



Balancing basic and applied research outputs: a study of the trade-offs between publishing and patenting

Journal:	<i>Technology Analysis & Strategic Management</i>
Manuscript ID:	CTAS-2014-0183.R2
Manuscript Type:	Original Article
Keywords:	Quantitative < METHODOLOGY, Linkages between science base & commercialization < TOPICS & ISSUES, Public research organisations < RESEARCH SITE, Patents < TOPICS & ISSUES
DISCIPLINE:	Business & Management Studies
METHODOLOGY:	Quantitative

SCHOLARONE™
Manuscripts

1
2
3 **Balancing basic and applied research outputs: A study of the trade-offs**
4 **between publishing and patenting**
5
6
7
8
9

10
11
12 Jasmina Berbegal-Mirabent*

13
14
15 *Department of Economy and Business Organization, Universitat Internacional de Catalunya*
16

17
18 C/ Immaculada 22, 08017, Barcelona, Spain
19

20
21 Email: jberbegal@uic.es
22

23
24 *Corresponding author
25
26
27

28
29 Ferran Sabate
30

31
32 *Department of Management, UPC • BarcelonaTech*
33
34

35 C/ Jordi Girona, 31, 08036, Barcelona, Spain
36
37

38 Email: ferran.sabate@upc.edu
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Balancing basic and applied research outputs: A study of the trade-offs between publishing and patenting

This study examines the relationship between academic publications and patents. First, we use regression models to investigate those factors that act as potential drivers when considering papers and patents individually. Second, we run a cluster analysis in order to test whether universities follow different patterns in the way they align their resources in regard to research objectives. The empirical application considers the Spanish public higher education system for the period 2006-10. The overarching conclusion is that cross-fertilisation relationships between academic research and its commercialisation are found. There are, however, important differences on how universities are disseminating research results when we in-depth in the analysis of the resources and capabilities universities possess. Results also stress the need to look at contextual and normative factors.

Keywords: Linkages between science base & commercialization, Public research organisations, Patents, Publications, University, Quantitative

Balancing basic and applied research outputs: A study of the trade-offs between publishing and patenting

1. Introduction

In a context where the intensity and the quality of university-industry links is assumed to generate technological spillovers and determine effective returns on investment in research, bridging the gap between science and industry has become a major concern for academics, managers and policy makers (Lai 2011). A number of initiatives and regulatory frameworks have been established aiming at involving scientists in commercialisation activities and facilitating the usage and exploitation of scientific discoveries through appropriate property rights protection mechanisms. One example is the passage of the Bayh-Dole Act in 1980 in the US and other similar favourable regulatory environments. The result is a natural increase in the number of patents granted to universities (Czarnitzki, Glanzel, and Hussinger 2007).

Patents are commonly seen as playing a major role in markets for intellectual property, facilitating the disclosure of technical information. Although they do not guarantee the future marketability of the technology, they represent a key tool for safeguarding their potential. However, some observers are slightly sceptical about the long-term consequences that commercialisation activities may have over publications and the academic culture of open science (Geuna and Nesta 2006). Similarly, doubts emerge about a potential shift in the

1
2
3
4 traditional incentives of researchers to engage in basic and applied research activities (Van
5
6
7 Looy, Callaert, and Debackere 2006).

8
9
10 This study is intended to shed some light on this debate. By means of an empirical
11
12 analysis we test the hypotheses of complimentary versus rivalry relationships between basic
13
14 (publications) and applied (patents) scientific achievements in academia. The sample
15
16 considers the Spanish higher education system for the period 2006-10.
17
18
19

20
21 Academic scientists build their careers mainly upon reputation and accreditation
22
23 systems. According to the Spanish National Agency of Quality Assessment and Accreditation
24
25 Trust (ANECA), the most valued criterion for being designated for any of the different types
26
27 of academic positions is papers published. The weights in the final evaluation range between
28
29 26-35% for publications, and 3-12% for patents, according to the knowledge field. Moreover,
30
31 the novelty requirements imposed by intellectual property rights (IPR) laws entail publication
32
33 restrictions. This means that academic inventors are usually asked to keep their research
34
35 secret until the patent application has been filed, resulting in publication delays. These facts
36
37 suggest that the reputational reward system of patents may be slightly different from the
38
39 publishing one. Yet, such incentives may be relaxed once the promotion is awarded.
40
41
42
43
44
45
46
47
48

49
50 Publications also tend to be more valued than patents when evaluating universities.
51
52 For instance, in the Academic Ranking of World Universities, 20% of the total score is based
53
54 on the number of papers published. Similarly, in the QS World University Ranking the same
55
56
57
58
59
60

1
2
3
4 percentage is given to citations per faculty. On the contrary, none of these two rankings
5
6
7 considers patents.

8
9
10 These records suggest that there is both an internal pressure (at the individual level of
11
12 the researcher, to advance in his/her academic career) and an external one (at the aggregate
13
14 level of the university, to achieve a better position in rankings) to publish more and better,
15
16 rather than to disseminate research results through patents.
17
18
19

20
21 In order to investigate the extent to which academic patenting is compatible with
22
23 publication activities a two-step analysis is proposed. First, we investigate, through different
24
25 regression models, those factors that act as drivers when considering papers and patents
26
27 independently. Second, based on a cluster analysis, we examine the conditions under which
28
29 these two outputs coexist. Conclusions and policy implications are discussed.
30
31
32
33
34
35
36

37 **2. Literature review**

38
39
40 A growing number of studies are examining the combined effects that publications and the
41
42 inventorship of patents have. Three effects are observed as follows.
43
44
45

46 47 ***2.1 No effect***

48
49
50 A first bunch of studies shows that the adoption of an applied research orientation is not at
51
52 the expense of publications. Using a large sample of active professors in Germany,
53
54
55

56 Czarnitzki, Glanzel, and Hussinger (2007) provide empirical evidence that commercialising
57
58
59
60

1
2
3
4 academic discoveries has no negative implications on publication counts. Similarly, Agrawal
5
6
7 and Henderson (2002) and Gulbrandsen and Smeby (2005) conclude that patenting activity
8
9
10 does not appear to be dependent on publishing activity.

11
12 The motives for patenting seem to play a key role. Choosing patenting over
13
14 publishing may be related with a tenured position (not needing further academic credentials
15
16 for promotion). This links with the idea that individual incentives gradually change over time
17
18 (Calderini, Franzoni, and Vezzulli 2007).
19
20
21
22

23
24 This no empirical evidence for a negative impact seems to support the idea that
25
26 substitution and reinforcement effects are blended. Therefore, unidirectional forces driving
27
28 university publications and patents are counteracted.
29
30
31

32 33 34 ***2.2 Positive effect***

35
36
37 A greater faculty involvement in industry can also lead to increased levels of basic research
38
39 outcomes. In order to test the 'co-activity' of science and technology, Meyer (2006) found
40
41 that, in nano-science and nano-technology fields, co-active researchers outperform their
42
43 colleagues. Similarly, Stephan et al. (2002) studied this relationship at the individual level,
44
45 and found that the probability to apply for a patent is related to previous experience in
46
47 publishing. Likewise, Carayol and Matt (2004) found that highly publishing labs were also
48
49 active in patenting. Going a step further, Klitkou and Gulbrandsen (2010) observed that
50
51 differences among fields, the university profile and other contextual factors also play a role in
52
53
54
55
56
57
58
59
60

1
2
3
4 the effects of patenting.
5
6

7 Recent studies are questioning the direction of this reinforcement effect (Carayol and
8
9
10 Matt 2004): is patenting opening up new scientific opportunities that lead to publications, or
11
12 is patenting preceded by publications? Although the answer is still unclear these studies
13
14 corroborate that, at least in some disciplines, university-industry links are enriching,
15
16 strengthening the idea that patents are by-products of scientific work rather than substitutes
17
18
19 (Breschi, Lissoni, and Montobbio 2007; Murray 2002).
20
21
22
23

24 25 *2.3 Negative effect* 26

27
28 A third stream of studies argues that patenting suppresses scientific publishing and vice versa.
29
30
31 Rizzo and Ramaciotti (2014) found a negative but low significant effect, signalling that the
32
33 scientific productivity of a university does not influence its propensity to apply for patents.
34
35
36 This substitution effect is explained by the difficulties and the time required for transferring
37
38
39 scientific discoveries into marketable creations (Thursby and Thursby 2002).
40
41
42

43 There are many norms of secrecy and interdictions that prevent researchers to share
44
45
46 research materials and disseminate the discoveries through publications before the patenting
47
48
49 opportunity has not been sorted out (Geuna and Nesta 2006). Furthermore, patenting is a
50
51
52 time-consuming task that implies a significant reduction in the time devoted to publishing
53
54
55 activities (Klitkou and Gulbrandsen 2010). In addition, not many researchers patent and those
56
57
58 that do it, do it rarely. Thus, a lack of practice may also support this substitution effect.
59
60

3. Hypotheses

Following Del-Palacio, Sole, and Berbegal (2011), we assess the explanatory power that universities' internal services have over publications and patents.

3.1. Human capital

The presence of high levels of human capital influences the quality of business behaviour (Becker 1975). This is especially relevant in universities, organisations that heavily rely on individual's knowledge and capacities (Benneworth and Hospers 2007).

The first dimension of human capital considered refers to the direct labour force [DLF], that is, those faculty members engaged in research activities. Academic staff constitutes a unique resource for universities, as they are the first frontline in command of the academic and research activities. This way we hypothesise that:

Hypothesis 1: The highest the proportion of faculty members highly involved in research activities, the greatest the research outcomes (in terms of patents and publications).

The second dimension relates to the personnel involved in specific support tasks such as administrative or service oriented activities but that are crucial for supporting researchers' daily activities (Kusku 2003). Support labour force [SLF] includes library and research support staff. As for the specific case of patenting, this activity requires coaching and an appropriate assessment, thus, it becomes necessary to consider the technical staff devoted to IPR. From here we hypothesise that:

1
2
3
4 *Hypothesis 2: There is a positive relationship between the access to support labour force*
5
6
7 *and the level of research outcomes (publications and patents).*
8
9

10 **3.2. Experience**

11
12
13
14 Accumulated knowledge [KA] provides individuals with the specific know-how and
15
16
17 capabilities which can help them develop more successful strategies, and consequently,
18
19
20 potentially achieve higher outcome rates. This dimension aims at capturing the dynamic
21
22
23 knowledge spillovers derived from past experience which may help create a more fertile
24
25
26 setting for the development of new activities (Ploeg and Veugelers 2008). In this sense, we
27
28
29 consider that the presence of knowledge stock or background that faculty and the institution
30
31
32 have in a specific field can help universities in obtaining new outputs. Accordingly, we
33
34
35 hypothesise that:

36
37 *Hypothesis 3: Knowledge accumulation is positively related to new research outcomes*
38
39
40 *(publications and patents).*
41
42

43
44 Another way to account for the experience is measuring how actively the university
45
46
47 has been involved in producing the desired outputs. Moreover, following Gueno (1998) and
48
49
50 Merton (1988) old universities can have both a halo and a Mathew effect based on historic
51
52
53 interactions of expertise and prestige. This translates in saying that those universities with
54
55
56 seniority [S] are likely to have developed appropriate policies, managerial capabilities and
57
58
59
60

1
2
3
4 infrastructures that facilitate the production of the desired outputs. Consequently, we
5
6
7 hypothesise that:

8
9
10 *Hypothesis 4: There is a positive relation between seniority and the achievement of higher*
11
12 *levels of outcomes (publications and patents).*

13 14 15 16 **3.3. Financial resources**

17
18
19
20 Previous research reports a positive relation between access to financial resources and
21
22
23 knowledge transfer activities (Landry, Amara, and Ouimet 2007). Income from R&D
24
25
26 activities is considered an appropriate proxy for university's financial resources as it
27
28
29 represents the monetary income from the exploitation of research results (Cohn, Rhine, and
30
31
32 Santos 1989). This income may be seen as that derived from specific fundraising universities-
33
34
35 industry partnerships or that coming from the commercialization of specific research
36
37
38 outcomes. Given that financial resources are critical for developing new research activities,
39
40
41 we hypothesise:

42
43 *Hypothesis 5: There is a positive relationship between universities' income from previous*
44
45
46 *R&D activities and the level of research outcomes (publications and patents).*

47
48
49 Technology transfer activities are also supported by specific units, known as
50
51
52 technology transfer offices (TTOs). These units act as knowledge brokers (Berbegal-
53
54
55 Mirabent, Sabate, and Cañabate 2012) linking university discoveries with practical
56
57
58 application with industry's needs. Because knowledge commercialization is possible due to
59
60

1
2
3
4 previous investment in research, the commercialization of the results is likely to be
5
6
7 influenced by the amount of funding available at TTOs. As a result, we hypothesise that:

8
9
10 *Hypothesis 6: There is a positive relationship between the budget of the TTO and the*
11
12 *number of patents.*

13 14 15 16 **3.4. Profile**

17
18
19
20 This dimension captures the university's academic diversification and the orientation of the
21
22
23 research engaged. Previous research indicates that universities either with medical schools or
24
25
26 more oriented towards engineering studies are more likely to generate higher levels of
27
28
29 research outcomes with a clear market orientation than those universities with a greater
30
31
32 orientation in social science or humanities (Landry, Amara, and Ouimet 2007). In terms of
33
34
35 publications, a similar behaviour is observed. In some knowledge fields it is easier for
36
37
38 academics to develop their research activities and publish in scientific journals than in other
39
40
41 fields. For instance, according to the Spanish ANECA, for being considered as a full
42
43
44 professor, researchers are expected to have published in the last 10 years between 16 and 40
45
46
47 papers, according to the knowledge field. Based on this rationale, we hypothesise that:

48
49 *Hypothesis 7: Polytechnic universities are more prone to achieve higher levels of research*
50
51 *outcomes (publications and patents).*

52
53
54
55 *Hypothesis 8: Universities with medical schools are more prone to achieve higher levels of*
56
57
58 *research outcomes (publications and patents).*

1
2
3
4 Finally, concerning the intrinsic characteristics of universities, we take into account
5
6 university size. Empirical studies have found that university size is positively related to the
7
8 amount of knowledge transferred (Belenzon and Schankerman 2009). Based on this
9
10 argument, we hypothesise that:
11
12

13
14
15 *Hypothesis 9: Larger universities will be linked to higher rates of research outcomes*
16
17
18 *(publications and patents).*
19

20 21 22 **3.5. Patterns followed by universities** 23

24
25 Universities face multi-dimensional objectives (teaching, research and technology transfer)
26
27 and align their internal resources and capabilities according to their strategic vision. In this
28
29 line, previous studies suggest that universities behave differently, and thus, follow different
30
31 patterns in the way they shape their strategies with their objective function (Berbegal-
32
33 Mirabent, Lafuente, and Solé 2013).
34
35
36
37
38

39
40 Moreover, universities are somehow embedded in their regional context;
41
42 consequently, the exposure to specific regional economic variables may influence
43
44 universities' capacity to achieve high performance rates (Shattock 2009), especially in terms
45
46 of research productivity. Accordingly, we hypothesise:
47
48
49

50
51
52 *Hypothesis 10: Spanish public universities follow different pathways in relation to the*
53
54
55 *strategy adopted to address the research objective mission.*
56
57
58
59
60

4. Data and method

4.1 Data

We focus on the Spanish case, using data from all presence-based public universities of the country (47) for the period 2006-10, included in the reports of the Council of Rectors of Spanish Universities (CRUE) and the Spanish Network of Technology Transfer Offices (RedOTRI).

4.2 Variables

Two dependent variables are used: the number of papers published in journals indexed in the ISI-Web of Knowledge in 2010, and the number of patents granted in 2010 by the Spanish Patent and Trademark Office (OEPM).

Direct labour force has traditionally been measured by total number or full-time equivalent faculty staff (Archibald and Feldman 2008), or by categorising research staff according to the position they hold (Caballero et al. 2004). We use this latter approach, and consider the percentage of academic staff holding a PhD, a quality criterion which is expected to be linked to a greater academic productivity in terms of publications. To quantify the direct labour force that will be likely to patent, prior patenting involvement of researchers is commonly used (Czarnitzki, Hussinger, and Schneider 2011). Accordingly, we use the percentage of faculty members involved in knowledge transfer activities. As for the staff

1
2
3
4 supporting researcher's activity, similar to previous studies (Caldera and Debande 2010; del-
5
6
7 Palacio, Solé, and Berbegal 2011) we use library staff relative to total support staff, and
8
9
10 research support staff relative to total support staff for the model predicting the number of
11
12 publications. In the patents model we use specialised employees in IPR tasks relative to the
13
14 total number of employees working in the TTO.
15
16

17
18 Knowledge accumulation employs two measures. For the model explaining papers,
19
20 we use the percentage of papers published in the first quartile of ISI-Web of Knowledge
21
22 ranked journals in the last two years. As for the model predicting patents we calculate the
23
24 effectiveness ratio of patents emerging from invention disclosures. In both cases measures
25
26 aim at capturing not only the knowledge spillovers derived from past experience but the
27
28 quality of the prior activity. The second dimension of experience, seniority, is captured using
29
30 the number of years that both the university and the TTO have been in operation (Conti and
31
32 Gaule 2011).
33
34
35
36
37
38
39

40
41 To assess financial resources we use the income coming from R&D activities, and the
42
43 budget of the TTO (Bergebál-Mirabent, Sabate, and Cañabate 2012). According to the
44
45 RedOTRI, for the period under analysis over 76% of the budget of Spanish TTOs comes from
46
47 their parent university, public grants and overheads. This means that the rents resulting from
48
49 the commercialization of the knowledge and technology are unfortunately still low.
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4 Accordingly, it makes sense hypothesising that those TTOs with larger budgets would have
5
6 more opportunities to invest resources in the valorisation of their research outcomes.
7
8

9
10 Size effects are also controlled. The literature suggests different ways for taking it into
11
12 account. One option considers the amount of people working (faculty members) or studying
13
14 (students) in the organisation (Muscio 2010). An alternative approach account for the
15
16 availability of infrastructures and spaces (e.g. seats in classrooms, laboratories, total area)
17
18 (Agasisti and Dal-Bianco 2009; Kao and Hung 2008). Following this latter approach, we take
19
20 university total area in thousands of square meters.
21
22
23
24
25
26

27 Finally, concerning the nature of the research engaged, previous studies looked at the
28
29 presence of specific hard-science schools (e.g. medicine or engineering), or considered the
30
31 diversity of the portfolio of studies offered (Conti and Gaule 2011). In this paper we use two
32
33 dummy variables: whether the university offers medical studies, and if the university is a
34
35 polytechnic university.
36
37
38
39
40
41

42 43 ***4.3 First stage analysis*** 44

45
46 First stage assesses the explanatory power that universities' internal services have over
47
48 scientific productivity. The linear regression is the econometric technique chosen to assess
49
50 the number of publications (Model 1). A negative binomial regression method is used for the
51
52 patents model (Model 2) due to the highly skewed distribution of the dependent variable
53
54
55
56
57
58 (Greene 2008).
59
60

1
2
3
4 Some considerations are in order. First, to control for potential endogeneity problems
5
6
7 explanatory variables were introduced as lagged terms and the values of these variables
8
9
10 correspond to those reported for the year 2008/09. Second, to ensure the robustness of the
11
12
13 significance of the results on the full model, we also examined the explanatory power that
14
15
16 each exogenous variable has over the corresponding research output in an individual fashion.
17
18
19 Results validate the consistency of both full models. Third, some variables were transformed
20
21
22 by use of the natural logarithm (R&D income, TTO budget, university size, university age
23
24
25 and TTO age) to obtain normality. Fourth, normal probability plots of the residuals for Model
26
27
28 1 corroborate that they were normally distributed. Fifth, no collinearity problems were
29
30
31 observed, as the maximum VIF calculated was 4.17 (Rogerson 2001). Sixth, due to the lack
32
33
34 of information on certain explanatory variables six universities have been dropped out from
35
36
37 the final sample for Model 2.

38 39 ***4.4 Second stage analysis***

40
41
42
43 We first analyse the relationship between patents and publications considering the whole set
44
45
46 of Spanish public universities. Missing values in the number of patents were linearly
47
48
49 estimated by means of the least square method. Only one university (Universidad de
50
51
52 Salamanca) was dropped from the final sample due to insufficient data.

53
54
55 Second, based on the hypothesis that Spanish public universities follow different
56
57
58 behavioural patterns in the allocation of internal resources, we propose a non-hierarchical
59
60

1
2
3
4 cluster analysis (K-means) using the variables that are found to be significant in stage one. As
5
6
7 the number of clusters must be specified prior the estimation, two approaches are used to
8
9
10 validate the number of clusters: we computed the Calinski and Harabasz (1974) statistic,
11
12 being four the number of clusters that maximises the $CH(k)$ index (*pseudo-F* value=79.930);
13
14
15 then, we ran a discriminant analysis to further corroborate that our approach was appropriate.
16
17

18 The lack of information on certain explanatory variables (TTO budget) leads us to
19
20
21 drop five universities from the final sample.
22
23

24 25 **5. Empirical results and discussion**

26 27 28 ***5.1 Forces driving academic research outputs***

29
30
31
32 Table 1 presents the results. As for the direct labour force dimension, results indicate that the
33
34
35 proportion of faculty members holding a PhD does not help explaining publications. A
36
37
38 similar behaviour is found in Model 2 for the proportion of faculty members involved in
39
40
41 knowledge transfer (KT) activities. To further examine this finding we correlate these two
42
43
44 variables with their respective dependent variables. Additional descriptives corroborate that
45
46
47 holding a PhD is linked to a greater academic productivity in terms of publications (42.8%, p-
48
49
50 value=0.003), whereas the proportion of faculty members involved in KT activities is not
51
52
53 statistically significant (-16.7%, p-value>0.100). This lack of significance can be explained
54
55
56 by the conditions that dominate the research landscape in Spain, where incentive schemes
57
58
59
60

1
2
3
4 play a decisive role.
5
6

7
8 <Insert_Table1_about_here>
9

10
11 Considering the support labour force dimension, we found that due to the complexity
12
13 of the legal aspects and/or because researchers are not used to patent, those universities with a
14
15 higher proportion of TTO staff devoted to IPR tasks are more prone to achieve better
16
17 performance rates in terms of patents. Therefore, specialised assessment and coaching are
18
19 desired services when patenting. However, this positive and significant effect diminishes in
20
21 Model 1, indicating that publishing mainly relies on researchers' capabilities and that this
22
23 process is commonly well-known for academics.
24
25
26
27
28
29

30
31 Knowledge accumulated helps people develop their tasks more efficiently. In Model 1
32
33 previous publishing activity in highly qualified journals is positively related with new
34
35 publications, pointing out to dynamic knowledge spillovers derived from past experience.
36
37 This hypothesis is not supported in Model 2. However, if we analyse the correlation between
38
39 patents granted in 2010 and those for the period 2007-9, there is a positive and significant
40
41 correlation (80.1%, p -value<0.010). Nonetheless, the mechanisms that should facilitate
42
43 efficient conversion rates have not yet been fully implemented.
44
45
46
47
48
49

50
51 The seniority effect is significant in both models. While the age of the university is a
52
53 determinant factor for publishing, the age of the TTO positively influences the patenting
54
55 activity, signalling a potential relationship between seniority and reputation.
56
57
58
59
60

1
2
3
4 Access to financial resources is also crucial. The income generated from prior R&D
5
6
7 activities represents an economic cushion that boosts new research activities which may turn
8
9
10 into publications. Although this effect weakens in Model 2, a strong correlation is observed
11
12 between R&D income and the number of patents (65.34, p-value<0.010%). Results also
13
14 confirm that those TTOs with higher annual budgets generate more patents.
15
16
17

18 The effect of the profile of the university over research outcomes is also evidenced.
19
20 Polytechnic universities and those with medical studies outperform their peers in the number
21
22 of patents; however, there are no differences in terms of publications.
23
24
25
26

27 Finally, size also plays a role. While there is no doubt of its significance in Model 2
28
29 (p-value=0.009), some interrogations arise in Model 1 (p-value=0.103). Nevertheless, when
30
31 the standard errors for Model 1 are based on the observed information matrix instead of
32
33 robust, this variables turns out to be statistically significant (p-value=0.069). Accordingly, we
34
35 posit that large universities have a greater capacity to create economies of scale and produce
36
37 research outputs.
38
39
40
41
42
43
44

45 ***5.2 Publishing versus patenting activities***

46
47

48 Spanish public universities have substantially increased their research activity for the 2006-
49
50 10 period. While the total number of publications has increased by 136.7%, the number of
51
52 patents granted has almost duplicated (179.6%). This double intensification suggests a
53
54 potential reinforcement effect between publishing and patenting.
55
56
57
58
59
60

1
2
3
4 In order to better understand the underlying rationale of this relationship we first
5
6
7 correlate the accumulated number of papers and patents for the last 5 years. A positive and
8
9
10 statistically significant effect is observed (p-value=0.009), signalling a slightly lineal
11
12
13 relationship between both variables ($R^2=0.163$) (Figure 1). Thus, our preliminary results are
14
15
16 not conclusive to support the hypothesis of reinforcement effects.

17
18
19 <Insert_Figure_1_about_here>
20
21

22 Because universities face multi-dimensional objectives and shape their research
23
24
25 activities following different strategies, these results should be taken with a grain of salt. To
26
27
28 further investigate the ways through which Spanish universities align their resources with
29
30
31 regard to research outputs, we ran a cluster analysis. Table 2 presents the results. Four
32
33
34 different groups are observed, confirming H10 which states that Spanish universities follow
35
36
37 different pathways in relation to the strategy adopted to address the research objective
38
39
40 mission.

41
42
43 <Insert_Table2_about_here>
44
45

46 Universities in **cluster 1** do not seem to excel in any of the performance variables.
47
48
49 Yet, their results are much better in publishing than in patenting. These universities published
50
51
52 on average 3,139 for the period 2006-10 (766.75 in 2010), and 21.500 patents were granted
53
54
55 for the same period (6.750 in 2010). Although these universities are large institutions, have
56
57
58 on average 178.000 years of experience, and offer medical studies, their low performing rates
59
60

1
2
3
4 are explained by a resource shortage, both in financial terms and human capital (except for
5
6
7 the proportion of faculty members holding a PhD).
8

9
10 In this group, Universidad de Zaragoza (UZA) is an influential point since its Cook's
11
12 distance is above the convention cut-off point of $4/n$ ($1.125 > 1$). Particularly, UZA doubles
13
14 the average number of papers published in 2010 by the other three universities in this group
15
16 (1,190; average: 766.75). A similar behaviour is observed in the accumulated number of
17
18 patents (period 2006-10), where UZA is first ranked with 44 patents, far ahead from
19
20 University of Córdoba, with 22 patents. The overreaching conclusion is that although
21
22 universities in group 1 have a comparable level of resources, certain universities have created
23
24 an enabling atmosphere for the development of university-industry alliances with no
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

damaging effect on traditional research outcomes.

Universities in **cluster 2** are more oriented towards disseminating new knowledge through publications, however, they show both the lowest concentration of papers (average number of papers: 1,814.048) and patents (17.143) for the period 2006-10, explained by a weak previous experience in publishing and patenting. Universities in this group are lacking an enabling environment. They have important constraints in terms of financial resources and human resources are also scarce. Even though these universities better excel in disseminating knowledge through publications, there is no substitution effect but a lack of a culture aimed at safeguarding research results for future commercialisation and exploitation activities.

1
2
3
4 According to Cook's distance rule of thumb, cluster 2 has two influential
5
6 observations: Universidad de Cádiz (UCA) and Universidad de Vigo (UVI). Within
7
8 universities in this cluster and for the period 2006-10, UCA exhibits the highest production of
9
10 patents (45; average: 17.143), while UVI shows the highest production of papers (3,534;
11
12 average: 1814.048).
13
14
15
16

17
18 Universities in **cluster 3** stand out for their experience in the market. Despite their
19
20 relative youth (average: 36.890 years), they possess senior TTOs (second ranked). Other
21
22 shared features include size (large universities), an important stock of human resources and
23
24 the access to financial resources. Because this cluster comprises universities offering studies
25
26 in medicine and three out of the four Spanish polytechnic universities, this group reports the
27
28 highest figures in patents. Additionally, publication numbers are also above the average.
29
30 These results corroborate that specialised universities have a greater capacity to accumulate
31
32 knowledge which accelerates researcher's activity in form of publications and marketable
33
34 inventions.
35
36
37
38
39
40
41
42
43

44 In this group Universitat Autònoma de Barcelona (UAB) clearly outperforms in terms
45
46 of publications (9,479; average: 5,046.444) being to some extent this basic research
47
48 orientation counterproductive for transferring knowledge through patents (14; average:
49
50 56.333). From the statistical point of view, UAB is an influential observation (Cook's
51
52 distance rule of thumb: $0.682 > 4/9$). Although Figure 2 seems to indicate a slightly negative
53
54
55
56
57
58
59
60

1
2
3
4 relationship between publications and patents, an in-depth analysis reveals that universities in
5
6
7 cluster 3 are taking advantage of the natural spillovers that arise from a close relationship
8
9
10 with the industry sector. Accordingly, they base their strategy on their capacity to transform
11
12 their different resources, previous experience and academic specialisation to strengthen
13
14 university-industry collaborations which may turn into new knowledge that will be
15
16 disseminated through different mechanisms. Therefore, patenting and publishing are
17
18 important objectives to be accomplished simultaneously.
19
20
21
22

23
24
25 <Insert_Figure_2_about_here>
26
27

28 For the period under analysis, the average number of publications and patents for
29
30 universities in **cluster 4** (papers: 7,663.143; patents: 44) is relatively high compared to that of
31
32 Spanish public universities (papers: 3,651.488; patents: 30.756). Universities in this group
33
34 seem to base their strategy in disseminating new knowledge through publications.
35
36
37 Nevertheless, their publication intensity seems to be slightly negatively correlated with the
38
39 patenting activity despite its non-statistical significant effect (p-value=0.911) (Figure 2),
40
41
42 indicating that although possessing the resources, these universities leave aside the possibility
43
44 to translate research results into something valued by the market. This path suggests that
45
46 academics perceive no or few motivations to engage in commercialisation activities.
47
48
49 Consequently, universities from this group should define specific incentives to create an
50
51 enabling environment for transferring academic research.
52
53
54
55
56
57
58
59
60

1
2
3
4 Within this group Universidad de Valladolid (UVA) acts as an influential point
5
6 (Cook's distance: $1.199 > 0.571$; studentized residual: -2.794). Compared to universities in
7
8 cluster 4, UVA exhibits the lowest performance rates in terms of publications (590) and
9
10 patents granted in 2010 (11), a trend that is also observed when considering the accumulated
11
12 number of papers and patents for the last 5 years (papers: 2,790; patents: 19). In terms of
13
14 research outcomes, this university seems to fit better with those in cluster 1; however access
15
16 to financial resources is much in line with those universities in cluster 4.
17
18
19
20
21
22
23

24 25 **6. Conclusions and policy implications** 26

27
28 Universities are seeking for additional sources of rents and reputation, but they certainly do
29
30 not want to do this so if these activities are in detriment of traditional research activities. In
31
32 this context, the analysis of the trade-offs between publications and patents is paramount.
33
34
35

36
37 Throughout this study we have brought further insights on this specific topic by
38
39 focusing on the Spanish public university sector. We first embarked on the analysis of the
40
41 determinants of papers and patents in an individual fashion. As for the key results, we found
42
43 that TTO staff involved in IPR activities helps explain the number of patents. Both
44
45 knowledge accumulation and seniority positively influence publishing activities, while this
46
47 effect dilutes when patenting is the main objective. The access to financial resources is also
48
49 decisive, especially R&D income for publishing and the budget of the TTO for patenting.
50
51
52
53
54
55

56
57 This latter result should be interpreted with caution, because larger TTOs may lead to a
58
59
60

1
2
3
4 greater activity in terms of knowledge flow, without this availability of results being
5
6
7 necessarily translated into higher investments in patent activity. Lastly, we found that the
8
9
10 profile of the university is a key determinant, particularly when patenting. Size effects are
11
12
13 also observed.

14
15
16 Second, we empirically assessed how universities allocate their resources when
17
18
19 simultaneously dealing with publishing and patenting objectives. Our results indicate that, for
20
21
22 the whole set of Spanish public universities, patents and papers are positively correlated,
23
24
25 indicating complementary effects. To get a better grasp on how universities behave, we
26
27
28 conduct a cluster analysis, and identify four different patterns. Universities in clusters 1 and 2
29
30
31 exhibit acceptable levels of publication outcomes, but a resource shortage and a lack of a
32
33
34 culture aimed at safeguarding research results diminish their capacity to transfer scientific
35
36
37 discoveries into marketable products. In terms of policy making these universities should
38
39
40 enhance the interconnectivity of the different university's structures, while reinforcing the
41
42
43 linkages with the industry. Universities in clusters 3 and 4 outperform their peers in terms of
44
45
46 publications and patents. While for universities in cluster 3 patenting and publishing
47
48
49 objectives seem to coexist without damaging effects, universities in cluster 4 mainly drive
50
51
52 their research efforts on behalf of publications, an orientation that, to some extent, implies
53
54
55 sacrificing the patenting activity.
56
57
58
59
60

1
2
3
4 The aforementioned results seem to corroborate those contributions that suggest that
5
6 publications and patents can be obtained simultaneously. Nevertheless, universities are
7
8 carrying out basic and research activities at different levels of commitment, which clearly
9
10 depend on structural, normative and cultural factors. These differences materialises in
11
12 multiple ways of addressing their research objective mission, complicating any effort to
13
14 converge on a homogenous policy design.
15
16
17
18
19

20
21 In terms of policy making, universities should define specific incentives that create a
22
23 favourable environment for the valorisation of academic research. Potential extraordinary
24
25 revenues, new research opportunities or the creation of scientific networks are some
26
27 initiatives that can both motivate institutions and their faculty members.
28
29
30
31

32
33 The global economic downturn has strongly hampered the Spanish higher education
34
35 system, which is suffering from its begging (2008-2009) an important resource shortage. This
36
37 scarcity in the resources may have affected the performance of universities in their research
38
39 activities. We believe this question to be of great interest. Future studies should consider this
40
41 analysis and determine whether the different pathways identified are maintained over time.
42
43
44
45
46

47 The main limitation of this study relates to the specific analysis of the Spanish public
48
49 higher education system. Nevertheless, other countries can benefit from this research. First,
50
51 trade-offs between publishing and patenting are not specific of the Spanish higher education
52
53 system. Several factors such as public-private expenditures on R&D (Botta 2014),
54
55
56
57
58
59
60

1
2
3
4 governance models (Dobbins, Knill, and Vögtle 2011), and university autonomy (Moscatti
5
6
7 2012), suggest similarities with higher education systems in Italy, Portugal and France.

8
9
10 Second, normative, social and cultural heritage generates different ways of operating.

11
12 Accordingly, further research efforts should be directed towards analysing the extent to
13
14
15 which the geographical dimension is influencing academic research.
16
17

18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
New research avenues should compare how public and private universities perform,
and determine whether the presence of shareholder-driven objectives and different financial
structures affect university performance. However, the lack of a homogenous disclosure
policy for public and private universities prevents us to undertake this comparison.

Finally, it is important to remark that data available are rich and reliable variables
were created. However, future studies might consider the use of complementary indicators
that make possible to evaluate, to a greater extent, the quality of the outcomes produced.

References

- Agasisti, T., and A. Dal Bianco. 2009. Reforming the university sector: effects on teaching
efficiency - evidence from Italy. *Higher Education* 57: 477–98. [doi: 10.1007/s10734-008-9157-x](https://doi.org/10.1007/s10734-008-9157-x).
- Agrawal, A., and R. Henderson. 2002. Putting patents in context: exploring knowledge
transfer from MIT. *Management Science* 48: 44–60. [doi:10.1287/mnsc.48.1.44.14279](https://doi.org/10.1287/mnsc.48.1.44.14279).
- Archibald, R.B., and D.H. Feldman. 2008. Graduation rates and accountability: Regressions
versus production frontiers. *Research in Higher Education* 49: 80–100.
[doi:10.1007/s11162-007-9063-6](https://doi.org/10.1007/s11162-007-9063-6).

- 1
2
3
4 Azagra-Caro, J.M., F. Archontakis, and A. Yegros-Yegros. 2007. In which regions do
5
6 universities patent and publish more? *Scientometrics* 70: 251–66.
7
8 [doi:10.1007/s11192-007-0202-9](https://doi.org/10.1007/s11192-007-0202-9).
9
- 10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- Becker, G. 1975. *Human capital*. Chicago: University of Chicago Press.
- Belenzon, S., and M. Schankerman. 2009. University knowledge transfer: private ownership, incentives, and local development objectives. *The Journal of Law and Economics* 52: 111–44.
- Benneworth, P., and G. Hospers. 2007. Urban competitiveness in the knowledge economy: universities as new planning animateurs. *Progress in Planning* 67: 105–97.
- Berbegal-Mirabent, J., E. Lafuente, and F. Solé. 2013. The pursuit of knowledge transfer activities: an efficiency analysis of Spanish universities. *Journal of Business Research*, 66: 2051–59. [doi:10.1016/j.jbusres.2013.02.031](https://doi.org/10.1016/j.jbusres.2013.02.031).
- Berbegal-Mirabent, J., F. Sabate, and A. Cañabate. 2012. Brokering knowledge from universities to the marketplace: the role of knowledge transfer offices. *Management Decision* 50: 1285–307. [doi:10.1108/00251741211247012](https://doi.org/10.1108/00251741211247012).
- Botta, A. 2014. Structural Asymmetries at the Roots of the Eurozone Crisis: What’s New for Industrial Policy in the EU? *SSRN Scholarly Paper ID 2508164*. Rochester, NY: Social Science Research Network. <http://papers.ssrn.com/abstract=2508164>.
- Breschi, S., F. Lissoni, and F. Montobbio. 2007. The scientific productivity of academic inventors: new evidence from Italian data. *Economics of Innovation and New Technology* 16: 101–18. [doi:10.1080/10438590600982830](https://doi.org/10.1080/10438590600982830).
- Caballero, R., T. Galache, T. Gómez, J. Molina, and A. Torrico. 2004. Budgetary allocations and efficiency in the human resources policy of a university following multiple criteria. *Economics of Education Review* 23: 67–74. [doi:10.1016/S0272-7757\(03\)00049-9](https://doi.org/10.1016/S0272-7757(03)00049-9).

- 1
2
3 Caldera, A., and O. Debande. 2010. Performance of Spanish universities in technology
4 transfer: an empirical analysis. *Research Policy* 39: 1160–73.
5
6 [doi:10.1016/j.respol.2010.05.016](https://doi.org/10.1016/j.respol.2010.05.016).
7
8
9
10 Calderini, M., C. Franzoni, and A. Vezzulli. 2007. If star scientists do not patent: the effect of
11 productivity, basicness and impact on the decision to patent in the academic world.
12
13 *Research Policy* 36: 303–19.
14
15
16
17 Calinski, T., and J. Harabasz. 1974. A dendrite method for cluster analysis. *Communications*
18 *in Statistics - Theory and Methods* 3: 1–27. [doi:10.1080/03610927408827101](https://doi.org/10.1080/03610927408827101).
19
20
21 Carayol, N., and M. Matt. 2004. Does research organization influence academic production?
22 Laboratory level evidence from a large European university. *Research Policy* 33:
23 1081–102. [doi:10.1016/j.respol.2004.03.004](https://doi.org/10.1016/j.respol.2004.03.004).
24
25
26
27 Cohn, E., Sherrie L.W. Rhine, and M.C. Santos. 1989. Institutions of higher education as
28 multi-product firms: economies of scale and scope. *The Review of Economics and*
29 *Statistics* 71: 284–90. [doi:10.2307/1926974](https://doi.org/10.2307/1926974).
30
31
32
33
34 Conti, A., and P. Gaule. 2011. Is the US outperforming Europe in university technology
35 licensing? A new perspective on the European Paradox. *Research Policy* 40: 123–35.
36
37 [doi:10.1016/j.respol.2010.10.007](https://doi.org/10.1016/j.respol.2010.10.007).
38
39
40
41 Czarnitzki, D., W. Glanzel, and K. Hussinger. 2007. Patent and publication activities of
42 German professors: an empirical assessment of their co-activity. *Research Evaluation*
43 16: 311–9. [doi:10.3152/095820207X254439](https://doi.org/10.3152/095820207X254439).
44
45
46
47 Czarnitzki, D., K. Hussinger, and C. Schneider. 2011. Commercializing academic research:
48 the quality of faculty patenting. *Industrial and Corporate Change* 20: 1403–37.
49
50 [doi:10.1093/icc/dtr034](https://doi.org/10.1093/icc/dtr034).
51
52
53
54 del-Palacio, I., F. Solé, and J. Berbegal. 2011. Which services support research activities at
55 universities? *Service Industries Journal* 31: 39–58.
56
57 [doi:10.1080/02642069.2010.485194](https://doi.org/10.1080/02642069.2010.485194).
58
59
60

- 1
2
3
4 Dobbins, M, C. Knill, and E.M. Vögtle. 2011. An analytical framework for the cross-country
5 comparison of higher education governance. *Higher Education* 62: 665–83.
6
7 [doi:10.1007/s10734-011-9412-4](https://doi.org/10.1007/s10734-011-9412-4).
8
9
10 Geuna, A. 1998. The internationalisation of European universities: a return to medieval roots.
11
12 *Minerva* 36: 253–70. [doi:10.1023/A:1004391922122](https://doi.org/10.1023/A:1004391922122).
13
14 Geuna, A., and L.J. Nesta. 2006. University patenting and its effects on academic research:
15 the emerging European evidence. *Research Policy* 35: 790–807.
16
17 [doi:10.1016/j.respol.2006.04.005](https://doi.org/10.1016/j.respol.2006.04.005).
18
19
20 Greene, W. 2008. Functional forms for the negative binomial model for count data.
21
22 *Economics Letters* 99: 585–90. [doi:10.1016/j.econlet.2007.10.015](https://doi.org/10.1016/j.econlet.2007.10.015).
23
24
25 Gulbrandsen, M., and J.C. Smeby. 2005. Industry funding and university professors' research
26 performance. *Research Policy* 34: 932–50. [doi:10.1016/j.respol.2005.05.004](https://doi.org/10.1016/j.respol.2005.05.004).
27
28
29 Kao, C., and H.T. Hung. 2008. Efficiency analysis of university departments: An empirical
30 study. *Omega* 36: 653–64. [doi:10.1016/j.omega.2006.02.003](https://doi.org/10.1016/j.omega.2006.02.003).
31
32
33 Klitkou, A., and M. Gulbrandsen. 2010. The relationship between academic patenting and
34 scientific publishing in Norway. *Scientometrics* 82: 93–108. [doi:10.1007/s11192-009-](https://doi.org/10.1007/s11192-009-0050-x)
35
36 [0050-x](https://doi.org/10.1007/s11192-009-0050-x).
37
38
39
40 Kuskü, F. 2003. Employee satisfaction in higher education: the case of academic and
41 administrative staff in Turkey. *Career Development International* 8: 347–56.
42
43 [doi:10.1108/13620430310505304](https://doi.org/10.1108/13620430310505304).
44
45
46
47 Lai, W-H. 2011. Willingness-to-engage in technology transfer in industry-university
48 collaborations. *Journal of Business Research* 64: 1218–23.
49
50 [doi:10.1016/j.jbusres.2011.06.026](https://doi.org/10.1016/j.jbusres.2011.06.026).
51
52
53
54
55
56
57
58
59
60

- 1
2
3 Landry, R., N. Amara, and M. Ouimet. 2007. Determinants of knowledge transfer: evidence
4 from Canadian university researchers in natural sciences and engineering. *The*
5 *Journal of Technology Transfer* 32: 561–92. [doi:10.1007/s10961-006-0017-5](https://doi.org/10.1007/s10961-006-0017-5).
6
7
8
9
10 Merton, R.K. 1988. The Matthew effect in science, II: cumulative advantage and the
11 symbolism of intellectual property. *Isis* 79: 606–23.
12
13
14 Meyer, M. 2006. Are patenting scientists the better scholars? An exploratory comparison of
15 inventor-authors with their non-inventing peers in nano-science and technology.
16 *Research Policy* 35: 1646–62. [doi:10.1016/j.respol.2006.09.013](https://doi.org/10.1016/j.respol.2006.09.013).
17
18
19
20
21 Moscati, R. 2012. University Governance in Changing European Systems of Higher
22 Education. In *European Higher Education at the Crossroads*, 599–611. Springer
23 Netherlands. http://link.springer.com/chapter/10.1007/978-94-007-3937-6_32.
24
25
26
27 Murray, F. 2002. Innovation as co-evolution of scientific and technological networks:
28 exploring tissue engineering. *Research Policy* 31: 1389–403. [doi:10.1016/S0048-](https://doi.org/10.1016/S0048-7333(02)00070-7)
29 [7333\(02\)00070-7](https://doi.org/10.1016/S0048-7333(02)00070-7).
30
31
32
33
34 Muscio, A. 2010. What drives the university use of technology transfer offices? Evidence
35 from Italy. *The Journal of Technology Transfer* 35: 181–202. [doi:10.1007/s10961-](https://doi.org/10.1007/s10961-009-9121-7)
36 [009-9121-7](https://doi.org/10.1007/s10961-009-9121-7).
37
38
39
40 Ploeg, F. van D., and R. Veugelers. 2008. Towards evidence-based reform of European
41 universities. *CESifo Economic Studies* 54: 99–120. [doi:10.1093/cesifo/ifn015](https://doi.org/10.1093/cesifo/ifn015).
42
43
44
45 Rizzo, U., and L. Ramaciotti. 2014. The determinants of academic patenting by Italian
46 universities. *Technology Analysis & Strategic Management* 26: 469–83.
47
48
49 [doi:10.1080/09537325.2014.882502](https://doi.org/10.1080/09537325.2014.882502).
50
51 Rogerson, P. 2001. *Statistical methods for geography*. London; Thousand Oaks, Calif.:
52 SAGE Publications.
53
54
55
56
57
58
59
60

1
2
3 Shattock, M. 2009. *Entrepreneurialism in universities and the knowledge economy:*
4
5 *diversification and organizational change in European higher education.*

6
7 Maidenhead: Open University Press.

8
9
10 Stephan, P.E., S. Gurmu, A.J. Sumell, and G. Black. 2002. Individual patenting and
11
12 publication activity: having one's cake and eating it too. In *Conference rethinking*
13
14 *science policy: analytical frameworks for evidence-based policy, held on, 21–23.*

15
16 University of Sussex, Brighton, UK.

17
18
19 Thursby, J.G., and M.C. Thursby. 2002. Who is selling the ivory tower? Sources of growth in
20
21 university licensing. *Management Science* 48: 90–104.

22
23 [doi:10.1287/mnsc.48.1.90.14271](https://doi.org/10.1287/mnsc.48.1.90.14271).

24
25
26 Van Looy, B., J. Callaert, and K. Debackere. 2006. Publication and patent behavior of
27
28 academic researchers: conflicting, reinforcing or merely co-existing? *Research Policy*

29
30 35: 596–608. [doi:10.1016/j.respol.2006.02.003](https://doi.org/10.1016/j.respol.2006.02.003).

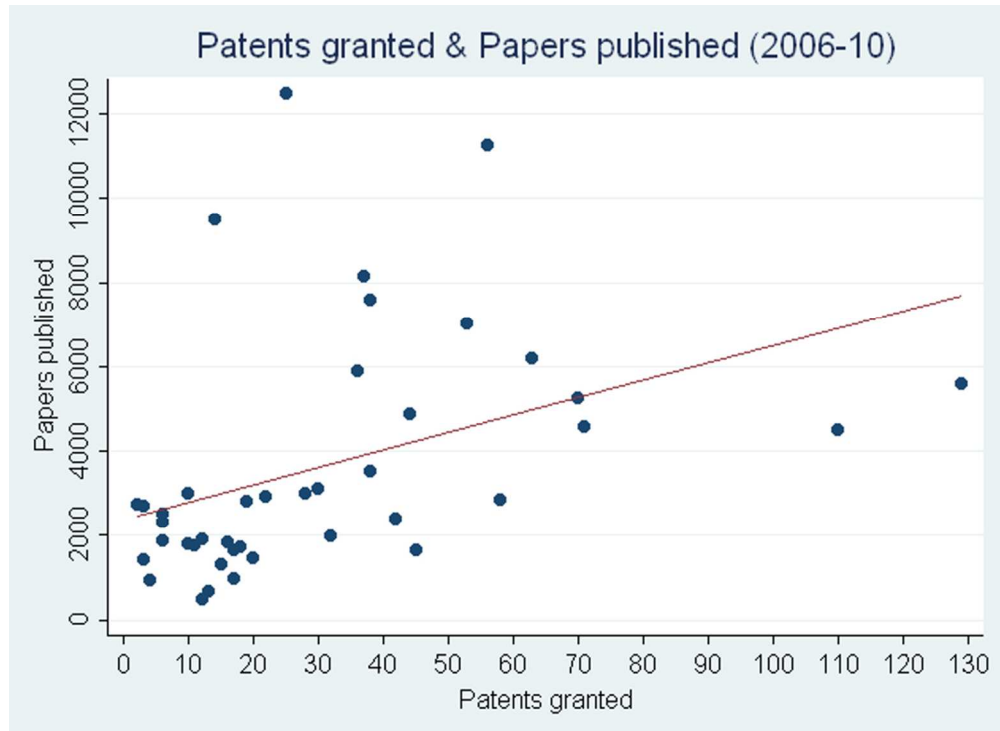


Figure 1. Scatterplot for the accumulated values of papers published and patents granted (2006-10)
48x34mm (600 x 600 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

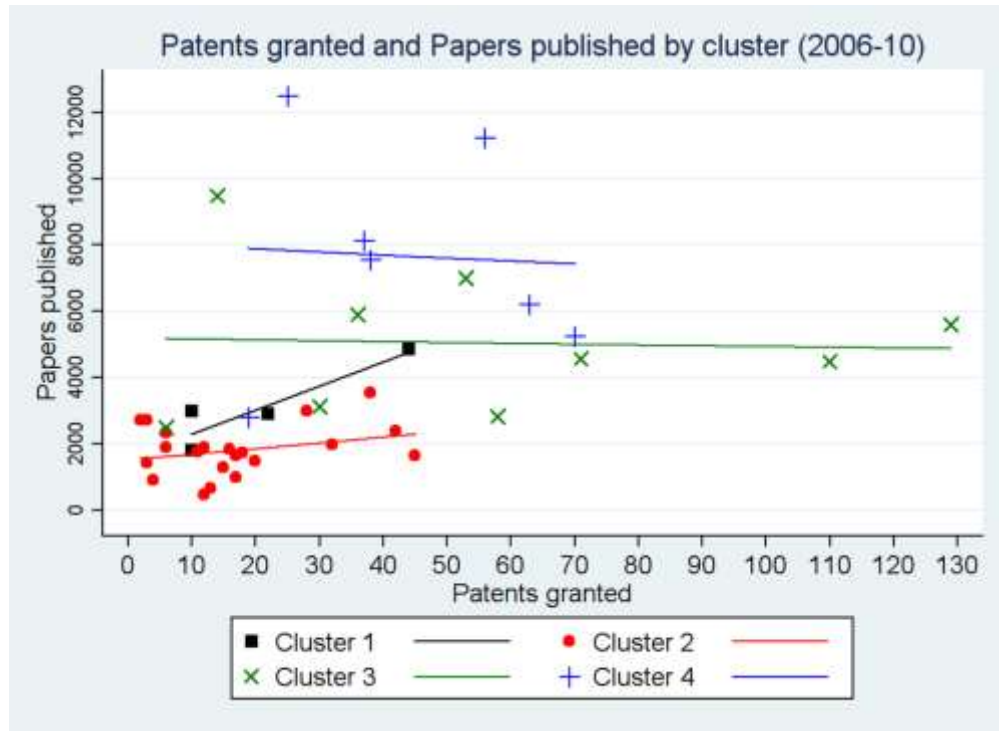


Figure 2. Scatterplot for the accumulated values of papers and patents (2006-10) by clusters
48x34mm (600 x 600 DPI)

Table 1. Results of the regression analysis.

		Model 1: Publications		Model 2: Patents	
Factor		Coefficient	Standard Error ^a	Coefficient	Standard Error ^a
Human resources					
[DLF]	PhD faculty (%)	0.618	0.458		
	Faculty in KT activities (%)			0.553	0.887
	Library support staff (%)	0.560	1.205		
[SLF]	Research support staff (%)	0.713	0.464		
	TTO staff in IPR tasks (%)			4.301**	2.052
Experience					
[KA]	Papers Q1 (%)	2.223**	1.090		
	Patents/Invention disclosures			-0.297	0.427
[S]	Age HEI	0.086**	0.042	-0.094	0.058
	Age TTO			0.925**	0.432
Financial resources					
	R&D income	0.503***	0.102	0.141	0.237
	Budget TTO			0.047**	0.021
Profile					
	Polytechnic university	-0.200	0.132	1.063*	0.579
	Medicine school	0.089	0.117	0.760**	0.329
	University size	0.238****	0.142	0.638***	0.246
	Intercept	-3.456**	1.206	-11.280***	2.379
	F – test	63.300***			
	R squared	0.890			
	RMSE	0.268			
	Log likelihood			-109.184	
	Pseudo R ²			0.190	
	Wald chi ²			112.210***	

^aRobust standard errors adjusted by heteroskedasticity.

*, **, *** Significance at the 10%, 5%, and 1%, respectively.

**** Significant at the 10% without robust standard errors treatment.

Table 2. Results of the cluster analysis (means and standard errors).

Variables	Cluster 1^a	Cluster 2	Cluster 3	Cluster 4
Papers (2006-10)	3,139.000 (1,264.350)	1,814.048 (770.190)	5,046.444 (2,242.783)	7,663.143 (3,367.826)
Patents Granted (2006-10)	21.500 (16.031)	17.143 (12.924)	56.333 (41.566)	44.000 (19.374)
TTO staff in IPR tasks (%)	5.6 (0.036)	8.0 (0.060)	10.3 (0.084)	7.2 (0.047)
Papers Q1 (%)	46.0 (0.072)	45.6 (0.055)	46.4 (0.034)	45.4 (0.039)
R&D income	25,559.34 (17,109.62)	15,653.84 (8,535.591)	62,626.99 (28,828.61)	53,206.10 (18,390.86)
Budget TTO	208.770 (86.072)	124,733.4 (42,809.59)	333,190.4 (103,834.6)	405,770.3 (131,779.8)
Age HEI	178.000 (208.040)	20.667 (7.052)	36.889 (6.972)	554.857 (114.596)
Age TTO	19.250 (3.304)	16.048 (3.735)	19.889 (2.804)	20.857 (2.268)
Polytechnic university	0 (0)	0 (0)	0.333 (0.500)	0 (0)
Medicine school	1 (0)	0.762 (0.436)	0.667 (0.500)	1 (0)
University size	348,801.3 (170,995.00)	170,112.6 (81,984.8)	373,016.3 (128,049.7)	511,222.5 (199,756.6)
Universities	4	21	9	7

Standard error in brackets.

^aCluster 1, after excluding Universidad de Salamanca.