Analysis of university-driven open innovation ecosystems: the UPM case study[1]

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Abstract

The concept of an "innovation ecosystem" has been formulated as a conceptual tool to reason about the desirable interaction between the main actors of national innovation systems to become competitive and to generate growth and employment. The analysis of innovation ecosystems can be done at macro, meso or micro levels depending on the emphasis placed on policy instruments and type of activities exhibited by stakeholders. This article is focused on the meso-system level of description to be able to describe the university-industry relationships as a key factor for success in the case of technology-based innovation ecosystems.

More specifically, attention is paid to "university-driven open innovation ecosystems" in the EU. Emphasis is placed on the instruments used to align and support innovation activities between public and private actors and the dynamic creation of these ecosystems. The level of integration in the knowledge triangle seems especially relevant to ensure success in increasing attractiveness in people, funding and new firms, as well as competing in an international market of ideas, technologies, products and services. The analysis reinforces the idea of complementarity between actors and the need to ensure a highly dynamic governance model.

The conceptual model is applied to the specific case of the Technical University of Madrid (UPM) in the creation and consolidation process of the "International Campus of Excellence of Montegancedo". Some lessons are extracted from the experience carried out since 2010 in the domain of biomedical engineering to assess future trends in the international arena through a sound long-term alignment and partnership between technical universities and some high-tech industries.

Keywords

Innovation; open innovation; innovation ecosystem; levels of description; university-driven open innovation ecosystem; university-industry partnerships; Technical University of Madrid (UPM); International Campus of Excellence of Montegancedo.

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1. Introduction

The literature on innovation has reflected a growing interest in the idea of an **innovation ecosystem**[3] as a mechanism to improve the flaws in "structural innovation" (Howells and Elder, 2011). Under this concept, scholars like to see the need to improve the relationships between *actors* of a given innovation system[4] by creating a favourable framework to attract better ideas and investments and to accelerate the introduction of innovative products and services in the global market. The specific case of innovation ecosystems that focus on *technology innovation* has been very relevant for public administrations because of its strong relationship with economic growth and high quality employment in regions and nations.

The construction process of the European Research Area (ERA) since 2000 by the European Union (EU) has been especially relevant as a driver to create the best policy framework for facing increased global competitiveness in innovation, and then to ensure higher growth and employment embedded into the "Innovation Union" flagship (COM, 2012). During the process, the crucial importance of avoiding internal fragmentation between main stakeholders has been stated and then, to look for better and richer interactions between public and private actors in the European innovation system (Barré et al., 2013), (Velu et al., 2013), (Sousa, 2013).

It is too early to assess the final benefits of ERA as it is still a non-finished process[5]; however, some *European innovation systems* at lower scales (with selected groups of innovative actors), territories (in inter or intra-European regions) and thematic scopes (i.e. ICT or biotech) within the EU seem to start working (Hollanders, 2013).

Many authors have tried to identify the key factors for ensuring the success of innovation ecosystems. For instance, Xiangjiang et al. (2013) stated that "t*he most successful innovation clusters are those that combine private and public investment with a public policy commitment to create an active and open environment where innovation is encouraged, investments are made and a supportive system can thrive"*.

The analysis of an innovation ecosystem is usually made in a ***macro-system level*** to deal with the systemic behaviour of actors at the regional, national or international level as regards innovation by using some adaptations of the "principal-actor" theory where public authorities delegate responsibilities and functions to specific actors. This is typically the realm of public innovation policies which has attracted considerable attention in the past. As a consequence, the innovation process at this level is also dominated by the rightness of framework conditions set up by public administrations and its interactions with other relevant actors' behaviour. Many studies on regional innovation describe the main characteristics and evolution of these policies (Foray and Goenaga, 2013).

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[3] The term ecosystem will be used in this article although many of the concepts are also borrowed from the concepts of "cluster" and "hub". In many cases, these terms have a geographical bias while the concept of ecosystem is more open and not necessarily linked to any territory.

[4] A national innovation system is conceptually defined as *"a set of processes of production, diffusion and use of knowledge through interactions and relationships of actors, including the governance of the system and the institutional and social arrangements that characterize a nation state"* (Lundwall, 1988).

[5] In fact, the Horizon 2020 proposal for the period 2014-2020 (COM, 2011) will continue with the effort towards this goal by closely linking research and innovation and by including the European Institute of technology and Innovation to cover higher education in entrepreneurship.

Nevertheless, other levels of analysis of innovation ecosystems are also very relevant to understand their evolution over time and relative failures or successes: a ***meso-system level*** centred in the behaviour exhibited by groups of entities working cooperatively by aligning their own interests (in many cases with a clear leadership from an industry, university or research centre) in long-term partnerships. The concept of open (technology) innovation is very relevant in this context because this *"openness"* is related to the need to capture knowledge everywhere in highly dynamic network structures to cope with fast technology evolution and to become more competitive.

Finally, it is also possible to pay attention to a ***micro-system level*** centred in the development of specific (open) innovation activities or the implementation of institutional policies carried out by a reduced group of actors during a limited period of time oriented to specific goals (i.e. for the development of collaborative research projects).

These three possible levels of ecosystem analysis are not independent and *macro-meso-micro levels* influence each other. Figure 1 details the interaction between the three levels mentioned in this section where some examples of interactions are also identified.

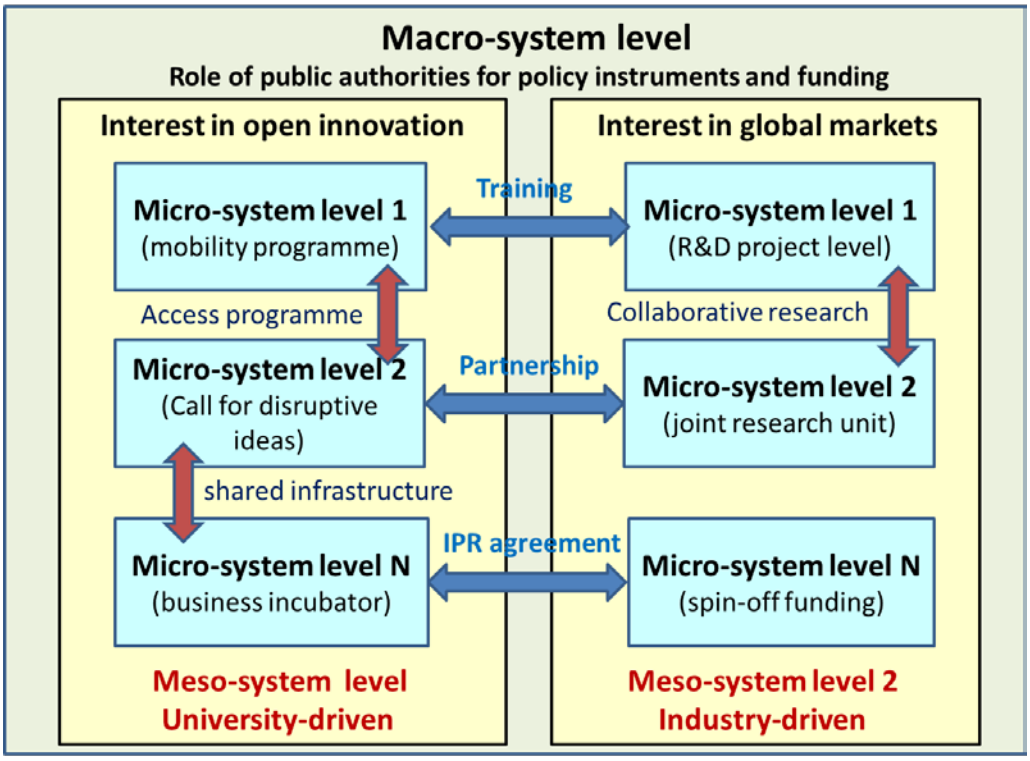

Figure 1. Levels of innovation ecosystem analysis

At the macro-system level both political frameworks (as ERA aims for) and regulatory and legal structures (such as H2020 or regional specialisation strategies) are defined; this level also provides the framework supported by public authorities to trigger decisions at the intermediate **meso-system level** taken by specific actors (universities or industries) to adapt their own innovation strategies.

This intermediate level is also conditioned by the support needed and alignment obtained by key actors in a global technology market and the evolving behaviour of industries and universities in this field. We postulate that at this level ***industry-university relationships*** constitute a basic element to enhance disruptive innovation; even if the collaborative behaviour of these actors is also strongly dependent on the policy framework conditions to ensure stability.

For this reason, our interest has been mainly focused on the ***meso-level analysis of open innovation ecosystems*** where one specific entity acts as a driver for its creation, consolidation and sustainability over time.

The incentives for successful cross-sector research collaboration between university and industry have been extensively analysed in the literature. In short, university-industry cooperation seems to work better *"where rewards for collaborating with industry, clear regulations and organisational support are in place in a coherent way"* (Schiller, 2011). This analysis reflects the need to insert research collaboration into an institutional setting where bottom-up interests from faculty members and specific technical levels in industry are framed in top-down strategies designed and implemented by both types of entity over long periods of time (Jaruzelski et al., 2013).

Historically, **industry-driven ecosystems** appeared when one large company has the will and capability to attract many other actors around it to facilitate and increase its rate of innovation. These companies usually provide platforms or subsystems where other companies or actors can develop their own products or services. The cases of Phillips in Eindhoven (The Netherlands), Siemens in Munich (Germany) or Microsoft in Seattle (USA) are well known examples. Even when the origins of these industry-driven ecosystems had a clear geographical reference framework, their evolution has relativized the links to territory to involve other actors located in other regions or countries.

Notice that this model is an evolution and differs from the technological park model developed in the eighties (see Sophia Antipolis in France as an example) where not a single company takes the leadership of the ecosystem; in this case it corresponded to regional or national authorities to provide some attractiveness (via common infrastructures or economic incentives such as tax-reduction schemes) to favour the location of companies and other actors in a given geographical area to boost regional/local growth.

The same ideas can be applied to **university-driven ecosystems** generated when one world-wide recognised research university acts as an attractor for developing and transferring disruptive ideas through spin-offs or other partnerships with consolidated high-tech companies. The cases of MIT in Boston (Massachusetts, USA) or Stanford University in Palo Alto (California, USA) are examples imitated in other places over the world with mixed results. In the EU, something similar is happening in the UK around Cambridge and Oxford.

In other geographical areas the influence of public administrations with some university champions is stronger. The case of Huawei in Shenzhen (China) is a good example driven by public authorities over long periods of time[6]. In the EU, the cases of Sweden around Lund University or Switzerland around the federal universities such as "Ecole Polytechnique Fédéral de Lausanne" (EPFL) in Laussanne or ETH in Zurich are recent examples of converging interests between national or federal authorities and the universities themselves.

The present article after describing the general concepts related to open innovation ecosystems compares the cases of industry-driven and university-driven innovation ecosystems at the meso-system level to extract some commonalities and striking differences. This description is oriented towards the situation found in the EU by analysing the impact of some policy and funding instruments in the behaviour of the actors involved.

The second part of the study addresses the specific peculiarities of the university-driven cases to learn from the lessons and set up the conditions for success. It is focused on the analysis of the origins, current situation and feasible evolution of the UPM-driven open innovation ecosystem created around the International Campus of Excellence of Montegancedo. More specifically, the policy framework (linking to the macro-level analysis), the main components, the types of relationship, the collaborative instruments, the governance structures, and an analysis of its weaknesses and strengths are described to explore possible future alternatives.

2. Open innovation ecosystem

Historically, the concept of **innovation ecosystem** has been used by policy makers to emphasise those geographical areas where the rate of innovation is higher (or aims to be) than in other zones measured in terms of several innovation indicators (IUS, 2013). Later on, this geographical bias was relativized to focus attention on one firm or group of them which shared some common goals in a global sector or market challenges whereas it is linked or not to one specific territory.

An innovation ecosystem[7] comprises all stakeholders required to enable an innovation and entrepreneur based economy in the area of influence. The components of the innovation ecosystem include: the innovation actors, the interactions that take place between actors in the ecosystem to facilitate innovation, and the agencies associated to policy instruments used for promoting innovation. This definition includes both closed[8] and open innovation because the goal is to increase some of the innovation indicators (i.e. patents or other IP assets, licenses, PhD thesis, attraction of technology-based investments, start-ups creation, etc.).

The concept of an **open innovation ecosystem** is defined for the purposes of this article[9] as a subset of the "innovation ecosystems". More precisely, it is defined as "***an innovation***

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[6] To assess the dramatic change in the region, it is worth noting that Shenzhen population has grown from 20,000 in 1980 to 15.5 million people en 2010.

[7] The word "community" was sometimes used as an alternative, but "ecosystem" was generally preferred since "ecosystem" recognizes the reality that companies have competitive relationships as well as the "friendly" relations implied by the word "community".

[8] The concept of closed innovation refers to the type of innovation performed by one entity in-house without the intervention of external actors.

[9] Several authors have used the concept of open innovation ecosystem in much broader contexts to include regional or national policies and public administrations which favour the interactions between

ecosystem where a substantial number of the supported activities are classified as open innovation initiatives". Then, it is interpreted as a subset of the whole domain of innovation ecosystems where open innovation is the dominant behaviour of the stakeholders involved. Then, interactions between actors and the implementation of policy instruments assume that the goal as a distinctive character of the ecosystem.

The reference to a *"substantial number"* of the activities came from the fact that the implementation of an isolated open innovation initiative in a given firm is not enough to consider it as an "open innovation-driven organisation". To recognise it as an open innovation organisation it is necessary that the existence of several open initiatives running simultaneously over time, which have generated above average values for the respective impact factors of the sector. If several open innovation initiatives coexist we can speak about an open innovation ecosystem.

Figure 2 gives a schematic view of the concept in the case of an industrial-driven ecosystem. Bubble colours represent different types of actor (universities, start-ups, research centres, etc.); some of them can appear and disappear over time due to the dynamic character of the membership. In fact, the stability of the ecosystem is very important and this is the reason for thinking about "partnerships" and not only about "relationships" which could be shorter.

Figure 2 also represents three proximity circles to the core activity of the industry. Even if partnership occurs in all of them, entities in the outer circles have more freedom to contribute to future innovations because they are less linked to product development. For this reason, it is more frequent that open innovation initiatives occur with entities located in the external circle.

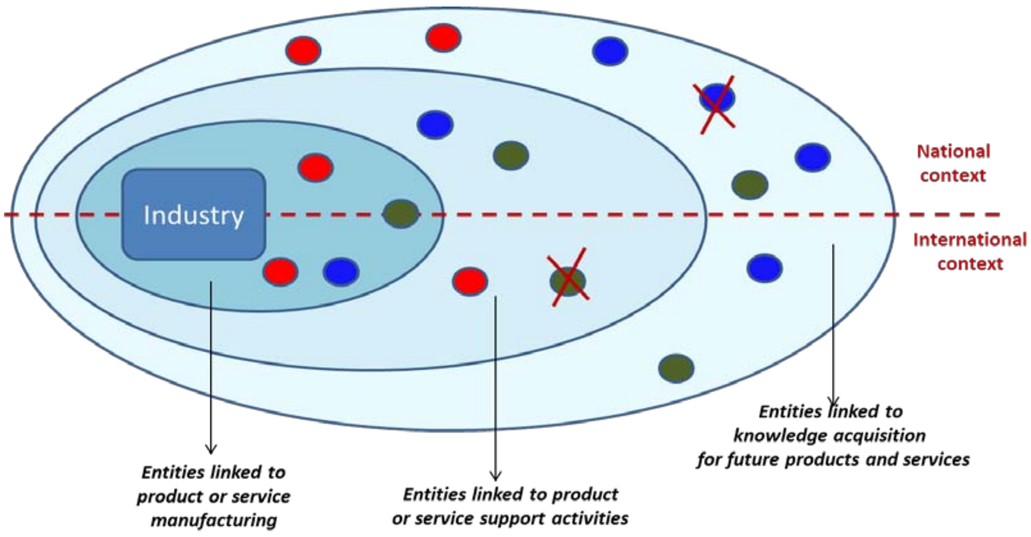

Figure 2. Industry-driven innovation ecosystem

stakeholders. Our intention is to focus the concept on a micro-context related to the behaviour of specific private firms.

The cooperating partner entities with the key industry[10] acting as the driver of the ecosystem assume different roles in the value chain (in figure 2, production, support or knowledge acquisition processes are explicitly mentioned) both in the national and international context. As figure 2 suggests, instruments for interaction and management could be very different depending on the proximity level chosen. The farther from the core activity, the more freedom and less committed activity is possible.

As figure 3 shows, several industrial-driven innovation ecosystems could usually coexist and interact in the same geographical area or in a closely integrated industrial sector; then, one given entity could be associated to several industrial ecosystems under the principle of non-exclusivity; this is typically the case of university or public research organisations (PRO) partners. These are not necessarily isolated ecosystems and industries can also cooperate thematically.

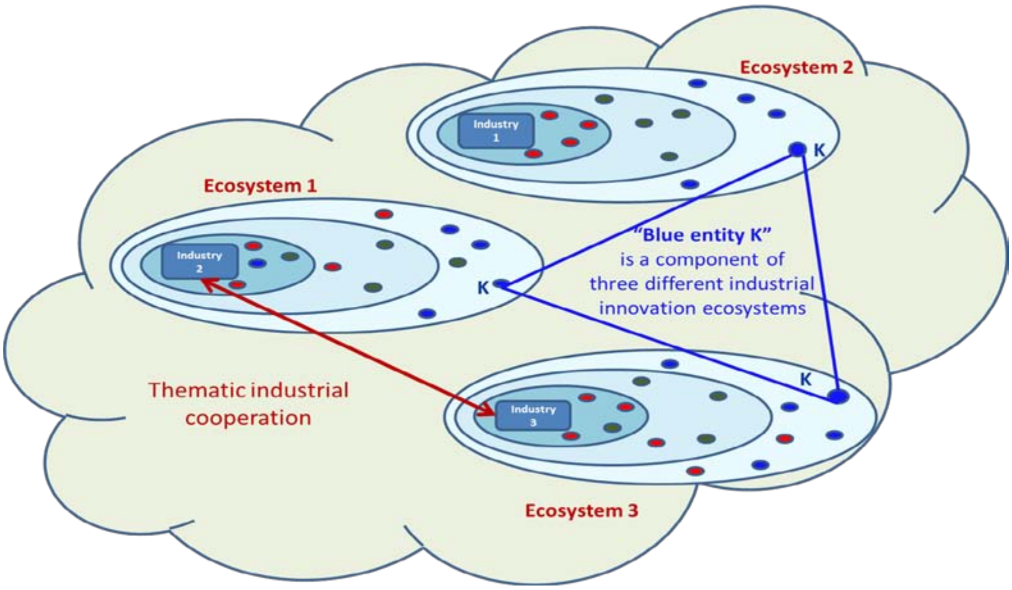

Figure 3. Coexistence of several industrial ecosystems in a given territory

The potentiality of innovation clusters or regions to attract investment and quality jobs depends on the coexistence of several ecosystems with potential inter-cross interactions. Within this context, the cohesion role of public and intermediate entities becomes essential. Nevertheless, the attraction of knowledge-based investments in one specific territorial context does not imply that the innovation effect is geographically constrained. The borders of the visible impact of innovation are becoming fuzzier when the location of innovative firms does not condition the dissemination of these innovations.

The ecosystem structures represented in figures 2 and 3 constitute true **open Innovation ecosystem** if ideas are not monopolised by one individual or organisation. This does not mean that intellectual property (IP) is not important in open innovation but rather is proactively managed to maximise its exploitation. When a concept/product is exclusively owned and

[10] This concept also evolves. The example of Philips in Eindhoven is a good example where, after many years the role of Philips is less dominant and other fast-growing companies are also taking the lead.

controlled, its potential to evolve is greatly diminished because relationships depend on contract-research and recruitment strategies.

Another more restricted subset case occurs when the creation of an open innovation ecosystem is **driven by one university** and not by a private firm. In this case, the goal is not to support any production process but to accelerate scientific and technological knowledge creation and transference[11]. The open innovation schemes in conceptually free ecosystems driven by universities favour that goal. Some hybrid models can be described when strong partnerships with a limited set of industries around one university serve as catalysts for the creation of the ecosystem.

Figure 4 schematically represents the main interactions which could appear between universities and industries (represented as key actors at the meso-system level) and the commitments, funding, control and influences dictated by other key actors at other levels. The X-axis represents the temporal scale and the Y-axis the stability of the relationships created amongst actors. The temporal scale is associated to the level of description by assuming that policy framework (not necessarily specific policy instruments) are stable enough to be used as an umbrella for decisions at the meso-system level.

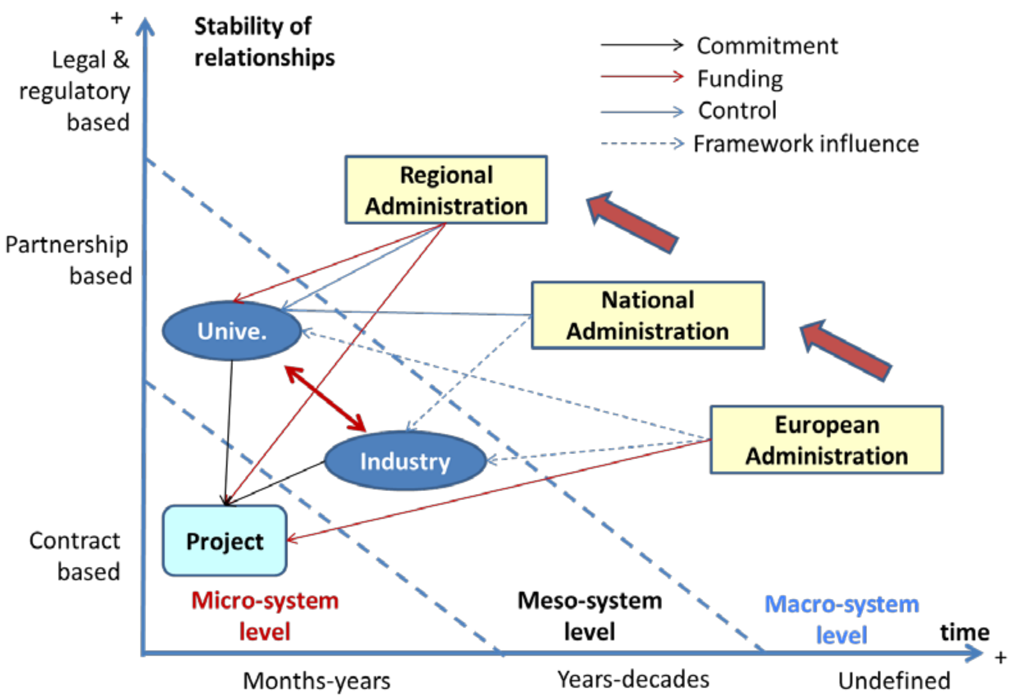

Figure 4. Influences and interactions in innovation ecosystem

We postulate that decisions taken at the macro-system level for public administrations (for instance, by creating a long-term funding programme with specific requirements) can trigger other decisions at the meso-system level (for example, to create specific partnerships or to

[11] It does not mean that the university is not interested in commercialising their own results but this goal is not the only or main driver for launching the process.

participate in long-term international research projects) in specific units of the key actors[12]. The lack of stability over time of the behaviour of public administrations to support ecosystems introduces *political instabilities* which could reduce the level of commitment between the main actors and reduce the probability of success[13].

Note that many of the initiatives launched by public administrations involving public universities cannot be considered as open initiatives *per se*. This is the case with the support of *university-driven S&T parks* which do not necessarily benefit the implementation of open innovation initiatives unless some of the above mentioned policy instruments were implemented.

The same situation happens with the so-called "campus of excellence" initiatives across the EU: they should be oriented towards the provision of a favourable context for open innovation initiatives and to serve as a driver to create open innovation ecosystems. But they are excellent starting points if open innovation is kept in mind. This issue will be further developed in the next section.

Table 1 compares main features of both types of ecosystem at different levels.

Main feature	Eco-system level	Industry-driven ecosystem	University-driven ecosystem
Type of innovation supported	Macro-level	Technology innovation	Open innovation
Economic impact on the territory	Macro-level	Global or regional	Regional (State-based)
Drivers of public support	Macro-level	Regional or national authorities	Channelled through the university funds
Geographical focus	Macro-level	Industrial interest with public-private agreements	Pre-existing university Campus
Internationalisation	Macro-level	Networking in several geographical areas	Weak alliances
Leadership	Meso-level	Industrial excellence driven by a multinational high-tech industry (or group of related industries)	Academic excellence driven by a technologically-based research university campus
Main actors	Meso-level	SMES, start-ups, research centres, universities, venture capital	Spin-offs, (joint) research centres, high-tech industries, business angels
Sectorial or thematic focus	Meso-level	Linked to the main sector of the lead industry	Multi-sector by emphasising inter-disciplinary work
Type of activities and instruments	Meso-level	Project-based	Project-based and educational programmes
IPRs	Meso-level	Patent cross-licensing agreements controlled by larger companies	Open licenses (based on non-exclusivity) Diffusion of academic publications

[12] This situation is easier to find in the public system where research groups have enough freedom to prepare and present project proposals driven by their scientific interest.
[13] This situation happens when governmental changes due to political cycles or deep economic crisis (more than sound assessments of success) modify the political priorities and the interest of stakeholders in the participation in ecosystems.

Cultural bias for evolution	Meso-level	Mergers and acquisitions	Entrepreneurship
Attractiveness for location of actors	Meso-level	Access to contracts and venture capital funds	Access to ideas and seed capital funds
Governance schemes	Meso-level	Based on bilateral or multilateral contracts	Advisory Boards
Recruitment of key personnel	Micro-level	Doctorate, technicians	Engineers, technicians
Research projects	Micro-level	Company decision	Research groups decision
Technology transfer offices	Micro-level	Large departments in companies	University offices Specialised companies

Table 1. Main features of ecosystems

In a more specific way, the entity that drives the **leadership** in the creation and consolidation of the ecosystem is the key factor because many other features derive from it. Table 1 also indicates the relative importance of factors linked to a meso-system level of description. We postulate the key relevance of the meso-system level to ensure success through the long-term involvement of institutions.

A review of table 1 shows that even if many actors are present in both types of ecosystem, the role they assume is very different. Many of the main features depend on the meso-system level giving relevance to the specific partnerships which can be launched between different types of actors. Public administrations (at the macro-level) also had relevance in defining a stable framework to be able to make decisions at lower levels.

3. Characterisation of university-driven open innovation ecosystems

3.1. Relevance of university-driven open innovation ecosystems

In the previous section we mentioned the concept of a university-driven open innovation ecosystem as a particular case in which the main attractor is a **recognized university acting as the leader** for the creation and consolidation of the whole ecosystem in one specific geographical context.

The role of universities as "open innovation partners" for industrial firms is increasing in relevance as technology knowledge becomes the key differentiation factor for world-wide competitiveness. This approach differs from the conventional sub-contracting process which has dominated university-industry relationships in the past.

The relevance of **open innovation by partnering with universities** to reduce risks and increase technology disruptiveness in the innovation process when universities are involved as knowledge contributors can be justified from three complementary perspectives as follows:

- University research groups are well prepared to explore possible avenues of research in curiosity-driven processes. If these activities are framed in some scientific or technological long-term challenges proposed by industrial groups they will receive strong support from universities. As a consequence, research priorities are modulated by industrial interests.

- Research groups are the basic unit for training new generations of researchers. The interaction with PhD programmes provides the possibility of focusing the development of new PhD Theses towards industrial interests in the so-called industrial PhDs or similar schemes.
- Absorption of tacit knowledge could be easily covered though mobility programmes (involving faculty members or researchers) from university to industry and vice versa[14].

As a consequence of these three elements there is an **evolution from contract-based research to open innovation cooperation models**. More specifically, the use of open innovation approaches between industries and universities is useful in exploring new technology solutions where specifications are not totally clear and contract-research cannot be used. The potential benefits of using open innovation initiatives in this context are:

- To share risks in exploring solutions with immature technologies. One or more university partner can explore the applicability of some promising lines of research by using young researchers. Industries (supported or not by public administrations) can delegate this “exploration” to partner universities in combination with technology watch.
- To carry out pilot experiences under the partners’ control. Again, the goal is to minimize risks by involving university contexts to launch very innovative services and receive early feedback.

Figure 5 represents a conceptual scheme of the university-driven open innovation ecosystem. The figure places the university as a driver with other types of entity. Note that a number of industries can also cooperate in knowledge creation by postulating future challenges to be addressed. It is too early to know if this kind of open innovation accelerates technology innovation but fragmented experiences in Europe (i.e. Grenoble) are symptoms of this benefit[15].

[14] This absorption also happens in reverse although this mobility scheme is less used. The creation of joint units where employees from both types of entity cooperate in the same physical location can help in the absorption of new ideas.

[15] Success will depend on the type of policy instruments and the governance mechanisms used. A full analysis of this issue is outside the scope of this article.

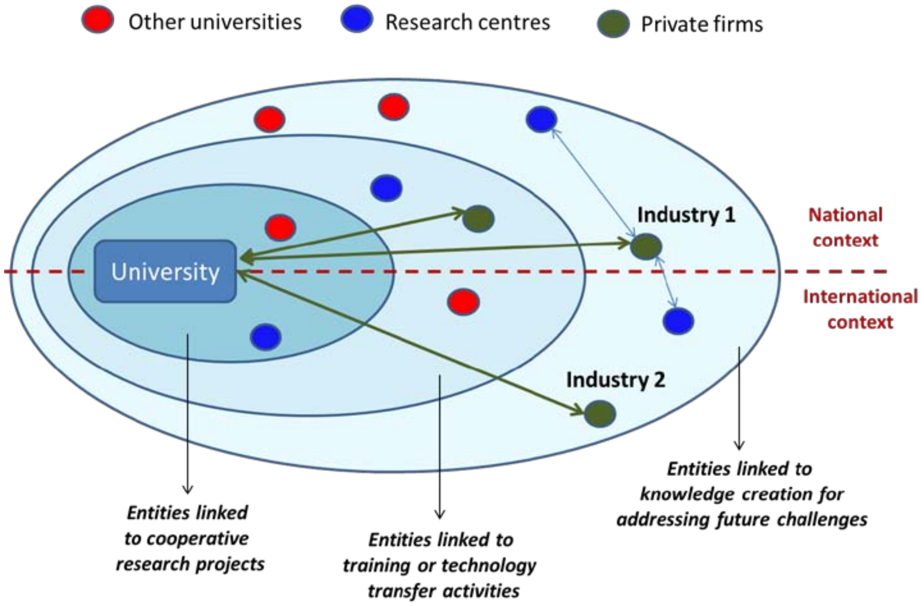

Figure 4. University-driven open innovation ecosystem

Figure 4 also shows specific partnerships with different industries located at different levels of proximity (both at the national and international contexts). The rationale is to distinguish between university-industry partnerships to commercialise or to integrate research results obtained by the university (playing the role of brokers) and university-industry partnerships where the main goal is to contribute to knowledge creation in some areas jointly proposed for addressing future challenges. Both types of partnership complement each other.

Unfortunately, only a few set of universities have created rich ecosystems around them. At what extent the main features of a university condition the success in creating a university-driven open innovation ecosystem? Two elements become decisive to ensure the stability of these university-driven ecosystems: 1) the existence of a strong internal institutional positioning towards supporting innovation and 2) it is also necessary to establish rich interactions with the external environment.

The first point refers to the existence university policies which should be supported from top management of to reward the efforts towards innovation support in faculty members, institutes and departments. The prioritisation in the allocation of resources for these activities is also compatible with the interest in increasing economic returns from innovation support activities. Obviously, technical universities are well prepared to push this policy in close interaction with research and innovation.

The second point refers to the interaction with main actors of the innovation system at the local, regional, national or international context. Many of the goals behind the successful implementation of an open innovation ecosystem depend on the mutual trust created between the university and main private actors to conduct innovative activities.

3.2. Policy instruments for university-industry cooperation in university-driven open innovation ecosystems

The taxonomy of conceptual cooperation instruments between universities and industry to implement open innovation initiatives could range from:

- **Long-term agreements for research line support**. This case happens when one industry promotes some lines of research[16] previously jointly defined by stimulating creativity through experimental prototype design with one university. One special case of this type of instrument is the sponsored university-industry chair focused thematically towards a scientific or technological challenge.
- **Location of industrial units in university premises**. This case happens when industrial research labs are moved to university premises to work with other research teams. A special case comes from the creation of a business incubator where the location of start-ups is also related to the availability of some services.
- **R&D contract-research**. This is the well-known instrument where industry pays for some well-defined R&D services offered by public research groups or other entities.
- **Cooperative research projects**. This case corresponds to research projects carried out by research teams of two or more entities where the goals are shared between several universities and industries to explore solutions for common challenges.
- **Creation of joint units or labs**. Within this approach university-industry cooperation is more intense and the industrial commitment is also stronger. Here, the experience of moving people from industry to work in a more “free context” needs to be assimilated by the working culture of the industry[17].
- **Maturing university technology**. The objective is to support the maturation of selected research results by supporting the development of industrial prototypes or proof of concepts with the involvement of some specialised departments of the industry.
- **Graduate mobility programmes**. This instrument corresponds to university-industry mobility schemes. The movement is not usually symmetrical, going from university to industry.
- **Space for technology demonstrations**. In this case, universities are looking for experimenting with advanced technologies or solutions and to explore their usefulness. Industries are also looking for early feedback by installing equipment in university premises.
- **Risk capital investment for university spin-offs**. The support with seed-capital to selected spin-offs emerging from research groups and/or to contract them to carry out some activities is increasingly used for private companies to access knowledge generated by universities.
- **Licensing and commercialization agreements**. These agreements could be included as open innovation instruments when it implies sharing risks in the commercialisation

[16] This instrument does not mean the development of specific products or components which is the realm of contract research instruments not included in this analysis.

[17] The well-known experience in Google to allow its employees to devote 20% of their time for their own projects in order to stimulate creativity has encountered problems and the discontinuation of this experience was reported in August 2013.

process and not only the agreement to license patents or other intellectual assets for commercial exploitation.

- **Joint activities for internationalisation support**. It refers to the alignment of university-industry interests in international activities to increase exploratory activities in other countries through the signing of agreements with third parties.

These instruments are compatible and all of them can be used for different purposes at a given time with the same or different partners. Figure 5 details a **bi-dimensional positioning** of those instruments. The X-axis indicates the commitment from the university when the Y-axis represents the relative complexity of the instrument. Two main types of instrument are shown: open innovation and not open innovation instruments.

All types of instrument represented in figure 5 in *"blue clouds"* could be used for open innovation initiatives. In all cases leadership corresponds to industry although university research groups maintain enough freedom to decide. The instruments circled in *"yellow clouds"* cannot be considered as open innovation instruments although all of them contribute to the strengthening of university-industry relations. A brief description of instruments (from lower to higher complexity) is as follows:

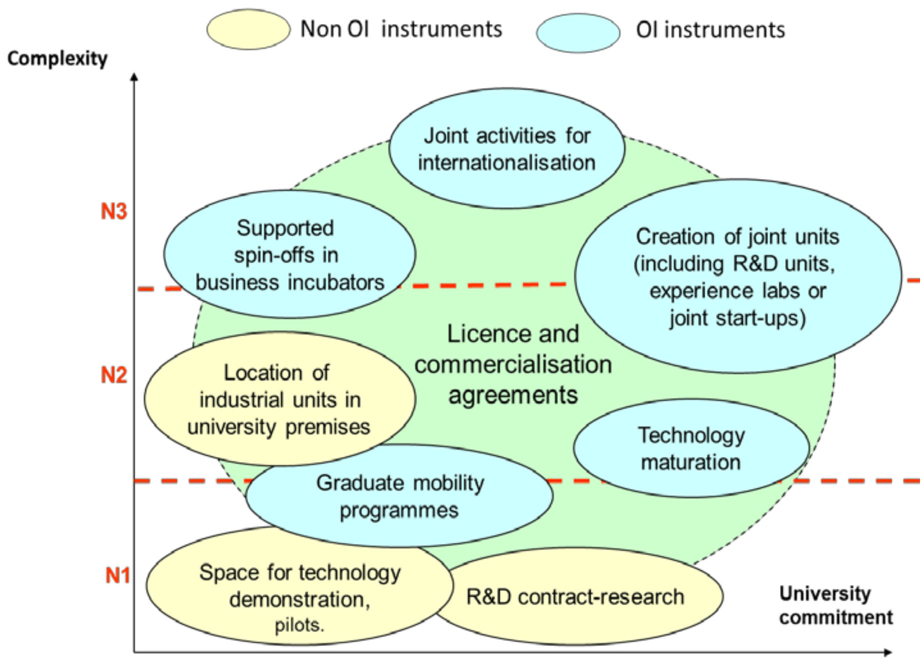

Figure 5. Open innovation instruments for university-industry cooperation

These instruments are compatible and when relationships are mature, all of them could be used for different purposes and domains. The actual implementation of one activity by using any of the aforementioned instruments belongs to the micro-system level of description.

4. The open innovation experience of the UPM with the industrial sector

4.1 The institutional framework

The UPM is the largest technical university in Spain. It was created in 1971 on the basis of the pre-existing engineering schools attached to a number of ministerial departments. Even today, the UPM only addresses engineering and architecture studies[18] and the "engineering schools" continue to be the basic structure of the university life.

From the previous historical period and reinforced in the last decade at the international level, there is a strong connection with the interests of industrial sectors which has derived in a very large number of contract research agreements and joint participation in collaborative research at the national and international level. As a consequence, schools, departments and individual faculty members of the UPM keep a continuous and solid relationship with the industrial sector through a number of funding instruments and personnel interactions in research, education and knowledge transfer activities[19]. It is not strange at this level, to think of very close relationships.

From the institutional perspective, the UPM was aware of the need to consolidate these relationships by offering a long-term perspective for partnerships. The Spanish government had fostered the creation of S&T parks at the beginning of the 2000s promoted by universities and years later, in 2009, the programme of "International Campus of Excellence" (ICE) to reinforce the idea of partnerships (both public-public or public-private partnerships) and to serve as stimulus for the modernisation of public universities.

As a consequence of this process, in 2004 the UPM created one S&T park ("*Parque UPM*") with several sites to promote entrepreneurship and research centres, and in 2010 it obtained the recognition of two ICEs: Moncloa[20] supporting a public-public partnership with the Universidad Complutense (UCM), and Montegancedo[21] to support a public-private partnership oriented towards the strategic relationships with a set of high-tech industries. The next section will present the creation process of the ICE Montegancedo as an example of university-driven open innovation ecosystem to extract a set of lessons learned.

4.2. The creation process of the UPM-driven open innovation ecosystem in the Montegancedo Campus

The institutional decision of the UPM to promote an open innovation ecosystem and to accept commitments for long-term investments came from the idea that it is necessary to move from a project-based relationship with industry to a more partner-oriented relationship. The

[18] More recently, the Faculty of Sports was added, and the curricula studied have been expanded to cover other disciplines (such as Biotechnology, Biomedical engineering or Materials) not included in the initial "engineering studies". Nevertheless, it continues to be a very specialized technical university.

[19] In terms of annual budget, the UPM is signing about 1,000 contracts with the private sector which corresponds to the 20% of the budget.

[20] See http://www.upm/Moncloa for further information.

[21] See http://www.upm/Montegancedo for further information.

creation of the ICE Montegancedo was supported by public funds (around €90M were invested by the UPM since 2005 in Montegancedo) and private funds (around 30 in the same period).

Figure 6 summarizes this change of institutional goal by using the "knowledge triangle" as the guiding concept for the evolution. The idea is to align a number of instruments to convince several industries to move towards strategic partnerships. As figure 6 suggests these relationships are not confined to research; the goal was to be able to use instruments closer to education, research or innovation and, if possible, to promote synergic actions by combining several perspectives.

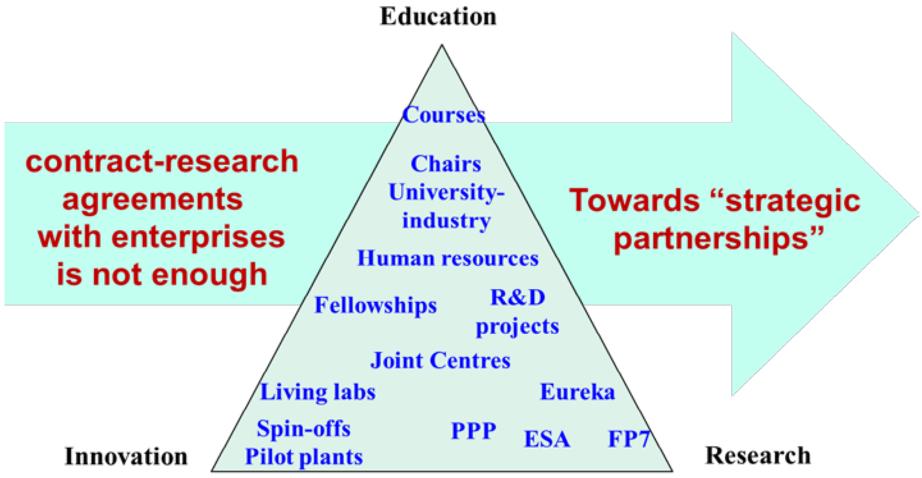

Figure 6. Change of relationship paradigm.

Within this framework, the creation of the ICE Montegancedo was conceived as a policy instrument at the meso-system level taking advantage of the policy framework created by the Spanish Government (macro-system level) to launch a set of specific actions. Formally, the Montegancedo site of the S&T Park was embedded in ICE Montegancedo to reinforce the entrepreneurship activity.

In three years, the UPM has signed long-term agreements with 18 entities (aggregated entities), it has created 6 joint research units with the private sector and 6 more with the public sector, and it has also pursued educational and technology transfer agreements with 8 private companies. This activity was carried out in parallel with the participation in collaborative or contract research projects which were also stimulated by the signed agreements and also the promotion of spin-offs (located or not in the business incubator at Montegancedo).

Figure 7 indicates how the UPM is establishing a dense set of relationships with different goals and intensities with their aggregated entities (and also with spin-offs and start-ups located in the Campus) in order to address a **number of objectives in the national and international context**:

1. Linked to knowledge creation in order to address industry proposed S&T challenges with research centres (cases of LPI, CSIC, URJC, UCM; the cases of the alliances (aggregations) with Santander, ISBAN, PRODUBAN could be also located here).

2. Linked to the implementation of cooperative R&D projects through the creation of joint research units (Telefónica, Santander, IBM, Repsol, INIA IMDEA Software, Univ. Colorado, Univ. Campinas, Univ. Pal Sabatier, etc.)[22].
3. Linked to education or technology/knowledge transfer activities (Plant Response, Accenture, Elekta, Zeiss, T-system, BICG, UCB, e-Gauss, Cisco, Elekta, etc.).

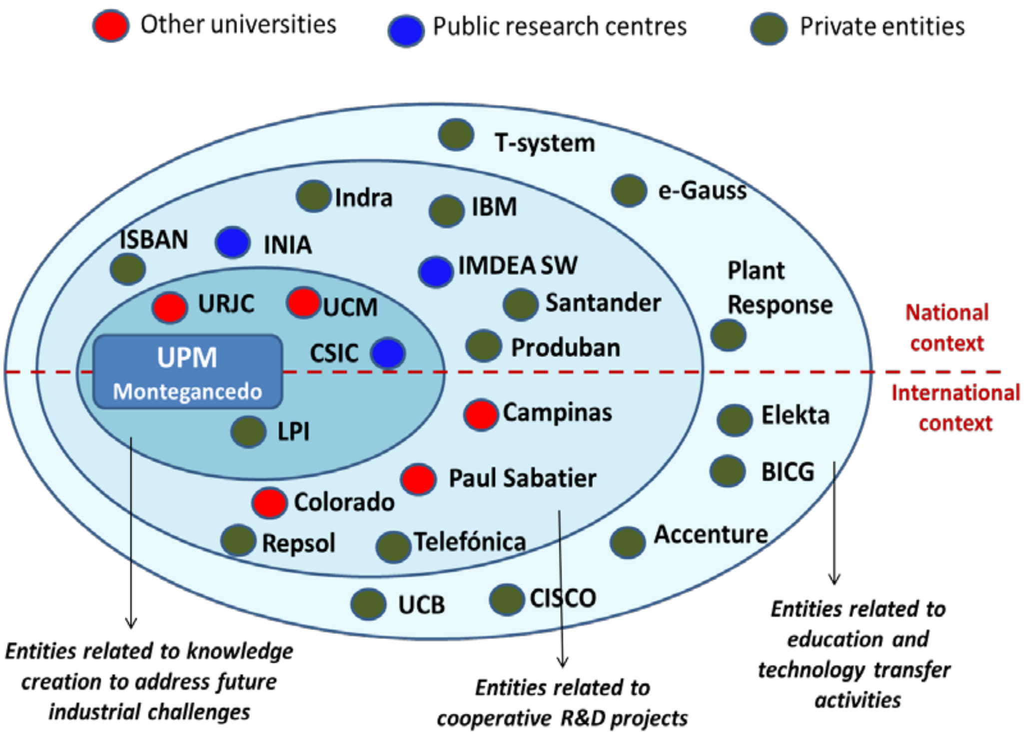

Figure 7. UPM ecosystem of ICE Montegancedo

The number and position of aggregated entities will evolve dynamically over time. The institutional intention of the UPM is to reach 2015 with 30 long-term active agreements. The types of private firm participating in the ecosystem range from small enterprises to large companies.

The management process of this ecosystem is not very hard because at the end, commitments between the UPM and any of the aggregated entities follow a bilateral scheme. The links between aggregated entities are weak in economic terms because they are not participating in joint activities (although it is not forbidden). Then, the management structure is driven by the UPM with a General Advisory Body without executive competences where all aggregated entities nominate a representative. Additionally, individual activities (such as a joint research unit) have their own management structures.

Within the general open innovation ecosystem related to ICE Montegancedo to support new approaches for university-industry cooperation, a more specific set of policy instruments were

[22] Telefónica and Repsol are positioned in the international context because joint activities with them are not limited to Spain. Specifically, with Repsol activities are also located in Brazil.

implemented **to support technology commercialization and entrepreneurship**. Figure 8 explicitly describes the *"daisy-model"* used around the Centre of Support to Technology Innovation (CAIT) which was created for that goal.

The intention is to support from business ideas their initial capture and their pre-incubation (linked to the *actúaupm* programme and educational entrepreneurship activities) to the consolidation of the most promising ones in spin-offs or start-ups through the use of the business centre, to the commercialisation and demonstration of their results (via the experience and living labs, technology watch and consulting services, and the technology commercialization programme). The recent location in the ICE Montegancedo of the Spanish node of the ICT-Labs (knowledge and innovation community of the EIT)[23] to be fully operational in 2014 will constitute a key milestone in entrepreneurship support.

Finally, to be able to increase networking on innovative technology and solutions crated at the end of multiple projects by research teams, the CAIT has created the International Advisory Board (with members from the EU, USA and India), the Club Innovatech (and its business angel's network) etc. to complete the support ecosystem and also to create stronger links between the allied entities.

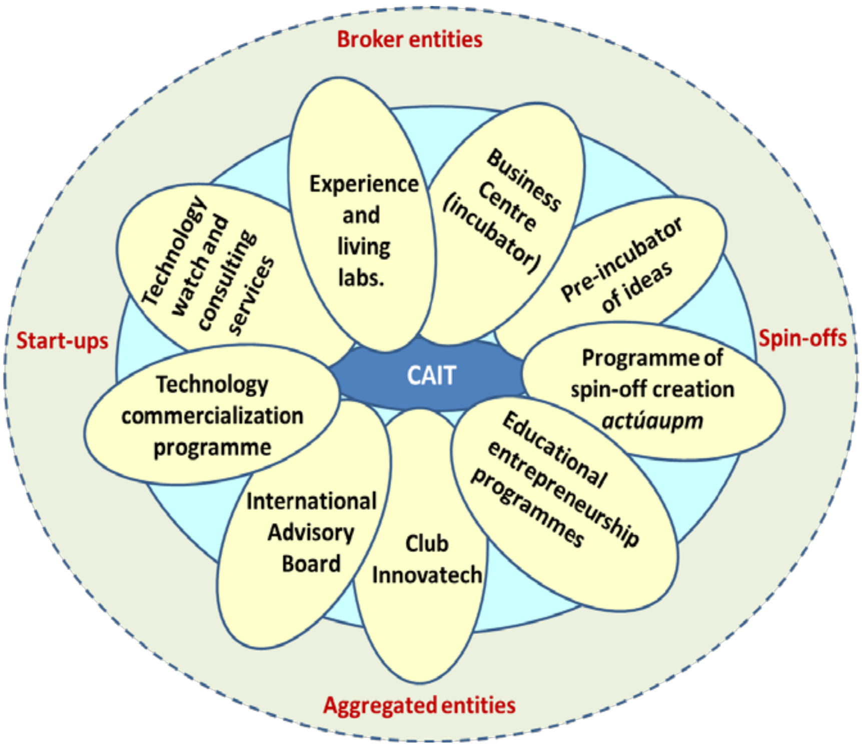

Figure 8. Ecosystem around CAIT

The main idea behind the implementation of this model was to support a very **dynamic structure** where additional "leaves" of the model can appear (or disappear) without changing the general structure of the approach chosen. The UPM is trying to use this model not only for the entities located in Montegancedo but also to serve the same goals in other campuses of the UPM.

[23] See http://www.icet-labs.org for further information.

The activities carried out under this model should pay clear benefits for the stakeholders involved. The concept of an open innovation ecosystem as formulated in this section cannot depend on public resources in a stable situation (after finishing the initial set of activities).

Finally, we will revisit Table 1 as Table 2 to customise the main items to the specific case of the ICE Montegancedo as open innovation ecosystem.

Main feature	Eco-system level	Commitments from aggregated entities	Strategic goals of UPM-driven ecosystem
Type of innovation supported	Macro-level	Applied research linked to the exploration of new products and services	Support for open technology innovation by using ICTs as enabling technology
Economic impact on the territory	Macro-level	For many companies they plan to use the results in the international market.	Mainly national although international impact is searched
Drivers of public support	Macro-level	INIA, CSIC, IMDEA, UCM, URJC are also public entities interested in strategic alliances with the UPM.	Channelled through the university funds received in the Programme of International Campus of Excellence
Geographical focus	Macro-level	Location of shared facilities in the Campus.	Pre-existent university Campus
Internationalisation	Macro-level	Possible extension in a second phase of some of the activities	Weak alliances today
Leadership	Meso-level	Shared leadership with some companies such as Santander	Academic excellence driven by a technologically-based research university campus
Main actors	Meso-level	Santander, ISBAN, PRODUBAN, INIA, CSIC, IMDEA have assumed a relevant role.	Spin-offs, (joint) research centres, high-tech industries, business angels
Sectorial or thematic focus	Meso-level	ICT, Biomedical technology, Plan genomics, aerospace	Emphasis on ICT and its applications in other domains
Type of activities and instruments	Meso-level	Joint research units	Project-based and educational programmes
IPRs	Meso-level	There is no common model. Negotiation is done case by case	Open licenses (based on non-exclusivity) Dissemination of academic publications
Cultural bias for evolution	Meso-level	Leaning to work in joint public-private research groups	Entrepreneurship embedded in research groups
Attractiveness for location of actors	Meso-level	Long-term cooperation Natural landscape	Access to ideas and seed capital funds
Governance schemes	Meso-level	Participation in advisory bodies Ad hoc schemes in each centre	Advisory Boards
Recruitment of key personnel	Micro-level	Contracts with several companies as brokers	Engineers, technicians, brokers
Research projects	Micro-level	Moving from small to large cooperative research projects	Research groups decision
Technology transfer offices	Micro-level	Looking for joint exploitation models	CAIT services Vice-Rector for Research

Table 2. Main features of ICE Montegancedo as university-driven open innovation ecosystem

5. Conclusions and future work

We are living in a globalised world where technology innovation ecosystems are rapidly evolving by relativizing the geographical and sectorial scope. In this context, it is crucial to ensure the long-term survivability of open innovation ecosystems as a tool to accelerate economic growth in a given region or country. All public authorities in the EU are increasing their support in this field in the framework of "smart specialisation strategies".

This article has tried to analyse the internal structures of these ecosystems by paying specific attention to those cases in which one university acts as the driver for its creation and support in cooperation with the industrial sector.

From our analysis, the main features of open innovation ecosystems depend on the actors' behaviour at the so called meso-system level of description; that level is even more important once the public effort has decreased since the economic crisis which began in 2008. On the other hand, the micro-level is important to increase mutual confidence but it lacks driving forces to increase overall attractiveness towards specific ecosystems.

The Campus of Montegancedo was used as an example of university-driven open innovation ecosystem generated by a technical university around the ICT domain. It does not intend to demonstrate that this approach could directly work in other cases. Here, its location in Madrid, a large city where many multinational and SMEs companies of the ICT sector have their research and innovation labs, the existence of sound relationships over years have facilitated networking and creation of strategic partnerships. In other cases, the contextual constraints could favour a more focused approach towards those local capabilities.

The UPM-driven open innovation ecosystem in Montegancedo is a very innovative approach but it is still in its infancy. To mature, the UPM will need to work jointly with the allied entities in four different directions:

1. **To be able to increase the relationships between aggregated entities and the UPM**. The level of commitment is very variable from one case to another and a minimum level should be guaranteed for the future. In other terms, the sustainability of relationships cannot be a matter of future warning because the benefits are clearly stated.
2. **To explore the extensive use of open innovation initiatives in the three dimensions of the knowledge triangle**. Again, from our integrated conception it is very important to convince the current private partners to act in all of them (even if emphasis is biased towards one specific dimension) and to attract others.
3. **To guarantee economic sustainability**. In 2015 the period granted by the Ministry for the Programme of International Campus of Excellence will finish. During the next three years, the ICE Montegancedo will need to demonstrate its usefulness for all the actors involved regardless of public support. The basis for the success in this direction will depend on the agreement signed with private entities and the economic recovery of Spain.
4. **To continue the internationalisation process**. We are convinced of the possibilities to use the ecosystem to accelerate the internationalisation of the university. In many cases, the aggregated (allied) entities are multinational companies with operations in

many other countries where alignment with UPM interests are possible by involving local partners. The cases of Colorado (USA), Campinas (Brazil) o Paul Sabatier (France) are examples of this line.

The experience with the ICE Montegancedo indicates that the creation of a university-driven open innovation ecosystem in countries like Spain is possible if two conditions are met: the efforts from a public university are backed by public authorities, and there is a strong long-term commitment between the university and a group of high-tech industries (even if other industries were also involved).

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