Reforming higher education in times of uncertainty:
Autonomy, institutional integrity and linkages

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Submitted to Comparative Education

Abstract
This article analyses critically the process of reforming higher education systems in times of increasing uncertainty. We argue that effective institutional autonomy and integrity of modern universities should be promoted, as qualified human resources and the science base are reinforced. In this scope, alliances, networks, and partnerships between universities worldwide and between them and industry assume a major role, but require their integrity to be preserved. Our evidence is provided by critically discussing the reform of higher education in Portugal during the period 2006-2010. The results are presented and extrapolated in a context of the increasingly relevant role that \textit{adaptable} and \textit{resilient} institutions play in fostering socially-robust knowledge and in supplying talented people and researchers to increasingly globalized economies and labour markets.

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1. Introduction

In this study we analyse the development of modern universities and systems of higher education and argue that universities need to be both increasingly adaptable and resilient. This appears to be a subject of particular importance when framed under recent developments in emerging regions and countries (Roberts and Hite, 2007; Willis, 2005). First, higher education systems and institutions have to consider accommodating new configurations of knowledge production by establishing alliances with an increasingly large range of “knowledgeable” institutions (Nowotny et al., 2001). Second, they need to secure a sufficiently stable environment to train and supply talented people, including researchers, for that growing range of “knowledgeable” institutions (Peters et al., 2009). This leads to our main argument about the need, more relevant than ever, for systems and related public policies to promote effective institutional autonomy and integrity of modern universities (Shapiro, 2005). This is relevant in a context where alliances and partnerships among universities worldwide, as well as between them and corporations, gain significant prominence (Heitor, 2012, forthcoming).

The university in mass higher-education systems continues to fulfil two basic functions that depend on it being a relatively stable institution (Nowotny et al, 2001). First, among the most essential roles of universities is the supply and training of talented people. Increasingly, this is one of the most essential contributions that universities are expected to make (Harkavy, 2006). In terms of advanced formal training, it remains the most important incubator of the next generation of researchers. This requires effective “University-Science” relationships, because research-intensive environments are critical to train researchers. No other institution is as well prepared as the university to undertake this task in modern societies (EC, 2011). But this function is gaining greater relevance through innovation and the need to secure and explore “University-Industry” relationships (e.g., D'Este and Patel,
Second, is the university function of generating and promoting “cultural norms” that the university should promote in both substantive and procedural terms (as claimed by Nowotny et al., 2001). Nussbaum (1997) is more ambitious and claims for the maintenance of a “culture of liberal rationality”. Here we adapt and expand the notion explored by Conceição and Heitor (1999) that, at the starting of the 21st century, universities should promote the necessary institutional integrity to facilitate students to experience environments of free knowledge production and diffusion. Again, no other institution is so well fitted out to undertake this task in modern societies. For example, Shriberg and Harris (2012) explore this idea in terms of building “green campus” and making the university a “living laboratory” to better educate youngsters towards a sustainable society.

For the purposes of this article, we will use sample examples of the recent Portuguese higher education reform as a case study to illustrate our main arguments. The reforms of the Portuguese higher education are relevant for catching-up regions in Eastern Europe, South and Central America, Africa and Asia, mainly for two reasons. The first is that several characteristics are common, including fragile higher education institutions, often with low degrees of autonomy, internationally recognized low levels of funding, and slowness to respond to societal demands. Local challenges also tend to be the same: increasing the formal qualifications of the population, struggle to create a more robust knowledge base, and contribute to local and national socio-economic development (Buckner, 2011; Sirat, 2010; Horta, 2010; Shin and Harman, 2009; Padilla, 2008; Balan, 2006; Kwiek, 2004). The second is that a throughput legal reform of the Portuguese higher education system was successfully implemented (OCDE, 2007), and many lessons taken from its conceptualization and implementation can be applied elsewhere.

The reform of the Portuguese higher education considers significant changes in the
internal system of governance of higher education institutions (including the management structure), and external relations (including internationalization, research partnerships and business links, external evaluation and accountability; Heitor, 2008).

Through the analysis of these reforms we discuss lessons learned in a scope where we do strengthen the message of Nowotny et al (2001) that “science is contextualized”. In other words, we do not intend to list a normative set of policies or recipes. But, in discussing the reforms, we consider the dynamic relationship between society, knowledge production and the social construction of technological systems, as seminally described by Bijker et al. (1987), and continuously developed over the last decades (e.g., Klein and Kleinman, 2002; Heitor, 2012, forthcoming). In particular, we underline the ideas that learning processes and the implementation of reforms need to be “context-sensitive” and should be pursued towards “inclusive learning” at an institutional level (see, for example, Conceição and Heitor, 2005). In other words, any nation and higher education institution worldwide have to learn their own way and built their own development path even if the temptation to emulate others is both powerful and potentially dangerous (Deem et al., 2008). Certainly this needs to be done by continuously adapting, building upon, and improving lessons learned from others (Marginson et al., 2010).

We emphasize these arguments by presenting first the process of reforming higher education in Portugal in terms of promoting institutional autonomy and integrity in modern higher education systems. Then, we discuss emerging issues on university governance and higher education systems and the role of external linkages, including those between science and higher education.

2. The process of reforming higher education: Portugal, 2006-2010
The recent reform of higher education in Portugal is discussed as a whole based on related main policy actions and steps. These policy actions have been implemented under the opportunity provided by the Bologna process in Europe, and are presented in terms of their evolution and linkages between them.

2.1 Launching the process of reform

The full regulation designed to bring higher education in Portugal in line with the Bologna process was implemented in the period 2006-2008 as part of a profound legal reform of the higher education system. The overall reform process was launched in 2005 through an international assessment of the higher education system and its institutions, involving the Organization for Economic Co-operation and Development (OECD), the European Network for Quality Assurance (ENQA) and the European University Association (EUA). By the end of 2006 the OECD presented an overall assessment of higher education, while ENQA presented an evaluation of the system of quality assurance and accreditation practices in higher education, which drove the reform for the following years. In the meantime, a voluntary program of institutional assessment was also conducted by the EUA from 2006 and until the new Higher Education Evaluation and Accreditation Agency became fully operational in 2009/10.

In addition, in 2009 two separate international evaluation committees were formed to assess the system for distance education and the specific characteristics of higher education in the arts. Also, in 2010/11 the National Qualifications Framework underwent international evaluation following Bologna procedures and in line with the European Qualification Framework.

2.2 Reforming degrees and diplomas
The first step in the reform of degrees and diplomas was an Act amending the Basic Law of the Education System, to ensure the legal basis for implementing the Bologna Process. This was followed by specific regulation establishing the general principles for the organization of programs and their accreditation, establishing transition rules for the reorganization of existing programs and creating new ones. This had a significant mobilizing effect throughout the higher education system and full institutional adaptation to Bologna was achieved in the academic year 2008/09.

In alignment with this process, new legislation was passed to regulate the creation of post-secondary education programs, aiming at increasing the availability of technical and vocational education and widening access to such programs for new publics. This process has brought a new dynamism to post-secondary education in Portugal, in particular at polytechnic institutes. About 5,000 students have enrolled in these programs every year since 2007/08 (compared to around 300 in 2005). In 2009/10 more than 6,000 students were enrolled in Courses of Technological Specialization, with 81% of them in the polytechnic system, representing a significant opening up and promotion of the binary character of the higher education system.

Additional new legislation was passed towards opening the access of students to higher education, in particular for students aged over 23 and those meeting certain specific educational qualification criteria, thereby widening the recruitment pool and making it possible to reverse the decline in student numbers in higher education observed in the mid-2000s (Amaral and Magalhães, 2008). Over 10,000 new students have been enrolled in higher education through this type of mechanism since 2007/08 (up from around only 900 adults who started higher education in the 2005/06 academic year), representing another significant step in opening up of higher education to society.

Still, more flexible procedures for access to higher education have been implemented. This included the possibility for anyone interested to attend individual
curricular units/courses to do it with a guarantee of certification and accreditation in the case of successful completion. The scope of these flexible procedures were extended, encompassing the opportunity for students of a given program to attend curricular units/courses not included in their cycle of studies and provided in any higher education institution. In the case of successful completion, certification and inclusion of this curricular unit in the diploma supplement was assured. Students also had the opportunity to attend programs on a part-time basis and mechanisms were implemented to ensure compliance with the Bologna Process. The transition from an education system based on knowledge transmission to one oriented towards the development of students’ skills became monitored and made available on the institutional websites by the higher education institutions themselves.

2.3 Reforming the legal framework – the process

Following the OECD and ENQA reports of December 2006, the reforms of the legal framework for higher education, as well as that of the higher education quality assessment system, were approved by Parliament in 2007. They brought about significant changes in the internal governance of higher education institutions (including their management structure), as well as in their relations with society (including internationalization, research partnerships and business links, as well as external assessment and accountability). Each of the new laws for higher education was implemented after a wide-ranging consultation process with relevant stakeholders, notably university rectors, heads of polytechnic institutes and of private higher education institutions, students’ associations, and professional associations.

The new legal regime of higher education institutions, established the organizational principles of the higher education system. It defined the autonomy and accountability of institutions, established governing Boards with external participation, allowed for organizational diversity and the possibility to change legal status of public institutions.
(these can become independent legal status institutions, namely “public foundations” run under private law), permitted the establishment of consortia, and recognized research centers as part of the university management. At the same time, a new legal framework for the assessment of higher education and the creation of an independent accreditation agency were both designed to ensure the quality of higher education through the assessment and accreditation of higher education institutions and their cycles of studies. These followed international practices in which independent external assessments are mandatory.

2.4 Strengthening institutional autonomy through independent legal status

Granting independent legal status to higher education institutions is a mean of giving them greater autonomy (Hufner and Landfried, 2003). Following the OECD review, the new Portuguese legislation approved in 2007 promoted this process by allowing public higher education institutions, on a voluntary basis, to become public foundations governed by private law (Hasan, 2007). A university foundation has typically four main defining features: i) it is an independent legal entity; ii) it has a mission (charter or mandate) to serve defined public (national or societal) interests in higher education and research; iii) it is a not-for-profit public interest legal entity, with favorable tax treatment on its incomes, assets and trading activities undertaken in the pursuit of its goals; and iv) it has the autonomy to raise funds and manage its assets in pursuit of the foundation’s goals. In its more extensive form, it may grant the rights to: borrow and raise funds, own buildings, equipment and other financial assets. It fully controls budgets to achieve objectives, sets internal administrative and management procedures, as well as academic courses and evaluation procedures. It consents to employ and dismiss staff, set salaries and reward systems, fix criteria and size of student enrolment and the level of tuition fees.

University foundations have a number of advantages (Walters, 2006). First,
institutional leadership has the maximum autonomy to pursue strategic and operational goals with little external constraint. Second, institutional leadership can plan for the long term without being subjected to changes in the government’s budgetary policies. Third, there are new opportunities for generating additional resources. Fourth, the strategic influence wielded by the curators regarding the establishment of institutional and research agendas can lead to closer collaboration with external stakeholders in the university. Finally, accountability is placed on the shoulders of those in whom responsibility rests.

There are also a number of potential shortcomings. International experiences with the development of university foundations, particularly in Germany (Palandt, 2003), Austria (Pechar, 2005) and Sweden (Chalmers, 2004), suggest a number of challenges, mainly those associated with managerial skills to run foundations (Huisman, 2006). In addition, staff might see the transition from the status of public servant to university employee as fraught with uncertainties. Concern about the viability of foundations persists, such as, insufficient size to permit economies of scale to be made and explored.

Still, the expectation remains that universities which opted for the status of public foundations would become more flexible, more adaptable to the demands of society and more alert to the structural problems that could affect both their research proficiency and productivity (Gonçalves, 2011). By the end of 2009, three universities had acquired this status, namely: i) the University of Porto, the largest Portuguese public university, with about 30,000 students, which brought together into the Foundation four large non-profit research organizations created over the last two decades by several research groups associated with the university; ii) the University of Aveiro, a middle-size public university, with about 13,000 students; and iii) ISCTE – Lisbon University Institute, one of the smallest public universities, with about 6,000 students, which brings together a business school and two large non-profit research
organizations created over the last two decades by several research groups associated with ISCTE. The University of Minho, by the end of May 2011, has also internally approved a proposal to become a public foundation governed by private law and submitted an application for Government approval.

2.5 Evaluation and Accreditation: establishing a new independent Agency

Following the ENQA report of November 2006, the new legal framework for the evaluation of higher education was introduced and the Higher Education Evaluation and Accreditation Agency (A3ES) established. A3ES became fully operational in July 2009, and was created as a private and independent foundation established for an indeterminate period of time. It is responsible for the assessment and accreditation of higher education institutions and their study cycles, as well as the execution of every task intrinsic to the integration of Portugal in the European system of quality assurance of higher education.

The role of A3ES has been critical, as it has promoted internal systems of quality assurance throughout universities and polytechnics. By 2010, A3ES completed the first cycle of the accreditation process. By that time, the electronic submission of new degrees was also concluded. Among the main outcomes of these processes was a significant reduction in the traditional proliferation of degree programs. This underlines the impact of the accreditation agency in the higher education system, but also the efforts made by higher education institutions in the reorganization of their educational portfolio (A3ES, 2010).

2.6 Fostering student mobility

The reform of the higher education system in Portugal included the implementation of a series of measures seeking to ensure a more effective and less bureaucratized
national and international mobility of students. The implementation of such measures was critical because student mobility depends on the recognition of prior learning and qualifications, a requirement when moving between qualifications or cycles in order to access more advanced programs (Teichler, 2011).

This has involved a number of important steps, towards leading to adaptive institutions that fostered student mobility. First, new regulations were introduced for mobility of students between national higher education institutions, from the same or different sub-systems, as well as between national and higher education institutions located abroad, based on application of the European Credit Transfer and Accumulation System (ECTS).

Second, new regulations were implemented for re-entering higher education, changing programs, and transferring between higher education institutions. By these means all the previously existing obstacles to re-entry were removed for those who have interrupted their higher education studies at some point of their lives. In addition, procedures for transfer or changing courses were changed making possible to integrate students coming from both national and institutions abroad into a single system. This enabled to extend admission limits and simplify admission and transferability procedures.

Third, a new regime was implemented for the recognition of academic degrees based abroad of the same level and nature (and with the same objectives) as licenciatura (bachelor's), master's and doctoral degrees awarded by Portuguese higher education institutions. This new regime, based on the principle of reciprocal trust, removed a serious obstacle in the form of administrative and bureaucratic procedures, facilitating the free circulation of diploma holders who wished to study in Portugal after obtaining their academic degree abroad.

Finally, a new regime for access to Medicine degrees was created to promote diversity of academic and educational backgrounds for candidates applying for higher
education degrees in this area. It follows practices in many other countries, particularly in the United States. It was specifically designed for undergraduates with a diploma in a related disciplinary field (e.g., biology), thus broadening the areas of training that will permit students to be admitted in a Medicine degree, although guaranteeing an appropriate level of knowledge in the core subjects that are an enrolment condition.

2.7 Facilitating the immigration of qualified people from third party countries

The role of immigration policies to facilitate the development of countries and regions and their systems of higher education is well documented in the literature (e.g., Wit, 2002) and, although of relatively modest intensity, they were also part of the Portuguese reform process. The main focus was, again, on removing obstacles to the free circulation of qualified people, independent of nationality, by avoiding bureaucratic impediments and delays that hitherto existed. The removal of obstacles had a significant effect. According to the Ministry of Foreign Affairs, Portugal granted 648 visas for highly qualified foreigners of about 50 nationalities outside the European region in 2010, in comparison with only 156 when this reform was initiated in 2007. In 2010, this figure included 84 researchers, 171 academics and about 393 business professionals, medical and paramedical practitioners, computer experts, electrical engineers, chemical specialists, legal specialists, liberal professionals, and other highly trained personnel. The time needed by third country nationals to request a visa to enter Portugal was also marginally reduced.

2.8 Promoting an adequate framework for the public expenditure on R&D

The reform was implemented together with a significant increase in the public expenditure on research in association with a established and systemic international assessment of research and development activities (Heitor and Horta, 2011). Public
policy upheld international research assessment exercises as a regular practice, scrutinizing the output of scientific institutions, and concentrating on increasing what is termed “critical mass” by fostering job openings in the science and technology sphere (see also the analysis of Hicks, 2012, and Horta and Lacy, 2011). An associated priority was placed on setting up international partnerships to foster scientific networks and industry-university partnerships, and on strengthening the bonds between graduate education and research (as also recently documented by Patricio, 2010).

The systematic increase in public expenditure had important impacts and generated large spillovers in academia and business communities. For example, recent years saw the emergence of two distinct, but inter-related trends: first, a remarkable increase in business expenditure on R&D (BERD) and university-industry collaboration. BERD rose from 425 million Euros in 2005 to over 1,300 million Euros in 2009. The second trend involved a marked increase in academia’s research capacity, which, taken together with the legal reform of higher education, saw the number of PhD and post-doctoral fellowships rise more than two fold. In general, it can be said that the speeding up in the development of the Portuguese S&T system in the period 2006-2010 went hand in hand with its capacity to attract and train human resources. It clearly bolstered the concentration of researchers across disciplines and built-up knowledge integrated communities with an increasingly marked international outreach (Heitor and Bravo, 2011).

This analysis can be better documented through the various lines of action and programs executed through the Portuguese Science and Technology Foundation (FCT), as the main R&D funding agency in Portugal. These programs focused on people, institutions and ideas, including the advanced training of human resources, scientific employment, public awareness of science, institutional development of research units and their internationalization, project based competitive R&D, and the
consolidation and upgrade of the scientific infrastructure.

The advanced training of human resources included a competitive program of PhD fellowships, which has been considerably enlarged since 2006 to about 2,000 new fellowships per year (it was about 1,000/year in 2005). It also includes a postdoctoral fellowship program, also on a competitive basis. By the end of 2010, over 11,000 fellowships were actively funded (against some 5,000 in 2005), with an overall annual public expenditure of over 160 million Euros. This program has been the backbone base of the Portuguese science public policy in the last decades and continues to have a critical role in qualifying the higher education faculty and promoting the internationalization of Portuguese academia (Horta, 2010).

Scientific employment and the renewal of scientific and academic staff was fostered through a new program launched in 2007 to hire researchers on a competitive basis (five-year contracts), which involved about 1,200 new contracts by Portuguese universities and research institutions by the end of 2010. More than 40% of these contracts were obtained by foreigners, with an overall public expenditure of over 67 million Euros. This program also supported further the internationalization of Portuguese universities, as discussed by Delicado (2010).

In addition, the promotion of R&D and the internationalization of advanced training was strongly fostered through the participation in international organizations (e.g., CERN), the development of bilateral cooperation in science and technology, and the promotion of strategic international partnerships (namely with large international organizations and universities, including MIT, Carnegie Mellon University, UT Austin, Harvard Medical School). The latter have also been a major instrument towards the implementation of thematic networks in S&T (Heitor, 2012 forthcoming).

Institutional development of research units continued to be pursued through a seed-funding program for research units, based on periodic evaluations that started in the mid 1990s. In addition, this line of action was considerably strengthened through a
program of creating and promoting large research units and networks, in the form of “Associate Laboratories”, as described below. Related to these policy instruments, funding competitive research activities has been achieved through the systematic opening of national competitions for funding R&D projects in all scientific areas. By the end of 2010, more than 4,000 projects were active corresponding to an overall public expenditure of 85 million Euros. Also, the improvement of the scientific infrastructure continued to be supported by the funding of a diversified network of physical facilities and equipment, with an overall public expenditure of over 90 million Euros from 2006 to 2010.

Public awareness of science has been promoted in Portugal through a unique network of science centers and related activities; most of them oriented towards children, as developed through the Ciência Viva Agency. With an overall public expenditure on this type of activities of over 15 million Euros in 2010, the systematic development of science projects in schools and other activities for families oriented towards understanding the role of science in daily life as become a major changing factor of Portuguese culture.

2.9 Strengthening R&D institutions

The continuous strengthening of research institutions, including those in higher education institutions, and the adoption of policy measures to foster and strengthen their international relationships, represent key elements in driving the reform of higher education in close interaction with the increasing research capacity. We argue that three major institutional breakthroughs characterize the continuous process of institutional reform and building over the last fifteen years, as documented in Table 1.
### Portugal (1995-2010)

<table>
<thead>
<tr>
<th>Main institutional breakthrough</th>
<th>Rationale for breakthrough</th>
<th>Independent research assessments</th>
<th>Independent higher education assessments</th>
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<tbody>
<tr>
<td><strong>Associate Laboratories</strong>, to foster research excellence through networks of academic research centres</td>
<td>Fostering critical masses, aggregating several R&amp;D groups and attracting new talent, under the direct support of FCT</td>
<td>Every 3 years, since 1996, through the Portuguese Science Foundation (FCT), involving international review panels:</td>
<td>...</td>
</tr>
<tr>
<td><strong>University Foundations</strong></td>
<td></td>
<td>1996/97 exercise</td>
<td>Since 2009, the Agency for Assessment and Accreditation of Higher Education (AIES), through the assessment and accreditation of study cycles in higher education institutions, is impacting their organization (about 1200 courses were discontinued by 2010)</td>
</tr>
<tr>
<td>(includes three leading examples in 2008: University of Porto, University of Aveiro and ISCTE-IUL in Lisbon)</td>
<td>Enable flexible management and organizational mechanisms; institutional autonomy and responsibility of higher education institutions; more responsive institutions</td>
<td>1999/00 exercise</td>
<td>2002/03 exercise</td>
</tr>
<tr>
<td><strong>Research and advanced training networks</strong>, through thematic international partnerships</td>
<td>Networks of research centers across leading Portuguese universities brought together to cooperate with leading institutions worldwide, involving business and industry and end users. These networks are reviewed on a yearly basis.</td>
<td>2000/01 exercise</td>
<td>2004/05 exercise</td>
</tr>
<tr>
<td>(includes partnerships with MIT, CMU, Harvard and UT Austin in emerging themes, including ICT, energy, bioengineering, design, and clinical research)</td>
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In the period 1995-2005, institutional building of research organizations has been initially based on two main pillars. One refers to the “National Research Assessments” that strengthened the network of research centers based or linked to universities. These systematic international research assessments, consistently implemented in Portugal since 1996, are performed every three years with direct impact on research centers funding levels.

The second initial pillar refers to the public support of a Program of “Associate Laboratories”, which were created to promote critical mass and establish a network of relatively large research institutions oriented towards strategic lines of thrust and thematic networks.

By 2010, the network of scientific institutions included 510 research centers (compared to 257 after the first international research assessment in 1996) and 25
Associate Laboratories (the first three were created in 2001), with an overall level of institutional funding of about 85 million Euros in 2010 (25 million Euros in 2000). Associate Laboratories have opened the way for advancing a culture of large scientific institutions in Portugal, grounded in institutional autonomy, sustained by the provision of incentives and stimulated by the continuous application of independent scientific evaluation. They have facilitated the expansion of science-based jobs by recruiting doctorate researchers and technicians. In 2010, Associate Laboratories grew more than 30% in the previous five years, from an average of about 97 to 130 researchers (FTE) per laboratory.

Since 2005, the institutional building of research organizations was heightened by two major new developments: the guarantee of independent legal status in the form of “University foundations”, as granted by law, and the formation of research and advanced training networks, though thematic international partnerships. The university foundations have strengthened academic networks by bringing together university schools, research units, associate laboratories and related private, non-profit institutions, with leading examples in the University of Porto, University of Aveiro, and ISCTE-IUL. The thematic international partnerships fostered critical mass across the Portuguese research landscape in the form of relatively large consortia bringing together leading US research universities, Portuguese universities, research centers, end users, and innovative businesses.

Strengthening the internationalization of higher education and S&T was recognized in the reform process as a way to stimulate the integration of national institutions in emerging scientific networks at an international level (Heitor and Bravo, 2010). In this context, a unique set of international collaborations with leading institutions worldwide has been successfully developed in recent years based on thematic R&D networks, integrating advanced training initiatives and industrial affiliation programs. Projects of interest to Portuguese industry have been launched, especially in stem
cell engineering for regenerative medicine, automotive engineering, sustainable energy systems (via the MIT-Portugal Program), information and communication technologies (via the CMU-Portugal and Fraunhofer-Portugal programs) and interactive digital media (via the UT Austin-Portugal Program).

2.10 Promoting competences on technology commercialization and diffusion oriented towards global markets

Universities worldwide are establishing a range of technology transfer offices and commercialization activities, together with industrial liaison programs, mostly intended to foster entrepreneurial environments and launching technology-based start-ups. Bringing ideas to the market is their main goal. In Portugal this has been particularly promoted by the University Technology Enterprise Network (UTEN).

UTEN involves all Portuguese university-based technology transfer offices, in addition with other scientific institutions and science parks. It has three main objectives: (i) training a highly capable pool of professionals in the area of technology transfer and commercialization; (ii) promoting the institutional building of university-based offices of technology commercialization; and (iii) assisting business development and grant loft landing of university-based startups in international markets. It was launched in 2007 in partnership with the University of Texas at Austin, and later has extended its operations to the other strategic partnerships with the Massachusetts Institute of Technology (MIT), Carnegie Mellon University (CMU) and the Fraunhofer-Gesellschaft. The novelty of the approach in Portugal is that it focused on the process of building a system of competence building driving innovation and the diffusion of knowledge through the economic appropriation of the results and methods of science by society oriented to global markets.
3. Discussion and concluding remarks

It is well known that higher education systems are under pressure to meet demands imposed by a globalised knowledge-society without compromising quality deliverance. Although universities have recognized the need for change for many years, the way institutions are organized, as well as their structure of incentives, have continuously postponed reforms (Enders and De Boer, 2010). As a result, reforms have been mostly conducted by governments. The Portuguese case is no exception to these mounting pressures and change has been recently introduced through governmental actions (Gago and Heitor, 2007).

The lesson of the Portuguese reform shows that while development was rapid in recent years, it has yet to reach a state of maturity of other industrialized countries. The R&D system has gained from a diverse set of policy instruments and programs to fund and foster research, but investment set aside for science ought to continue, if the maturity of the more industrialized countries is the term of reference. For example, expanding and maintaining critical mass, reinforcing the institutional strength of science institutions, stem from the system’s own internal dynamic. Other challenges entail the need to keep investing in R&D, to continue the support to international networks, and to strengthen links between graduate education and research.

Meeting these challenges is critical to ensure the stability of higher education institutions, their autonomy and institutional integrity. In this context, it is worth remembering the argument used by the Chairman of the US Federal Reserve, Ben Bernanke, “…economists have identified some persuasive justifications for government policies to promote R&D activities, especially those related to basic research. In practice, we know less than we would like about which policies work best. A reasonable strategy for now may be to continue to use a mix of policies to support R&D while taking pains to encourage diverse and even competing
approaches by the scientists and engineers receiving support. "

Drawing from this, our main argument is associated to the need to focus on the process of building human capital, which requires adaptable, autonomous and resilient institutions. Critical mass is vital for the creation and dissemination of knowledge, and attaining it is of the utmost importance for all regions, but a focus that is particularly relevant for developing countries. Our evidence and lessons learned are that achieving this ultimate goal requires, per si, policies and strategies towards effective institutional autonomy and integrity of modern universities in a context where alliances and partnerships among universities worldwide, as well as between them and businesses, ought be pursued.

The evidence provided in section 2 indicates the need to give constant priority to people and knowledge contributing to foster networks of institutions with the necessary critical mass to sustain the international standing of scientific and higher education institutions. In this regard, two aspects need to be emphasized.

First, innovation must be considered together with competence building and advanced training in individual skills through the complex interactions between formal and informal qualifications. This requires a broadening of the social basis for knowledge activities, including higher education enrolment, and strengthening the top of the research system leading to knowledge production at the highest level. Figure 1 underlines the importance of having critical mass of researchers to create and reshape knowledge. The most developed regions of the world have high rates of researchers per 1000 labour force (see Japan and the US), and are striving to increase even more those rates (see OECD countries and Europe). With the exception of Russia, all the other regions are striving to attract and increase the numbers of talented people.

Second, strengthening experimentation in science networks necessarily involves flows of people. It is the organized cooperation among networks of knowledge workers and institutions, together with different arrays of users that 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, sophisticated research projects, and a diversified and non-structured array of informal processes of networking (Kitagawa, 2009). This requires public policies to foster “brain circulation” between institutions worldwide.

As this point, we must remember that scientific progress is a source of development and that higher education institutions play a critical role in this process (Geiger and Sá, 2008). Public resources invested under rigorous international assessment
policies lead to new knowledge, better advanced training of human resources for the
society, new ideas and processes, which increasingly result in innovation,
modernization of institutions, improved quality of living, economic productivity and
better employment (see High Level Group on Human Resources for Science and
Technology, 2004).

Consequently, the renovation and expansion of the social basis for scientific and
technological development is paramount. This calls upon strong conviction not only
from the scientific and technical professions and of public and private research
organizations, but also from students and the general population (Heitor, 2008). To
cope with such a variety of demands and with a continuously changing environment,
we all know that the higher education systems, in particular, needs to be diversified.
But the challenge of establishing modern higher education systems requires effective
international networks and a platform of research institutions. They are vital for
stimulating the debate among stakeholders, and assisting constituencies in
promoting the positioning of institutions in the emerging paths of the global brain
circulation.

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