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How university global partnerships may facilitate a new era of international affairs and foster political and economic relations ☆

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ABSTRACT

A new paradigm of structured international university relationships is emerging as shaped by a new era of government and industry intervention in association with knowledge. It is driven not only by political and economic interests, but also by an increased perception of the growing perceived evidence of the potential benefits resulting from the economic appropriation of the results and methods of science by the society.

This paper builds on the Triple Helix of university–industry–government relations and shows that structured international relationships may act as agents of change if associated with activities that are fundamentally different from the traditional role of universities, involving, most of the times, capacity building and various forms of social and economic appropriation of knowledge. They also require understanding the nature of international cooperation beyond the exporting/importing of "academic services" in all the institutions involved. In addition, they clearly break traditional boundaries of "national systems of innovation" and bring new challenges in terms of the necessary institutional integrity that universities need to preserve and foster.

1. Introduction

I argue in this paper that our societies are entering critical times that require the creation of conditions able to strengthen institutions fostering change through knowledge-based international cooperation. This is well beyond the boundaries of "national systems of innovation" and requires people trained to act in quite diversified and global environments. Universities may play that role if their internationalization and specialization path is understood as a key element in a new era of international affairs, where governments and industry intervene through knowledge.

It should be noted that it has become a common place to argue in favor of the internationalization of universities (Knight, 2004; Johnstone et al., 2010) and this includes the need to promote student mobility (Bhandari and Blumenthal, 2011), to foster attractive and competitive research environments (Capaldi, 2010) and to attract and train highly qualified human resources (Vest, 2007). It is also clear that the concept of universities includes the international dimension since their establishment as institutions of higher education and research (since "universe" is fundamental to their identity (Knigth, 2010)). Furthermore, the mobility of students and scholars has been a central feature of higher education for centuries. But the key emerging issues to understand is why universities need to go international and promote international agendas of teaching and research? And, why governments need to fund universities beyond national borders?

Two main aspects should be clarified before any attempt to address these questions. First, the specialized literature has been clear in differentiating the terms "internationalization" and "globalization" of academic institutions (Knight, 2004; Huisman and van der Wende, 2005; Altbach and Knight, 2007), although the two concepts are too often confused with each other (Altbach, 2004). Specifically, internationalization of

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higher education has been described as "the process of integrating an international, intercultural, and global dimension into the purpose, functions and the delivery of higher education" (Knigth, 2010; OECD, 2008). It refers to an increased activity of universities across borders with the persistence of a national or local identity. On the other hand, globalization has been described as a process that is increasingly associated with the flow of people, cultures, ideas, values and economy across borders, resulting in a more interconnected and interdependent world. It implies that national borders are softened, or even disappear (Teichler, 2004). Under this context, the emerging orientation worldwide towards the internationalization of academic institutions has been associated with the economic, political and social changes pushed by the increasingly globalized society we leave in (Altbach and Knight, 2007; OECD, 2008).

Second, clarifying the concepts of "cooperation" and "competition" among universities is also necessary when considering higher education internationalization. This is because internationalization primary deals with academic cooperation, individuals' mobility and knowledge transfer (Marginson et al, 2002; Altbach and Knight, 2007). On the contrary, globalization is often associated with university competition and market steering (El-Khawas, 1994; Lenn, 1999; Sadlak, 2001). In particular, the specialized literature commonly refers to internationalization when focuses on cooperating ventures of academic institutions in continental Europe, while globalization has been often associated with competition among English-speaking countries (Luijten-Lub et al., 2005) and the rise of the "American Research University" model worldwide (Leydesdorff and Etzkowitz, 1996).

It is in this context that this paper considers the international collaboration between universities, in a process where its systematic interaction with governments and industry cross borders is giving rise to a new paradigm of higher education internationalization. The university is identified as the crucial player in such dynamics, being a privileged locus wherein developing international relationships with other academic institutions, government and industry. It involves, most of the times, triple relations with a strong international dimension.

It should be noted that several authors have already discussed the benefits arising from such relationships, theorizing the so-called "Triple Helix" of university–industry–government relations, and suggested "the university can play an enhanced role in innovation in increasingly knowledge-based societies" (Leydesdorff and Etzkowitz, 1996; Etzkowitz and Leydesdorff, 2000a). A leading example of the evidence initially used to develop that model at an international level was introduced by Leydesdorff and Sun (2009) when investigating Japan. This paper builds on that idea and extends its potential impact to facilitate a new era of international affairs, where universities are becoming key players to foster political and economic relations. Although the "Tripe Helix Model" is too often addressed in association to co-authorship of scientific publications (Leydesdorff and Meyer, 2007), we consider as well this theoretical framework in the present paper because it directly deals with the interplay of universities, governments and industry towards innovative societies. It should also be noted that Leydesdorff and Meyer (2007) explicitly argue that institutional arrangements in a knowledge-based economy may be considered as support structures for cognitive developments. In addition, those relations can be considered as a "foreign" dimension to national innovation systems (Leydesdorff, 2012). Moreover said, "national systems" have been commonly discussed in the literature as a necessary base for international university relations and the condition for their sustainable development (Ye et al., 2013).

Analysis also suggests that the sustainability of these relations depend, in a great degree, on corresponding organizational structures, particularly for social systems oriented towards stimulating innovation. For example, Ivanova and Leydesdorff (2014) show that the sustainable development comprising self-organization, caused by non-linear interactions, can be achieved in systems with number of actors more than two. This paper builds on that concept and brings new evidence of emerging forms of foreign–government–university triple relations.

By addressing these issues, the paper leads to a new narrative in the relation between universities, governments and industry. It claims for the need of public policies to go beyond the spatial boundaries imposed by the concept of "national systems of innovation". It is aimed to address the new conditions for international scientific and academic cooperation and development, to identify main supporting relationships between university, industry and government, and to discuss their impact on the emergence of new social realities in many countries and their potential as factors of economic and social development on a global scale (Chan, 2004). The paper is, therefore, a new contribution about the way international affairs may shape universities and their positioning in increasing globalized societies and economies.

Next section briefly describes the research framework and methodology used in this paper. The third section attempts to explain our conceptual framework and justifies the need to go beyond the commonly used concept of national innovation systems. The paper builds on the so-called "Triple Helix" of university–industry–government relations and considers the changing perception of "academic divide" at world level, as well as the dynamics of the social construction of knowledge-based societies. Then, the fourth section presents our evidence in four parts. It starts by addressing the evolution of university partnerships, from student mobility to knowledge-integrated communities. Then, the second part presents key issues described in the literature in association with US research universities, taking into particular consideration the leading role of the Massachusetts Institute of Technology, MIT, in that process. The third part presents the Portuguese initiative on international partnerships, as launched in 2006, and the fourth parts discusses the specific case of MIT–Portugal joint venture. The fifth section discusses our main findings in terms of the conceptual framework given and the paper concludes with a set of main summarizing remarks.

2. Research framework and methodology

The analysis presented in this paper draws from international comparative studies, fieldwork and interviews conducted over the last three years, in addition to the author's self-experience in research, university administration and policymaking in the field of science and higher education. On-site visits and many discussions with researchers and policymakers were carried out to address challenges for the internationalization of higher

education and innovation with special emphasis in Europe (Portugal, Spain, Belgium, Germany, UK), North America (MIT, Harvard, Carnegie Mellon University, University of Texas at Austin), China (Tsinghua University, Hong Kong University, Macau University), Brazil (Rio de Janeiro, São Paulo, Brasilia), and Colombia (Bogota, Medellin, Cartagena). The work involved participation in Research Seminars, Policy Research Workshops organized by the World Bank and the OCDE (e.g., Rio de Janeiro, October 2011; Yerevan, Armenia, 2013; Istanbul, 2014), a Doctoral Consortium in Technology, Management and Policy (Lisbon, June 2014), a School of Advanced Studies at the Federal University of Rio de Janeiro (UFRJ, March 2013), and an Education and Innovation Summit in Bogota (May 2014). A major Research Workshop was organized in Porto, Portugal, in October 2013 bringing together experts in science, technology and innovation policies (http://www.altec2013.org/).

The evidence and new narrative provided in this paper are based on lessons learned with international partnerships in science, technology and higher education, as established historically, but with emphasis over the last decade. Four main approaches are used. First, evolving partnerships in the last three decades are discussed, with emphasis in European consortia built with the goal to foster student mobility and, more recently, to help accelerating innovation. Second, structured partnerships established with MIT are briefly discussed to help reflecting why so many governments and universities worldwide want to cooperate with MIT. Third, the program of structured joint ventures established between Portuguese universities and US counterparts since 2006 is addressed, as an example of a government strategy towards change through international cooperation in higher education (Heitor and Bravo, 2010). Last, but not least, I briefly discuss details associated with one of those programs, as represented by the MIT–Portugal joint venture established in 2006.

It should be noted that examples of the Portuguese higher education reform launched in 2006 are used as case studies to illustrate our main arguments. The ultimate goal is to derive lessons learned that are relevant for emerging and developing regions worldwide. This approach is justified due to several common characteristics between Portugal and those regions, such as low degree of autonomy, internationally recognized low levels of funding, and slowness to respond to societal demands. Societal challenges are also similar, although at different levels: need to increase the formal qualifications of the population, struggle to create a more robust knowledge base, and contribute to local and national socio-economic development. In addition, the Portuguese initiative of international partnerships in science, technology and higher education was effectively introduced in 2006 through governmental action following an international assessment exercise (OECD, 2007; Gago and Heitor, 2007; MCTES, 2011). Lessons from its conceptualization and implementation can be used as a reference to inspire change elsewhere.

It should also be noted that the choice of case studies as the methodological approach to this article follows similar studies in the literature (Dao, 2014; Dakowska, 2014). As a case study representing an empirical enquiry into a complex, social phenomenon that is contemporary, situated in a real-life setting, several sources of information are required to sustain an analytically meaningful case (Yin, 2003). Therefore, the analysis is based on documental information from ministerial reports, international organizations evaluation reports (e.g., OECD) and national and international official statistics. These data sources are aligned with those used in existing studies analyzing university–industry–governments relationships.

3. The conceptual framework: towards a new narrative to address international university–industry–government relationships

This section considers the proposed conceptual framework to address knowledge-driven societies in a new era of international affairs. It builds on the Triple Helix thesis of university–industry–government relations, which emerged from a confluence between Etzkowitz' longer-term interest in the study of university–industry relations (Etzkowitz, 2002) and Leydesdorff's interest in evolutionary models that can generate a next-order hyper-cycle, or an overlay of communications (Leydesdorff, 1995). The metaphor of a Triple Helix emerged in Amsterdam in January 1996 (Etzkowitz and Leydesdorff, 1995), in reference to the initial work of Lowe (Lowe, 1982). Since then, it has mobilized many researchers worldwide in recent years, including the realization of many conferences and research workshops.

The following paragraphs provide the rational to extend the Triple Helix model to international relations involving universities, industry and governments, resulting on the need to think and act beyond "national systems of innovation". It considers the changing perception of the "academic divide" at world level and the related increasingly globally distributed geography of innovation, as well as the need to consider the dynamics of the social construction of knowledge-based societies.

3.1. Beyond national systems of innovation

The basic premise of this paper is that the central locus of innovation has increasingly become distributed and increasingly dependent upon linkages between many different institutions and sources of knowledge worldwide (Mazzucato, 2013; Hepburn, 2011; Aghion et al., 2011). First, the increasingly transnational business, technology and science require evolving from nationalistic approaches to new collaborative policy frameworks (Goransson and Brundenius, 2011). Among these, large international collaborative arrangements play an emerging role. Second, the science and technology performance sectors, namely government, industry and academia, remain key players, but the connectivity, links and associations with other institutional players and agencies are no less important (Ivanova and Leydesdorff, 2014; Mazzucato, 2013). In particular, the increasingly relevant role played by new technology-based firms is identified, which are also becoming global. This requires strengthening science policies, promoting investments in R&D, involving multiple public and private agents and stimulating global research networks towards socio-economic resilience and active learning mechanisms worldwide (Mazzucato, 2013).

These questions are gaining increasing relevance as much of the political debate worldwide is centered on economic competiveness in the long term, most of the times under a rather "nationalistic" approach to innovation for growth (McKinsey Global Institute, 2012). The question that does arise is that if the acceleration of knowledge investments in China and the impact of the international context in the US and

EU, with the notable exception of Germany, should it be countered by aggressive "techno-nationalism" elsewhere?

Any new narrative on global research and innovation networks requires the analyses of, at least, in the last decades and the seminal work of Ostry and Nelson (1995), among many others for the last twenty years (Romer, 1994; Conceição et al., 2001), that has called for our attention of the relationship between the globalism of firms and the nationalism of governments, as well as the related interplay of cooperation and competition that characterizes high technology and knowledge-based environments.

It should be noted that, although in a different international context, the Brookings Institution's project of the early 1990s described by Ostry and Nelson (1995) has clearly shown that tensions about deeper integration arise from three broad sources: cross-border spillovers, diminished national autonomy, and challenges to political sovereignty. As a result, the technoglobalism of the 1980s gave rise to national policies designed to help high-tech industries become more innovative and, consequently, the emergence of technonationalism.

It is under this context that the concept of "national systems of innovation" emerged in academia (Lundvall, 1992; Nelson, 1993), mainly through economists and related schools of thought, to explain and explore how and why the systems have evolved differently in the major industrial nations, mainly US, Japan, UK, Germany and France. It was clear then that the increasing international tensions and economic instability were largely a result of the attempt of governments to impose national technology and innovation policies in a world in which business and technology are increasingly transnational (Galbraith, 2012; Easterly, 2013).

This paper contributes to address challenges and opportunities for global university collaborations in coming years. It was written having in mind the unique opportunities and challenges that many regions worldwide are facing to develop new and modern universities, together with processes of technical change (Mazzucato, 2013). The key role for policy makers and governments, in those regions where new investments are being made, is to select priority actions and make the correct decisions: where and how to start the process?

This requires many observations and, certainly, deepening the debate in relation to the current economic and social situation in the US and EU, as compared to those in newly industrialized regions. First, the myth of "national" high tech industries and related policies to protect them requires to be better understood, if analyzed in terms of the increasing unemployment rates (Moretti, 2013; Head, 2014). Second, the debate itself on "national innovation policies" is in any case naïve. No country, even in non-democratic regimes, ever seems to have had a broad, well coordinated one, mainly because of the complex structures associated with any "innovation ecosystem". Following Mazzucato (2013), it is essential to understand innovation as a collective process, involving an extensive division of labor that can include many different stakeholders.

It is under this context that this paper builds on the metaphor of "Triple Helix" of university–industry–government relations, considering related international dimensions (Leydesdorff and Sun, 2009) in a new era where universities are becoming key players to foster political and economic relations. The "Tripe Helix Model" considers that institutional arrangements in a knowledge-based economy may be considered as support structures for cognitive developments (Leydesdorff, 2012). Their sustainable development can be achieved in systems with at last three actors, due to non-linear interactions and related dysfunctions (Ivanova and Leydesdorff, 2014). This paper builds on that concept and brings new evidence about the role of global university partnerships.

3.2. On the changing perception of "academic divide" at world level

A new agenda for research in global university partnerships is emerging based on lessons learned and extending the "Triple Helix" thesis. It is in this context that this paper attempts to explore the dynamic relationship between economy and knowledge production at an international level and consider the social construction of technological systems (Bijker et al., 1987). Following the message of Conceição and Heitor (2002) and Nowotny et al. (2003), that "science is contextualized", we consider the idea that knowledge diffusion processes, and therefore innovation, are "context-sensitive" and should be pursued towards "inclusive learning". In other words, any region worldwide has to learn its own way and built its own development path. Certainly, continuously adapting and improving lessons learned from others, in a continuously changing environment. This dynamic nature of innovation systems is taken into account on the Triple Helix of university–government–industry relations and allows us to explore the emerging role of international partnerships and agent of change in many developing regions worldwide (Etzkowitz and Leydesdorff, 2000b).

This is important because the recent explosion in demand for higher education by millions of young people around the world, associated with a growing perceived evidence of the potential benefits resulting from the economic appropriation of the results and methods of science by society, have changed the perception of the "academic divide" or "scientific divide" at world level (Altbach et al., 2009).

Academic institutions from many regions worldwide are now operating internationally, addressing not only potential students individually (this was the traditional paradigm), but increasingly addressing foreign universities, foreign local authorities and governments, in order to develop new types of institutional arrangements. These include helping creating, monitoring or evaluating emerging institutions in other countries, transferring organizational skills, operating training programs for teachers and researchers, contributing to higher education and research capacity building abroad and to the marketing of its benefits for economic and social progress in other societies. Such new arrangements may also include the coaching and steering of research programs in emerging and developing regions, their early inclusion in international networks, and the affiliation of private companies to academic and research programs.

We note that these relations usually consider at least three agents (namely, universities, foreign universities, and foreign authorities and/or industry), in a way that helps fostering their sustainability because of their systemic non-linearity (Leydesdorff, 2012; Etzkowitz and Leydesdorff, 2000b).

On the other hand, many emerging regions and developing countries are now facing the need and the opportunity of large investments in science, technology and higher education

(public and private), aiming at responding to the explosive social demand for higher education and to the vast social and political transformations already induced by new waves of educated youth (UNESCO, 2010). These investments not only seek new skills and but also the certification of quality that may be expected from working along together with well established academic and scientific institutions from developed countries. For these institutions, such institutional arrangements provide new forms of expansion, as they tend to help securing new financial or human resources, and to challenge their own traditional competences and agendas.

However, this new paradigm in international academic cooperation does not appear to match the usual model for exporting services. Franchising, for instance, may seem attractive at short notice but its glamor fades away under increasing academic and political criticism. It seems that a new reality is emerging, in which the export of services is intimately associated with the development of national institutional capacities deriving their strengths from the much needed accumulation of qualified human resources, as well as from institutional participation in and recognition from international academic and research networks.

The issue is certainly how far we all take advantage of opportunities that arise with the increasingly dynamic and globally distributed geography of innovation, as well as how it fosters a new global order and help others to use similar advantages at local levels.

3.3. On the dynamics of the social construction of knowledge-based societies

Extending the notion of Triple Helix of university–government–industry relations to consider the dynamic nature of innovation (Etzkowitz and Leydesdorff, 2000b) as a collective process (Mazzucato, 2013), involving different stakeholders at an international level, is a critical step to improve our understanding of global university partnerships as agents of change. This is because one must take up the challenge of probing deeper into the relationships between knowledge and the development of our societies at a global scale.

Our inspiration comes from, among others, the seminal work of Lundvall and Johnson (Lundvall and Johnson, 1994), who challenge the commonplace by introducing the simple, but powerful, idea of learning. Lundvall and Johnson speak of a "learning economy", not of a "knowledge economy". The fundamental difference is to do with a dynamic perspective. In their view, some knowledge does indeed become more important, but some also becomes less important. There is both knowledge creation and knowledge destruction. By forcing us to look at the process, rather than the mere accumulation of knowledge, they add a dimension that makes the discussion not only more complex and more uncertain, but also more interesting and intellectually fertile in an international context (Lundvall, 2011).

The richness of the concept of the learning economy has been demonstrated in recent years throughout the world, by both leading scholars and policy makers. It has been recently addressed beyond Europe and it is at the center of the debate in China, India and Brazil. For example, MGK Menon, former Indian Minister of S&T and Member of Parliament and current President of the India International Center in New Delhi, has recently written about the conditions necessary for innovation to thrive, which require specific local action through a process of "communitization".

This closely follows the lessons Eric von Hippel (1988), a well-known professor at MIT, has provided in recent years based on the American experience that user-centered innovation is a powerful and general phenomenon. It is based on the fact that users of products and services — both firms and individual consumers — are increasingly able to innovate for themselves. It is clear that this is growing rapidly due to continuing advances in computing and communication technologies and is becoming both an important rival to and an important feedstock for manufacturer-centered innovation in many fields (Harhoff et al., 2003).

Eric von Hippel (1988) has also shown that the trend towards democratization of innovation applies to information products such as software and also to physical products, and is being driven by two related technical trends: first, the steadily improving design capabilities (i.e., innovation toolkits) that advances in computer hardware and software give to users; and second, the steadily improving ability of individual users to combine and coordinate their innovation-related efforts via new communication media such as the Internet.

In other words, beyond suitable technical infrastructure, the process of "democratization of innovation" at a global scale requires people with the ability to engage in knowledge-based networks without borders. It is about people and knowledge beyond national borders, and this constant interaction has gained particular importance in recent years (Gault and von Hippel, 2009).

It is clear that the emerging patterns of innovation require new perspectives for public policies, which in the US and other developed countries have in the past relied on supporting manufacturers and their intellectual property. Certainly we need to move on from those days and consider better ways to integrate policies, as well as to diversify them at a global scale to better consider "win-all" approaches. A potential way to achieve this is to avoid overemphasizing current rivals sectors and competitive strategies, but rather to look at science, education and innovation policies towards new challenges that require a strong collaborative and pre-competitive approach.

Long-term challenges, namely those with current direct implications for firms (large and small), researchers and universities include the emerging opportunities associated with the democratization of human genome sequencing and the emergence of personalized medicine throughout the world, as well as the increasing convergence between health sciences, physical sciences and engineering. Sustainable energy systems worldwide should also be a subject of priority for innovation policies with a great potential for global impact. The question that does arise is that how far can we help transforming R&D and human capital into productivity gains everywhere?

It is not a trivial matter to understand the processes that enable investments in R&D and human capital to be transformed into productivity gains everywhere, at a global scale. Actually, there is a widespread view among economists in many world regions that this kind of investment is too costly for the economic efficiency gains it provides.

This however is a too naïve and superficial approach. Viewed from a wider perspective, in the longer term R&D and human capital investments do matter and are probably the

most important factor in explaining economic growth (Romer, 1994; Conceição et al., 2001; Lundvall, 1992; Nelson, 1993). However, the naïve view has a point: the transition of human capital to growth is not automatic. Specific policies and actions are needed to make this transition happen successfully. And, in addition, to make policies and actions successful, one needs understanding of the principles for the social construction of technical systems and innovation driving those policies and actions organization (Leydesdorff, 2012).

As mentioned above, this challenge is particularly true in what concerns small and transition economies worldwide, but also developing regions in large countries without knowledge-intensive critical masses.

We argue that "international knowledge networks" oriented for S&T policy purposes help in enabling investments in R&D and human capital to be transformed into productivity gains if oriented towards exports and lead markets worldwide. A possible approach is that developed through direct government and diplomatic actions, such as "Swissnex — Switzerland's Knowledge Network" (http://www.swissnex.org/), "GAIN — German Academic International Network" (http://www.gain-network.org/), "GIAN — The Geneva International Academic Network" (http://www.ruig-gian.org/) and, more recently, "ISTP Canada — International Science and Technology Partnerships Canada Inc." (http://www.istpcanada.ca/). These initiatives cover a wide range of approaches, with different scopes and methodologies, and have been, in general, a major tool for national S&T policy action.

Another emerging approach is the establishment of a new paradigm of international academic and scientific cooperation, as reported in this paper and described below.

4. Data analysis: building evidence towards a new paradigm of international academic and scientific cooperation

The focus of this paper is on the establishment of well-organized and structured international academic and scientific cooperation, which may include the following:

- to set up and maintain a dense network of contacts with universities, research institutions, companies and other organizations worldwide, as well as to support national/regional scientists and entrepreneurs;
- to strengthen the emergence of the different nations and/or regions as a location for science, technology and innovation in close international cooperation;
- to structure, strengthen and promote the interests of national research institutions, universities and leading corporations;
- to support the internationalization efforts of national institutions worldwide, strengthening the development of scientific and technological exchange;
- to help structure, implement and extend bilateral and international research and advance training cooperation programs;
- to facilitate opening-up national universities and research institutions to emerging regions and countries worldwide; and
- to facilitate the access of national companies to emerging markets worldwide, making use of research and knowledge networks with leading researchers and academic institutions worldwide.

Looking at the present and tentatively forecasting the future, we argue in this paper that a new paradigm of international academic, scientific and technological cooperation is emerging as shaped by a new era of international affairs and driven by political and economic interests. At the same time, it may result as a major shaping factor for development at an unprecedented level. Strengthening the internationalization of universities is recognized as a way to stimulate the integration of national institutions in emerging scientific and economic-oriented networks at an international level. To build our evidence, the following paragraphs describe several leading examples and present a few case studies.

4.1. On the evolution of university partnerships: from student mobility to knowledge integrated communities

At this stage it should be clear that the internationalization of universities has significantly emerged over the last 30 years and Table 1 lists sample initiatives with emphasis in promoting student mobility making use of university networks, most of them with a strong European flavor (OECD, 2008). They refer to large international partnerships that have been able to attract undergraduate students, mainly those with economic capacity to support additional costs of living abroad (Johnstone et al., 2010; Altbach, 2004).

These partnerships have facilitated a major change in the internationalization of a new generation of people in Europe, together with provoking entrepreneurial attitudes among them (Bhandari and Blumenthal, 2011; Huisman and van der Wende, 2005). They have also helped strengthening institutional links at the highest international level, mainly within Europe, although their impact in establishing cross-country institutions is far from being acceptable (OECD, 2008). They largely represent low cost initiatives, student-oriented and, most of the times, without any serious alteration of institutional paths and/or the creation of new dual degrees and/or joint diplomas.

The analysis of Table 1 shows a clear trend on the institutional level, usually based on bilateral agreements (Leydesdorff, 2012). They include schemes of student and faculty mobility, although consider in recent years the gradual implementation of "Graduate Schools" with a cooperative nature among quite restricted networks, which have been developed progressively worldwide over the past decade in diversified ways (e.g., doctoral schools under IDEA league and EIT).

The orientation towards graduate studies is involving, in many cases, third parties, and Table 2 lists examples of recent and emerging collective actions among different universities, bringing together governments and/or industry at a world level, as launched in the 2000s. They range from interdisciplinary structures, based in a single university, to subject-specific inter-university structures. In general they aim to provide a better link between research training and research strengths and, in a few cases, have provided flexible structures to attract and hire researchers and graduate students far beyond the traditional university departments.

The examples in Table 2 include academic institutions from industrialized countries operating internationally and developing new types of institutional arrangements, such as the British University of Dubai and the Sino-Danish Center for Education and Research, in Beijing. These are two of the leading

Table 1
Examples of typical collective actions among different universities developed in EU since the 1980s.

Example	Main characteristics
Utrecht Network Launched in 1980	The Utrecht Network represents 31 European universities in 29 countries, co-operating in the area of internationalization in the broadest sense of the word. The group is particularly committed to such areas as student and staff mobility, summer schools, the internationalization of curricula, joint curricula and double/joint degrees (mainly at Master level). The Utrecht Network started off as a small group that was active in student exchanges since the early 1980s. At the start of the ERASMUS program, the existing activities were adopted as the first framework ICP, followed by a steady expansion in the number of partners and exchange students. Initially, this quick start formed the great advantage of the institution-wide approach taken by the Utrecht Network. At present, however, the fact that this construction makes practically every student, from each discipline and from all affiliated universities, a potential ERASMUS student, is regarded as the most important advantage. Each academic year student mobility within the Utrecht network in Europe totals about 1200 students. Approximately 100 students are exchanged each year to the American Universities and 50 to Australian Universities.
Cluster Network Launched in 1990	CLUSTER has grown to a community of 13 research-intensive universities, with emphasis on engineering, science and technology, collaborating in areas of research and advanced education, including joint Master and PhD programs.
Universitas 21 Launched in 1997	From its origins in Melbourne in 1997, Universitas 21 has grown to a community of 24 research-intensive universities who collaborate in areas of common interest and application to students and faculty. It considers a framework for collaborative research, including undergraduate research opportunities, and joint PhD programs.
IDEA League Launched in 1999	The IDEA League is a strategic alliance between five leading European universities of technology, which was launched in October 1999. It has created a special grant scheme for students that is open to all levels: bachelor, master and doctorates. In addition, it runs one joint master program and it is in the process of launching a doctoral school.
EIT, European Institute of Innovation and Technology Launched in 2008, and promoted since 2010	EIT is a top-down initiative launched through the European Commission with the goal to strengthen innovation in the European area. It has been promoted since 2010 through three "knowledge and innovation communities", which link higher education, research and business institutions to one another in the following topics with high societal impact: Climate change mitigation (Climate-KIC), Information and Communication Technologies (EIT ICT Labs), Sustainable Energies (KIC InnoEnergy).

initiatives recently established in developing countries bringing together a network of well-established European institutions trying to access new and emerging economies. The joint ventures between Portuguese and leading American Universities, also listed in Table 2, represent a complementary type of action, with a strong capacity building nature, as described later in this paper.

It should also be noted that a few examples of joint ventures >in Table 2 are based on bilateral agreements and, therefore, they are also based on local legislation. The result is, at least when analyzed from a structural approach viewpoint, three-lateral contingency, which may cause system dysfunctions (Leydesdorff, 2012). But the main remark about the examples in Table 2 is that strengthening experimentation in social networks does necessarily involve flows of people. It is the organized cooperation among networks of knowledge workers, together with different arrays of users that will help diffuse innovation and the design of products and services. Establishing these innovation communities requires the systematic development of routines of collaboration on the basis of formal education programs, sophisticated research projects, and a diversified and non-structured array of informal processes of networking.

In this respect, and following some of the issues raised by John Ziman (1968) many years ago and also noted by Nobel Laureate Richard Ernst (2003), one critically important and emerging institutional issue refers to the training of students and young scientists in order to provide them with core competencies that help them to become successful researchers and prepare them with the adequate "transferable skills" for the job market outside research and academia.

Table 3 summarizes potential forms of global university partnerships making use of the information included in the previous tables together with that collected in a recent review of higher education of the OECD (2008) and identifies various forms of joint ventures in research and higher education at a world level. They range from attempts to build new universities, to research collaborations and offering of degrees in association, as well as bilateral agreements among institutions aimed to promote joint academic degrees. But they also consider, with an increasing emphasis worldwide, the development of consortia oriented towards a new paradigm of technology commercialization through international academic and scientific cooperation (Etzkowitz and Leydesdorff, 1995; Heitor and Horta, accepted for publication). It refers to the capacity to turn science-based inventions into commercially viable innovations and related new potential factors of progress on a global scale, in association with a growing perceived evidence of the potential benefits resulting from economic appropriation of the results and methods of science by society (Etzkowitz, 2002). The approach is on sustained growth in emerging and developing regions, which can occur only with the continuous introduction of truly new goods and services, namely in the form of radical technological innovations that disrupt markets and create new industries.

The research behind the development of this paper has suggests that the accumulation of knowledge by skilled people and institutions in the area of technology-based entrepreneurship requires a specific learning process that takes place together with the building-up of the necessary critical masses in the research community, but needs to be oriented to external and emerging markets worldwide (Heitor and Horta, accepted for publication). Making-off local knowledge intensive communities, which are associated with local and specific institutional and university contexts and operate in global and very much sophisticated markets, requires organized networks fostering new competences in international technology commercialization and diffusion (Conceição and Heitor, 2002).

The basic principles for such network organizations, resulting from the observations made during the preparation of his paper, are threefold: i) give emphasis on training and competence building; ii) promote cooperative R&D and experimentation to access external markets; and iii) develop a professional organizational structure, including the necessary

Table 2
Examples of recent and emerging collective actions among different universities, bringing together governments and/or industries at a world level, as launched in the 2000s.

Example	Main characteristics
British University of Dubai Launched in 2004	Established in 2004 with five British universities to facilitate access to world-class education, training and research in the Middle East. It is the Middle East region's first, research based, postgraduate university. It is organized around specialized Institutes, each linked to a leading UK partner university. Each Institute offers a distinctive discipline based on their excellence in research and teaching: University of Edinburgh Faculty of Engineering and IT (MSc Informatics (Knowledge and Data Management) and MSc in IT Management); Cardiff University Faculty of Engineering and IT (MSc in the Sustainable Design of the Built Environment and MSc in Intelligent Buildings Design and Automation); King's College London Faculty of Business (MSc in Construction Law and Dispute) Participating institutions: University of Edinburgh|University of Birmingham|University of Manchester Cardiff University|King's College London
Portugal–US universities (MIT; Harvard Medical School, Carnegie Mellon; Univ. Texas at Austin)Launched in 2006	Established in 2006 through the Portuguese Science and Technology Foundation to facilitate thematic networks in world-class research and advanced education across Portuguese universities. The leading American Universities served as catalysts of the networks formed among Portuguese universities, bringing the necessary leadership to guarantee the success and operation of the networks, as well as their international recognition. Partnerships were continuously open to all Portuguese Universities, but included the following: MIT—Portugal: 6 Portuguese Universities, with 8 schools providing joint degrees. Carnegie Mellon—Portugal: 8 Portuguese Universities, with 10 schools providing dual degrees UT Austin—Portugal: 2 Portuguese Universities, with 4 schools providing joint degrees Harvard Medical School—Portugal: 6 Portuguese Universities collaborating in translational research
Sino-Danish Center for Educ. & Res., Beijing Launched in 2010 to become operational in 2013	A joint project on education and research between the eight Danish universities, the Danish Ministry of Science, Technology and Innovation, the Graduate University of the Chinese Academy of Sciences (GUCAS) and the Chinese Academy of Sciences (CAS). The Center will be located at GUCAS' future Yanqihu Campus. The Sino-Danish Center will be fully operational in March 2013. It will accommodate 100 researchers from both countries. Moreover, the Center will offer high quality master programs to 300 master students as well as PhD training programs to 75 PhD students. Participating institutions: University of Copenhagen|Roskilde University|Copenhagen Business School|Aalborg University|University of Southern Denmark|University of Aarhus|Technical University of Denmark|IT University of Copenhagen
Songdo Global Univ. Campus, South Korea Launched in 2011	The Songdo Global University is aimed to have 10 different foreign universities operating on a single campus. It is under construction on land reclaimed from the Yellow Sea in the Incheon Free Economic Zone, which aims to be an educational and high-tech hub. Participating foreign universities have each received a $1 million planning grant to study the feasibility of opening a campus in Songdo, and generous subsidies to support a campus in its first five years of operation. The State University of New York at Stony Brook was the first — and so far only — university to move in. Stony Brook's Songdo location began operating in March 2012 with an enrollment of 35 students in four master's and Ph.D. programs in two fields — computer science and technology and society. George Mason University's Board of Visitors has authorized the university to move forward in establishing a campus in Songdo in October 2012. This will be the Virginia university's second attempt to establish an overseas branch: its first, in the United Arab Emirates, ended in failure. The university devoted three years to developing a degree-granting campus in the Ras-Al-Khaimah province only to withdraw in 2009 due to slow enrollment growth, funding difficulties, and disagreements with the U.A.E. government body that was financing the campus. Other universities that are moving ahead with planned campuses in Songdo are Ghent University, in Belgium, and the University of Utah, which is currently conducting a feasibility study. A number of other American universities that were originally interested in opening a campus in Songdo have dropped out, including North Carolina State University.

assessment routines oriented towards institutional building. These observations agree with the theoretical description of the "Tripe Helix" interplay of universities, governments and industry towards innovative societies (Leydesdorff and Meyer, 2007; Ivanova and Leydesdorff, 2014), suggesting that their sustainable development may be achieved in systems with number of actors more than two.

For example, UTEN Portugal (MCTES, 2011; Heitor and Horta, accepted for publication), as established through the Portuguese Science and Technology Foundation in cooperation with Portuguese technology transfer offices and the University of Texas at Austin, focuses on stimulating competences in technology commercialization in a way to help fostering access of technology-based start-ups to emerging markets worldwide. It is a clear example of foreign–government–university triple relations (Ivanova and Leydesdorff, 2014), with emphasis on training and competence building. In addition, it has shown that the implementation of "university technology enterprise networks" calls for the need to better understand endogenous growth through the accumulation of human capital, beyond the need to access capital and markets.

4.2. Lessons learned from partnering with US research universities: the leading role of MIT

It is well known that leading American research universities are playing a key role in the process of internationalizing higher education worldwide and, overall, America is gaining from that role. It should also be clear that this is not a new issue. For example, Morgan (1979) describes the role US universities

Table 3
Sample forms of joint ventures in research and higher education at a world level.

Main focus	Example
Creation of campuses abroad	Sino-Danish Center for Education & Research, Beijing
	European University Centre at Peking University
	Songdo Global University, South Korea
Collaboration in the creation of a new university and campus	Singapore University of Technology and Design (SUTD, with MIT)
	Masdar Institute of Science and Technology (with MIT)
	Skolkovo Institute of Science and Technology (Skolkovo Tech with MIT)
Research collaboration and offering of degrees in association	British University of Dubai
	Utrecht Network
	Portugal–US universities (MIT; Harvard Med. School, Carnegie Mellon; Univ. Texas Austin)
Collaboration and mobility in R&D programs	IARU Alliance
	Worldwide Universities Network
	Matariki Network of Universities
	British Universities Iraq Consortium
Bilateral agreements among institutions — joint degrees	Cluster
	Universitas 21
	IDEA League
Collaboration oriented towards technology commercialization	University Technology Enterprise Network, UTEN — Portugal
	Skolkovo Institute of Science and Technology (Skolkovo Tech with MIT)

played in helping to build and indigenous S&T base in developing countries until the 1970s and how far American Universities, and the US overall, has gained from that process. Most of his examples consider foreign–government–university triple relations, which have been sustainable and facilitate the development of new institutions.

An example of such arrangements includes the creation of the Brazilian Institute of Aeronautic Technology, ITA, in S Jose dos Campos in the vicinity of São Paulo, as founded with MIT's help in 1950. It ranks today among Brazil's top technical universities, with a particular close development to Embraer, the main Latin American aeronautical manufacturer.

Some thirty years ago, Morgan recommended universities and policy makers about the future involvement on four main areas: institutional building, cooperative R&D, resource base development, and education and training. By that time, he already identified the negative impact of short-term approaches based on franchising academic activities and called for the need to better develop the capacity of the "supplier" university to promote effective institutional building in the "receiving" institution and country.

More recently this theme has been subject of various books and papers in the technical literature (Johnstone et al., 2010; Altbach et al., 2009) and, for example, the analysis of Knight (2011), shows an active participation of US universities in indigenous and local development practices, indicating related major advantages, as well as challenges for them and the US innovation policies in the near future. They mostly rely on student mobility frameworks and in the capacity of US universities to attract thousands of immigrants, although they launch a few concerns for the need to foster global research agendas. A recent report by the Royal Society (2011) further emphasizes these aspects in terms of scientific collaboration.

In the context of global partnerships with American research universities, it is worth mentioning the specific case of the Massachusetts Institute of Technology, MIT, because a unique set of international collaborations with governments worldwide has been developed for a number of years, Table 4. They mostly rely on foreign–government–university triple relations, as based on advanced training initiatives, but integrating most of the times thematic R&D networks, research agendas with local impact and, in a few cases, industrial affiliation programs.

The Institute has long held a unique position in research and education and has had a remarkable capability to attract students worldwide (Vest, 2007; Etzkowitz, 2002). Today, though, MIT has become increasingly involved in larger collective experiments with international research and education, most of which are funded by foreign governments. These partnerships rely on the success that MIT has had pioneering new frontiers of knowledge through scientific and technical research, as well as working with industry in North America and as a "local" leader in innovation and entrepreneurship. These traits attract other universities, companies, as well as countries and their politicians, through partnerships aimed to "emulate" MIT's success and the environment that has created its success through capacity building (Heitor and Horta, accepted for publication; Morgan, 1979).

But the reality is that this is very difficult to enact. People underestimate the social, political and economic challenges, beyond the more basic cultural differences (Morgan, 1979). Creating an exact replica of an environment such as the MIT innovation ecosystem is extraordinarily difficult, if not impossible, no matter where the attempt might be made (Etzkowitz, 2002). For example, MIT's own failed effort to replicate its world-famous Media Lab in Ireland is a clear example of relationship network deformation that causes system dysfunction. Analysis suggests that it was mainly designed on the basis of bilateral agreements and, above all, ignoring the local engagement of stakeholders and the development of a local identity. This is certainly not the appropriate goal of any international partnership. This is because these processes are context-sensitive and, above all, technological systems are social constructs (Bijker et al., 1987). In other words, a nation, region, or even a university, anywhere in the world, has to learn its own way and create its own development path.

Although MIT is a relatively large institution in international terms, it is interesting to note that most of the partnerships shown in Table 4 have involved a rather restricted number of MIT faculty and very much concentrated in a nucleus of senior faculty involved in multidisciplinary themes associated with engineering systems. Most notably, the MIT's "Engineering

Table 4
Sample MIT joint ventures in research and higher education — the last decade.

Strategic partnership	Period	Brief description and evolution
Argentine (Mendonza) — MIT	1994–1998 (only one single phase)	The Province of Mendoza in Argentina sponsored this program to develop technologies for its socio-economic development to expedite the transfer and adaptation of technology and management skills to public and private sectors. To meet these objectives, the Fundación Centro de Innovación Tecnológica (CIT) was established within the state university in Mendoza in 1995 and its focus was as follows: i) Improve the quality of research and graduate education; ii) Begin a new research tradition imbedded in regional needs; iii) Create a research environment attractive to young, ambitious faculty and to government and/or industry, and iv) Establish a favorable context for developing a rich reciprocity between academia, industry, and government. Joint research projects were developed involving faculty from MIT, Universidad Nacional de Cuyo, and other regional and national research and academic institutions.
Singapore–MIT Alliance	Since 1998 (currently under 3rd phase)	1st phase (1998–2005): Singapore–MIT Alliance (SMA) was founded in 1998 as an initiative to develop research talents who can contribute locally to the economy. Born out of a collaboration between the Massachusetts Institute of Technology, the National University of Singapore and the Nanyang Technological University, it started by offering five postgraduate programs: Computational Engineering (CE); Computation and Systems Biology (CSB); Manufacturing Systems and Technology (MST9), Advanced Materials for Micro- and Nano-Systems (AMM&NS); Chemical and Pharmaceutical Engineering (CPE). 2nd phase (2007–2010): The Singapore–MIT Alliance for Research and Technology (SMART) Center was designed and developed as a major research enterprise in Singapore established by the Massachusetts Institute of Technology and the National Research Foundation of Singapore. The SMART Center brought together faculty, researchers, and graduate students from MIT with academic and industry researchers in Singapore and Asia to collaborate in exciting new areas of science and technology. Interdisciplinary Research Groups (IRGs) at the SMART Center included: BioSystems and Micromechanics (BioSyM); Center for Environmental Sensing and Modeling (CENSAM); Future Urban Mobility (FM); Infectious Disease (ID) 3rd phase (2010–…): The Singapore University of Technology and Design (SUTD) is developed in collaboration with MIT to nurture technically-grounded leaders and innovators to serve societal needs. The collaboration with MIT is multifaceted — the development and offering of curriculum, establishment of a major co-located research center, and recruitment and professional development of SUTD's university leadership team and faculty.
Cambridge-MIT	2000–2006 (only one single phase)	The Cambridge-MIT Institute (CMI) was established in 2000 to explore how academics, industrialists and educators might work together to stimulate competitiveness, productivity and entrepreneurship. It was proposed by former British Chancellor of the Exchequer Gordon Brown in the summer of 1998, who wanted to bring the entrepreneurial spirit of MIT to British universities. Cambridge University was chosen as MIT's partner because of its strong record in science/engineering and the abundance of high-technology firms located in the Cambridge area. Funded through the predecessors to the UK's Department for Innovation, Universities and Skills, with additional financial support from the public and private sectors, CMI set out to enhance competitiveness and innovation by improving knowledge exchange between universities and industry. CMI worked with over 100 universities and more than 1000 companies and public enterprises on a series of challenging projects involving education, research and knowledge exchange. Working with other UK institutions, CMI encouraged wide participation in an active program of open events, in order to share lessons learned and provide insight into effective practices that impact productivity, competitiveness and entrepreneurship. CMI invested some £65 million in the 6-year period 2000/01 to 2006, through more than 100 research projects and almost 200 education and dissemination initiatives, with the dissemination activities facilitating engagement with scores of universities and several hundred businesses.
Malaysia MIT Program Malaysia University of Science and Technology (MUST)	2002–2004 (only one single phase)	The Cooperative Program between MIT and MUST Ehsan Foundation for assistance in the establishment of the Malaysia University of Science and Technology (MUST) was conceived and planned as part of Malaysia's Second Industrial Master Plan in response to the Prime Minister's call for a creation of a world-class science and technology sector. The major objective of the program was to produce top quality graduate engineers who would understand and participate effectively in Malaysia's program for a balanced social and industrial development. The program was sponsored by the Ministry of Science and Technology in Malaysia and the Motorola Foundation and Motorola GTSS and GSG at MIT. MIT participation ended November 30, 2004 due to withdrawal of Motorola commitment to MIT because of economic circumstances. MIT provided advice and assistance to MUST regarding faculty recruitment, IT infrastructure, course delivery, as well as setting up a library, academic media production services, and other critical offices needed. By the end of 2004, MUST had hired 24 faculty members who were graduates from leading universities. It offered seven Master of Science degree programs, which comprised of approximately 50 courses developed with MIT's assistance. MIT and MUST completed nine joint research projects.
MIT Portugal Program	Since 2006 (currently in the 2nd phase)	A post-graduate education network of intense and wide ranging collaboration between Portuguese Universities, research institutions, companies, and the Massachusetts Institute of Technology (MIT), has been funded by the Portuguese Science Foundation (FCT) for the period 2006–2011. The network offers Portugal a truly international education program serving as a model for the intersection of engineering education, research, innovation and entrepreneurship. The program has built a research platform for cutting-edge concepts in three promising areas of

(continued on next page)

Table 4 *(continued)*

Strategic partnership	Period	Brief description and evolution
		science and technology: novel biomedical therapies and devices; sustainable energy and transportation systems; and integrated product design.
MIT — Abu Dhabi: Masdar Institute of Science and Technology	2007–…	The Masdar Institute started recruiting students in September 2009, with five 24-month Master of Science programs. It involves about 170 students from 32 countries in spring 2011. The establishment of Masdar Institute is part of a resource diversification policy for the Emirate of Abu Dhabi. Abu Dhabi's leadership views research and education in alternative energy as a keystone for the future development of the emirate and have expressed their commitment through the establishment of Masdar Initiative, Masdar City and the Zayed Future Energy Prize. The Masdar Institute is a private, not-for-profit, research-driven university, governed by an independent Board of Trustees. MIT's role with the Masdar Institute is diverse and evolving, but currently is focused on the following four main areas: 1) development and management of joint collaborative research; 2) assistance in development of degree programs; 3) outreach that encourages industrial participation in Institute research and development activities; and 4) support for capacity building at the Institute in terms of its organizational and administrative structure as well as scholarly assessment of potential faculty candidates. The Masdar Institute faculty, once chosen and appointed, spend up to one year working closely with faculty at MIT in Cambridge, Massachusetts in joint research projects on topics of relevance globally and to Abu Dhabi. The faculty also spend considerable time auditing the graduate-level classes they will eventually teach at the Masdar Institute.
Skolkovo–MIT	Since 2012	A three-year collaboration between the Skolkovo Foundation, Skolkovo Tech and MIT to develop a new graduate research university — the Skolkovo Institute of Science and Technology (Skolkovo Tech) in Skolkovo, Russia. The new institution aims to break new ground in bringing together Russian, US and global research and technology — and in integrating teaching, research, innovation and entrepreneurship. Education and research at Skolkovo Tech will be organized around multidisciplinary technological challenges, rather than traditional academic disciplines. The new institution will focus on the following programs: energy science and technology; biomedical science and technology; information science and technology; space science and technology; nuclear science and technology. Master's and doctoral degree programs will be organized under these programs, with focused degree tracks in specialized research areas within each program. Research centers under the Skolkovo Tech organizational umbrella will be multidisciplinary and multi-institutional. In each center, faculty, researchers and students from one or more Russian universities will collaborate with faculty, researchers and students from one or more universities outside Russia. A defining component of Skolkovo Tech will be its Center for Entrepreneurship and Innovation (CEI), which will integrate education, research and practice in entrepreneurship and innovation, as applied to the research results of the Skolkovo Tech research centers. MIT will assist in creating the CEI organization and education program.

Systems Division" brings together most of the faculty involved in international ventures. Traditional disciplinary departments and related faculty have resisted engaging in international cooperation abroad.

What, then do, MIT global partnerships offer? They are an opportunity to work closely with a very successful institution to adapt and improve lessons learned in the building of an environment that promotes innovation. Overall, they are unique opportunities for political and strategic actions fostering change. But it does not occur automatically and requires building a dynamic process of "transformation" in both MIT and the partner institutions, involving the continuous learning and assessing "what works?" and "who effectively cooperates?".

Among them, it is clear that student and faculty exchange schemes together with "teaching the teacher" programs have certainly been very successful, mainly when concentrated in Cambridge, Massachusetts. The most problematic and complex activities rely in "in-house" developments in the partner institutions and in building-up research agendas with local impact. Setting-up "test beds", as experienced through the MIT Portugal joint venture, has become a relevant tool and it is further discussed below.

Time is usually underestimated in assessing short-term implementations of global partnerships and, in general, misunderstanding the dynamic nature of innovation (Etzkowitz and Leydesdorff, 2000b) gives rise, from a structural approach viewpoint, to system dysfunction (Leydesdorff, 2012). In this regard, it is interesting to note that only one single venture shown in Table 4 has lasted for more than three consecutive periods (i.e., Singapore). This is associated, in many cases, with the political nature of the involvement of foreign governments in the partnerships, which may not consider the high level complexity and non-linearity of establishing sustainable research and advanced educational infrastructures. It is a long-time frame process dependent upon many factors, including the host country's determination, the economy, the political stability, the resources available and the long-term commitment that is required to guarantee the maturity of such organizational structures, For example, financial agreements with students (scholarships) are very important to the success of these projects. Student recruitment standards must remain high and government support is a key over long periods of time, in a way is independent as much as possible from political cycles.

Analysis of the various examples provided in Table 4 also shows that emerging partnering ventures with governments represent important socio-political shifts. In the past, many institutions (including MIT) have attempted to "export" services or to franchise their brands, so that, for instance, a country could have a local "branch" of a certain foreign university. In addition, most universities were conceived with

a strong "national approach" to their work, oriented towards highly localized needs and locally related research. In many countries, very few (if any) leading universities have adapted to a genuinely international research agenda. Again, from a structural approach viewpoint, network deformation occurs above all under bilateral agreements or in association with very weak ties to third parties.

4.3. A case study: the Portuguese initiative of international joint ventures in research and higher education

International partnerships, as we have already noted, were introduced in Portugal in 2006 through thematic networks among Portuguese and a sample of leading American universities, as described in Table 5 (OECD, 2008; Heitor and Horta, accepted for publication). They introduced a new slant on institutional development, very specifically intended to offset the disadvantages of scale, which limited size imposes on some research units (Heitor and Horta, 2011). The vision was that multiplying science-based networks stimulates the generation and diffusion of new knowledge (Heitor et al., 2014; Heitor and Horta, 2014). It drives scientific development forward at a time of constant change when the internationalization of the science base is itself a phenomenon of constant flux.

This was a bold step on Portugal's part, looking outside of Europe to link up with leading universities in the United States. That boldness, though, is not what makes that set of programs unique. Rather, it is that the programs' objectives were specifically, and deliberately, outlined as part of the national political priority given to scientific and technological development, with elements that go well beyond the traditional bilateral and cross-national collaborations between higher education institutions. Furthermore, the programs were not initiated by the Portuguese universities, but at the level of the national government, in a way to call for "collective action" of all universities and research laboratories. These programs were funded by the Portuguese Science Foundation, and have since enjoyed the imprimatur of the Portuguese people, and are indeed known throughout the country. In general, foreign–government–university triple relations (Ivanova and Leydesdorff, 2014) were guaranteed for all the programs listed in Table 5, with Government funding the necessary organizational structure to keep the various programs moving, at least in their first phase.

The designing of this strategy gained from other experiences in Europe and elsewhere, namely that established by

Table 5
Main projects involved in the Portuguese initiative of international joint ventures in research and higher education (2006–2011).

Strategic partnership	Launched	Brief description and evolution
MIT Portugal	October 2006	Focused on the field of "engineering systems", with special emphasis to the complex processes associated with industrial production, sustainable energy, bio-engineering and transport systems. Three main thematic areas for R&D in close cooperation with an industrial affiliation program were established in sustainable energy and transportation systems, stem cell engineering for novel therapies in regenerative medicine, and materials and design-inspired products with specific applications in electric mobility and new medical devices. Overall, the program involved over 340 master and doctorate students at the beginning of its third year in September 2009.
	October 2007	Through the joint program with MIT, co-operation with the Sloan School of Management was strengthened through an international MBA program, "Lisbon MBA". This involves co-funding from seven major Portuguese companies and banks in a way that will stimulate new research and the quality of education in management sciences in Portugal.
Carnegie Mellon—Portugal	October 2006	Focused on information and communication technologies, in particular the so called Future Internet technologies and services, and involving dual professional masters and PhD programs by Portuguese institutions and Carnegie Mellon University. The areas covered include new generation networks, software engineering, cyber–physical systems for ambient intelligence, human-centric computing (including language technology), public policy and entrepreneurship research, and applied mathematics. Overall, the program involved about 170 master and doctorate students at the start of its third year in September 2009. Three new innovation networks were launched at a later stage, whose goal is to consolidate and expand the successful cooperation among all partner institutions and industrial affiliates: 1) Security and Critical Infrastructure Protection (NET-SCIP); 2) Future Internet Services and Technologies (NET-FIT); and 3) Services and Technologies for Interactive Media (NET-STIM).
UT Austin—Portugal	March 2007	An "International Collaboratory for Emerging Technologies, CoLab" was established with emphasis on collaborative research in advanced interactive digital media and integrating advanced computing and applied mathematics. Overall, the program involved about 70 doctorate students at the start of its third year in September 2009. Under the joint collaboration with the University of Texas in Austin, a "University Technology Enterprise Network, UTEN" was established in 2007 and oriented towards international technology commercialization and the professionalization of university technology managers.
Fraunhofer Portugal Research Association	May 2008	Establishment in Portugal of the first Fraunhofer Institute in Europe outside Germany. This project focuses on emerging information and communication technologies, such as "Ambient Assisted Living", to be complemented by the establishment of R&D consortia and co-operative projects involving several Portuguese institutions and Fraunhofer institutes in Germany.
Harvard Medical School—Portugal	May 2009	Focus on translational research and information fostering translational and clinical research programs and the development of a new infrastructure for delivering medical information produced by medical schools to medical students across the academic institutions, to health practitioners and to the general public, thus contributing to strengthen the relationships of medical schools and health science institutions with their main constituencies.
International Iberian Nanotechnology Laboratory	July 2009	It is the first research laboratory setup under international law in the Iberian Peninsula and it is the first such institution worldwide explicitly focused in nanotechnology. It is expected to achieve a reputation as an international institution of excellence in application areas of food and water quality, environmental monitoring and nanomedicine, conceived for about 200 researchers from all over the world, a total of 400 people, and an annual investment and operational budget of around 30 million Euros that is being funded equally by both countries. It is expected that this laboratory will develop strong links with industry and will attract the membership of more European countries and countries of other continents.

the British Government in 2000 involving a single university partner in Britain, the University of Cambridge, and a single American university, MIT. It was understood at the very initial stage the need to engage not only one, but several universities in Portugal, as well as to work independently with several leading universities in America. This has facilitated engaging a larger number of academic research groups in Portugal, as well as the specialization of the programs towards well defined thematic areas, with those working with MIT focused on engineering systems, those with Carnegie Mellon focusing on information and communication technologies, those with the University of Texas at Austin focusing on digital media and technology commercialization, and those with Harvard Medical School on translational biomedical research. But, above all, it has also facilitated a rather interesting "natural competitive" and dynamic environment among the various thematic networks established throughout the years, which has been particularly stimulating for the success of the overall initiative.

Strengthening the international dimensions in higher education and in S&T is a well-established way to integrate national institutions in science networks as they emerge at the international level (Heitor et al., 2014). An important challenge, though, is to build flexible organizational structures able to take into account for time dynamics. This is because complex socio-technical systems can be expected to remain in transition (Etzkowitz and Leydesdorff, 1998), so that in order the system (or network) keeps sustainability, the accent should be continuously shifting to different components and type of actions.

In this context it is important to note that internationalization spurs on the mobility of academics, research staff and students and benefits are considerable in a long time frame (Bhandari and Blumenthal, 2011). Early mobility in a research career is highly important in determining the work that will be carried out in the future just as it is in forging international ties as part of academia's development paths. With such considerations in mind, each program shown in Table 5 is tied in with an international partner, strategically and carefully selected in the light of those specific and equally strategic objectives that identify and differentiate each program from others.

Also to guarantee a time evolution of actions taken, R&D projects and test beds directed towards the internationalization of Portuguese industry were started, together with a network of technology transfer offices supporting technology-based entrepreneurial ventures through the University Technology Enterprise Network (UTEN) described above. Thus, the synergy generated by cross national partnerships within academia is extending onward to industrially linked programs — to stem cell engineering for regenerative medicine, automotive engineering, low-energy systems through the MIT Portugal joint venture, telecommunications and information systems with the Carnegie Mellon–Portugal partnership, the Fraunhofer–Portugal association and the UT Austin–Portugal program. This presents the effect of self-generation of a properly organized system (Ivanova and Leydesdorff, 2014), keeping always tripe relations.

4.4. A specific development: the MIT Portugal joint venture

Looking backwards to the 2005 Portuguese political campaign for prime minister, Jose Socrates made the enhancement of Portuguese science and technology a major part of his strategy. The population at large embraced a "Technology Plan" as part of a new political movement to strengthen Portugal's march to modernity. At the center of the Technology Plan, is the MIT Portugal joint venture, an international partnership that focuses on improving economic and societal development in Portugal (Heitor et al., 2014; Heitor and Horta, 2014). As noted before, it was developed together with a few other joint ventures in a way to guarantee a "natural competitive" and dynamic environment among various joint ventures, but it represents a unique initiative. It goes far beyond the traditional cooperative ventures that research universities in the United States have undertaken with institutions in other countries. As such, it has lessons not only for countries and regions like Portugal, but also for America's leading schools.

The MIT Portugal program has been promoted as a post-graduate education network of intense and wide ranging collaboration between Portuguese Universities, research institutions, industry, and the Massachusetts Institute of Technology

Table 6
Sample data about MIT Portugal partnership on "Engineering Systems" (1st phase, 2006–2011).

Areas	Bioengineering Sustainable Energy and Transportation Systems Engineering Design and Advanced Manufacturing
Partner institutions and affiliation of private firms	Portugal: 6 Universities, with 8 schools providing joint degrees Research groups in 13 Universities, 9 Associate Labs and 1 State Lab. involved in R&D projects 59 firms involved in R&D projects and advanced education programs, as affiliated companies MIT: 5 schools 25 departments
Faculty	Portugal: Doctorate researchers contracted and funded (100%): 23 University professors involved: 270 Faculty exchange program at MIT: 28 MIT: University professors involved: 70
Advanced education	- 4 PhD programs: Bioengineering Systems, Sustainable Energy Systems; Transportation Systems; Engineering Design and Advanced Manufacturing - 3 Master programs: Sustainable Energy Systems; Transportation Systems; Engineering Design and Advanced Manufacturing
Students	- Total number: 631 (414 PhD students, 217 master students) - Degrees awarded (November 2012): 214 (171 master degrees; 43 PhD degrees) Student fellowships funded: 234 Fraction of Portuguese students: 70% Students with long periods at MIT (one year): 120 Date of first PhD degree awarded: 25 July 2011
R&D projects	R&D projects contracted and funded: 20 projects in 3 years (out of 72 applications). 36 firms involved
Assessment	Yearly based, by external review committee

(MIT), funded by the Portuguese Science and technology Foundation (FCT), as described in Table 6. The network offers Portugal a truly international advanced education platform, serving as a model for the intersection of engineering education, research, innovation and entrepreneurship. Again obtains triple contingency formed by university–foreign–funding agent relations (Leydesdorff, 2012).

A total of 6 Portuguese universities, 28 Portuguese research centers and national laboratories, together with faculty from many MIT departments, and all 5 Schools within MIT are involved in this ongoing partnership. Seven Doctoral, Master's of Business Engineering and Master's of Science programs have been created in the areas of Bioengineering, Sustainable Energy and Transportation Systems and Engineering Design and Advanced Manufacturing.

Over the period analyzed in this paper (2006–2011), the program has built a research platform for cutting-edge concepts in three promising areas of science and technology: novel biomedical therapies and devices; sustainable energy and transportation systems; and integrated product design. This has been attempted through scalable living laboratories, which were designed to take the form of "test beds". They include development and demonstration programs oriented to design, test and implement systems, new products and modeling capabilities for markets worldwide.

In addition, a high-visibility venture competition, building global innovators, has helped identify and reward global projects that are at an embryonic stage — projects with high-level technological content, or products or services that are able to demonstrate a highly innovative approach (see http://mitportugal-iei.org/). Finalists from other national Portuguese competitions have been encouraged to participate. The venture competition has been launched with four tracks: i) Sustainable Energy & Transportation systems; ii) Life Sciences; iii) Information Technology and the Web; and iv) Products and Services.

The MIT Portugal joint venture was designed to be implemented along with the medium term and three main challenges identified today, by the end of the initial six years of the program, as follows. First, the need to continuously promote change in the patterns of teaching and learning. This considers promoting student active work and fostering student-centered education schemes, together with stimulating entrepreneurial attitudes. Several design studios have been created or adapted for the MIT Portugal program in several participant universities (e.g. IST-Lisbon, FEUP-Porto). Although significant improvements have been achieved in some classrooms, there is still a great room for improvement in most of them, namely in what regards classroom physical environment and in the use of interactive technologies in teaching (e.g. course materials and assignments). Main current challenges include forms of "systems thinking" and establishing routines of an entrepreneurial culture. The ultimate goal is to guarantee triple contingency formed by university–foreign–industry relations (Leydesdorff, 2012).

Second, establishing stable "test beds" for collaborative research and industry–science relationships, making use of long-term triple relations. Significant research outcomes and new patterns for collaborative research have been produced in the last years, but there is still room for improvement in stakeholder engagement, together with deepening a basic research infrastructure at the university level. Current examples of test beds developed for collaborative research include the following: i) Green Island, at Azores archipelago (Portugal), leading to new sustainability approaches for islands worldwide (MCTES, 2011); ii) new therapies in regenerative medicine, involving hospitals (Eibes et al., 2010); iii) urban metabolism, fostering comparative urban studies at international level (Niza et al., 2009); and iv) Revisiting regional development in the Tua Valley, a remote and isolated area of northeastern Portugal, involving comparative studies at international level (McCants et al., 2011).

Third, promoting modern industrial strategies and policies, through the continuous involvement of large and modern industries, supporting the integration of new technology based firms in large and international industry value chains. Although many activities have been launched and promoted in terms of stimulating entrepreneurial actions by young researchers, including a national venture competition, there is still a great room for improvement in accessing international markets and in linking them with medium and large companies worldwide and, above all, to promote manufacturing. Typical emphasis on "knowledge-based services" should continue, but also foster forms of "industrial innovation" and this represents a major challenge worldwide, with particular implications in peripheral and small economies, such as Portugal. Current activities that may be used to foster new opportunities include engineering design and lean manufacturing in the aerospace and the oil & gas sectors. Also, urban systems and new therapies, such as those deriving from tissue engineering, are being considered in the current phase of the program. Form a structural viewpoint, the challenge is always to guarantee sustainable triple contingency formed by university–foreign–industry relations.

5. Discussion

A new paradigm of organized international university relationships is emerging to help accelerate knowledge diffusion and exchange in many regions worldwide, considering activities that are fundamentally different from the traditional role of universities. They are shaped by a new era of international affairs and involve, most of the times, capacity and institution building, together with forms of social and economic appropriation of knowledge.

It should be noted that looking at the last two decades, the picture that is emerging at a global level is not very much different from that discussed by Sylvia Ostry and Dick Nelson in the early 1990s (Ostry and Nelson, 1995). In other words, it is one of increasing internationalization of private business strategies, while government innovation polices and science-funding agencies remain overwhelmingly national. This is leading to new dilemmas for policymaking and to new sources of international friction, although with new boundaries and new players. The key issues to better understand include the implications of increasing technoglobalism for national and international innovation policies. And, also, what new approaches are required to reduce international frictions and where do public policies need wider integration.

Analysis in the literature has clearly shown that China's capacity to innovate is still quite limited as compared especially to the capacity of the US. A similar comment could be raised about Brazil, India or Russia and, therefore, there is a large scope to better discuss US and EU innovation policies in a broad international context, well beyond national borders. It is under

this context that national innovation policies should help fostering a better understand of future international collaborative paths in education, science and innovation. Ultimately, this will become a key issue for competitiveness everywhere, as discussed in this paper.

Building on the metaphor of "Triple Helix" of university–industry–government relations and considering related international dimensions (Leydesdorff and Sun, 2009), our analysis shows that those relationships have to consider accommodating new configurations of knowledge production by establishing alliances with an increasingly large range of "knowledgeable" institutions (McCants et al., 2011). Also, they need to secure and promote a sufficiently stable and collective environment to train and supply talented people (Mazzucato, 2013), including researchers for that increasingly large range of "knowledgeable" institutions. I argue this leads to the need, more relevant than never before, for systems and related public policies promoting effective institutional autonomy and integrity of modern universities (Nowotny et al., 2001; Conceição and Heitor, 1999), in a context where alliances and partnerships among universities worldwide, as well as between them and corporations, gain significant relevance (Knight, 2004; Mazzucato, 2013).

Our analysis agree with the theoretical description of the "Tripe Helix" interplay of universities, governments and industry towards innovative societies (Leydesdorff and Meyer, 2007; Ivanova and Leydesdorff, 2014), suggesting that their sustainable development may be achieved in systems with a number of actors of more than two. An important challenge, though, is to build flexible organizational structures able to take into account for time dynamics. In addition, our observations have underlined the need to better consider the process of developing human capital, as well as the institutional framework to facilitate it (Heitor et al., 2014). Human capital is vital for the creation and dissemination of knowledge, and striving towards greater human capital is of the utmost importance for both developed and developing countries.

Two further issues should be emphasized. First, innovation must be considered together with competence building and advanced training of individual skills through the complex interactions between formal and informal qualifications (Shapiro, 2005). Second, strengthening experimentation in social networks necessarily involves flows of people, independently of their socio-economic level (Helpman, 2004). It is the organized cooperation among networks of knowledge workers, together with different arrays of users across the entire social fabric of our societies that will help diffuse innovation and the design of products and services. But establishing these innovation communities requires the systematic development of routines of collaboration on the basis of formal education programs, research projects, and a diversified and non-structured array of informal processes of networking.

It is under this context that this paper argues that the creation of "organized forms" of international partnerships have become important policy instruments to strengthen institutions and the necessary critical masses to compete at an international level and, at the same time, they need to guarantee the adequate level of institutional integrity of universities in emerging and developing regions (Nowotny et al., 2001; Tung, 2008). These networks may have an important impact in advanced education and research, also helping to attract students, as well as to training their future teaching staff in times when higher education systems at those regions are becoming increasingly relevant.

The main challenge is that such "organized forms" can't be of any kind, but should follow some structural constraints (Leydesdorff, 2012), in a way to promote education and training for competence building; foster cooperative R&D and experimentation to access external markets; guarantee the necessary organizational structure oriented towards institutional building, together with resource base development.

Understanding the new paradigm of international partnerships in higher education will gain from our increasing knowledge of the operational advantages and shortcomings of large international research consortia and organizations. It also requires the understanding of the local characteristics of the processes of technical change and of their specific regulatory and institutional constraints and it calls upon our knowledge of the social construction of technological systems.

Our analysis suggests the emergence of a new model, rather complex and time and resources consuming, which is intimately associated with foreign–government–university triple relations, with the role of government considering the continuous assessment and funding of an organizational structure, to guarantee the continuous development of research and education activities. It requires the development of national institutional capacities that derive their strengths from the accumulation of qualified human resources and from institutional participation and their recognition from international academic and research networks. This approach does not appear to match the usual model for exporting services, but it is rather a "learning process" for all partner institutions involved. The temptation for easy adoption of "academic services" may seem attractive at short notice but its glamor fades away under increasing academic and political criticism.

It should also be noted that this new model of academic cooperation, that includes but does not seem to be a hostage of the traditional forms of services' international commerce, may derive its uniqueness from the very nature of academic communities and from the strong meritocratic and universalistic ideals that prevail in science on an international scale. In addition, they are also driven by the flow of students and researchers, and by the citizen sense of being part of a "mission" for scientific and social development that motivates some of the best professionals in academic institutions worldwide. However, under which conditions is such a model sustainable?

To answer this question, Table 7 summarizes major lessons learned from the Portuguese experience in setting-up international research networks. It considers three major steps, including the following: i) people, mainly through education and training and including co-hiring of young researchers and exchange programs for faculty; ii) promote R&D through "test beds" and thematic networks, facilitating the integration of researchers and scientific institutions in international thematic networks with local relevance; and iii) institutional building, by adequate organizational conditions promoting the role of scientific institutions in society, their links with the private sector and adopting policies that

Table 7
Potential guidelines to foster international research networks.

Major objectives and policy instruments	Justification
People Train, attract and co-hire researchers, fostering their exchange and the training of a teaching body	•Sustain excellence and internationalization in doctoral programs •Foster and systematize the hiring of researchers with PhDs
Institutions Reinforce and promote the role of scientific institutions in society and their links with the economy and society	•Reinforce institutional evaluation mechanisms, in order to improve systemic and organizational efficiencies •Adopt policies that foster activities able to promote the creation of critical masses, including policies oriented towards fostering R&D consortia. •Promote the training of scientist, together with a new generation of technicians and other human resources to support R&D activities •Foster scientific and technological cultural in society
Incentives for R&D, Test beds and thematic networks Facilitate the integration of researchers and scientific institutions in international networks focused on "test beds", as living laboratories for the production and dissemination of knowledge with local relevance and facilitating ideas for markets worldwide	•Reinforce international partnerships and foster participation in international knowledge-based networks as a way to improve scientific quality and the employability of researchers •Foster S&T thematic networks in terms of test beds and living laboratories that can boost companies' capacity to export and access emerging markets.

foster the creation of critical mass, including those oriented towards fostering R&D consortia.

Making use of the Triple Helix paradigm, "test beds" are "living laboratories" for the production and dissemination of knowledge and facilitating ideas for markets worldwide, bringing together triple relations of university–government–industry with a strong international dimension. They may be assembled and integrated in international collaborative programs in a way to boost local companies' capacity to export and access new markets.

6. Summary

A new paradigm of international academic, scientific and technological relationships is emerging as shaped by a new era of international affairs. They consider activities that are fundamentally different from the traditional role of universities, involving, most of the times, capacity building and institution building, together with forms of social and economic appropriation of knowledge.

Those relationships may act as a new narrative in university–government–industry relationships, requiring national policies oriented beyond the traditional boundaries of "national systems of innovation". The new model of academic cooperation, that includes but does not seem to be a hostage of traditional forms of services' international commerce, may derive its uniqueness from the very nature of the academic communities.

In addition, it is influenced by the strong meritocratic and universalistic ideals that prevail in science at an international scale, as well as by the flow of students and researchers, and by the citizen sense of being part of a "mission" for scientific and social development that motivates some of the best professionals in academic institutions worldwide. As a result, this paper addresses new conditions for international scientific and academic cooperation and discusses their emergence as agents of change, as well as their potential impact on new social realities in many countries.

The approach considered in this paper builds on the conceptual framework of "Triple Helix" of university–industry–government relations, following four main lines of thought. First, the paper discusses the evolution of emerging partnerships worldwide, namely those involving the collective action of different universities, and argues that large networks have been very interesting and relevant, but are not effective in promoting change. Network competitiveness depends on many factors, requiring increasingly focused partnerships.

Second, the paper looks at partnerships established with MIT and reflects why so many governments and universities worldwide want to cooperate with MIT. It is argued that people underestimate the social, political, and economic challenges associated with establishing leading institutes of science and technology. Any research and advanced educational infrastructure is a very complex process and dependent upon many factors, including the host country's determination, the economy, the resources available and long-term commitment that is required for maturity of such institutions.

Third, the paper discusses the case of the Portuguese program of joint international ventures, established in 2006, as representing a new slant on institutional development, very specifically intended to offset the disadvantages of small scale. Multiplying science-based networks stimulates the generation and diffusion of new knowledge. It drives scientific development forward at a time of constant change when the internationalization of the science base is itself a phenomenon of permanent flux.

Fourth, the paper analyzes the main "case study" of the joint MIT Portugal partnership established in 2006. The program has built a research platform for cutting-edge concepts in three promising areas of science and technology: novel biomedical therapies and devices; sustainable energy and transportation systems; and integrated product design. The MIT Portugal joint venture positions Portugal as a scalable living laboratory, making use of test bed developments and demonstrations to help designing and testing systems, new products and modeling capabilities for markets worldwide.

Overall, the paper discusses the way international affairs may shape universities and their positioning in increasing globalized societies and economies. Universities may play an increasingly relevant role in modern societies if their

internationalization and specialization path is understood as a key element in a new era of international affairs, where governments and industry intervene through knowledge.

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