Greek Universities and Knowledge Transfer Performance: Assessment, Implications and Prospects*

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Abstract

Starting from the fact that public R&D consists the majority of R&D spending in Greece, and Universities perform the lion's share of research in terms of scientific output, we assess the Knowledge Transfer (KT) activities of Greek Universities by benchmarking them to peer institutions from European countries that have similar science and technology profiles. To do so, we use publicly available reports on pan-European Technology Transfer Surveys and our complete census of KT outcomes by Greek HEIs (i.e., spin-offs, university patents). We discuss the outcomes of this benchmarking exercise by critically analysing the environmental and systemic factors that affect KT and provide recommendations that could enhance both the quality and the quantity of academia-industry linkages and the national innovation system in Greece. Our results indicate that the outcomes of KT in Greek Universities are lagging, by an order of magnitude, those of comparable institutions in Europe. This is due to the apparent lack of appropriate policies, procedures and structures in support of KT activities, including systematic country-wide measurements of the inputs and the outputs. We were not able to estimate the potential of Greek HEIs in terms of building patent portfolios due to lack of data on invention disclosures, but we assert that the potential of spin-off generation is heavily influenced by the availability of funding through the Structural Funds.
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1 Introduction

As elaborated by Etzkowitz et al. (2000) and Etzkowitz (2003), in the late 20th century universities worldwide are gradually converging into incorporating a 'third mission' of regional economic development in addition to research and teaching, thus becoming 'entrepreneurial universities'. Universities contribute to regional development by four mechanisms: research-driven regional innovation; promoting enterprise, business development and growth; human capital development and social equality enhancement through regeneration and cultural development. For each type of intervention, there exist several approaches that are followed, or can be followed, which can vary in terms of complexity and in their expected impact (Goddard 2011).

Knowledge (or Technology) Transfer (KT) is one of the above mechanisms that has consistently led to a increase in the rate of commercialization of university-based technologies through patenting, licensing and the establishment of spin-off companies (Link et al. 2003). Most researchers attribute this increasing trend of KT activities to the Bayh-Dole Act of 1980 in the U.S.A. which instituted a uniform patent policy and removed restrictions on licensing, while it allowed universities, except from the government, to own the patents coming from federal research grants (Colyvas et al. 2002, Grimaldi et al. 2011, Mowery et al. 2004). Knowledge Transfer Offices (KTOs), which according to Anderson et al. (2007) are the most important stakeholders in defining

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universities' entrepreneurial activity, were established with a view to promote and re-enforce university-industry collaboration, being the formal gateways to the exploitation of university-developed knowledge through invention disclosures, patent applications, licenses and spin-offs, the so-called "commercial outputs" (Thursby & Thursby 2002). A Society of University Patent Administrators was founded in 1974 in the U.S. to promote the public use of research: it was rebranded later as the Association of University Technology Managers (AUTM) claiming today 350 institutional members.

A similar increase in academic entrepreneurship has been recorded in Europe as well, especially after the term 'European Paradox', i.e. the conjecture that EU countries play a leading global role in terms of top-level scientific output, but lag behind in the ability of converting this strength into wealth-generating innovations, was coined by the European Commission in 1994 (Dosi et al. 2005, 2006). There is plenty of evidence that the European Commission, the Member States and Universities in Europe have been trying to catch up with the U.S. in terms of legislation–including intellectual property rights regimes, strategies, policies, interventions and practices (European Commission 2004, 2008, 2009, Geuna & Rossi 2011, OECD 2003). Organisations similar to AUTM were also established in Europe, such as the Association of European Science and Technology Transfer Professionals (ASTP) in 1999 and the Public Research Organisations Transfer Offices Network-Europe (ProTon Europe) in 2005.

As expected, these activities have also caught the attention of scholars and several review papers summarise the research on various aspects of university technology transfer (Djokovic & Souitaris 2008, Rothaermel et al. 2007, Siegel et al. 2007).

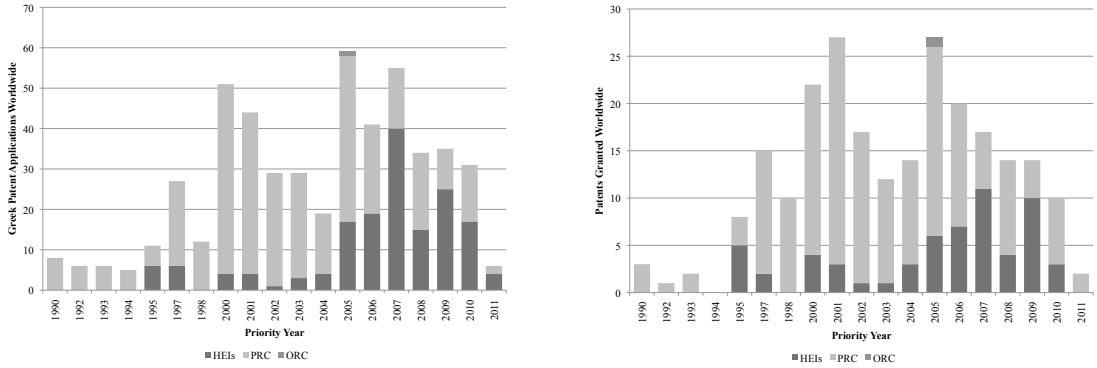
The objective of this paper is to estimate the potential of university technology transfer in Greece and discuss the determinants that might transform this potential into high-valued outcomes, both for the universities and the Greek economy. As far as we know, this is the first attempt to do so in Greece, a country whose innovation system exhibits certain unique characteristics with respect to other EU/OECD countries: over-reliance on EU funding for Gross Expenditure on R&D (GERD)–most of which is consumed by higher education institutions–while business expenditure on R&D (BERD) is very weak and one of the lowest in the OECD/EU countries; very weak academia-industry links and low-profile support for technology transfer (Grant et al. 2011); limited, if any, return on investment in R&D (Komninos & Tsamis 2008); an immature technology transfer market (Fafaliou et al. 2010); several highly competent research groups in terms of securing EU funding under increasingly competitive terms (Protogerou et al. 2010). The stakes are high for Greek Universities: by consistently producing approximately 70% of the country's output in scientific publications during the last decade (National Documentation Centre 2010) while consuming 50% of GERD, they can become the major lever for knowledge-led economic development in Greece.

The rest of this paper is structured as follows: in Section 2 we describe our benchmarking exercise, the selection of peer countries and KT indicators, the data that we have used and their sources. Then, in Section 3 we use the outcome of this exercise to quantify the potential of Greek Universities in terms of KT outputs and put it in perspective with what is already known in the literature regarding the determinants of successful university technology transfer–university technology transfer policies, size and maturity of the KTOs, university characteristics–with data that we have compiled. Finally, in Section 4 we present our concluding remarks.

2 Methodology

2.1 Approach

When we started the research project that lead to this paper, we tried to apply, for the first time as far as we know, the European Commission's methodology (European Commission 2009) for measuring the knowledge transfer activities of Greek HEIs and understanding which are the main factors that influence the outcomes. During the autumn of 2011, it became clear that we would not be able to collect complete and correct data from HEIs. This indicates a serious deficiency in the way knowledge transfer is managed in Greek HEIs and lead us to review the Greek context in terms of the key institutional enablers identified in the literature: government policies, the HEIs mission and the policies put in place to achieve their mission (Friedman & Silberman 2003, Siegel et al. 2007, 2003) and the operation of KTOs as intermediary agents (Caldera & Debande 2010).



(a) Patent applications (b) Patents granted

Figure 1: Patenting activity of Greek HEIs/PRCs per priority year.

We base our arguments on evidence collected through publicly available, but highly unstructured data (see Section 2.2). We calculate the key KT performance indicators for Greece for year 2009 to fill the void of comparable metrics between Greece and the rest of Europe and we benchmark Greece with two other countries, namely Italy and Ireland, based on the evidence provided in the EU Competitiveness Report 2011 (European Commission 2011).

Finally, using the data we have compiled, the analysis of the operating context of Greek HEIs and the results of our benchmarking exercise, we estimate the prospects of knowledge transfer in Greece and elaborate our recommendations.

2.2 Data Sources

We used publicly available data to approximate the knowledge transfer activities of Greek HEIs since it seems that is no formal mechanism to collect standardised, and therefore comparable, measurements of KT activities.

The number of the faculty members, undergraduate and graduate students and PhD candidates in each HEI was obtained by the official figures provided by the Greek Statistics Authority (EL.STAT), which also provides detailed data per department. The number of research publications per year was collected from Thomson/Reuters' Web of Science and National Documentation Centre (2010), which also provided the academic profile of each HEI in terms of its scientific publications.

With regard to the year of establishment of Knowledge Transfer Offices, we consulted their respective websites. Using the same source, we collected staffing data.

Invention disclosures could not be calculated since no relevant data are publicly available.

Regarding the number of patent applications per HEI per year, we searched the databases of the European Patent Office (espacenet) for worldwide patents having as applicant one of the Greek HEIs using their official names in English. We did the same with the databases of the Greek Industrial Property Organisation (OBI) and combined the results accordingly. We also did the same for the Greek Public Research Centres (PRC). The aggregate results are shown in Fig. 1 and discussed later in Sec. 3. We used the same data to calculate the active patent portfolio per HEI.

To measure the number of spin-offs per HEI we tracked all the companies that received funding from the PRAXE-B programme, a measure to stimulate the establishment of knowledge-intensive new firms that run from 2001 to 2006, and its successor programme, in place since 2009. Both were administered by the General Secretariat for Research and Development (GSRT). We classified the firms as university spin-offs or as newly established knowledge-intensive firms by reviewing their charters of incorporation, which are available from the Official Journal of the Government of the Hellenic Republic (OJGHR), for explicit references to licensing agreements between them and the HEIs. From the same source (OJGHR) we collected the annual balance

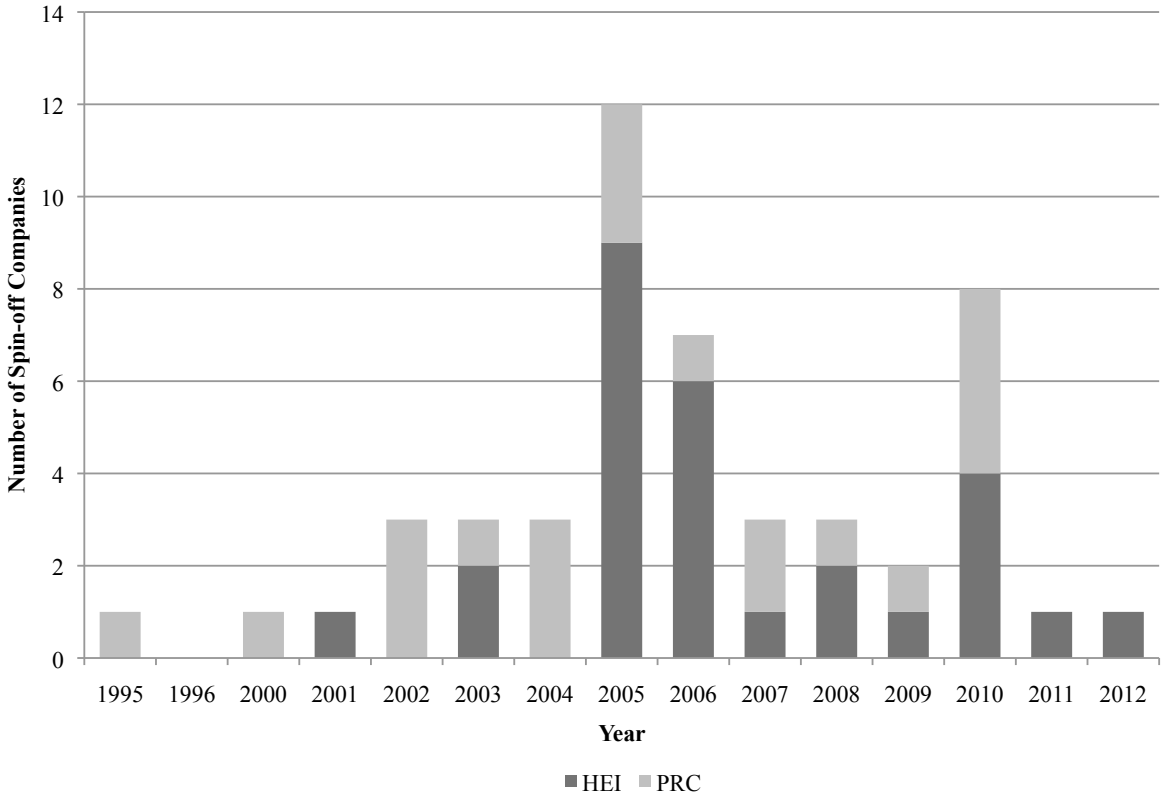


Figure 2: Spin-off establishment activity of Greek HEIs and PRCs.

sheets of all spin-offs and used the reported annual sales to estimate the HEIs licensing revenues since the latter do not report such figures. The summarised results are shown in Fig. 2 and discussed later in Sec. 3. We used the same data to calculate the number of active spin-offs at the end of each year.

3 Results and Discussion

3.1 The Context of Greek HEIs KT Activities

3.1.1 Legal Framework

The modern legislative framework for Greek HEIs was based on Law 1268/1982 that included "contributing to addressing the country's social, cultural and developmental needs" as one of the three parts of the mission of Greek HEIs. This was amended by Law 3549/2007 to include "...by following the principles of sustainable development and social cohesion" but it was Law 4009/2011 that explicitly added knowledge transfer in the mission of Greek HEIs, by including, in Art. 4, the following statement: "...to promote the diffusion of knowledge, the exploitation of research results and innovation by following the principles of scientific ethics, sustainable development and social cohesion". Therefore, the Greek version of the entrepreneurial university was officially born in late 2011.

In May 1981, Presidential Decree 432/1981 authorised the establishment of the so-called "Special Accounts for Research Funds" within Greek HEIs and the Research Committees (RCs) whose mission included the elab-

oration of the HEIs research strategy and policies. This Decree was amended in August 1996 to authorise the RCs to elaborate special policies for technology transfer, especially in terms of exploitation of research outcomes (patents, software, devices, etc) and the remuneration of the holders of appropriate IPRs. Therefore, although knowledge transfer was officially included in the mission of Greek HEIs in 2011, the RCs, being the organisational units in charge of elaborating the institutions' research and technology policy, had been authorised to develop KT policies approximately 15 years earlier. The RCs did not exercise this right until January 2001, the date when the Presidential Decree 17/2001 was introduced. This piece of legislation aimed to stimulate the development of novel entrepreneurial activities by commercialising the knowledge produced by private- and public-sector research. It authorised HEIs (and other public-sector organisations) to acquire equity stakes up to 50% in such enterprises, set a framework for establishing licensing agreements between the newly established knowledge-intensive firms and HEIs and Public Research Centres and also authorised faculty members to own minority equity stakes in them[1].

Judging from the data presented in Figs. 1a and 2, this piece of legislation can be considered as being the equivalent of the Bayh-Dole Act in Greece. The RCs, overwhelmed by enquiries of interested faculty members, soon discovered that they should urgently review the HEIs policies on KT, develop licensing policies and contract templates and instutionalise royalty-revenue sharing mechanisms.

The legal framework for IPR in Greece is based on Law 1733/1987. Article 6 defines when invention disclosures should be made and suggests that employers should share the value captured by commercialising an invention with the inventors. It also states that ownership of IPRs depends on the kind of the employment relation between the inventor and the employer. Three different categories of inventions are defined: (a) Free inventions, made outside the inventor's terms of employment, belong to the inventor, (b) service inventions, made wholly within the terms of an inventor's contract, thus belonging to the employer, and (c) dependent inventions, made outside the inventor's terms of employment but making use of information materials and/or equipment that belongs to the employer. In this case, the employer owns 40% and the inventor owns 60% of the invention. However, there seems to be a disagreement, even among HEIs, whether faculty inventions are service or dependent inventions. Although most studies classify the Greek IPR regime as weak institutional ownership, e.g., Geuna & Rossi (2011) (p. 1070), the majority of the HEI policies we have reviewed (see Section 3.1.2) acknowledge that the inventors own 60% of the IPRs, a *de facto* partial application of the professor's privilege.

3.1.2 KT Policies

University research creates, among others, novel approaches in doing things and solving problems, thus creating potential for competitive advantage to the industry. Given that knowledge transfer is explicitly included in HEIs mission statement, adequate policies, structure and processes need to be developed, become aligned to the HEIs research strategy and exploit the complementarities between KT, teaching basic and applied research (Debackere & Veugelers 2005, European Commission 2004, 2008).

To understand the level of sophistication of the Greek HEIs' KT related policies we thoroughly searched their websites for evidence of documented policies and processes regarding invention disclosure and assessment, patent applications, IPR ownership–including the cases of multi-partner projects, licensing, royalties, spin-off creation, equity shares, incentives and motives for faculty and KTO staff. These constitute the minimum set of prerequisites for any type of KT activity. Of the 12 criteria that we used to measure KT policy sophistication, we have seen evidence for 10 in AUTh, 9 in 2 HEIs (TUC and DUTh), 7 in 2 HEIs (UPatras and NTUA) and 6 in other 2 HEIs (UoA and UoC). However, in most cases, the evidence was just the repetition of legal framework. The most recent addition were NTUA's 2011 policies on spin-offs and inventions.

Only 3 (14.3%) HEIs have published their KT-related policies in the form of a single document (AUTh in 2006, TUC in 2008 and DUTh). AUTh's guide covers most of the topics that we checked and clearly states the university's policies on all aspects of KT. It is referenced by almost all other KTOs in Greece. However, it seems that it hasn't been updated ever since to cover more recent developments and EU guidelines.

[1]The rules of engagement of faculty members with spin-off companies were set six months later with Art. 11 of Law 2919/2001 and later amendments. Faculty members can own minority equity shares but cannot hold management positions in such companies.

Procedures to deal with invention disclosures and their subsequent assessments are provided by 6 HEIs (28.6%), but no performance data on this critical aspect of the KT activity are provided.

All HEIs do not seem to have adopted policies on providing performance-based incentives to the KTO staff (i.e., bonuses and other kinds of rewards), faculty members (KT outcomes consideration upon promotion or tenure decisions) and research groups (royalty-sharing schemes with departments or laboratories). All three are found to be positively associated with a HEI's KT performance (Rothaermel et al. 2007).

3.1.3 KTOs

As mentioned earlier, the HEIs' Research Committees were, according to legislation introduced in 1996, the organisational units in charge of KT activities in Greek Universities. In May 2005, seven HEIs (NTUA, UTh, DUTh, AUTh, UAegean, TUC and AUEB) received funding from the Operational Programme "Competitiveness" 2001-2007 to introduce KTOs as separate units within their RCs. They were followed by the remaining HEIs very soon, together with all the Greek Public Research Centres. A total of €6m was spent for developing or upgrading KTOs within HEIs' RCs until 2009.

KTOs constitute the main institutional units responsible for the transfer of research activities generated at HEIs, while university researchers are expected to disclose their inventions to them. The mission of Greek KTOs is defined by Law 4009/2011, Art. 60. They are expected to support and facilitate the consolidation of IPR of the institution, to promote communication and cooperation between researchers and enterprises for the exploitation of research conducted in universities and to promote innovative student ideas with commercial prospects.

We managed to collect RC staffing data for 19 out of 21 Greek HEIs. They collectively employ 422 people with the median being 22. Only 7 HEIs report their KTO headcount: they employ 16 people for KT activities (average 2.28, median 2) when their total RC headcount is 257. Clearly, these figures do not depict the actual number of staff engaged in KT activities since the latter also benefit from staff working within the legal and marketing functions of RCs. Unfortunately, there is no evidence of the professional qualifications of RC/KTO staff in all Greek HEIs and therefore we cannot make any judgement whether the suggestions of European Commission (2004) are fulfilled.

3.1.4 The macroeconomic environment

Greece was one of the OECD countries having experienced rapid growth development during the beginning of the 2000s, with GDP growth rates to be 1-2% higher than the European average while its labour productivity has been improved by 3.5%, over the period 1995-2004, a percentage that was 2% higher than that of the European average (OECD n.d.). Despite this accelerated development, the country has not succeeded to acquire sustainable productivity growth over the long term so as to gain competitiveness. Low interest rates were the motors for high growth until 2009, when the global financial crisis revealed major fiscal and structural weaknesses.

According to the most recent European Innovation Scoreboard (2011) Greece presents a weak overall innovation performance, holding a position in the group of "moderate innovators", still being well below the EU average.

The Greek R&D system is heavily dependent on EU structural funds, with EU supporting about 18% of research activity (Grant et al. 2011) in an attempt to enhance research and innovation capacity in the country. More specifically, over the period 2007-2013 Greece was expected to spend about €4bn on innovation, enhancing the business environment, emphasizing on R&D innovation and building stronger linkages between the public and private sector.

During the last decade R&D intensity in Greece has been rather stable at 0.58% of GDP, whereas the private sector still remained less active with BERD being 0.16% of GDP-being one of the lowest in the OECD/EC (Grant et al.,2011). This indicates low demand for research-based knowledge from enterprises. Also, constrained access to capital and the absence of motives for firms to invest in research and innovation are among the factors discouraging the dynamic presence of private sector. The fact that companies in Greece present relatively low

Table 1: Knowledge Transfer Outcomes of Greek HEIs (1996-2011)

	Spin-offs	**Patent Applications**	**Active Patent Portfolio**
Univ Thessaloniki (AUTh)	5	69	29
Univ Patras (UPatras)	4	42	17
Univ Athens (UoA)	6	23	4
Natl Tech Univ Athens (NTUA)	3	11	5
Univ Crete (UoC)	2	8	4
Univ Thessaly (UTh)	4	1	1
Athens Univ Econ Bus (AUEB)	2	0	0
Agr Univ Athens (AUA)	1	0	0
Univ Thrake (DUTh)	0	9	0
Tech Univ Crete (TUC)	0	3	1
Univ Ioannina (UoI)	0	1	0
Univ Aegean (UAegean)	0	1	0
Public Research Centres	21	310	165

levels of R&D expenditure (BERD) can be somehow explained. The Greek industrial sector consists of small firms, which most of the times lack the resources for improved R&D performance. The lack of R&D activity and expenditure in the majority of Greek enterprises is revealed in the type of innovation activity they tend to engage in, since an obvious asymmetry between knowledge and innovation creation and adoption is observed. In fact, an adoption/diffusion focused strategy towards innovation is not in the priorities of Greek businesses that regard innovation as an integral part of their competitive strategy. A developed adoption strategy implies relations between technological sources, talented and skilled human capital capable to understand and use the existing knowledge and technology effectively (Komninos & Tsamis 2008).

On the other side, about half of all research activity in Greece (47%) is generated by the HEIs while only 31% of research is performed by the business sector (Grant et al., 2011). Universities acquire know-how and generate absorptive capacity, nevertheless they are away from the market demands and they seem not to have the skills to launch product innovations in the market. Therefore, since most of the research activity in Greece is conducted within the HEIs, Greek businesses could benefit by establishing and growing links with HEIs for the benefit of both parties.

In general, the Greek national innovation system has been developed faster than the EU on average, fostering scientific value and technological competence. With regard to scientific production, Greece approaches to the EU average values accounting for 438 co-publications per million population against 491 for the EU average. In addition, Greece is above the average in the scientific publications within the top 10% most cited publications globally as a percentage of total publications of the country. The aforementioned indicate that Greece research is of a good quality (Grant et al. 2011) and imply some potential of knowledge-led economic development and progress.

3.1.5 KT Outcomes

The key KT outcomes of Greek HEIs in the period between 1996 and 2011 are summarised, per HEI, in Table 1. Patent applications cover all patent offices. The aggregate distribution of the patent applications per priority year of the first application was presented in Fig. 1a. This means that the actual distribution of the patent applications per year might be slightly different. The active patent portfolio of each HEI includes all patents that were active on 28 September 2012.

The majority of the KT outcomes, in terms of spin-off establishment and patenting activity, occurred after 2001, the year when the Presidential Decree 17 came into force. Spin-off establishment activity is highly cor-

related with funding from PRAXE-B, running from 2003 to 2007 and its successor programme that started in September 2009 and kept accepting funding applications until June 2010. The two peaks in Fig. 2 are consistent with this observation. It is clear that the combination of P.D.17/2001 and PRAXE-B were the necessary condition to unleash the entrepreneurial activity of Greek HEIs. However, since we were not able to locate an ex post evaluation of this programme, we cannot explain the reasons that lead to the decline of HEIs spin-off funding that is evident since 2009 in Fig. 2. Three plausible explanations are that all interested faculty members have already set-up their spin-offs, or that public-research centres were able to produce more feasible business plans, or that GSRT has shifted their focus to funding newly established knowledge-intensive firms and not spin-off companies.

The overdependence of spin-off activity on the availability of funding through Structural Funds is a direct consequence of an underperforming private equity / venture capital market which is evident by reviewing the activity of Greek PE firms in 2009 (EVCA 2011): venture investments were €15m in 4 domestic companies: two were start-ups in the fields of energy/environment (€150.000) and life sciences (€5m) and two later stage ventures (€9.9m). None of them were high-tech. No VC activity was reported for 2010. Therefore, the only real alternative in the absence of funding by Structural Funds is relying on own or family savings to start a spin-off (or a start-up).

The patenting activity of Greek HEIs is very low. According to the WIPO Statistics Database (WIPO 2011), Greek organisations and individual inventors submitted 9928 patent applications worldwide in the period from 1996 to 2010. The share of Greek HEIs in this figure is, according to our data, only 155 applications (1.6%). In a similar fashion, only 55 out of the 5489 patents (0.98%) granted worldwide to Greek organisations or individuals between 1996 and 2010 belong to Greek HEIs, and 6 of them have already lapsed. Most of them were granted by OBI, the Greek Patent Authority. It should be noted that we have identified a considerable number of patent applications and patents whose inventors are active HEI faculty members. In approximately half of these cases, the inventors were also the applicants, while in the rest of the cases the applicants were spin-off companies where the faculty members have direct or proxy equity shares. Since our search was not exhaustive, we cannot estimate the total patenting activity of *both* the HEIs *and* their faculty members, but such cases indicate that either HEIs do not fully enforce their IPRs or they underestimate the commercial potential of invention disclosures made by their staff and choose not to proceed with applying for patents. Given that no invention disclosure data are available, the supply-side–the inputs to the patenting activity within Greek HEIs cannot be measured and therefore the KTO efficiency cannot be calculated. As noted by Geuna & Rossi (2011), the creation of an infrastructure for knowledge transfer involving an active role of universities and not IPR ownership is the key determinant of increasing enforcement of IPR ownership on the part of universities. Moreover, contrary to the suggestion by Friedman & Silberman (2003) that KTOs age matters since successful KTOs need to build a qualitative portfolio of inventions, which is time intensive, KTO age in Greek HEIs seems to be rather irrelevant to their patenting performance and to the size of their patent portfolios.

Given that HEIs do not report licensing revenues, we cannot elaborate any measure of the commercial impact of their patents. However, to gain an insight of the potential of their licensing revenues we used the turnover of their spin-offs as a proxy. We were able to find, through public sources, the balance sheets of 12 out of 19 spin-offs for the F.Y. 2009. Their aggregate revenues were €3.06m̃ with AUTh's 3 spin-offs in our sample to contribute 53% of this sum, followed by UoA (3, 22.2%), AUA (1, 15.3%), UPatras (3, 5.2%), AUEB (1, 4.3%) and UTh (1, 0.1%). Although the specific terms of the licensing agreements between the HEIs and their spin-offs are not known, and we cannot be sure which part of their revenues comes from licensed IPRs, we can only set the upper limit of the HEIs total licensing revenues from spin-offs, for FY 2009, to be in the range of €100.000, a very marginal contribution to their annual budgets. This might partially explain the HEIs apparent reluctance to actively engage into KT activities in a systematic manner. From the data provided by the ProTon Europe 7th annual survey (Piccaluga et al. 2011, Tables 5.4, 6.7 and 7.3), KTOs in Europe have average annual budgets of €421.000, average annual IPR expenditure[2] of €160.700, and average licensing revenues of €262.300. These indicate that European KTOs invest in KT with a long-term perspective, despite the short-term deficits from the KT activity.

Only 12 out of the 21 HEIs that we have examined have produced some kind of KT activity. Three of them,

[2]IPR expenditure includes the external fees paid for patent applications, maintenance and prosecution.

Table 2: Key selected variables of the national innovation systems of Italy, Ireland and Greece (European Commission 2011, Table N.P.1.1).

	R&D Intensity (%), 2009	BERD (%), 2009	GOVERD (%), 2009	EPO patent applications per mil pop, 2007
Italy	1.27	0.64	0.27	86
Ireland	1.77	1.17	0.08	67
Greece	0.58	0.16	0.12	10
EU	2.01	1.25	0.27	117

Universities of Athens (UoA), Thessaloniki (AUTh) and Patras (UPatras) have established 55% of the HEIs spin-off companies, submitted 80% of the HEIs patent applications worldwide and hold 82% of the Greek HEIs active patent portfolio. They collectively employ 47.41% of the faculty of Greek HEIs, have the 48.24% of the population of PhD students and have produced 45% of the Greek output of scientific papers in 2009. It is clear that the output of the Top-3 is disproportionally higher than their resources and the reasons that lead to their performance should be further investigated. For all of them, the KT-policy sophistication score that is reported in Section3.1.2 is higher than the country average.

3.2 Benchmarking Greek KT outcomes

The Innovation Union Competitiveness Report of 2011 (European Commission 2011, p. 433–438) provides an interesting classification of the EU member states using two variables: the knowledge capacity and the importance of the manufacturing industry in their innovation systems. Under this classification, Greece belongs to a group characterised by medium-low knowledge capacity with a strong role of agriculture and low knowledge-intensive services. This group also includes Latvia, Lithuania and Malta. There exist no published data regarding the KT outcomes in countries of this group, a void that this partially addressed for Greece with this paper. However, Piccaluga et al. (2011) provide country-specific data for Italy and Ireland which share a single dimension in this classification with Greece while they exhibit approximately the same deviation in the other dimension. Specifically, Italy is classified in a group characterised by medium-low knowledge capacity (slightly higher than that of Greece), but with an important industrial base. In a similar manner, Ireland (together with Luxembourg, the Netherlands, Norway and Iceland) belongs to a group characterised by medium-high knowledge-capacity innovation systems with an economic specialisation in knowledge-intensive services and similar importance of manufacturing with Greece. Table 2 shows a summary of key selected variables that characterise the innovation systems of these countries.

Italy's economic growth averaged only 0.8% in the period 2001-2008. GDP contracted as the Euro zone and world economies slowed, decreasing 1.3% in 2008 and 5.2% in 2009 largely due to the global economic crisis and its impact on exports and domestic demand. GDP recovered only part of the ground lost, growing 1.2% in 2010. In 2011 GDP grew 0.6%. The country has increased its R&D intensity from 1.05% of GDP in 2000 to 1.27% in 2009, at an annual rate of 2.3%, but it was still lagging behind the EU average of 2.01% of GDP. During the same period BERD increased rather marginally, with small contributions from both the public and the private sector. In 2009, BERD accounted for 0.64% of GDP while the EU average was 1.25%. In general, Italy's R&D and innovation system presents positive and negative characteristics. With respect to its innovation system Italy, has been ranked below the EU average as a "moderate innovator". Several policies have been tried to enhance research and innovation, but there exist several structural weaknesses, especially within the industrial sector, that do not enable the accelerated development of the country. Italian Universities are ranked above average in the percentage of scientific publications within the 10% most cited publications globally. while the country demonstrates significant activity in terms of patent intensity (86 patent applications in 2007) being at a higher level than in analogous knowledge-based countries such as Czech Republic, Slovenia, Slovakia and Hungary (16, 51, 8 and 17, respectively). In other words, Italy has an important industrial base, but structural changes

Table 3: Knowledge Transfer Performance Indicators (2009)

	Italy $n = 57$ or 69	**Ireland** $n = 26$	**Greece (Top 3)** $n = 21(3)$	**ProTon** $n = 320$
Average KTO age (yrs)	5.9	5.1	11.4 (13)	14.0
Total KTO staff (FTE)	186.7	83.1	16 (4)	1151.8
Average KTO Staff (FTE)	3.7	3.6	2.28 (2.0)	7.8
Total Disclosures	400	455	n.a.	6039
Average Disclosures	8.7	17.5	n.a.	19.9
Total priority patent applications	243	150	25 (23)	3227
Average priority patent applications	**5.0**	**6.0**	**1.13 (7.67)**	**10.6**
Total Patent Portfolio	2541	1025	51 (48)	21310
Average Patent Portfolio	**52.9**	**41.0**	**2.42 (16)**	**70.6**
Total licenses/options	65	100	n.a.	4872
Average licenses/options	1.5	4.2	n.a.	16.4
Total licensing revenues (M €)	1.5	n.a.	n.a.	70.6
Average licensing revenues (k €)	**33.1**	n.a.	n.a.	**262.3**
Total spinoffs yearly created	70	33	1 (0)	473
Average spinoffs yearly created	**1.2**	**1.4**	**0.05 (0)**	**1.5**

(i.e., increased R&D intensity) towards a more knowledge-intensive especially in the traditional manufacturing sectors, which constitute the major motors the Italian economy, are required (European Commission 2011).

Until 2008, Ireland boasted one of the most vibrant, open economies in the world, often called the "Celtic Tiger" due to a liberal industrial policy that was fuelled by Foreign Direct Investment in the 1990s. Average GDP growth rates were approximately 5% between 2004 and 2007 until a slowdown was experienced in 2008. The overall R&D intensity increased from 1.45% of GDP in 2008 to 1.77% in 2009, with BERD being 1.17% in 2009. The Irish research and innovation system performs quite well, supported by R&D investments which remain a priority for the country to enhance its productivity and maintain its competitiveness. In addition, this satisfactory degree of performance enabled Ireland to be among the European countries with strong scientific and technological performance, and simultaneously reach values closer to the EU average (European Commission 2011). Another important point that should also be cited is that in 2006 Enterprise Ireland started a five year programme to strengthen and support the Ireland's KT system. The aim of this programme was to increase the level and quality of IP produced by HEIs and also to enable the development of effective systems and policies so that IP is well-protected and transferred into Irish enterprises. As a result, a considerable increase in KT activities was noticed between 2007-2010. Moreover, between 2007 and 2010, more than 80% of the IPRs produced by Irish HEIs was transferred to Irish firms (Enterprise Ireland 2011).

Although Greece is by no means comparable to both Italy and Ireland, we benchmark, in Table 3, its KT performance indicators versus those of these two countries in an attempt to highlight the gap in the normalised indicators, shown in bold face. Clearly, for reasons beyond the scope of this paper, Greece cannot be expected to develop a manufacturing base like that of Italy's. More probably, Greece might be able to upgrade its knowledge capacity and develop stronger linkages between the academic sector and industry, the latter not necessarily operating in Greece.

From Table 3 it is evident that the patenting activity in terms of average priority patent applications of Greek HEIs is an order of magnitude lower than that of all the respondents of the pan-European ProTon survey (Piccaluga et al. 2011) and considerably lower than those of Italy and Ireland. In the same year, the top 5 KTOs in Ireland and Italy filed 67.3% and 40.7% of the total priority patent applications, respectively, versus 100% for their Greek counterparts. This means that patenting activity in both Italy and Ireland is more or less widespread among HEIs, while in Greece the opposite is true. The metrics might not be totally comparable since the ProTon survey counts patent applications filed to both national and international (i.e., EPO and USPTO) patent

offices. Of the 21 priority patent applications from Greek HEIs in 2009, 7 of them were filed only in Greece. Our data indicate that 81% of the Greek HEIs did not file a single patent in 2009, while the same figure for the participants in the ProTon survey was 31.3%. Since there are no timeseries available for all three countries, we cannot comment on the fact that Italy and Ireland exhibit similar performance in this metric in 2009. We cannot estimate whether there is potential for improvement in Greece since no disclosure statistics are available.

In a similar manner, the average patent portfolio of Greek HEIs is very small when compared to both Italy and Ireland. The active patent portfolio for Italian KTOs has grown by 38% between 2007 and 2009, while there are no data available for Ireland. These figures should be considered having in mind that the average age of KTOs in these countries were 6 yrs in Italy and 5 yrs in Ireland, while Greek HEI KTOs were formally introduced between 2005-2007 as distinct organisational units within the HEIs' Research Committees. Moreover, by examining the portfolios of Greek HEIs, we did not identify patterns of portfolio-building along a particular technology path.

The average number of spin-off companies created per KTO per year is reported by ProTon Europe to oscillate between 1.4 and 1.8 in the period from 2005 to 2009, with Greece's performance being 10 times lower. The total number of active spin-offs on 31 December 2009 managed by 285 KTOs in Europe was 2857 (Italy: 743), while the same number for Greece was 29, of which 20 belonged to HEIs. All of them have their primary place of business very close to the licensing institution's location, a pattern that also happens in Italy (Italian Trade Commission New York 2009, pp. 17–19). As already discussed, spin-off activity in Greece is highly correlated to funding availability through the Structural Funds. There is clear evidence that demand is higher than the available funds. From September 2009 to June 2010, 158 proposals for spin-offs and new knowledge-intensive ventures were submitted to GSRT requesting funding that exceeded €103m versus the €25m that were earmarked for this purpose. Only 41 of them succeeded, covering 58% of the available budget. This suggests that although demand is strong, lack of funding will probably inhibit the establishment of approximately 25 spin-offs per year in the near future, as required to meet the EU average.

4 Conclusions and Recommendations

Until 2011, knowledge transfer was not explicitly included in the mission statement of Greek HEIs. As a consequence, most of them have not adopted concrete policies on every aspect of KT activities. This requires urgent action towards elaborating, among others, policies and / or procedures for invention disclosure, IPR ownership, royalty-sharing schemes, equity stakes in spin-offs, incentives for faculty to engage into KT activities and others. The best practices that have been identified at the European level and the guidelines provided by the European Commission (2008) should be carefully reviewed and adapted to the Greek environment.

Most of the Greek KTOs have been established between 2005 and 2007 and therefore their maturity remains rather low. It seems that some of them were able to build on the experience gained since 2001 by the Research Committees they belong to, but the majority seems to need more time to develop their activities. It is obvious that the experience gained by the top performing HEIs should be systematically disseminated. Given that in most cases the costs of operating a KTO are considerably larger than the medium-term benefits, an organisation similar to NETVAL, the Italian network for the valorisation of University Research, might be a good solution for obtaining economies of scale and aggregating the geographically dispersed experience.

We have seen very limited evidence of systematic management of the KT process in Greek HEIs. KTOs do not measure and report the inputs, outputs and outcomes of their KT activities. ADIP, the Quality Assurance and Accreditation Agency of Greek HEIs that was established in 2005, might probably be the right vehicle for standardising data collection and providing annual reports.

Although we have observed very positive and encouraging trends in patent applications since 2005, in absolute and normalised terms the number of patent applications by Greek HEIs constitutes a very small share of the country's patenting activity. Moreover, it seems that they are lacking an orchestrated approach towards building patent portfolios in specific areas. That might lead to fragmented portfolios with very limited impact factor. It is clear that an underlying technology strategy per HEI, building on the HEIs strengths, could help the proper alignment of the HEIs patenting activity.

One of our major observations is that proper legislation, i.e., Presidential Decree 17/2001, and innovation

measures, i.e., PRAXE-B, have actually helped HEIs to unleash their KT potential. Such interventions should continue in terms of supply-side incentives and linkages of KT activities and performance to research funding, thus providing motivation to researchers and HEIs to consider and engage into KT activities.

Finally, the reasons that lead to the superior performance of the Top-3 Greek HEIs in terms of KT should be carefully researched, documented and disseminated. Given that the Top-3 HEIs operate in essentially the same environment as the rest, the factors that have influenced their superior performance could lead to very usable insights.

References

Anderson, T. R., Daim, T. U. & Lavoie, F. F. (2007), 'Measuring the efficiency of university technology transfer', *Technovation* **27**(5), 306–318.

Caldera, A. & Debande, O. (2010), 'Performance of Spanish universities in technology transfer: An empirical analysis', *Research Policy* **39**(9), 1160–1173.

Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R. R., Rosenberg, N. & Sampat, B. N. (2002), 'How do university inventions get into practice?', *Management Science* **48**(1), 61–72.

Debackere, K. & Veugelers, R. (2005), 'The role of academic technology transfer organisations in improving industry science links', *Research Policy* **34**, 321–342.

Djokovic, D. & Souitaris, V. (2008), 'Spinouts from academic institutions: a literature review with suggestions for futher research', *Journal of Technology Transfer* **33**(3), 225–247.

Dosi, G., Llerena, P. & Labini, M. S. (2005), Science-technology-industry links and the "european paradox": Some notes on the dynamics of scientific and technological research in europe, LEM Papers Series 2005/02, Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy.
URL: *http://ideas.repec.org/p/ssa/lemwps/2005-02.html*

Dosi, G., Llerena, P. & Labini, M. S. (2006), 'The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'european paradox", *Research Policy* **35**(10), 1450–1464.

Enterprise Ireland (2011), 'Technology Transfer in Ireland 2007-2010'.
URL: *www.enterprise-ireland.com/ResearchInnovate*

Etzkowitz, H. (2003), 'Research groups as 'quasi-firms': the invention of the entrepreneurial university', *Research Policy* **32**(1), 109–121.

Etzkowitz, H., Webster, A., Gebhardt, C. & Terra, B. R. C. (2000), 'The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm', *Research Policy* **29**, 313–330.

European Commission (2004), Improving institutions for the transfer of technology from science to enterprises, Expert Group Report Best Project ITTE 1.11/2002, European Commission-DG Enterprise, Brussels, BE.

European Commission (2008), *Commission Recommendation on the management of intellectual property in knowledge transfer activities and Code Practice for Universities and Other Public Research Organizations*, Office for Official Publications of the European Communities, Luxemburg.

European Commission (2009), Metrics for knowledge transfer from public research organisations in europe, Report from the European Commission's Expert Group on Knowledge Transfer Metrics, European Commission-DG Research, Brussels, BE.

European Commission (2011), *Innovation Union Competitiveness Report 2011 Edition*, Publications Office of the European Union, Luxemburg.

EVCA (2011), *EVCA Yearbook 2011*, European Private Equity and Venture Capital Association, Brussels.

Fafaliou, I., Melanitis, N. E. & Tsakalos, V. (2010), 'Commercialising research results in immature technology transfer markets: cases from the Greek experience', *International Journal of Entrepreneurship and Innovation Management* **11**(2), 213–227.

Friedman, J. & Silberman, J. (2003), 'University technology transfer: do incentives, management, and location matter?', *Journal of Technology Transfer* **28**(1), 17–30.

Geuna, A. & Rossi, F. (2011), 'Changes to university IPR regulations in Europe and the impact on academic patenting', *Research Policy* **40**(8), 1068 – 1076.

Goddard, J. (2011), *Connecting Universities to Regional Growth: A Practical Guide*, European Commission-DG Regional Policy, Brussels, BE.

Grant, J., Ling, T., Potoglou, D. & Culley, D. M. (2011), A rapid review of the Greek research and development system, Report DB-631MEGR, RAND Europe, Cambridge, UK.

Grimaldi, R., Kenney, M., Siegel, D. S. & Wright, M. (2011), '30 years after Bayh–Dole: Reassessing academic entrepreneurship', *Research Policy* **40**(8), 1045 – 1057.

Italian Trade Commission New York (2009), *Research in Italy: "Land of Hidden Gems"*, Italian Trade Commission New York.

Komninos, N. & Tsamis, A. (2008), 'The system of innovation in Greece: structural asymmetries and policy failure', *International Journal of Innovation and Regional Development* **1**(1), 1–23.

Link, A. N., Scott, J. T. & Siegel, D. S. (2003), 'The economics of intellectual property at universities: An overview of the special issue', *International Journal of Industrial Organisation* **21**(9), 1217–1225.

Mowery, D., Nelson, R. R., Sampat, B. N. & Ziedonis, A. (2004), *Ivory Tower and Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh-Dole Act*, 1 edn, Stanford Business Books.

National Documentation Centre (2010), *Greek Scientific Publications 1993-2008 (in Greek)*, National Documentation Centre, Athens, GR.
URL: *www.ekt.gr/metrics*

OECD (2003), *Turning Science into Business: Patenting and Licensing at Public Research Organisations*, OECD Publishing, Paris, FR.

OECD (n.d.), 'OECD Compendium of Productivity Indicators 2008'.
URL: *http://www.oecd.org/dataoecd/6/3/40605524.pdf*

Piccaluga, A., Balderi, C. & Patrono, A. (2011), *The ProTon Europe Seventh Annual Survey Report (Fiscal Year 2009)*, ProTon Europe, Brussels.

Protogerou, A., Caloghirou, Y. & Siokas, E. (2010), 'The impact of EU policy-driven research networks on the diffusion and deployment of innovation at the national level: the case of Greece', *Science and Public Policy* **37**(4), 283–296.

Rothaermel, F. T., Agung, S. D. & Jiang, L. (2007), 'University entrepreneurship: a taxonomy of the literature', *Industrial and Corporate Change* **16**(4), 691–791.

Siegel, D. S., Veugelers, R. & Wright, M. (2007), 'Technology transfer offices and commercialization of university intellectual property: performance and policy implications', *Oxford Review of Economic Policy* **23**(4), 640–660.

Siegel, D., Waldman, D. & Link, A. (2003), 'Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study', *Research Policy* **32**(1), 27–48. Conference on Organizational Change and Performance Improvement, SANTA ROSA, CALIFORNIA, APR, 1999.

Thursby, J. G. & Thursby, M. C. (2002), 'Who is selling the ivory tower? sources of growth in university licensing', *Management Science* **48**(1), 90–104.

WIPO (2011), *World Intellectual Property Indicators*, number 941, 2011 edn, WIPO.