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by

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Patents, competition and firms' innovation incentives

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Abstract

In this paper we analyze how industrial property rights (IPRs), measured by patents granted, affect competition at the industry level, and their induced effects on firms' innovation incentives. We use for that purpose a panel dataset of Spanish manufacturing firms for the period 1990-2006. Using indicators of fundamentals of competitive pressure and factor analysis techniques, we construct a new synthetic measure of competition. Our results indicate that although the use of IPRs (in terms of industry patenting intensity) reduces market competition, it may also encourage firms' innovation incentives (in terms of firms' R&D expenditures and the number of product innovations).

Keywords: IPRs, patents, competition, innovation.

JEL Classification: D22, L10, L60, O31, O34.

1. Introduction.

In spite of the significant controversy, both in law and economics, about the interaction between industrial property rights (IPRs) and innovation, this is an area in which very little empirical research has been done.[1] The debate is mainly focused on the trade-off between the IPRs system and competition policy and their final effects on firms' innovation incentives (see, e.g., Dumont and Holmes, 2002, and Ganslandt, 2008, and references therein). On the one hand, IPRs are meant to encourage innovation by protecting the future rents of the innovators (the *incentive effect* of IPRs on innovation). On the other hand, IPRs provide monopoly power to the innovative firms, preventing entry of both new firms into the market and of new innovations, hindering competition and, allegedly, innovation (the *prevention effect* of IPRs). This latter negative effect of IPRs on innovation by weakening competition is based on the assumption that enhanced competition encourages innovation. However, without any further refinement, it can be misleading taking for granted that enhanced competition spurs innovation. This issue is also related to the broad industrial organization literature that has analyzed the relationship between competition and innovation (see, e.g. Aghion et al. 2005, and Peneder, 2012, and references therein). This literature is still unsettled, at least in part due to the conflicting results

[1] According to the European Commission "A strong industrial property rights system is a driving force for innovation, stimulating R&D investment and facilitating the transfer of knowledge from the laboratory to the marketplace" http://ec.europa.eu/internal_market/indprop/rights/index_en.htm.

between the predictions of theoretical models and empirical evidence (see, e.g., Vives, 2008, and references therein). Which of the two potential on-going effects of IPRs on innovation incentives dominates is, to a great extent, a matter of empirical assessment.

The scarce existing empirical evidence is mixed. On the one hand, a number of studies suggest that the use of IPRs may in some cases protect the dominant positions of incumbent firms. Boldrin and Levine (2008, 2009), for instance, argue that incumbent firms have strong incentives to protect their leadership position through patents and that intellectual property protection damages creation and innovation. On the other hand, there is evidence also supporting the positive effect of IPRs on firms' performance indicators (see, e.g., Greenhalgh and Rogers, 2007, for a survey of the available literature on the value for firms of using IPRs). Kanward and Evenson (2003) provide empirical evidence supporting an unambiguous positive effect of IPRs (proxied by patents granted) on innovation incentives (proxied by R&D expenditures) for a cross-countries panel data set. However, they do not make any attempt to explore the role of market competition in shaping this relationship.[2]

The aim of this paper is to provide empirical evidence on how IPRs and competition interact and jointly affect firms' innovation incentives. In particular, we aim at investigating the impact of patenting activity within an industry on the degree of market competition faced by firms

[2] See also Hall and Harhoff (2012), and references therein, for a recent survey on the effect of patents as an incentive for innovation.

in that industry, and, in turn, on their incentives to innovate.[3] Thus, our main research questions in this paper are: Does the use of IPRs weaken market competition to the point that they discourage innovation (through the prevention effect), or do they strengthen innovation (through the incentive effect)? Do different types of innovation activities (R&D expenditures, product and process innovations) respond similarly to changes in competition and in IPRs?

In order to tackle these empirical questions we proceed in three steps. First, we need to construct a synthetic measure of market competition that serves as the dependent variable in our analysis of the effect of patents on market competition. Recently, new contributions to the literature have insisted on reconsidering the use of the standard indicators of product market competition in empirical work, such as the price-cost margin, PCM henceforth, or market concentration mesures. The main criticism to these empirical measures is that they do not always respond in the expected way to changes in the level of competition in the industry. Boone (2008), for instance, argues that, with asymmetric firms' cost efficiency levels, the average PCM of the industry may raise as a consequence of the most inefficient firms exiting the market when competitive pressure intensifies. We consider in this paper that, for a measure of competition to be valid in empirical

[3] This has been precisely one of the lines of research recently encouraged by the *UK Intellectual Property Office* (*Intellectual Property and Growth Review*, http://www.ipo.gov.uk/irpeview-c4e.pdf).

analysis, it has to move in the right direction when any fundamental determinant of competitive pressure in the market changes. For that purpose, we propose a competition index at the industry-year level based in what the industrial organization literature identifies as the fundamental determinants of competitive pressure in a free entry context (endogenous market structure): the degree of product substitutability, market size and entry costs (see, e.g. Vives, 2008). We show that the new measure of competition, unlike traditional measures such as PCM or the number of competitors in the market, is unambiguously related to enhanced competition.

In a second step, we investigate the effect of patenting at the industry-year level on this new measure of market competition. The availability in our dataset of information on firms' patent counts and innovation outcomes allows us to distinguish patenting from innovating as different issues, and to focus on investigating the role of patenting as a tool of the IPRs system used by firms to affect market competition. We consider the joint availability of information on both innovation activities (firms' product and process innovations, as well as R&D expenditures) and on patents granted to be a particularly appealing feature of our data as compared with most of empirical work on IPRs, which often rely on patent counts but lack information on innovation results (or *viceversa*). The number of patents granted in an industry depends, among other factors, upon the legal and technical features of that industry. While some patents are issued for purely legal purposes, having little or none innovative contents, many others have a substantial innovative content. In the latter case, patents may approximate two dimensions of the innovation process of firms. On the one hand, they are measures of firms' innovation outcomes, like product/process innovations or innovative sales. On the other hand, patents represent a mean to ensure the appropriability of the rents derived from innovation (i.e. patents are a form of IPRs). When patents are the only variable in the analysis, it is not possible to identify properly those industries that make an intensive use of IPRs from those that are just more innovative. We estimate at the industry level the effect of patents on competition and investigate whether the results obtained are robust to including in estimation the level of innovations achieved in a given industry.

Finally, in the third step we examine the impact of patenting intensity and competition in an industry on the firms' incentives to innovate, using firm level data. We measure firms' innovation incentives using firms' R&D expenditures, the number of product innovations, and the decision to introduce process innovations. The dataset is drawn from the Survey of Business Strategies (ESEE henceforth) for the period 1990-2006. This survey is an annual panel survey that is representative of Spanish manufacturing firms and that includes detailed information on a number of firm and market characteristics.

To anticipate our results, we provide empirical evidence that, at the industry level, patenting activity lowers market competition. In addition, we obtain that market competition is negatively associated with firms' innovation incentives in terms of firms' R&D expenditures and the number of product innovations (in favour of the Schumpeterian thesis),[4] although positively associated with the introduction of process innovations (in favour of the so-called *escape competition* effect following Arrow, 1962).[5] Thus, we provide evidence that, although the use of IPRs, measured as patenting intensity at the industry level, reduces market competition, it may also encourage firms' innovation incentives (in terms of firms' R&D expenditures or the number of product innovations).

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[4] The theoretical studies of competition and innovation go back to the work of Schumpeter (1943), who related the innovative activity to market structure. Schumpeter's seminal work argued that firms with greater monopoly power have a greater incentive to innovate because they can better appropriate the returns of their R&D investment.

[5] The line of thought postulated by Arrow (1962) in a context of perfect protection of the innovators' property rights was that increased product market competition may increase the incremental profits from innovating and thus encourage firms' R&D investments. Also Porter (1990) argued that monopoly discourages innovation because firms do not need to innovate to stay in business. More recently, Boone (2000) and Boone *et al.* (2007), as regards process innovation, claim that enhanced competitive pressure may increase the incentives for process innovation. This is explained by both an *adaptation effect* and a *selection effect* of competitive pressure: firms know that an increase in competitive pressure may decrease market shares of less efficient firms (*adaptation effect*) or evan can contribute to these firms exiting business (*selection effect*). Therefore, firms' face the challenge to adapt and to improve their efficiency throught process innovations.

To sum up, the contribution of this paper to the existing literature is threefold. First, it proposes a new way to measure product market competition, based on variables capturing the fundamentals of competitive pressure. Secondly, it provides empirical evidence on the effect of patent intensity at the industry level (as a measure of IPRs) on market competition in the industry. Thirdly, our results provide evidence that although patenting intensity lowers market competition at the industry level, it may also promote firms' innovation incentives. Thus, our results indicate that competition policies should consider the question of incentives for innovation as a key aspect to take into account when evaluating the effects of IPRs on competition. [6]

The rest of the paper is organized as follows. In section 2 we describe the data and variables used, and explain how we built a new measure of market competition. Section 3 presents our econometric results and section 4 concludes.

[6] The IPR system and competition policy share the common purpose of promoting innovation and enhancing consumer welfare. However, a conflict arises between the two (Ganslandt, 2008). On the one hand, IPRs seek to create rents by protecting innovators, giving the inventor exclusive property rights for the exploitation of the invention, and thus weakening competition in the market. On the other hand, competition law seeks to maintain competition, avoiding situations of market abuse by incumbents that may damage effective competition.

2. Data and variables, competition index and descriptive analysis.

2.1. Data and variables.

The data used in this paper are drawn from the ESEE, *Survey of Business Strategies*, for the period 1990-2006. This is an annual panel survey sponsored by the Spanish Ministry of Industry and carried out since 1990 that is representative of Spanish manufacturing firms by industrial sectors and size categories.[7]

The ESEE has three features that make it a particularly suitable database for our empirical analysis. First, it provides data both on IPRs and innovation outcomes as different variables. In particular, it provides data on patents registered by firms in each year, as well as data on R&D activities, the number of product innovations introduced by the firm, and on whether or not the firm has introduced any process innovation during the corresponding year. The availability of firms' data on patent counts and innovation activities allows us to distinguish

[7] The sampling procedure is the following. Firms with less than 10 employees were excluded from the survey. Firms with 10 to 200 employees were randomly sampled, holding around 5% of the population in 1990. All firms with more than 200 employees were requested to participate, obtaining a participation rate of 70% in 1990. Important efforts are made to minimize attrition and to annually incorporate new firms with the same sampling criteria as in the base year, so that the sample of firms remains representative over time. The annual average number of firms answering the questionnaire is approximately 1,800, with around 600 corresponding to small firms and approximately 1,200 to large firms. See http://www.funep.es/esee/ing/i_esee.asp for further details.

patenting from innovating as different, although linked, activities of firms. This makes an important difference of the ESEE as compared to other data sources, which only provide patents, forcing the researcher to use patents as indicators of innovation outcomes (see, e.g., Aghion et al., 2005, or Helmers and Rogers, 2009). In the latter case, when analyzing time or inter-industry patterns of patenting there is not enough information so as to determine whether the observed patterns are driven either by a higher/lower propensity to patent, or by a higher/lower innovation activity.

Secondly, the time dimension of the panel dataset is 17 years. The availability of such a considerable long time span is crucial for the purposes in this paper in several respects: i) typically the year in which a patent is granted occurs with delay respect to the year in which innovation has been achieved; ii) changes in competition may be better captured within a medium/long run perspective; and, finally, iii) we also consider the effects of (lagged) competitive pressure on firms' innovation incentives.

Thirdly, the ESEE is not an innovation survey. This feature, which could in principle be considered as a drawback, is, in our opinion, very convenient for our analysis since the ESEE provides a very rich set of variables at the firm level, other than innovation variables, characterizing firms and their economic environment. This is an advantage we exploit in the next section, where we turn to the construction of our synthetic competition index. Furthermore, there are also available a number of controls for econometric analysis such as firms' size and age, the percentage of skilled workers and industry classification.

Table 1 presents the definition and the measurement procedure for all the variables used in this paper to build up our competition index, and to perform the subsequent regression analysis. Given that most of our analysis is performed at the industry level, our original variables in the survey have been properly transformed into industry averages after weighting the firms' sample.[8] Therefore, for most of our analysis we will work with a resulting unbalanced panel of industries according to the NACE 74 three digits classification for manufacturing (excluding purely extractive industries, which are not included in the ESEE). Given that we do not observe a sufficient number of firms in all industries in all years, in spite of using 17 years and 109 digit codes, our resulting industry-year estimation sample is an unbalanced panel with 1,105 observations.

[Insert Table 1 about here]

[8] The weighting process consists of upgrading the number of small and large firms in the survey to Spanish manufacturing population proportions, given the different sampling procedure in the ESEE for firms with less than 200 workers in relation to firms with equal or more than 200 workers.

2.2. Construction of a competition index (CI).

A central question in the competition-innovation literature is how to construct a valid measure of the degree of competitive pressure in a market. In this paper we consider that any valid indicator of competition should either increase or decrease in an unambiguous way in response to enhanced competition from any source. If a change takes place in any of the fundamentals of market competition implying, unambiguously, enhanced competitive pressure in that market (say an increase in product substitutability or a fall in entry barriers, for instance), then any valid measure of competition should increase in response to that change. In other words, our aim is at constructing a competition measure that correlates positively with all those variables leading to enhanced market competition. In what follows we propose a new competition indicator that fulfils the above requirement and, in adition, we show that two traditional competition indicators, such as the industry average PCM and the number of competitors in the market, do not always respond in the right direction to changes in the fundamentals of competitive pressure.

The construction of our *competition index* (CI, henceforth) is based on the *factor analysis of data* technique. Factor analysis is a statistical technique that reduces the number of variables in an analysis (say, *p* variables) by finding a few common factors (say, *q* of them) that linearly reconstruct the set of original variables. Each *k*th extracted factor is associated with a set of linear coefficients (b_{kj}, with j=1,…, p), called the *factor loadings*. Interpretation of the obtained factors typically means examining the b_{kj}'s. Factor analysis may be used, as stated above, to represent in a parsimonious way a set of original variables, but also to provide measures (factors) approximating a given concept.[9] In this paper we use factor analysis with this second purpose, and try to determine if any of the extracted factors can be interpreted as an indicator of market competition. We will consider to have found a "competition" factor if there exist a factor which loads positively in all the fundamental determinants of (enhanced) market competition (i.e, $b_{kj}>0$ for all j=1,..., p).

The components of our competition synthetic index are going to be a number of variables considered by the industrial organization literature as the fundamentals driving unambiguously market competition for firms in industries with endogenous market structure (see, e.g., Vives, 2008, and references therein). These variables are the degree of *product substitutability* (measured in our paper by advertising, product promotion, brand promotion, sales agreements, and firm price changes in response to price changes by competitors); the *size of the market* (measured by the geographical scope of the firm's main market and the export-to-sales ratio); and *entry costs*, which are either determined by set-up costs for a new firm to enter an industry, or the

9 Pruett and Thomas (2008), for instance, use factor analysis to derive the two dependent variables of their analysis representing different degrees of complexity of the components of the firms' products.

fixed costs for a firm to introduce a new product into the market (using information provided by the ESEE, we construct a measure of set-up costs *à la* Sutton, 1991, and a measure of product obsolescence in the industry, respectively).[10] The selection of this set of variables is based on a previous work by the authors (see Table 1, and Beneito et al., 2011, for further details).

All the competitive pressure variables are constructed in such a way that larger values of them indicate enhanced competitive pressure in the market and, then, we apply the *iterated principal-factor* (ipf) method. Our *ipf* method provides a first factor (Factor 1) with positive loadings for all the included variables ($b_{1j}>0$ for all j). Table 2 reports the regression scoring coefficients used to create this factor, showing that the factor is obtained as a weighted sum of the variables listed therein, being positive all the scoring coefficients (implying that the factor loadings b_{1j}'s are also all posivite).[11]

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[10] We use the variable speed of *obsolescence* of products in an industry as an indicator of the "costs of introducing a new product" in that industry. In fact, authors as Wörter *et al.* (2010) relate slow product obsolescence to high fixed costs of introducing a new product. The idea behind this argument is that slow product obsolescence proxies for the existence of high fixed costs of introducing a new product into the market, since the firms' willingness to assume such high fixed costs is only compatible with markets where products survive for a considerable length of time.

[11] Although not reported here, no other factor shares with Factor 1 the property of being positively correlated with all the variables (constructed in positive direction to competition). These results are available from the authors upon request.

[Insert Table 2 about here]

In order to have further assurance on the interpretation of the factor as an indicator of market competition, we provide in Table 3 the correlations of Factor 1 with the industry PCM and with a variable indicating the proportion of firms in an industry claiming to face less than ten competitors. Larger values for these two latter variables have been considered traditionally as indicators of low market competition and, therefore, they should move in the opposite direction to our Factor 1. Table 3 shows that our estimated factor is negatively correlated with these competition measures, being the correlations statistically significant at conventional levels.

[Insert Table 3 about here]

Finally, we regress these two traditional 'market competition' indicators on our set of variables proxying for the fundamentals of competitive pressure. Table 4 reports these regression results. Given the way in which the variables are constructed (larger values indicating enhanced competitive pressure), they should exhibit a negative correlation with the dependent variable (either PCM or *number of* *competitors below 10*). As reported in Table 4, a number of variables proxying for enhanced competitive pressure correlate positively and significantly with either the PCM or the number of competitors, contrary to expected and, therefore, indicating that both traditional measures of competition do not always respond in the same direction to enhanced competition.

[Insert Table 4 about here]

Our Factor 1 has mean equal to 0 and variance equal to 1. Thus, positive values of this factor can be interpreted as corresponding to industries with a level of market competition above the mean, whereas negative values of it correspond to industries with competition levels below the mean. Henceforth, we will refer to this factor as our *competition index* (CI). In the next section we show descriptive statistics of this competition index and its relationship with other variables of interest in the analysis.

2.3. Descriptive statistics on patents, competition and innovation.

In this section we provide some empirical evidence about the relationship among the main variables of interest in this work. Given that one of our main focus in the paper is to study the relationship between patenting activity and competition at the industry level, in Graphs 1, 2 and 3 we present the evolution from 1990 to 2006 of our CI measure, the percentage of patentees and the average number of patents calculated over patentees. The annual average of our CI measure has been calculated averaging all the industries values for a given year. If we compare Graph 1, corresponding to the CI, with both Graphs 2 and 3, corresponding, respectively, to the percentage of patentees and to the average number of patents *per* patentee for a given year, we clearly observe that patenting activity and competition have been moving in an opposite direction during the period analyzed. On the one hand, the level of competition for manufacturing in Spain, as measured by our CI, has been rising continuously. This trend is probably the result of the process of globalization and liberalization of the Spanish economy that has been taking place during the last decades, which has implied enhanced competitive pressure for domestic firms. On the other hand, our two measures of patenting activity exhibit generally a decreasing trend. Therefore, the graphical analysis provides first evidence on a negative relationship between patenting activity and competition.[12]

[Insert Graph 1, Graph 2 and Graph 3 about here]

[12] In addition, if instead of using annual average values, we calculate the average values corresponding to each of the industry-year observations in our panel, we obtain that the correlation between the CI and the percentage of patentees is -0.2195 (statistically significant at the 1% level) and between the CI and the number of patents per patentee is -0.082 (statistically significant at the 5.7% level).

To provide further evidence, in Table 5 we present the percentage of patentees and the average number of patents *per* patentee, at the industry level, corresponding to each tercile of the distribution of the CI. According to these terciles, we can divide industries in three groups, corresponding to low-competition, med-competition and high-competition industries, respectively. The figures in Table 5 show that industries with higher competition are associated to lower levels of patenting activity (as measured by both indicators of patenting activity).

[Insert Table 5 about here]

Finally, and with the aim of providing also some evidence on the relationship between firms' innovation and patenting activity and competition at the industry level, we present in Table 6 the percentage of patentees in the industry, the average number of patents *per* patentee, and the CI in the industry, conditional to each tercile of the distribution of firms' log R&D expenditures (in real terms) and leaving as a separated category firms' observations with zero R&D expenditures. The figures in Table 6 provide evidence about firms' R&D expenditures being positively associated with patenting activity in the industry where they operate, both in terms of the percentage of patentees and the average number of patents *per* patentee in the industry. Differently, regarding the CI, we observe a negative association between firms' R&D expenditures and the level of competition, although this association at a descriptive level exhibits a jump in the second tercile of the distribution of firms' R&D expenditures. In order to disentangle the relationship and possible interaction among all these variables, in the next section we turn to regression analysis.

[Insert Table 6 about here]

3. Econometric results.

3.1. The effect of patents on competition.

Our econometric results are reported in Table 7. The dependent variable in all estimations is the competition index, CI, and the main objective is to investigate how this CI is affected by the patenting activity at the industry level. Table 7 includes three estimation models. In the first model, columns (1) to (3), the dependent variable and the explanatory variables are all dated at *t*. In the second model, columns (4) to (6), we lag twice the explanatory variables (excluding the controls) with the aim of capturing possible delays in the effect of these variables on the level of competition, and also with the aim of reducing potential simultaneity bias in the estimates. Finally, in the third model, columns (7) to (9), we calculate the average of all variables over periods of 3-years and then we lag explanatory variables once. Thus, for instance, we regress the average level of competition for the period 2004-2006 with the average of the explanatory variables for the period 2001-2003.

[Insert Table 7 about here]

For these three models, we consider, in turn, three sets of explanatory variables. First, we include only two variables capturing the patenting activity in the industry, namely, the percentage of firms that have registered at least one patent during a given year, and the average number of patents per patentee in the industry. In a second model specification, we include also three ‘innovation variables’: the percentage of product-innovative firms in the industry, the average number of product innovations in the industry (calculated over innovative firms) and the percentage of process-innovative firms in the industry. In our estimations, after including the above mentioned innovation variables, the estimated coefficients for the variables capturing patenting activity can be interpreted as the effect of IPRs on competition, for a given level of innovation activity (product and process innovations). Otherwise, the estimated coefficients for patenting activity could be interpreted as the response of competition to higher levels of innovative activity (given the positive relationship between patents and innovations). Finally, we include a set of control variables such as the average skill composition of the labour force in the industry, the average age of firms in the industry and the average value of (real) sales. All models include year dummies.

We look first at the estimated effects of our variables capturing patenting activity on competition, which is one of the main focuses of this paper. A first result that emerges is that the estimated effect of the percentage of patentees is negative and significant in all columns of Table 7, implying that this estimated effect is robust to the inclusion in the model of innovation variables and controls, and what is even more relevant, to the lagged structure of the estimation equation: both the percentage of patentees lagged two periods with respect to the CI, and the percentage corresponding to the previous 3-year period exhibit a negative and significant effect over the CI. By contrast, the estimated effect of the second variable capturing patenting activity (average patents per patentee) is non-significant in all specifications of Table 7. Thus, our results indicate that whenever the number of patentees in an industry increases, the level of competition in that industry decreases, although the number of patents *per* patentee does not seem to affect competition.[13] Therefore, our findings provide evidence that a higher

[13] It is worth mentioning that the estimated effect of the variable 'average number of patents *per* patentee' is always negative and, in some cases, statistically significant at the 14% level. The level of significance of this variable increases if the percentage of patentees is excluded from the estimation equation.

level of patenting activity in an industry (measured as a higher proportion of patentees) reduces the level of competition in that industry.

As shown in Table 7, the introduction of innovation variables and other control variables in estimation does not change qualitatively the results reported above. On the one hand, the percentage of product-innovating firms is not statistically significant. On the other hand, both the average number of product innovations and the percentage of process-innovating firms seem to be positively correlated with the CI, being this latter effect particularly stronger when these explanatory variables are lagged two periods or averaged over 3-year periods.

The finding that the introduction of the innovation variables does not make the estimated effects of patents on competition to change considerably, nor to lose statistical significance, indicates that the level of patenting activity in an industry (as measured by the percentage of patentees) is a separate issue, although related, to that of innovative activity, and that empirical analysis should take this into account.

3.2. The effect of patents and competition on firms' innovation incentives.

In Table 8 we explore the impact of patents and competition at the industry level on firms' innovation incentives. For this purpose we use the data provided by the ESEE at the firm level and construct, as measures of firms' innovation, three alternative variables, which are our dependent variables in estimation. First, we use information about firms' annual R&D expenditures. Secondly, we use information on the number of product innovations achieved by firms in a given year, and thirdly, we use information on whether the firm has introduced any process innovation in a given year.[14] In Table 8 we estimate the response of firms' innovation incentives to industry patenting activity lagged three periods, and competition in the industry in the previous period (this lag structure is consistent with Table 7, where the competition index in a given period has been found to respond to patents with a lag of two periods). We introduce sequentially in the estimations the percentage of patentees in the industry, the competition index and, finally, both of them. All estimations include our set of control variables defined at the firm level, as well as industry and year dummies.

[Insert Table 8 about here]

The results for firms' R&D expenditures are reported in columns (1) to (3) of Table 8. The variable R&D expenditures is censored from below at 0, given that there may be many firms wich do not spend on R&D in a given period. For this reason we apply in this case a *tobit*

14 Regarding the introduction of process innovations, the ESEE does not provide information on the *number* of process innovations introduced by firms, but only on the qualitative "*yes/no*" answer to the question on whether the firm has introduced any process innovation in a given year.

model to our firm level data. In columns (4) to (6) we report the results for the number of product innovations introduced by firms. In this case, given the count nature of the dependent variable (which may be 0 or a small non-negative integer number), we apply a *negative binomial model.*[15] Finally, results in columns (7) to (9) correspond to the estimation of a *probit model* applied to the dicothomous variable indicating wether or not the firm has introduced any process innovation in a given year.

According to the estimates, higher levels of patenting activity in an industry seem to be positively related to firms' R&D investments, given the positive and significant effect of the patenting activity variable. We further observe that higher levels of patenting activity in an industry exert also a positive and significant effect on firms' introduction of product innovations. However, higher levels of patenting activity in an industry do not seem to affect firms' process innovation in a significant way. These findings would suggest that the degree to which the patent system protects innovators and, thus, provides incentives to undertake innovative activities, is especially important in the case of product innovations. One possible explanation for this result is that the

15 The *negative binomial model* is preferred to the *poisson model* for count data when there is evidence of *overdispersion* in the data (i.e., when the variance of the dependent variable is different from the mean, an assumption neglected by the poisson model). The test for overdispersion is provided at the bottom of Table 8.

prospect and fear of imitation in the case of product innovations are stronger than in the case of process innovations.

Regarding the effect of competition on firms' innovation incentives, the estimated effects of our CI suggest that higher levels of competition in the market discourage firms' R&D expenditures, given the negative and significant effect of our CI in columns (2) and (3) of Table 8. In the case of the number of product innovations, similar negative and significant results of the CI are obtained. However, higher levels of competition seem to encourage process innovations given the positive and significant coefficient of the CI on the probability of introducing process innovations. Thus, our results suggest that enhanced competition discourages product innovations but encourages process innovations.

It is worth mentioning that the sign (and approximated magnitude) of the estimated effect of either patents or the CI hold irrespective of the other variables being included in the estimation. Given that patents and the CI are correlated according to previous results in Table 7, we might argue that excluding the CI from the equation could bias the estimated coefficient of patents and *vice versa*. Finally, control variables such as the skill level of the firm's labour force, have a positive and significant effect on firms' innovation incentives, and in particular on firms' R&D expenditures.

To sum up the above results, our findings provide evidence that patenting activity in an industry has a direct effect on firms' innovation incentives but also an indirect influence by means of its effect in lowering competition. In the case of R&D expenditures and product innovations, our findings indicate the existence of a direct positive and singnificant effect of patenting activity on firms' incentives to invest in R&D and to introduce product innovations. In addition to this direct effect, we also observe an induced positive effect of patenting activity on R&D expenditures and product innovations taking place by its effect in decreasing the level of competition in the industry (as reported in Table 7). These results give support to a negative relationship between competition and innovation incentives and, therefore, they are consistent with a Schumpeterian effect of competition on innovation. However, we also obtain that enhanced competition raises the probability of process innovations, probably because firms need to reduce costs to keep in business, giving support to the scape competition effect of Arrow (1962) or the adaptation/selection effects of Boone (2000).

4. Conclusions.

This paper has provided empirical evidence on the effect of IPRs, proxied by patenting activity, on market competition at the industry level, and its effect on firms' incentives to innovate. The data used for the empirical analysis has been drawn from the ESEE, a Spanish survey of manufacturing firms for the period 1990-2006. We have proceeded in three steps. First, using factor analysis techniques, we have constructed a new measure of product market competition at the industry-year level, based on the fundamentals of competitive pressure and which, unlike the traditional measures such as PCM or number of competitors, is unambiguously related to enhanced competition. Secondly, we have provided empirical evidence on the effect of patent intensity at the industry-year level (as a measure of IPRs) on the level of product market competition in the industry, proxied by our new measure of market competition. The availability in our dataset of information not only on firms' patent counts but also on innovation activities, such as product and process innovation, has allowed us to distinguish "patenting" from "innovating" as different, although related, activities of firms. Our results have shown that the level of patenting in an industry (measured by the percentage of patentees) has a negative and significant effect on market competition, and that this effect is robust to the inclusion in estimation of innovation outcomes, such as product and process innovations, and other controls. Therefore, we could infer from this result that patenting activity in an industry is a different issue, although linked, to that of innovative activity.

Finally, using firm level data we have examined the impact of patenting intensity and competition in an industry on the firms' incentives to innovate. Innovation incentives have been proxied by firms' R&D expenditures, the number of product innovations, and the decision to introduce process innovations. Our findings have indicated that patenting intensity at the industry level is positively associated with firms' innovation incentives measured as firms' R&D expenditures and the number of product innovations. In addition, we have obtained that market competition is negatively associated with innovation incentives in terms of firms' R&D expenditures and the number of product innovations, although positively associated with the introduction of process innovations. Thus, we have provided evidence that although the use of IPRs reduces market competition, it may also encourage firms' innovation incentives (in terms of firms' R&D expenditures and the number of product innovations). These findings contribute to the debate on the interface between IPRs and competition policy, and in particular to the understanding of the interaction between patenting activities and innovation. In particular, our findings have shown that patenting activity at the industry level has a direct effect on firms' innovation activities and an induced effect through reduced market competition. In the case of R&D expenditures and product innovations, as proxies for innovation activities, we have obtained a direct positive and significant effect of industrial patenting on these variables, and an indirect effect acting through the reduction in market competition. However, in the case of process innovations we only obtain an indirect effect between patenting and process innovation operating through the effect of patents on competition (patents reduce competition and, therefore, decrease process innovation).

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Table 1. VARIABLES DEFINITION.

VARIABLES CALCULATED AT THE INDUSTRY LEVEL

FACTOR ANALYSIS VARIABLES:

Product substitutability

Advertisement-to-sales ratio	Industry average value of firms' advertising-to-sales ratios (advertisement expenditures normalized by sales, in %).
Product promotion	Percentage of firms in the industry undertaking product promotion (it is calculated upon a dummy variable taking value 1 if the firm declares to perform product promotion activities).
Brand promotion	Percentage of firms in the industry undertaking brand promotion (it is calculated upon a dummy variable taking value 1 if the firm declares to perform brand promotion activities).
Sales agreements with wholesalers or retailers	Percentage of firms in the industry undertaking sales agreements (it is calculated upon a dummy variable taking value 1 if the firm declares to perform sales agreements with wholesalers or retailers).
Price changes by competitors	Percentage of firms in the industry declaring to change product prices as a reaction to changes in prices of equivalent imported products (it is calculated upon a dummy variable taking value 1 if the firm declares that the reason for a change on its prices has been changes in prices of equivalent imported products). We use this variable as a proxy for to what extent firms take care of and follow price movements by their competitors.

Market size

Main market is national & abroad, or only abroad	Percentage of firms in the industry that sell abroad (it is calculated upon a dummy variable taking value 1 whenever the firm exports).
Exports-to-sales ratio	Industry average value of firms' exports-to-sales ratios (value of exports normalized by sales, in %).

Entry costs

Set-up costs	We follow the method in Sutton (1991) for measuring set-up costs (sunk entry costs). They are measured as the output share of an industry's median-size firm multiplied by the capital-output ratio for the industry as a whole. The former part of the product is considered in Sutton (1991) as a measure for the firm's minimum efficient scale. Therefore, the total measure for set-up costs is a proxy for the amount of capital (relative to the industry's total market size) required to build such a firm.
Slow product obsolescence	Percentage of firms in the industry which declare that the industry products have a low speed of obsolescence (it is calculated upon a dummy variable taking value 1 if the firm declares that the type of products sold in the industry change with a frequency of more than one year, irregularly or do no change, against the reference category of changing more than once in a year).

SOME TRADITIONAL MEASURES OF COMPETITION:

Price-cost margin (PCM)	Industry average value of firms' PCM (calculated as the firm's ratio of [output - labour costs - intermediate inputs costs] over output).
Number of competitors < 10	Percentage of firms in the industry declaring to face less than 10 competitors (it is calculated upon a dummy variable taking value 1 if the firm declares that the number of competitors is smaller than 10, including the absence of competitors).

IPR VARIABLES:

Patentees	Percentage of firms in the industry that have registered at least one patent (it is calculated upon a dummy variable taking value 1 when the firm has registered a positive number of patents).
Number of patents	Industry average number of patents *per* patentee (each firm declares how many patents have registered at each particular year).

INNOVATION VARIABLES:

Product-innovating firms	Percentage of product-innovating firms in the industry (it is constructed upon a dummy variable taking value 1 if the firm has implemented product innovations).
Nº of product innovations	Industry average number of product innovations *per* product innovating firm (each firm declares how many product innovations has introduced at each particular year).
Process-innovating firms	Percentage of process-innovating firms in the industry (it is constructed upon a dummy variable taking value 1 if the firm has implemented process innovations).

CONTROL VARIABLES:

High-skilled labour	Industry average value of firms' high-skilled labour ratios (the number of highly qualified workers –superior engineers and graduates– over total employment, in %).
Medium-skilled labour	Industry average value of firms' medium qualified workers ratios (the number of medium qualified workers –technical engineers, High School Commercial Bachelors and helping people with a qualification title– over total employment, in %).
Age	Industry average firms' age (number of years since the firm was born).
Sales	Industry average value of firms' real sales in logs (firms' sales are in euros that have been deflated using specific industry deflators according to 20 industries of the NACE classification.

VARIABLES CALCULATED AT THE FIRM LEVEL

INNOVATION VARIABLES:

Firm's R&D expenditures	Log of firm's real R&D expenditures. Firms' R&D expenditures are in euros that have been deflated using specific industry deflators according to 20 industries of the NACE classification.
Firms with process innovations	Dummy variable taking value 1 if the firm has implemented process innovations, 0 otherwise.
Firm's number of product innovations	Firm's number of product innovations introduced at each particular year.

CONTROL VARIABLES:

Firm's % of highly-skilled labour	Ratio of the number of highly qualified workers (superior engineers and graduates) to total employment (in %).
Firm's % of medium-skilled labour	Ratio of the number of medium qualified workers (technical engineers, High School Commercial Bachelors and assistants with a qualification title) to total employment (in %).
Firm's age	Number of years since the firm was born.
Firm's sales	Log of firm's real sales. Firms' sales are in euros that have been deflated using specific industry deflators according to 20 industries of the NACE classification.

Table 2.
Factor 1: Scoring coefficients (method = regression)

Variables	Scoring coefficients
Product substitutability	
(-) Advertising-to-sales ratio	0.43340
(-) Product Promotion	0.17328
(-) Brand Promotion	0.15486
(-) Sales agreements	0.35602
Price changes by competitors	0.01692
Market size	
Main market abroad	0.18650
Exports-to-sales ratio	0.11095
Entry costs	
(-) Set-up costs	0.00910
(-) Slow product obsolescence	0.00057
% of variance accounted for by Factor 1: 36.77%	

The notation (-) denotes the variable has been transformed to indicate 'higher competition'.

Table 3.
Correlation of Factor 1 with market competition measures (price-cost margin and "number of competitors below 10")

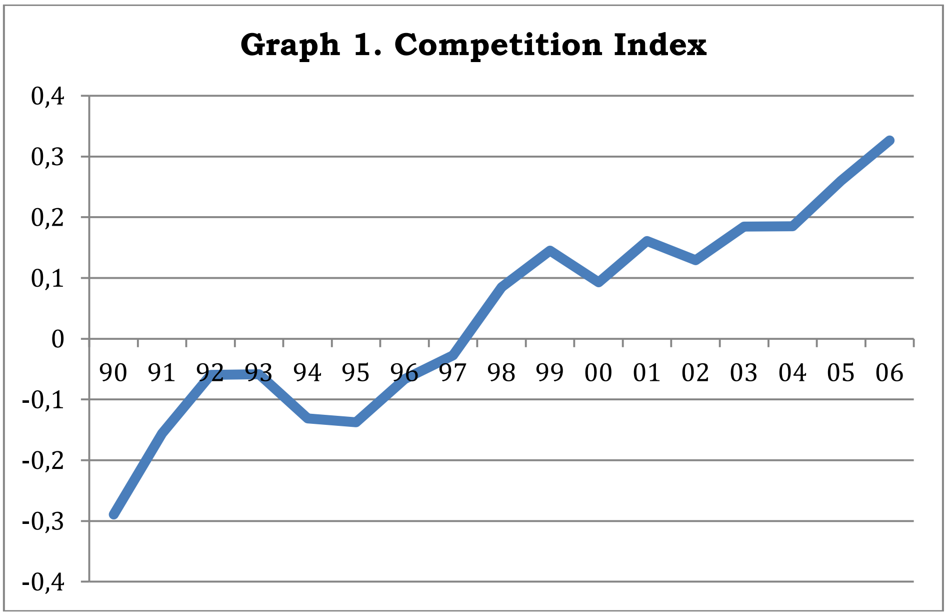
Variables	Correlation coefficients
Price-cost margin	-0.0506*
Number of competitors < 10	-0.1768***

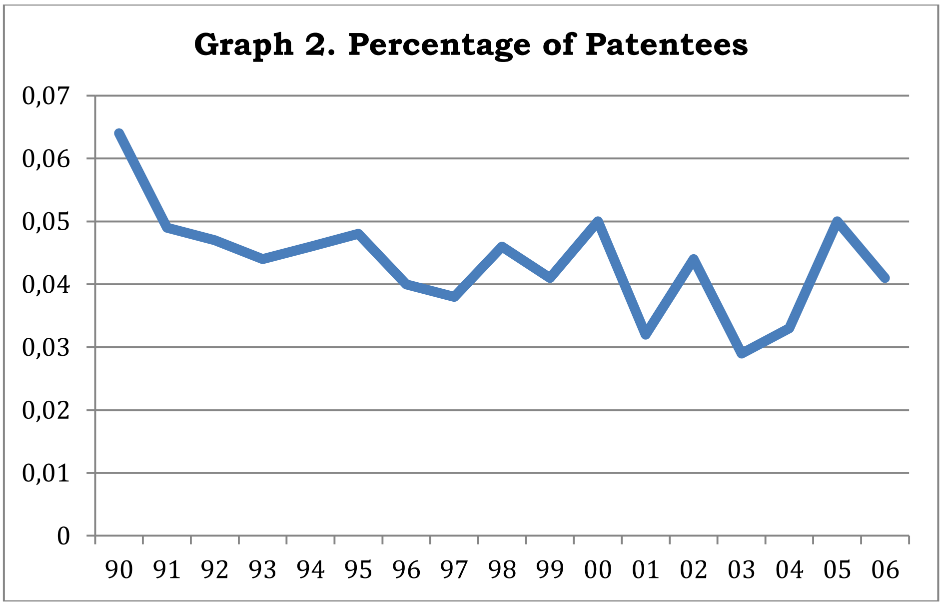
*** p<0.01, ** p<0.05, * p<0.1

Table 4.
Market competition measures (PCM and "number of competitors below 10") and determinants of competitive pressure.

Variables	Dependent: PCM	Dependent: Ner competitors < 10
(-) Advertising-to-sales ratio	-0.018***	-0.041***
	(0.004)	(0.008)
(-) Product Promotion	0.048**	-0.403***
	(0.021)	(0.043)
(-) Brand Promotion	0.183***	-0.224***
	(0.041)	(0.086)
(-) Sales agreements	0.016	-0.331***
	(0.022)	(0.045)
Price changes by competitors	-0.063*	0.487***
	(0.037)	(0.078)
Main market abroad	0.070**	0.966***
	(0.030)	(0.064)
Exports-to-sales ratio	-0.000	-0.001
	(0.000)	(0.001)
(-) Set-up costs	0.018	-0.304***
	(0.027)	(0.057)
(-) Slow product obsolescence	-0.007	0.036
	(0.037)	(0.075)
Observations	1,105	1,105
R-squared	0.039	0.754

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The notation (-) denotes the variable has been transformed to indicate 'higher competition'.


Graph 1. Competition Index
0,4
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
-0,4
90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06


Graph 2. Percentage of Patentees
0,07
0,06
0,05
0,04
0,03
0,02
0,01
0
90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06

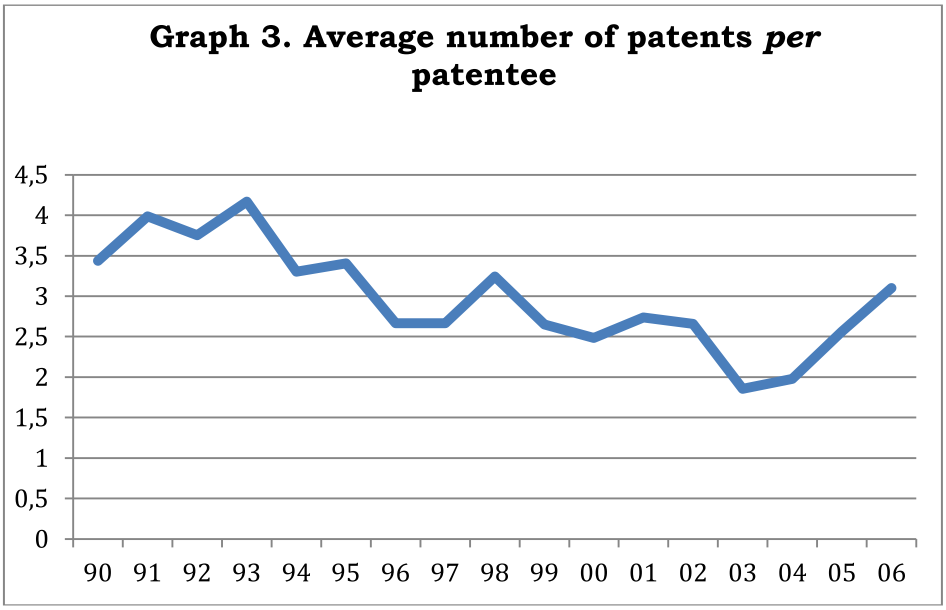

Graph 3. Average number of patents per patentee
4,5
4
3,5
3
2,5
2
1,5
1
0,5
0
90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06

Table 5.

Percentage of patentees in the industry and average number of patents *per* patentee, corresponding to each tercile of the distribution of the Competiton Index (CI).

CI distribution terciles:	Patentees (%)	Number of patents (average)
Low-competition industries	7.76	5.44
Med-competition industries	5.22	4.26
High-competition industries	3.75	3.11

Table 6.

Percentage of patentees in the industry, average number of patents *per* patentee, and Competition Index in the industry (CI) conditional to each tercile of the distribution of firms' log R&D expenditure (in real terms).

Firms' log R&D expenditure (real terms) distribution terciles	Patentees (%)	Number of patents (average)	CI
Zero R&D expenditure	4.19	3.76	0.07
Low-R&D firms	5.55	3.87	0.04
Med-R&D firms	5.80	4.12	0.07
High-R&D firms	7.21	4.51	0.01

Table 7. COMPETITION INDEX & PATENTS (Pooled regressions)

	MODEL I: all variables in t			MODEL II: explanatory variables in t-2 (except for control variables)			MODEL III: 3-year averages, with explanatory variables in t-1.		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Patentees (%)	-1.493***	-1.479***	-1.329***	-1.598***	-1.674***	-1.524***	-2.093**	-2.190**	-1.843*
	(0.356)	(0.376)	(0.355)	(0.405)	(0.424)	(0.400)	(0.900)	(1.045)	(0.963)
Average N^{er} Patents (per patentee)	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.006	-0.006	-0.007
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.006)	(0.006)	(0.006)
Product-innovating firms (%)		-0.312**	-0.144		-0.517***	-0.296*		-0.498	-0.290
		(0.153)	(0.152)		(0.185)	(0.179)		(0.428)	(0.414)
Average N^{er} Product Innovations		0.001***	0.001***		0.001***	0.001***		0.003***	0.001
		(0.000)	(0.000)		(0.000)	(0.000)		(0.001)	(0.001)
Proces-innovating firms (%)		0.251	0.205		0.652***	0.541***		0.951**	0.802*
		(0.177)	(0.166)		(0.198)	(0.182)		(0.440)	(0.413)
High-skilled labour (%)			-0.030***			-0.034***			-0.040***
			(0.007)			(0.007)			(0.014)
Medium-skilled labour (%)			-0.015*			-0.010			0.007
			(0.009)			(0.010)			(0.018)
Age			-0.010***			-0.010***			-0.009
			(0.003)			(0.003)			(0.006)
(log of real) Sales			-0.020			0.000			-0.074
			(0.036)			(0.044)			(0.081)
Constant	0.385***	0.387***	1.414***	0.381**	0.306*	0.776	0.337**	0.181	1.861
	(0.146)	(0.149)	(0.541)	(0.155)	(0.166)	(0.667)	(0.137)	(0.182)	(1.195)
Observations	1,105	1,105	1,105	906	906	906	310	310	310

Robust standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1. All models include year-dummies.

Table 8. PATENTS, COMPETITION & FIRMS' INNOVATION INCENTIVES

	Tobit Model for firms' R&D EXPENDITURES			Neg. Binomial model for firms' N^er of PRODUCT INNOVATIONS			PROBIT model for firms' PROCESS INNOVATIONS		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Industry % of patentees (t-3)	6.340***		7.290***	1.121**		1.102**	0.138		0.199
	(1.326)		(1.401)	(0.494)		(0.520)	(0.181)		(0.199)
Competition Index, CI (t-1)		-0.806***	-0.781***		-0.624***	-0.715***		0.094***	0.080**
		(0.238)	(0.275)		(0.082)	(0.097)		(0.032)	(0.036)
Firm's % of High-skilled labour	0.128***	0.133***	0.125***	0.006	0.022***	0.006	-0.000	0.001	0.000
	(0.015)	(0.014)	(0.015)	(0.005)	(0.005)	(0.005)	(0.002)	(0.002)	(0.002)
Firm's % of Medium-skilled labour	0.093***	0.092***	0.080***	0.013*	0.004	0.008	-0.006**	-0.005**	-0.005*
	(0.021)	(0.018)	(0.021)	(0.008)	(0.007)	(0.008)	(0.003)	(0.002)	(0.003)
Firm's Age	0.053***	0.041***	0.058***	0.014***	0.003	0.014***	-0.000	-0.000	-0.000
	(0.013)	(0.010)	(0.013)	(0.004)	(0.004)	(0.004)	(0.001)	(0.001)	(0.001)
Firm's (log of real) Sales	-0.000***	-0.000**	-0.000***	-0.000**	-0.000	-0.000**	0.092***	0.089***	0.090***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.008)	(0.007)	(0.009)
Constant	3.981***	3.891***	3.965***	0.397***	0.343***	0.384***	-2.734***	-2.714***	-2.742***
	(0.070)	(0.061)	(0.072)	(0.023)	(0.020)	(0.023)	(0.176)	(0.161)	(0.181)
Observations	12,229	15,251	11,431	12,099	15,063	11,304	11,912	14,834	11,130
Overdispersion parameter				2.407***	2.414***	2.379***			
				(0.023)	(0.020)	(0.024)			

Standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1. All models include year-dummies and 20-industrial dummies.