companies.[6] Due to its characteristics, venture capital is especially suitable to support fast-growing high-tech business and research areas, such as computer and bio technologies and thus played an instrumental role in developing many of the major Silicon Valley technology companies.

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[4] *European Union Parliament Website Lisbon European Council*, 23 and 24 March. Conclusion. http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/00100-r1.en0.htm. Retrieved 16 November 2013.

[5] *Europe 2020: Commission proposes new economic strategy* http://ec.europa.eu/news/economy/100303_en.htm. Retrieved 16 November 2013.

[6] The first two US venture capital firms were founded in 1946: the American Research and Development Corporation (ARDC) and the J.H. Whitney & Company.

Both the state and private highly funded research centres are at the core of the US network of excellence. An agile and protectionist patent system added to the above features.

As far as European investment in R&D policy is concerned, World War II left a landscape of destruction, with most of the industrial fabric at the brink of exhaustion. The recovery was largely based on the Marshall plan, which, in turn, emphasised American world leading role. Although traditional industrial sectors, such as steel and the chemical industry were able to recover and consolidate (Europe matched the US productivity in the 1980s[7]), the post-war Europe, divided by the so-called Iron Curtain, was no longer a leading player in the new globalised world. Investment in scientific and technological research remained a small percentage of the GDP (reaching a maximum of 2% for the former EU15) and innovation in industry was closer to the concept of improvement, i.e. doing the same thing better, than of doing something really different.

The absence of a strong and continuous investor, such as the defence industry in the US, the weakness of the venture investment (in 2008, in the UK, 4% of British investment went to venture capital, compared to about 33% in the U.S) and the fact that in competitive worldwide economies getting to the top first is critical to assume future leadership by setting the standards, prevented Europe to close the R&D gap to the US.

Concerning the education system, particularly in the area of engineering and sciences, the United States and Europe are also quite different.[8] The US adopted the so-called Anglo-Saxon paradigm, following the British tradition, pursuing a utilitarian view of science and encouraging a pragmatic market-driven approach to education and knowledge, a model suitable to the American economic, social and political reality, based on a strong private industrial initiative. In this context, the training of engineers and scientists was much more inductive and pragmatic. Engineers had often an informal training (workshop-culture and hands-on training) and their individual prestige laid mostly on their role as engineer-entrepreneur, through market mechanisms such as patents. Although the informal profile of engineering training in the US gave way to a more formal education, the hands-on gene continued to be a hallmark of the Anglo-Saxon education. In this context, the relationship between business and research (institutionalized at US universities and research centres) is easily accepted and the idea of university professors being simultaneously businessmen is perceived as a virtue, not as a sin.

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[7] Werner Roeger, Janos Varga and Jan in' t Veldy, *How to close the productivity gap between the US and Europe. A quantitative assessment using a semi-endogenous growth model*, Brussels: European Commission/Directorate-General for Economic and Financial Affairs Publications, 2009. http://ec.europa.eu/economy_finance/publications/economic_paper/2010/pdf/ecp399_en.pdf. Retrieved 16 November 2013.

[8] Maria Paula Diogo, "Engineering", in P-Y Saunier, A. Iriye (eds.) *Palgrave Dictionary of Transnational History*, London: Macmillan, 2007, pp.330-333.

In turn, in the 19th and 20th centuries, Europe has distinct experiences in education patterns, ranging from British model, favouring practical teaching oriented to industry, to the strong and influential French model of the selective and rigid *grandes écoles* oriented to public works (which dominated most of Europe and turned engineers and their corps into a true *noblesse d'État*[9]), and the German *Technische Hochschulen* associated with chemical industry. Following the long period of European supremacy, which extended to its empires, the two world conflicts, the Marshall Plan and the Cold War reformulated the matrix of European engineering, which in the West was inspired by the American example and in the East by the Soviet model.

The European educational model, which grew largely apart from the business world, has a much more reluctant approach to the relations between business and research. The idea of an enterprise-like University and the danger of commodification of higher education, with the consequent loss of intellectual freedom and subjugation to the business world, is increasingly a pressing and unavoidable question in international debates over University life.[10]

Last but not least, there are significant cultural differences between the US and Europe as far as risk and citizenship are concerned. In a dynamic economy, where finding financing is easy, such as the American one, failure is easily accommodated and regarded as part of a process of maturating. In the European case, not succeed in business is viewed as a personal failure and it is not easy to have another go. These social differences in perceiving risk taking and risk management are critical to the attitude of younger generations towards innovation and entrepreneurship.

On the other hand, the European public opinion is much more active and sensitive to topics such as environment, sustainability and privacy. The concept of European democracy itself rests upon the idea of citizenship as shaped by the French Revolution, thus implying a strong engagement of citizens in governmental decisions that may affect their lives.

To put it in a nutshell: the US have: a dynamic economy of scale with little state intervention, but where national and federal governments are strong clients; the US role as a world superpower relies on its military leadership, thus creating favourable conditions to fund research particularly relevant to the defence industry; a utilitarian view of science and an engineering teaching oriented to practice; high-level expensive private universities; an agile and protective patent system. Europe, on the other hand is a fragmented space dominated by competing Nation-States with different national interests and specificities, economic settings and cultural traditions.

The rising of the BRICS, particularly China placed further pressure on the EU economy and R&D policies. China has been increasing its GDP percentage devoted to research and training, the venture investment increased 50 percent (while venture

[9] Pierre Bourdieu, *La noblesse d'État: grandes écoles et esprit de corps*, Paris, 1989.
[10] Derek Bok, *Universities in the Market Place*, Princeton: Princeton University Press, 2003.

funding is dropping both in US and Europe).[11] In addition, technological innovation is becoming increasingly global, and patents less protective; laboratories of western large companies delocalize to China and investors and entrepreneurs' confidence in overseas markets and companies is growing; American and European professors are contracted to serve Chinese higher education; Chinese students are sent to prestigious American Universities. Many refer to this trend as the new Self-Strengthening Movement (China, 19th century) and wonder about the future results.

Horizon 2020, a European *Wakon Yousai*?[12]

To emulate the United States in Europe is useless. The European Union has to design a strategy that takes into account European history, mainly that Europe is not a unified political entity and that there were and there are asymmetries and tensions between states and regions. Both the Lisbon and the Europe 2020 agendas present Europe as a homogeneous identity, as an abstract concept that hardly matches reality. The biggest challenge for Europe is to learn how to deal with diversity and overcome the gap between the EU discourse, which is always plural, and its practice that is applied in a monolithic way.

The concept of collaboration is, thus, critical. The EU soon realized the importance of technology to its integration agenda. The construction of transnational infrastructures, the collaboration of experts in European projects, the adoption of common technological standards, unveil a more united Europe than conventional political practices.[13] Research funding has been consolidating in Europe, but it is obvious that innovation has not yet reached its intended role, very much because of political and economic reasons beyond the issues of research itself.

How can engineering schools contribute to modify this situation, in particular, in what sense the programme *Horizon 2020* can harbour effectively this new strategy? The answer is to be able to think ahead, to anticipate what we need for the future. The report of the US National Academy of Engineering when referring to the engineers for the year 2020 (*The Engineer for 2020*) – whose purpose is to anticipate the way in which engineering schools can contribute to sustaining the high rates of innovation, which can be compared to *Horizon 2020* – draws attention to the need of creating new curricula:[14]

> If the United States is to maintain its economic leadership and be able to sustain its share of high-technology jobs, it must prepare for a new wave of change. While there is no consensus at this stage, it is agreed that innovation is the key and engineering is essential to this task; but engineering will only contribute to success if it is able to continue to adapt

[11] http://venturebeat.com/2009/02/18/international-venture-funding-rose-15-percent-in-2008/. Retrieved 16 November 2013.
[12] The term "Wakon Yousai", which was coined during the modernization of Japan, means "Japanese spirit and Western technology"
[13] On this "hidden integration agenda" see *Tensions of Europe/Making Europe*. (http://www.tensionsofeurope.eu/www/en/research/tie-project).
[14] *The Engineer for 2020*, p.51.

> to new trends and educate the next generation of students so as to arm them with the tools needed for the world as it will be, not as it is today.

These new curricula have to educate students by promoting creativity, agility of reasoning and a critical understanding of the social world and its reflectivity. Obviously, the matter is not reducing the technical and scientific dimensions of engineering teaching; rather it is the need to realize that encyclopaedic knowledge no longer holds. At the speed of technological change in today's world, striving to teach everything to the students is totally unrealistic. What is really needed is to train students how to think and solve problems from a core base of solid instruments; anticipate new problems; retrieve information and measure the impact of their work in global terms; teamwork with colleagues from other fields of expertise and from different cultural traditions.

Creativity, which is at the core of invention and innovation, is twofold as it is simultaneously individual and collective. The complexity and diversity of technologies in the 21st century and the interactive multiplicity of their impacts requires the capacity of working in interdisciplinary teams. One is facing a tentacular technological world, in which traditional disciplinary boundaries crumble, and the organization of research changes in order to accommodate new dimensions, notably technological policies.

As mentioned before, for the first time one is at a crossroads of no return, in areas such as environmental problems and climate change; energetic and resource management and new materials; information technologies and privacy, freedom and surveillance of migration; or as bio/nanotechnologies and artificial intelligence with the dangers of inequality at a global scale introduced by trans-humanism.

The programme *Horizon 2020* can only be effective if integrating and responding to these challenges by promoting innovation, creativity and social awareness. The great amount of funds allocated to techno-scientific research, covering a variety of fields, including those associated with climate change, energy and resources sustainability, is an important step towards repositioning Europe in terms of innovation leadership. However, it is the *quality* of research and its capacity of reflecting the above mentioned civilizational aspects that will be decisive. A variety of studies and reflections carried out in American universities, such as Cal Tech, MIT, Columbia or Harvard, show that an excessive commitment to the business world can, for reasons of secrecy or of interest in moving too fast in order to patent first, undermine the academic research ethos, which also entails a commitment to society. The question is not "abhorrence" for the world of profit, but a real need to maintain the independence between these two spheres, which should communicate with one another, but never merge. Universities are not corporations and universities governance should be, therefore, different from corporative governance in a profit-seeking business. In the academic world, whose mission is to produce knowledge in the service of society, efficiency means excellence in research and teaching, and the pursuit of values such as independence and intellectual honesty and social conscience and ethics.

Europe has a diversified potential for innovation and a strong commitment to environmental issues and sustainability, which should be valued. Questions such as environmental protection, low-carbon energetic alternatives and transportation; the study and management of water resources and climate change; food safety; public health; aging and consumers' rights are transverse in Europe and with the potential of gathering together national efforts in common European projects.

Horizon 2020 should capitalize on the multiplicities and differences in Europe in order to be successful. The projects to be funded should be transnational, interdisciplinary and encompass Europe's historical experience, by reviving the notion of a Republic of Letters, an entity so characteristically European, which would enable the creation of a space where scientists, engineers, sociologists, historians, economists and anthropologists can cooperate and work on problems defining our future, by bringing in distinct but complementary perspectives regarding their solution. Undoubtedly, the success will be in the Europeans' capability of thinking locally and globally about the problems and beyond the short run.

What is the contribution of engineers and engineering course-syllabuses to endow Europe with an innovation structure? There is no doubt that engineering borders are increasingly more blurred. Today, the engineer of the 19th century first engaged in railway construction and then in electricity, and the 20th century chemical engineer, have no equivalent. One talks more about techno-science rather than about science and technology, and has to adapt to new research areas, emerging at a faster pace. Consequently, our teaching paradigm has to change in order to train "innovators" rather than engineers.[15] Curricula have to adapt by notably changing the workload between core disciplines and those which enable students to integrate technological innovation with organizational innovation and ethics. Training engineers with innovation in their DNA, however, is not making them entrepreneurs in the narrow sense; rather, it is to develop an entrepreneur-spirit (the schumpeterian *Unternehmergeist*), by encouraging them to risk new solutions to solve problems. It should be in the latter direction that Europe needs to go.

Engineering continues to be a crucial element to the development of civilization, as historically it has ever been, but its profile needs to keep changing and adapting to a world that challenge us constantly by posing unexpected questions with no straightforward answers. A major concern of today's educators is the decline of interest among young people in science and technology. These areas suffer the impact of a certain *zeitgeist* that, on one hand, emphasizes the value of money, attracting many young people to economics and management courses hoping to earn high salaries, and, alternatively, nourishes the desire for an active engagement in changing society, thus favouring social sciences courses. To be a scientist or an engineer is perceived as a difficult career, uncertain, dull, not necessarily well paid and technocratic, where civic intervention is marginal.[16]

[15] Williams, *Retooling*, p.63.
[16] See Euro-Case Position Paper on the Future EU 2020 Strategy.

If we succeed doing justice to dynamism and social conscience, which traditionally have characterized engineers, we will be able to attract young people to scientific and technological areas, allowing them to be "scientists and engineers with an attitude", participating in an inclusive society. If we create the conditions of job stability for young researchers and provide them with the capacity of not only exchanging ideas in a truly and borderless European space, but also technical, social and ethical instruments to think their research in the 21st century, Europe will be able to restore its leadership.

As to Horizon 2020 as leverage for European innovation, the Euro-Case Position on the *Common Strategic Framework for Research and Innovation* should be object of reflection.[17] Horizon 2020 should bring a new life to the *European Research Area* (ERA) and the European Institute of Technology (EIT). These should not be perceived by researchers, and mainly young researchers, as one more bureaucratic organization like those often harshly criticized by European citizens and in particular by the young; rather EU should commit to light and flexible structures promoting debates around research, either actually being carried out or intended, by congregating small groups whose mission would be analysing and brainstorming. By using the military metaphor, Europe needs not a conventional army, but guerrilla groups, agile, short-lived and in variable locations. These *pop-up* groups can hub small and temporary think-tanks bringing together universities, research units and companies, avoiding the traditional governmental appointment, in order to avoid the interference of political clienteles. To some extent, the Euro-CASE Innovation Platform is a fine prototype for temporary organizations of this kind. The very European Institute of Innovation and Technology (EIT) can work as a hub for these *think-tanks*, but it has to become more active, decentralized and agile.

A second aspect that Horizon 2020 should take into account is that Europe cannot equal or overcome the USA and countries like China by copying them. The European model has to be different, by using its own specificity – cultural diversity, including scientific, and the importance of citizenship and sustainability. History shows us that mere importation and imitation of foreign models is useless in the long term and that efficiency is better achieved when local specificities are used to build a global model. In this sense, one of the fundamental tools should be transnational and trans-disciplinary research oriented by principles of sustainability, and focused on particular niches such as transport, energy and health which bring together expertise from different industrial sectors, including the traditional ones.

Although political decision-makers have largely failed their project of creating a European 'nationality', it is possible to materialize it in the realm of techno scientific research. The collaboration between scientists and engineers, even in hostile periods such as that of the Cold War, went beyond the constraints of national borders. Europe has privileged conditions for the creation of a new generation of researchers, a sense of unity in diversity and citizenship in democracy, which on par with more substantial funding, are Europe's main assets. Thus, Horizon 2020 should not be

[17] See Euro-CASE Position Paper on the Common Strategic Framework for Research and Innovation.

seen as merely funding, but as an opportunity to innovate from the organizational point of view European research, which should have its own identity strengthened in a global world, rather than being a degraded image of other models.

Can schools of science and technology contribute to the repositioning of Europe in world innovation? Absolutely! The key is the restructuring of traditional curricula, by encouraging the capacity to think and learn. We need to endow our future scientists and engineers with the capacity of thinking in European terms, not necessarily by means of physical dislocation, but by using new information technologies and online debates; we need researchers who share a European agenda based on human sustainability on the planet, and whenever facing new challenges and situations are capable of understanding them and generate appropriate answers.

Specific Recommendations

1. Think in a transnational way and use European diversity as an asset to approach globalisation;
2. The precautionary principle needs to be tempered in order to accommodate and encourage innovation;
3. Consider public procurement as an efficient method to promote the development and deployment of innovations both in the public and the private sector;
4. Create ecosystems for innovation in EU that respect European values while promoting cultural change;
5. De-bureaucratize and “democratize” the European innovation landscape, by privileging small, agile, and temporary structures instead of the traditional huge, heavy, and time and money consuming institutions; overcame the distrust of population in the EU use of taxes;
6. Recognize that to train students to be innovators is not just a matter of adding one more course to the curricula; students have to learn how to think differently. The use of their professional historical memory may provide inspiring examples of how to deal with new problems (introducing the topic of success and failure), as well as a closer contact to “entrepreneurs in residence”, which can strengthen a culture of entrepreneurship.