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Innovation and industrial districts: a first approach to the measurement and determinants of the I-district effect

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3 INNOVATION AND INDUSTRIAL DISTRICTS: A FIRST APPROACH TO THE
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5 MEASUREMENT AND DETERMINANTS OF THE I-DISTRICT EFFECT
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29 Abstract. We analyse an exhaustive database of patents granted in Spain between 2001
30 and 2006 aggregated in a panel of 806 local labour markets classified by seven
31 typologies of local production systems. Our analysis shows that Marshallian industrial
32 districts generate 30% of Spanish patents and an innovative output per capita that is
33 47% above the national average and 31% larger than the manufacturing production
34 systems of large firms. The econometric estimates of a fixed effects model confirm the
35 existence of an Innovation-district effect (I-district) and its size. The I-district effect is
36 mainly related to the presence of Marshallian localization economies.
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50 Keywords: industrial districts, innovation, external economies, district effect
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52 JEL: O14; O31; R12
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57 ["Innovación y distritos industriales: una primera aproximación a la](#)
58 [medición y determinantes del efecto I-distrito"](#).
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3 **Resumen:** En la investigación se analiza una exhaustiva base de datos de patentes que
4 entre 2001 y 2006 solicitaron protección en España, agregadas en un panel de 806
5 mercados locales de trabajo clasificados en siete tipologías de sistemas productivos
6 locales. El análisis muestra que los distritos industriales marshallianos generan el 30%
7 de las patentes españolas, así como un output innovador per capita 47% mayor que la
8 media nacional y 31% mayor que los sistemas productivos manufactureros de gran
9 empresa. Las estimaciones econométricas de un modelo de efectos fijos confirman la
10 existencia de un efecto-districto en innovación (efecto I-districto) y su dimensión. El
11 efecto I-districto se asocia principalmente a la presencia de economías de localización
12 marshallianas.

13 Keywords are: distritos industriales, innovación, economías externas,
14 efecto distrito

15 **INNOVATION ET DISTRICTS INDUSTRIELS : UNE PREMIERE APPROCHE**
16 **DE LA MESURE ET DES DETERMINANTS DES EFFETS DES DISTRICTS**
17 **D'INNOVATION -**

18 **RAFAEL BOIX et VITTORIO GALLETTO**

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27 **Résumé :** Nous analysons une base de données exhaustive de brevets délivrés en
28 Espagne entre 2001 et 2006 dans un échantillon de 806 marchés locaux de l'emploi
29 classés en sept typologies de systèmes locaux de production. Notre analyse montre que
30 les districts industriels de type Marshall génèrent 30 % des brevets espagnols et
31 affichent une performance innovatrice par tête supérieure de 47 % à la moyenne
32 nationale et supérieure de 31 % aux systèmes de production manufacturière des grandes
33 entreprises. Les estimations économétriques d'un modèle d'effet fixe confirment
34 l'existence d'un effet "district d'innovation" et de son importance. L'effet "district

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3 d'innovation" est lié, pour l'essentiel, à la présence d'économie de localisation de type
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5 Marshall.
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10 Mots-clés : districts industriels, innovation, économies extérieures, effet de district.
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12 JEL : O14; O31; R12
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15 **Innovation und Industriebezirke: ein erster Ansatz für die Messung und**
16 **die Determinanten des I-Distrikt-Effekts**
17

18 RAFAEL BOIX and VITTORIO GALLETTO
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21
22 Abstract.
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25 Wir analysieren eine umfangreiche Datenbank mit zwischen 2001 und 2006 in
26 Spanien erteilten Patenten, die in einem Panel von 806 lokalen Arbeitsmärkten
27 zusammengefasst und nach sieben Typologien lokaler Produktionssysteme
28 klassifiziert werden. Unsere Analyse zeigt, dass Marshallsche Industriedistrikte
29 30% der spanischen Patente und eine innovative Pro-Kopf-Leistung
30 hervorbringen, die um 47% über dem Landesdurchschnitt liegt und 31% höher
31 ausfällt als die Produktionssysteme von Großfirmen. Die ökonometrischen
32 Schätzungen eines Festeffekt-Modells bestätigen die Existenz eines
33 Innovationsdistriktseffekts (I-Distrikt) sowie dessen Größe. Der I-Distrikt-Effekt
34 bezieht sich in erster Linie auf die Präsenz von Marshallschen
35 Lokalisationswirtschaften.
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46 Keywords:
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48 Industriebezirke
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50 Innovation
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52 Externe Ökonomien
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54 Distrikteffekt
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56 JEL: O14; O31; R12
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1. INTRODUCTION

A large body of Economic Theory attributes a central role to the technological innovations stemming from in-house investments made by large firms in R&D, high levels of educated human capital and large public research infrastructures such as universities. However, the complexity of the innovation process and the multiplicity of ways to innovate can make innovations the outcome of non programmed mechanisms and interaction between productive units located in specific environments. During the course of research of the spatial impacts of universities in Spain, we observed the extraordinary intensity of patent generation in Spanish industrial districts in relation to large-firm manufacturing and service local production systems. Local development theories, and in particular Marshall-Becattini's paradigm of the industrial district provided a "normal" framework to explore the causes of this differential. In this paradigm, the unit of analysis is displaced from the firm or the sector to the territory.

Our intention is not to validate or to subject to falsification the theory of the industrial district or a part of this theory. The main question is why Spanish Marshallian industrial districts show higher rates of innovation per capita than the country's other local production systems (LPS). Departing from the literature on industrial districts, we can focus on three hypotheses, representing three complementary approaches to the industrial district. Following BAGNASCO and TRIGILIA (1984), we can centre on the interaction between market, institutions and policy. Following BRUSCO (1975; 1991), we can focus on a network of small and medium enterprises (SME) characterized by heterogeneous production functions which result in higher rates of technical efficiency (static and dynamic). Finally, following MARSHALL (1890) and BECATTINI (2001), the external economies are at the basis of the system of innovation in industrial districts.

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3 Although the three approaches provide suggestive and complementary explanations, we
4 will focus on the mechanism that interests us most: the original Marshall - Becattini
5 explanation relying on external economies. Our hypothesis is that higher rates of
6 innovation per capita of Spanish industrial districts are explained by external
7 economies. The objective is to quantify the differential effect of the industrial district on
8 innovation (the I-district effect) and to test whether this effect is explained by external
9 economies.

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20 Given the importance of innovation for competitiveness and the arguments that
21 present industrial districts as a model of mature industries based on costs, the results we
22 present can help throw some light on some points related to this issue. Besides
23 transferring the measurement of the “district effect” to innovation, the research
24 introduces certain contributions such as the use of exhaustive databases and the division
25 of the country into seven types of LPS so that the differential effects are compared not
26 only with the national mean but also with the manufacturing LPS of large firms, large
27 metropolitan areas, service LPS, etc.

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38 The paper is structured as follows. The second section introduces the theoretical
39 framework relating industrial districts, innovation and the district effect. The third
40 section presents the typology of LPS and the first evidence of the I-district effect. The
41 fourth section introduces a modification of Griliches’ empirical model in order to
42 measure the I-district effect and its causes, and presents the results of the econometric
43 estimates. The fifth section presents the conclusions.

44 2. INDUSTRIAL DISTRICTS, INNOVATION AND THE “DISTRICT EFFECT”

45 2.1 Industrial districts

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6 MARSHALL (1890) documented the existence of a form of organization of production
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8 based on the concentration, in some districts of English industrial cities, of people and
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10 SME's specialized in the different stages of a production process. In these "industrial
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12 districts", internal scale economies were substituted by external economies related to the
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14 existence of qualified workers, specialized suppliers and an informal system of
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16 knowledge diffusion. The figure of the Marshallian industrial district was recovered by
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18 BECATTINI (1975) to explain the success of the specialized local production systems
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20 of SME in the Italian region of Tuscany at the same time that the large-firm productive
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22 model of Turin and Milan was at serious crisis. BECATTINI (1990) transferred the unit
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24 of analysis from the "firm" or the "sector" to the "industrial district", a "social and
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26 territorial entity that is characterized by the active presence of both a community of
27
28 people and a group of enterprises in a natural and historically determined area". From
29
30 the late 1970s, the key elements of Marshallian industrial district theory have been
31
32 addressed by Italian scholars (BECATTINI, 1990; BELLANDI, 2002; BRUSCO 1991;
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34 DEI OTTATI, 2002; LAZZERETTI and STORAI, 2003; SFORZI, 1989) and
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36 international literature (HARRISON, 1992; OKAMOTO, 2001; PIORE and SABLE,
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38 1984; SENGENBERGER and PYKE, 1992).

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46 The most particular features of the industrial district are the "community" of
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48 people who live and work in the same locality, and the concentration of many small
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50 firms and workers specialized in the different phases of the same production process
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52 (*filiere*). Although small firms do not benefit from large scale economies as big firms
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54 do, the social organisation of the production into specialized localities produces external
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56 localization economies, which depend on conditions that are external to the firm and
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3 internal to the location. These advantages lead to reductions in costs and higher levels of
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5 productive efficiency producing the so-called “district effect”.
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10 2.2. Industrial districts and innovation 11 12 13 14

15 The literature on industrial districts highlights the way that the district model fosters the
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17 innovative ability of firms and helps promote the adoption of innovations¹. PIORE and
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19 SABLE (1984) remark that continuous innovation is an intrinsic characteristic of
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21 industrial districts and a vital condition for their continuous change and growth.
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23 BELLANDI (1989; 1996) remarks that in industrial districts there is a “diffuse
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25 innovation capacity”, an ability to learn from experience (*learning by doing*) and to
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27 innovate from it, which conceptually substitutes the R&D department of the *Fordist*
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29 large firm (*learning by R&D*). GAROFOLI (1989, p.81) highlights that technological
30
31 and organizational innovation in industrial districts takes “the connotations of a
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33 continuous process, with accumulation and interdependence of the effects from a large
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35 number of technological changes, each small in its individual basis; therefore, the
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37 connotations of an incremental innovative process (*à la Rosenberg*), rather than through
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39 big steps (*à la Schumpeter*)”, although with the special feature that they are not bound
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41 to a single firm but rather tend to diffuse inside the LPS at great speed by means of
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43 informal mechanisms. ASHEIM (1994) points out that the “industrial atmosphere” can
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45 support the processes of imitation, adaptation and diffusion of innovation in industrial
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47 districts; and that agglomeration economies support incremental innovations through
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49 informal learning-by-doing and learning-by-using mechanisms that are primarily based
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51 on tacit knowledge.
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3 To understand how the innovation process takes place in an industrial district
4 there is a need to emphasize the dual nature of knowledge regarding its transmission:
5 contextual and codified. Contextual knowledge is closely related to the activity of a
6 location, and grows at the same time as its spatial, temporal and social context. An
7 important share of this knowledge is “tacit knowledge” which is difficult to transmit and
8 reproduce outside of its original cultural context (BECATTINI, 2001; GERTLER,
9 2003; LAWSON and LORENZ, 2003). Codified knowledge mostly refers to scientific
10 and technical knowledge compiled in codes that can be transmitted and learned by
11 means of the usual mechanisms of communication and formal education, and does not
12 need the experience of other people or a precise context.
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27 Regarding this distinction, BECATTINI (2001) divides the learning process into
28 four phases: socialization of contextual knowledge; decontextualisation and codification
29 of the experience acquired in the location; re-elaboration of knowledge; and re-
30 absorption of codified knowledge by the specific processes of the production of goods.
31 This sequence produces a “cognitive spiral” that enhances continuous feedback from
32 local knowledge, tradable goods produced, local agents and the local environment as a
33 whole. From this conceptualization of the learning process, BECATTINI (2001) drew
34 three conclusions: (1) “Empirical knowledge” becomes as important for production as
35 scientific knowledge; (2) Contextual knowledge should be codified in some way to
36 influence local processes; (3) Codified knowledge needs to be contextualized and
37 combined with contextual knowledge to affect the production and innovation processes.
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53 Empirical research of the links between industrial districts and innovation is one
54 of the least common themes in the literature on industrial districts. Nevertheless, some
55 scholars have contributed important research to the issue. BRUSCO (1975) finds that
56 small metal-mechanical engineering firms around Bergamo have similar levels of
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3 technology to similar large firms, which contradicts the theory that technological
4 innovation originates exclusively from internal investment. RUSSO (1996) showed that
5 the high rates of technical progress in the ceramic district of Sassuolo can not be
6 explained by R&D activities performed in individual firms but rather by the links
7 between the users and producers of machinery in the ceramic industry. MOLINA (2002)
8 finds that knowledge spillovers are important for the innovative dynamic in the Spanish
9 ceramic district of Castellón. CAINELLI and DE LISO (2003) find that the change in
10 added value for innovative and non-innovative firms in industrial districts is higher than
11 for firms outside districts. MUSCIO (2006) finds that innovation in industrial districts is
12 related to the cooperation between firms and the local division of labour while
13 innovation in non-district firms is more related to internal and external R&D activities.
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29 However, there has been little endeavour to find out whether industrial districts
30 are more or less innovative than other LPS. Very little has been done to measure the
31 differential performance of industrial districts regarding innovation or to model the
32 determinants of this differential, which we consider to be a key issue in a context where
33 innovation (and not cost) is increasingly more fundamental for the competitiveness of
34 localities and firms. In other words, is there an I-district effect and if so, what causes it?
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46 2.3. Theoretical determinants of the district effect

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50 The term “district effect” was coined by SIGNORINI (1994) to explain the higher rates
51 of efficiency of firms located in industrial districts. DEI OTTATI (2006, p.74) defines
52 the “district effect” as the “collection of competitive advantages derived from a strongly
53 related collection of economies external to the individual firms although internal to the
54 district”.
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3 Following MARSHALL (1890), the performance of firms in industrial districts
4 is related to external economies, which is the result of:
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8 1. A trained, specialized and flexible labour force: workers are more specialised
9 and skilled in the local industry and in the different stages of the production process.
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12 2. Specialized suppliers in all phases of the production chain: the spatial
13 concentration permits the existence of specialized (and differentiated) firms at all stages
14 of the production process, each forced to innovate in order to survive, reinforcing at the
15 same time both integration and the links between them.
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21 3. Knowledge spillover effects: the diffuse industrial culture, made up of a set of
22 intangible elements pertaining to the LPS as a whole (entrepreneurship, cooperative
23 spirit, technical know-how, knowledge socialisation) which Marshall referred to as an
24 “industrial atmosphere”. This allows knowledge to flow and allows firms in the district
25 to benefit from higher rates of innovation and productivity.
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34 MARSHALL (1890; 1919) exposes other sources of local advantages related to
35 the characteristics of the city, such as the size and income of the local market or the
36 existence of other local specializations which can absorb the effects of external shocks
37 affecting the district’s specialization. Regional economics theories group these factors
38 under the heading of “agglomeration economies”, where the “localization economies”
39 are basically the Marshallian district economies and “urbanization economies” describe
40 the effects of the size of the local market and the effects of cultural and productive
41 diversity (not only as a shock-absorber but also as an element that fosters the production
42 of new knowledge).
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55 Empirical research of the “district effect” has taken two approaches: parametric
56 and non-parametric. The parametric approach is based on the econometric estimations
57 of an economic function such that the parameters can provide information about the
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3 existence of the district effect. SIGNORINI (1994) uses this approach on a production
4 function, obtaining evidence of the existence of a district effect on productivity,
5 profitability, vertical integration and finance. FABIANI *et al.* (2000) find evidence that
6 productive inefficiency is lower for firms located in industrial districts. GOLA and
7 MORI (2000) and BRONZINI (2000) find evidence of the existence of a district effect
8 in terms of export performance. COSTA and VILADECANS (1999) also find evidence
9 regarding the characteristics of industrial districts and their positive influence on the
10 international competitiveness of Spanish LPS.
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22 The non-parametric approach used by HERNÁNDEZ and SOLER (2003)
23 departs from the concept of Efficient Production Frontier and Data Envelopment
24 Analysis (DEA) to obtain the inefficiency of each firm as the difference between its
25 actual output and the maximum feasible output that can be obtained from the inputs
26 used by the firm. Their findings for Valencia confirm the existence of a district effect
27 for the firms located in industrial districts.
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39 3. FIRST EVIDENCE OF THE I-DISTRICT EFFECT

40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 3.1. Measurement of innovation

48 The measurement of innovation is a widely discussed topic in the literature and there is
49 no agreement as to which indicator is the most appropriate (GRILCHES, 1990; ACS *et*
50 *al.*, 1992). Usually, innovation indicators are divided into “input indicators” (R&D
51 expenditure or jobs) and “output indicators” (patents, new product announcements). The
52 main inconvenience of the former is that they fail to take into account activities related
53 to contextual knowledge, which are more important in smaller firms, underestimating its
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3 innovative capacity. On the other hand, patents and new product announcements
4 represent the outcome of the innovation process. As long as granted patents imply
5 novelty and utility, and also an economic expenditure for the applicant, it is supposed
6 that patented innovation is of economic value (GRILICHES, 1990). Furthermore, patent
7 documents contain highly useful data such as the applicant's address, name, date and
8 technological classification. For these reasons, patent indicators are the most widely
9 employed indicators of innovation (KHAN and DERNIS, 2006)². Therefore, we will
10 use patents as our innovation indicator, which offers the additional advantage of being
11 able to discuss our results regarding the most extended empirical line.
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24 In order to avoid yearly fluctuations and taking into account the lags in the
25 outcome of innovation processes, the common practice is to consider data on innovation
26 in periods of 4-5 years (GRILICHES, 1992). We will focus on the data for the 2001-
27 2006 period (both inclusive)³. Patent data is not restricted to a single register as is the
28 usual practice but rather covers several sources to produce more precise counts: the
29 Spanish Patent and Trade Mark Office (OEPM), the European Patent Office (EPO), the
30 United States Patent and Trademark Office (USPTO) and the World Intellectual
31 Property Organization (WIPO), and covers applications with at least one applicant with
32 an address in Spain per year of application⁴. In treating the data, we avoided double-
33 counting (patents first applied for at the Spanish office and then extended by means of
34 the European or World treaty, or vice-versa). The final database covers 22,500
35 documents for the whole 2001-2006 period.
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55 3.2. Typology of local production systems in Spain 56 57 58 59 60

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3 The territorial units are the 806 local labour markets in Spain (BOIX and GALLETTO,
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5 2008) identified using the Italian SFORZI - ISTAT (2006) methodology, which is also
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7 very close to the English Travel-To-Work Areas (TTWA). The algorithm departs from
8
9 the municipalities (8,100 in Spain) and uses data on jobs, resident employees and travel-
10
11 to-work commuting coming from the national Censuses to form the market areas. Local
12
13 labour markets contain the area where the population lives and works, becoming a
14
15 community of firms and people that can be identified as a local production system (DE
16
17 PROPRIS 2005). Seven types of LPS are identified as shown in Table 1 and Figure 1:
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22 Three types of manufacturing systems:

23
24 1. 205 Marshallian industrial districts, identified by BOIX and GALLETTO
25
26 (2008) using the Italian SFORZI - ISTAT (2006) methodology. The industrial districts
27
28 are LPS specialized in manufacturing and basically composed of SME (Table 1).
29
30

31
32 2. 66 manufacturing LPS of large firms, obtained from the procedure for the
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34 identification of industrial districts as those manufacturing systems which are
35
36 specialized in large firms.
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39 3. Other manufacturing LPS. There are 61 LPS obtained as a residual since they
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41 specialized in manufacturing although they are not classified as industrial districts or
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43 manufacturing LPS of large firms⁵.
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46 We classify service LPS as those which, in the first stage of the SFORZI -
47
48 ISTAT algorithm, are specialized in services (Consumer services; Business services;
49
50 Traditional services; and Social services). Two types of service LPS are differentiated in
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52 terms of innovation:
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55 4. LPS specialized in services that belong to large metropolitan areas. BOIX
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57 (2006) identified five metropolitan areas in Spain of over 1,000,000 people (Madrid,
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59 Barcelona, Valencia, Seville and Bilbao) and found that their behaviour regarding
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3 innovation was quite different from that of other metropolitan areas. However, most of
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5 the LPS belonging to these metropolitan areas are in fact industrial districts and in the
6
7 case of Valencia, the core LPS is classified as an industrial district. This reduces our
8
9 category to only four central LPS: Madrid, Barcelona, Seville and Bilbao.

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12 5. The other LPS specialized in services are a total of 102 LPS.

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15 And finally, another two categories come from the first stage of the SFORZI -
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17 ISTAT algorithm:

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20 6. 333 LPS specialized in Primary (Agriculture, fishing, etc.) and Extractive
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22 activities.

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25 7. 35 LPS specialized in Construction.

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29 [INSERT TABLE 1]

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33 [INSERT FIGURE 1]

34 35 36 37 38 3.3. First evidence of the I-district effect

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43 The comparison of the maps of LPS by typology and innovations per million employees
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45 (Figures 1 and 2) show the high concentration of highly innovative LPS in the north-
46
47 east of the country matching up with the concentration of industrial districts and
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49 manufacturing LPS of large firms. The territorial distribution of innovations and
50
51 innovative intensity in Spain shows four stylized results:

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55 1. Marshallian industrial districts and the core of the largest metropolitan areas
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57 are determinant for the innovative capacity of the country (Table 2). The four cores
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59 specialized in services in the largest metropolitan areas (28% of the employment)
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3 generate 35% of Spanish innovations and a ratio of 288 innovations per employee,
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5 which is 25% above the national mean (230 innovations per employee). Marshallian
6
7 industrial districts (21% of the national employment) generate 30.6% of Spanish
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9 innovations and a ratio of 337 innovations per employee, 47% above the national
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11 average, being the most innovative LPS in Spain. Furthermore, 57.1% of industrial
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13 districts have an innovative intensity above the national mean and only 20 districts have
14
15 no innovative activity in this period (Table 3).
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20 2. Manufacturing LPS of large firms (10.9% of employment) account for 12.1%
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22 of innovations. The innovative intensity is 256 patents per million employees a year,
23
24 which is 11% above the national average but 32% below the industrial districts (Table
25
26 2). The sum of metropolitan areas, industrial districts and manufacturing LPS of large
27
28 firms is 78% of total innovations in Spain and tends to be spatially concentrated, as
29
30 shown in Figure 1 and Figure 2.
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34 3. The remaining LPS account for 22% of innovations generated in Spain and
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36 their innovative intensity is below the national average. The remaining manufacturing
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38 LPS account for only 0.6% of national innovations and their innovative intensity is 24%
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40 below the national average. Service LPS which do not pertain to a large metropolitan
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42 area have 16% of innovations and the innovative intensity is 36% below the national
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44 average. LPS specialized in Construction (2.2% of employment) generate 1.1% of total
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46 innovations with an innovative intensity that is 53% below the national average. Despite
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48 accounting for 41% of total LPS, those specialized in Primary and Extractive activities
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50 are the less innovative units with only 4.7% of total innovations, an innovative intensity
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52 62% below the national average and 64% of the LPS that do not have any innovation
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58 (Tables 2 and 3).
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4. The results are robust to different time periods and indicators. In the previous periods, 1991-1995 and 1996-2001, the innovative intensity of industrial districts was 33% and 35% above the national average. Regarding the sensitivity of the indicator of innovation (patents) we tested whether the results are maintained with other two indicators that are available on a microdata level covering the same period: (1) industrial designs and models from the databases of the Spanish Patent and Trade Mark Office (OEPM), which is another indicator of output innovation; (2) and grants and loans provided by the Centre for the Development of Industrial Technology (CDTI), which can be interpreted as an input indicator (demand for public loans to innovate). In the three cases, industrial districts show the most important differential effect in relation to the Spanish average, clearly above that of large metropolitan areas and manufacturing LPS of large firms. Furthermore, the choice of patent indicators seems to be the most conservative option since the differentials are much larger in terms of designs and CDTI loans (Figure 3).

[INSERT FIGURE 2]

[INSERT TABLE 2]

[INSERT TABLE 3]

[INSERT FIGURE 3]

4. MODELLING THE DETERMINANTS OF THE I-DISTRICT EFFECT

4.1. Empirical model

To test the existence of a district effect on innovation (I-district effect) and model its determinants, we need to relate this effect with some model of innovation. The most common specification in the literature is the knowledge production function introduced by GRILICHES (1979) and implemented by PAKES and GRILICHES (1984)⁶. This function relates innovation to R&D inputs. We modify the production function to also take into account other factors influencing innovative activity, such as in our case, external economies. Thus, the knowledge production function can be specified as:

$$I_j = \gamma R_j^\beta Z_j^\delta \varepsilon \quad (1)$$

where I stands for a measure of knowledge creation (innovation) in an LPS j , R is a measure of R&D activities, Z is a vector that collects other variables affecting innovation (e.g. external economies), ε is a nuisance, and γ , β and δ are parameters.

An important issue is whether the district effect should be measured regarding the total number of innovations in an LPS or its relative intensity per capita. Most specifications of the empirical innovation function focus on the absolute number of innovations and after JAFFE (1989) it is common practice to include a variable of scale (e.g. population) to take into account the fact that the number of innovations is directly related to the size of the LPS. However, for the measurement of the district effect the relevant question is whether there are significant differentials in innovative intensity between the industrial districts and other LPS⁷. Thus, the output and the input factors are divided by the total number of employees in the LPS:

$$i_j = \gamma r_j^\beta Z_j^\delta \varepsilon \quad (2)$$

where i is the average innovation per worker and r is the average R&D per worker in the LPS. The variables included in Z can also be normalized by size if necessary. Taking logarithms, we transform the production function into a simple log-linear expression:

$$\log i_j = \gamma + \beta \log r_j + \delta \log Z_j + \varepsilon_j \quad (3)$$

We can also consider that the sources of innovation are related to idiosyncratic effects associated to each typology of LPS so that $\delta^* = f(Z_j)$, and the equation can be specified as a fixed effects model:

$$\log i_j = \gamma + \beta \log r_j + \delta^* + \varepsilon_j \quad (4)$$

4.2. Dependent variable

The dependent variable is the innovative intensity output (patents per employee) in LPS, expressed as an annual average per employee and using 2001 as the base year for employment.

4.3. Explanatory variables

Explanatory variables use 2001 data to reinforce causality and avoid simultaneity. Following the theoretical model these are expressed in logarithms and can be interpreted as elasticities. They are divided into three groups:

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1. Inputs: R&D by LPS was assigned from regional data on the basis of the regional R&D intensity per employee in each institutional sector (business sector, universities and public administrations) and multiplied by the jobs per institutional sector in each LPS. Since university R&D and jobs are concentrated in few LPS, which causes problems with the logarithms, the data was grouped into two categories: private and public R&D⁸.

2. Marshallian industrial district economies, grouped into four categories:

2.1. Rate of specialization or non diversity of the LPS, computed as a Hirschman-Herfindahl index of diversity on employment at 2 digits inside the LPS. Higher values indicate higher specialization (less diversity) of the economic structure:

$$DIV_j = \sum_j (E_{ij}/E_j)^2 \quad (5)$$

2.2. Specialized pool of manufacturing workers: represented by the share of manufacturing employment in the LPS. We associate a larger average of manufacturing workers with more specialized skills in the local manufacturing productions.

2.3. Specialized suppliers in the LPS. Following DUMAIS *et al.* (2002), the presence of suppliers of sector i in the LPS j is:

$$P_{ij} = \sum_{i \neq z} v_{is} E_{zj}, \text{ where } v_{is} = v_{is} / \sum v_{is} \quad (6)$$

where v_{is} is the share that sector i demands from the other sectors, and E_{zj} is the local employment in the sector. These shares are obtained from the Spanish Input-Output

Tables (INE). The sum of these weighted sector employments are used to obtain a global indicator of the presence of suppliers in each LPS:

$$S_j = \sum_i E_{ij} / \sum_i P_{ij} \quad (7)$$

If S_j is larger than one, employment in supplying sectors in LPS j (E_{ij}) is larger than the weighted sum of employment in supplying sectors (P_{ij}) so that the presence of suppliers is above the local requirements and indicates the existence of a powerful chain of suppliers.

2.4. Social organization of production, using as a proxy the social capital index developed by IVIE (PÉREZ *et al.*, 2006). This index is only available by province and informs whether the province has a level of social capital above, equal or lower than the national average. We assign the value of the province to an LPS.

2.5. Average of SME in the LPS, to control which model of organization of production is related to differentials in the innovative intensity. In the Marshall-Becattini framework, the district effect should be related to SME:

$$SME_j = \sum E_{SME,j} / \sum E_j \quad (8)$$

, where E_{SME} is the employment in SME.

3. Urbanization economies:

3.1. Total population in the LPS (from 2001 Census).

3.2. Density index, which interprets that a greater density of employment (E) over population (N) is related to denser work-related networks, which generates higher

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3 spillovers. The index can not differentiate between intra and inter-industry spillovers
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5 and, in fact, could also be considered an indicator of Marshallian economies:
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$$D_j = \sum E_j / \sum N_j \quad (9)$$

14 15 4.4. Econometric evidence of the I-district effect

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20 To test the existence of the I-district effect we estimated equations 3 and 4 as a panel of
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22 806 LPS divided into seven typologies. The estimates were made in two stages: first, we
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24 tested for the existence of the I-district effect and its size and then modelled its
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26 determinants.
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30 We estimated equation 4 by only introducing R&D variables, which are the
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32 inputs in the model⁹. After subtracting the effect of inputs, we can assume that the
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34 remaining differential is due to the characteristics associated to each type of production
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36 system. Thus, we introduce a fixed effects estimation of the model. The seven fixed
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38 coefficients capture the different performances of each typology and inform whether
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40 they are statistically different from the average LPS. Since there are 206 LPS without
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42 innovations for which logarithms can not be computed, there is some doubt about a
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44 possible selection bias in the sample. On the one hand, it can be argued that LPS
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46 without innovations belong to rural and very sparsely populated areas and their
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48 inclusion could introduce more economic problems than the statistical problems solve.
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50 This is reasonable since these 206 systems only have 3.5% of the Spanish employment
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52 and 67% of this employment belongs to Primary and Extractive LPS (41% of non-
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54 innovative LPS) (Table 3). On the other hand, if we suspect that any selection bias is
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56 introduced, we can treat the problem as a censored sample and introduce a Heckman
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3 estimate of the fixed-effects model. Since both arguments are reasonable, we decided to
4 provide the estimates for the LPS that innovate (600 LPS) and the estimates of the
5 Heckman model (806 LPS)¹⁰.
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10 The results for input variables show that both private and public R&D are
11 statistically significant. The coefficients range between 0.13 and 0.26 for private R&D
12 and between 0.08 and 0.19 for public R&D (Table 4). The coefficients and statistical
13 significance of the fixed effects provide robust evidence of the existence of an I-district
14 effect that ranges between 0.44 and 0.48 in unitary deviations from the averaged group
15 effect, and similar to the 47% deduced from Table 2. The manufacturing LPS of large
16 firms have a fixed effect of between 0.05 and 0.10 although it is not statistically
17 significant. The other manufacturing LPS also show a high fixed effect (0.43 to 0.31).
18 With the exception of the large metropolitan areas (the coefficient is positive but not
19 statistically significant) all the other typologies show negative differential effects
20 ranging from -0.18 for Other service LPS to -0.52 for Primary and Extractive activities.
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[INSERT TABLE 4]

4.5. Modelling the determinants of the I-district effect

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48 To model the determinants of fixed effects we introduced the vector of external
49 economies Z_j to equation 4:
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$$\log i_j = \gamma + \beta \log r_j + \delta \log Z_j + \delta^* + \varepsilon_j \quad (10)$$

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3 Note that if δ and δ^* are correlated, as in fact we assumed, the value of the
4 coefficients and the statistical significance of δ^* will drop when we include Z_j .
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8 We estimate equation 10 by introducing first the determinants of the Marshallian
9 economies and later the urbanization economies. The results introducing Marshallian
10 economies (Table 5, estimates 2.1 to 2.3) show a reduction in the R&D coefficients
11 (0.11 to 0.14 for private R&D and 0.12 to 0.17 for public R&D). The variables
12 introduced are statistically significant, with large coefficients and the expected sign for
13 the global rate of specialization (0.12 to 0.25), specialization in manufacturing (0.63 to
14 0.65), suppliers (0.29 to 0.33) and social capital (0.23 to 0.27). The percentage
15 employment in SME is negative and statistically significant although the coefficient is
16 not very high (0.12 to 0.13). Given the very small average dimension of Spanish firms,
17 this can be interpreted as a correlation with a minimum dimension to innovate¹¹.
18 Regarding fixed effects, most of the coefficients decrease to almost zero and become
19 statistically non significant. The exception is manufacturing LPS of large firms, where
20 the coefficient becomes negative and statistically significant.
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38 Next, we include urbanization economies (Table 5, estimates 2.4 to 2.6). The
39 Population coefficient is small (-0.03 to 0.05), statistically non significant and negative
40 except in the Heckman estimate, where the model detects that it is an important variable
41 in the probability of having non-zero innovations. Density of jobs has a large coefficient
42 (0.43 to 0.77) and suggests the existence of general spillover processes related to
43 innovative performance. As expected, this variable is correlated with social capital
44 (which has a lower coefficient and loses statistical significance).
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55 We also test for the existence of other effects, mainly related to knowledge and
56 creativity. However, no solid evidence is found between patent intensity and other
57 knowledge variables such as knowledge-intensive manufacturing, knowledge-intensive
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3 services, ICT, creative class, percentage of employees in R&D sectors, and university
4 graduates (Figure 4)¹².
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8 The existence of spatial autocorrelation between LPS was tested on the basis of a
9 spatial contiguity matrix and simultaneous spatial lag and error effects. Although some
10 evidence of the existence of simultaneous spatial spillover processes is detected (the
11 spatial lag is dominant), its inclusion does not significantly improve the model¹³.
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28 29 5. CONCLUSIONS 30

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33 The objective of the research was to explore the existence of higher rates of innovative
34 intensity in the Spanish Marshallian industrial districts in the form of a “district effect”
35 (I-district effect) as well as its causes. Given the importance of innovation for
36 competitiveness and the arguments that present industrial districts as a model of mature
37 industries based on costs, the results we present, performed on the system of innovation
38 of an entire country, throw some light on this issue. The differential effects are
39 compared not only with the national mean but also with manufacturing LPS of large
40 firms, large metropolitan areas, other manufacturing LPS, service LPS, agricultural
41 LPS, and construction LPS . The main conclusions are:
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55 1. There is robust evidence of the existence of an I-district effect. The
56 Marshallian industrial districts generate 30% of Spanish patents and an innovative
57 intensity (patents per employee) of 47% more than the national average and 31% more
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3 than the manufacturing LPS of large firms. The econometric estimates of a fixed effects
4 model confirm the existence of a similar I-district effect set between 44% and 48% in
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6 deviations from the averaged group effect. The evidence of this effect is maintained for
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8 the previous periods and using other indicators such as designs or loans for innovation.
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13 2. The existence of the I-district effect is related to Marshallian economies as
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15 specialization, the existence of a specialized pool of manufacturing workers, specialized
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17 suppliers and social capital. As a result of the very small size of firms in the country,
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19 systems where the average firm is larger tend to innovate slightly more. Urbanization
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21 economies show less impact on innovation and on the explanation of the I-district effect
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23 although an important impact of spillovers coming from dense work-related networks is
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25 detected. Regarding the variables related to the knowledge economy, only private and
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27 public R&D, introduced as an input in the model, appear to be directly linked to
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29 innovation. No solid evidence is found for other knowledge variables such as university
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31 graduates, knowledge-intensive industries or ICT.
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37 3. The cores of the largest metropolitan areas specialized in services generate
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39 35% of Spanish innovations and a ratio of 288 innovations per employee, 25% above
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41 the national mean although below industrial districts. Marshallian industrial districts and
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43 the core of the large metropolitan areas are determinant of the country's innovative
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45 capacity.
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49 These results suggest the need to strengthen the territorial scope of innovation
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51 policies and to intensify research of their determinants by not only taking into account
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53 the characteristics of the firm but also the forms of innovation and the characteristics of
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55 the territory in each time period. In the light of our results, in Spain the common
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57 strategies based on basic research and development only explain a part of the innovation
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59 process and other forms of innovation coexist and are clearly operating in specific
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3 territorial contexts. The industrial district is one of the most outstanding as its
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5 innovative performance is correlated to its specialization, the existence of suppliers, and
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7 social and business networks. The State Secretariat for Industry (Ministry of Industry)
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9 synthesized this in a set of market-oriented measures and laws (Trullén 2007), centred
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11 on the so called “Innovative Business Groups”, which reconcile innovation policy with
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13 the characteristics of territory.
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23
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25
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27
28 Industry, Tourism and Trade), the Centre for the Development of Industrial Technology
29
30 (CDTI) and the Spanish Institute of Statistics (INE) for providing most of the data used
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32 in this research.
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41 ¹ A comparative review of the literature on territorial innovation models including
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43 industrial districts, clusters, *milieux innovateurs*, new industrial spaces, etc. can be
44
45 found in MOULAERT and SEKIA (2003).
46

47
48 ² The use of patents as indicators of innovation can be influenced by the industrial
49
50 specialization of the LPS and firm size distributions. GRILCHES (1990 and 1992) and
51
52 KHAN and DERNIS (2006) provide further discussion on their advantages and
53
54 limitations.
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57 ³ Our complete patent database includes 70,000 documents from 1991 to 2006. Patent
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59 counts include “utility models”, a figure granted by the OEPM which is similar to the
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patent although legal requirements are less strict and protection covers only ten years.

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5 Similar figures exist in Austria, Denmark, Finland, Germany, Greece, Italy, Japan,
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7 Poland and Portugal. Employment data comes from the 2001 Census of the Spanish
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9 Institute of Statistics (INE).
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12 ⁴ Data treatment follows international standards: patents are located according to the
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14 first applicant with an address in Spain (inventor's address is not available for national
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16 patents); reference date is the oldest application data in any register because it is the
17
18 closest to the invention date and does not introduce biases due to legal or procedural
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20 delays.
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24 ⁵ These include those LPS with the characteristics of an industrial district that BOIX
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26 and GALLETTO (2008) excluded because the number of employees in the main
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28 specialization was lower than 250 employees (considered too small), and also some LPS
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30 where manufacturing as a whole is of the average size of a large firm but without any
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32 large firm in the main specialization.
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36 ⁶ This framework facilitates to compare and discuss the results. The choice of the
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38 dependent variable (patents) was also related to comparability.
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42 ⁷ This follows the line of other research that has used relative indicators in the
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44 measurement of the district effect, e.g. productivity (SIGNORINI, 1994) or efficiency
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46 (HERNÁNDEZ and SOLER, 2003).
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50 ⁸ R&D and employment data are taken from the INE. It is also possible to use
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52 hierarchical multilevel models to avoid the assignation although the hypothesis
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54 introduced for the data generates other restrictions. We control the results by using
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56 additional data on R&D&i grants and loans provided by the Ministry of Industry (CDTI
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58 and PROFIT databases).
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⁹ R&D per employee in the initial year is conceived as exogenous in our model. Additional test of exogeneity proves that this variable is empirically exogenous in all the regressions.

¹⁰ Additional controls of the functional form of the model and the relation between the dependent and explanatory variables were introduced. The log-linear specification without non-linearities proved to be the most suitable specification.

¹¹ In fact, in industrial districts the average firm size is larger than in most of the other non manufacturing systems.

¹² In Spain more dynamic environments such as industrial districts provide numerous job opportunities for young people so that the necessity of higher levels of education to get work is not perceived. This result should not be interpreted as a direct indicator of the impact of contextual knowledge on innovation although it suggests the importance of contextual knowledge mechanisms (learning-by-doing, on-the-job training, etc.) to make up for the lower levels of standard-educated people.

¹³ When the data is pooled, the spatial lag ($\rho=0.14$) is statistically significant although it does not improve the fit. When fixed effects and external economies are included, the lag decreases to $\rho=0.08$ and again the most parsimonious model is preferred. This weak evidence and Figure 2 suggest that the impacts of inter-LPS spillovers could be locally important in the East and North-East of Spain where industrial districts and Large Firm LPS are concentrated.

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Table 1. Typology of local production systems in Spain: synthesis of criteria

Criterion \ Typology	Manufacturing LPS			Services LPS		Other LPS	
	Industrial districts	Large firms	Other areas	metropolitan	Other Primary and extractive	Construction	
Industrial specialization							
Manufacturing (1)	+	+	+				
Services (2)				+	+		
Primary/Extractive (2)						+	
Construction (2)							+
Firm size							
LPS specialized in SME (3)	+						
Main industry							
specialized in SME (4)	+						
Others							
Above 250 employees							
in the main industry	+	+					
Above 1 million inhabitants							
				+			

(1) Location Quotient ($LQ_{LLM,NACE} = (L_{LLM,NACE}/L_{NACE}) / (L_{LLM}/L)$) above 1 in manufacturing and prevalence index

($PR_{LLM,NACE} = [(L_{LLM,NACE}/L_{NACE}) - (L_{LLM}/L)]L_{NACE}$) is higher than those of Business services and Consumer services.

(2) For LPS non-specialized in manufacturing the specialization coincides with the largest LQ: Agricultural, Extractive, Construction, Business services, Consumer services, Social services, Traditional services.

(3) Largest LQ on firm size of the LPS corresponds to small or medium enterprises

(4) Percentage of SME in the main industry (2 digits) above 50%

Table 2. Distribution of innovation (patents) by Local Production System. 2001-2006

Type of LPS	Local production systems		Employment year 2001 (thousands)		Patents 2001-2006			LPS where patents per employee are above the national average		
	N°	%	Total	%	Total	%	Per million employees /year	Total typology	%	total LPS
Primary and extractive activities	333	41.3	1,994	12.2	1,048	4.7	88	41	12.3	5.1
Manufacturing	332	41.2	5,317	32.6	9,764	43.3	306	169	50.9	21.0
Industrial districts	205	25.4	3,419	20.9	6,908	30.6	337	117	57.1	14.5
LPS of large firms	66	8.2	1,776	10.9	2,728	12.1	256	30	45.5	3.7
Other manufacturing LPS	61	7.6	122	0.8	127	0.6	174	22	36.1	2.7
Construction	35	4.3	364	2.2	238	1.1	109	6	17.1	0.7
Services	106	13.2	8,654	53.0	11,502	51.0	222	28	26.4	3.5
Large metropolitan areas	4	0.5	4,567	28.0	7,901	35.0	288	3	75.0	0.4
Other service LPS	102	12.7	4,088	25.0	3,601	16.0	147	25	24.5	3.1
TOTAL	806	100	16,330	100	22,552	100.00	230	244	30.3	30.3

Source: Elaborated from Census 2001 (INE), OEPM, WIPO, USPTO and EPO.

Table 3. Local Production Systems without innovations (patents). 2001-2006

Type of LPS	Local production systems				Employment year 2001			
	Total	% typology	% non - innovative	% total LPS	Total	% typology	% non - innovative	% total LPS
Primary and extractive activities	132	39.6	64.1	16.3	379,657	19.0	67.2	2.3
Manufacturing	52	15.7	25.2	6.4	136,891	2.6	24.2	0.8
Industrial districts	20	9.8	9.7	2.5	72,982	2.1	12.9	0.4
LPS of large firms	8	12.1	3.9	1.0	21,627	1.2	3.8	0.1
Other manufacturing LPS	24	39.3	11.7	2.9	42,282	34.7	7.5	0.3
Construction	8	22.9	3.9	1.0	17,764	4.9	3.1	0.1
Services	14	13.2	6.8	1.7	31,009	0.4	5.5	0.2
Large metropolitan areas	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Other service LPS	14	13.7	6.8	1.7	31,009	0.8	5.5	0.2
TOTAL	206	25.6	100.0	25.6	565,321	3.5	100.0	3.5

Source: Elaborated from Census 2001 (INE), OEPM, WIPO, USPTO and EPO.

Table 4. Basic model and I-district effect

	(1.1)	(1.2)	(1.3)
	OLS	Fixed effects	Heckman fixed effects
Constant	0.3461 *** (0.000)	5.4645 * (0.095)	5.1464 *** (0.000)
R&D firms	0.1304 *** (0.000)	0.2362 (0.040) **	0.2635 *** (0.000)
R&D public	0.0881 ** (0.016)	0.1418 (0.057) *	0.1902 *** (0.001)
Fixed Effects			
Industrial districts		0.4441 *** (0.000)	0.4840 *** (0.000)
Manufacturing LPS of large firms		0.0514 (0.640)	0.1039 (0.344)
Other manufacturing LPS		0.4379 *** (0.001)	0.3167 ** (0.016)
Large metropolitan areas		0.0716 (0.833)	0.0994 (0.768)
Other service sectors		-0.2404 ** (0.016)	-0.1829 * (0.068)
Construction		-0.3387 ** (0.018)	-0.2989 ** (0.036)
Primary activities		-0.4259 *** (0.000)	-0.5222 *** (0.000)
Fixed effects F-test		0.000 ***	0.000 ***
LR selection (lambda=0)	0.924	0.000 ***	0.000 ***
Condition number	6.08	6.08	7.45
R2-ajd / Pseudo R2	0.126	0.282	0.297
Log-L	-755.85	-692.70	-681.46
Akaike	1517.70	1403.39	1370.91
BIC	1530.89	1442.97	1388.50
Number of obs	600	600	806

Notes: (a) Dependent variable = Patents per employee in the 2001-2006 period; (b) All variables are natural logarithms; (c) P-values are in parentheses and asterisks represent statistical significance at 1% (***), 5% (**) and 10% (*); (d) Within group effect model estimates; (e) Fixed effects provided under the restriction that $\sum \alpha_i = 0$, so that the dummy coefficients mean deviations from the averaged group effect (intercept); (f) Heckman adjusted coefficients; (g) Robust Huber-White estimators when slight problems of heteroskedasticity, collinearity or outliers are detected.

Table 5. Modelling the determinants of innovative intensity

	District economies			Urbanization economies		
	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)	(2.6)
	OLS	Fixed effects	Heckman Fixed effects	OLS	Fixed effects	Heckman Fixed effects
Constant	3.8702 *** (0.000)	4.0174 *** (0.000)	3.2688 *** (0.000)	4.5534 *** (0.000)	4.5179 *** (0.000)	3.5021 *** (0.000)
R&D firms	0.1166 *** (0.003)	0.1415 *** (0.000)	0.1484 *** (0.000)	0.1033 ** (0.008)	0.1264 *** (0.002)	0.1269 *** (0.005)
R&D public	0.1431 *** (0.003)	0.1251 ** (0.015)	0.1777 *** (0.001)	0.1479 ** (0.010)	0.1284 ** (0.027)	0.1197 ** (0.056)
Specialization	0.2517 *** (0.006)	0.2536 *** (0.007)	0.1264 (0.195)	0.1798 * (0.080)	0.1889 * (0.071)	0.1181 (0.248)
Specialization in manufacturing	0.6509 *** (0.000)	0.6346 *** (0.000)	0.6590 *** (0.000)	0.6465 *** (0.000)	0.6408 *** (0.000)	0.6951 *** (0.000)
Suppliers	0.3360 ** (0.016)	0.2941 ** (0.045)	0.2927 ** (0.045)	0.3174 ** (0.024)	0.2878 * (0.055)	0.3459 ** (0.014)
Social capital	0.2742 *** (0.000)	0.2307 ** (0.003)	0.2481 *** (0.001)	0.1633 * (0.083)	0.1430 (0.130)	0.1402 (0.128)
SMEs	-0.1213 ** (0.034)	-0.1394 *** (0.009)	-0.1229 ** (0.022)	-0.1094 * (0.058)	-0.1298 ** (0.016)	-0.1064 * (0.052)
Population				-0.0311 (0.314)	-0.0263 (0.452)	0.0563 (0.147)
Density of jobs				0.5029 * (0.069)	0.4320 (0.136)	0.7729 * (0.005)
Fixed Effects						
Industrial districts		0.0184 (0.844)	0.0557 (0.543)		-0.0007 (0.994)	0.0874 (0.335)
Manufacturing LPS of large firms		-0.2540 ** (0.023)	-0.2085 * (0.056)		-0.2650 ** (0.018)	-0.1975 * (0.063)
Other manufacturing LPS		0.1547 (0.218)	-0.0238 (0.850)		0.1244 (0.363)	0.1054 (0.418)
Large metropolitan areas		0.2027 (0.524)	0.1671 (0.590)		0.2783 (0.405)	-0.2749 (0.398)
Other service sectors		0.0660 (0.530)	0.1680 (0.107)		0.0486 (0.647)	0.1696 * (0.096)
Construction		-0.0867 (0.539)	0.0037 (0.979)		-0.0953 (0.502)	0.1296 (0.347)
Primary activities		-0.1011 (0.259)	-0.1620 * (0.066)		-0.0902 (0.339)	-0.0195 (0.828)
Fixed effects F-test		0.0730 *	0.0195 **		0.112	0.074 *
LR selection (lambda=0)	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***
Condition number	26.40	26.40	30.72	50.90	50.90	60.00
R2-ajd / Pseudo R2	0..3774	0.3760	0.4219	0.381	0.376	0.437
Log-L	-654.03	-648.14	-631.76	-652.02	-646.74	-615.62
Akaike	1324.06	1312.28	1281.53	1324.04	1313.48	1265.24
BIC	1359.23	1347.46	1321.10	1368.01	1357.45	1339.99
Number of obs	600	600	806	600	600	806

Notes: (a) Dependent variable = Patents per employee employment in the 2001-2006 period; (b) All variables are natural logarithms ; (c) P-values are in parentheses and asterisks represent statistical significance at 1% (***), 5% (**) and 10% (*); (d) Within group effect model estimates; (e) Fixed effects provided under the restriction that $\sum \alpha_i = 0$, so that the dummy coefficients mean deviations from the averaged group effect (intercept); (f) Heckman adjusted coefficients; (g) Robust Huber-White estimators when slight problems of heteroskedasticity, collinearity or outliers are detected.

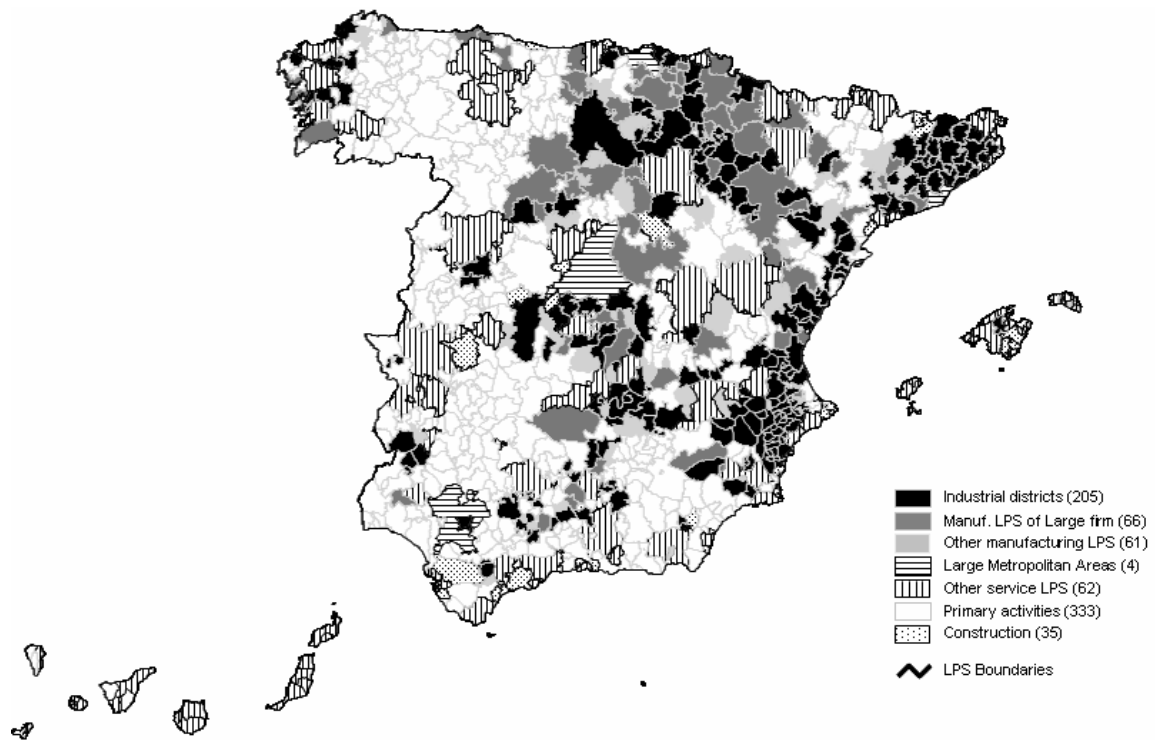
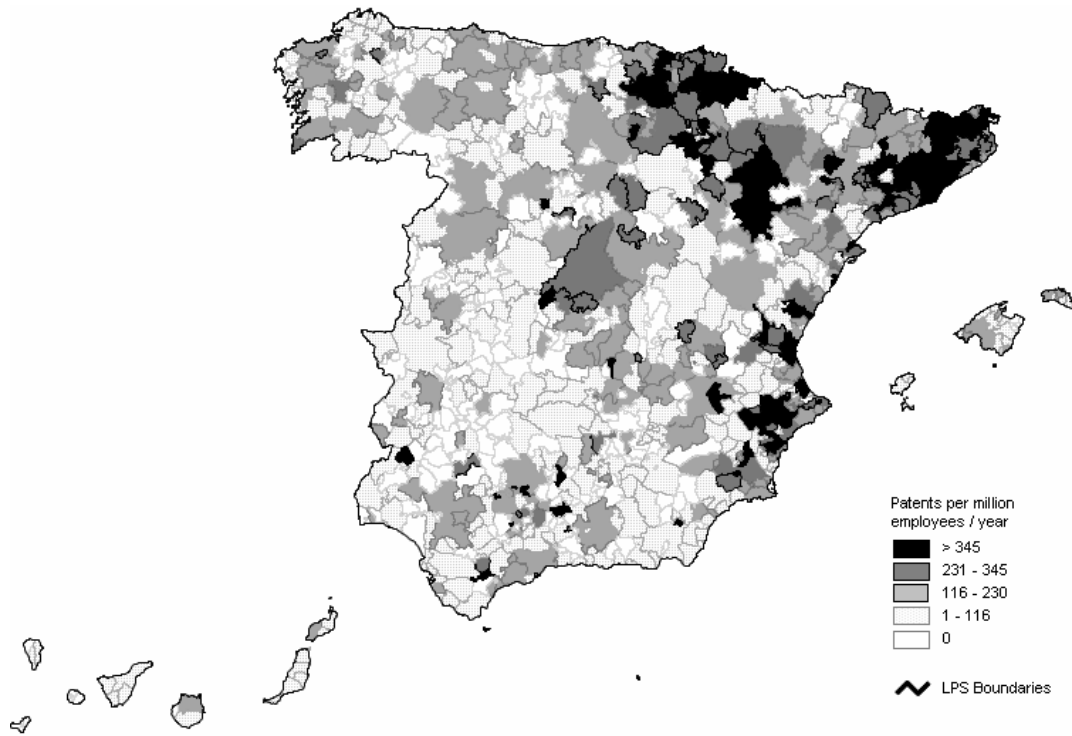


Figure 1. Typology of Local Production Systems in Spain

Source: Elaborated from Boix and Galletto (2008).



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Figure 2. Patents per million employees. Annual average 2001 - 2006

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Source: Elaborated from OEPM, EPO, WIPO, USPTO and Census 2001 (INE).

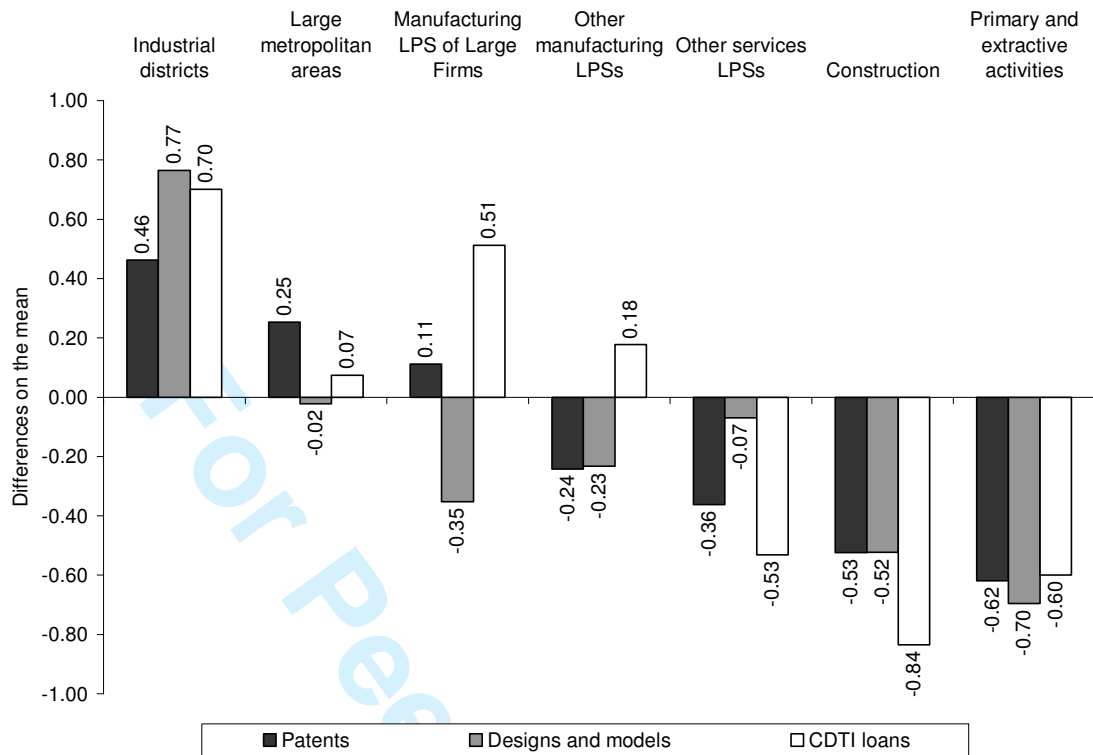


Figure 3. Innovative performance by typology of LPS and indicator. Innovations per million employees a year in differences to the mean of each indicator. 2001-2006

Source: Elaborated from OEPM, EPO, WIPO, USPTO, CDTI and Census 2001 (INE).

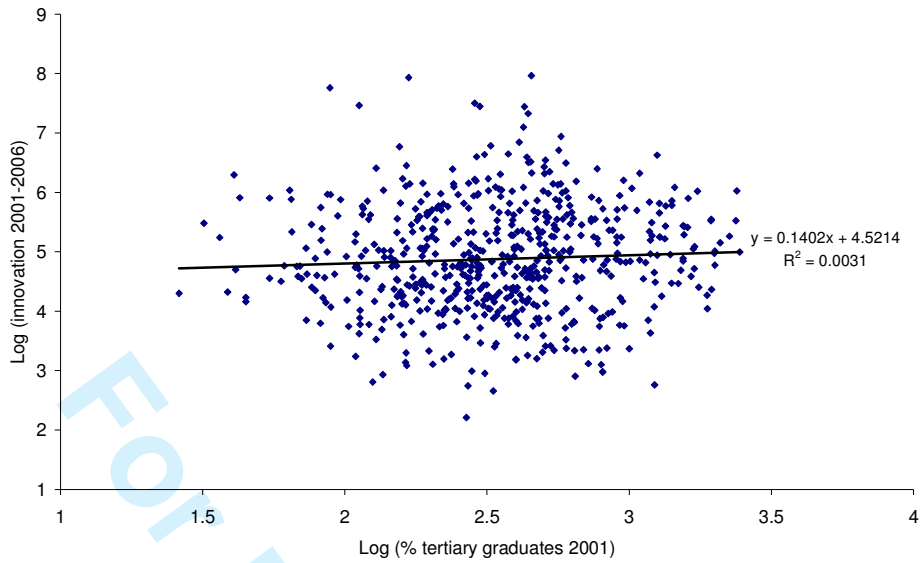


Figure 4. Innovation versus human capital (% university graduated employees of total employees)

Source: Elaborated from OEPM, EPO, WIPO, USPTO, CDTI and Census 2001 (INE).