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Firms' innovation across regions: an exploratory study

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Abstract

This paper investigates the geographical distribution and concentration of firms' innovation persistence and innovation type - product and process - based upon three waves of the Community Innovation Survey data covering the period 1998-2006. The main findings are: (i) both innovation persistence and innovation type are asymmetrically distributed across Portuguese regions; (ii) the degree of correlation between geographical location and innovative output varies with the innovation type; and (iii); the correlation between geographical unit and innovation increases when the spatial unit of analysis is narrower. Overall, results indicate that firm's choice of geographical location have a long-lasting effect, engendering no equal probabilities of being persistently innovator.

JEL Code: O31, L25, R11

Keywords: product innovation, process innovation, persistence, location.

1. Introduction

Studies on the geographical distribution of innovation have substantially documented that innovative activity and knowledge investments tend to be highly agglomerated in some locations (e.g., Jaffe et al., 1993; Audretsch and Feldman, 1996; Audretsch, 1998; Bottazi and Peri, 2003; Orlando, 2004; Thompson and Fox-Kean, 2004; Thompson, 2006; Muscio, 2006). It has been argued that co-location of firms (physical proximity) facilitate knowledge exhange. This happens for both explicit and tacit knowledge, but the latter travels badly and its returns can only be optimised through face-to-face interations. Despite the vast number of studies arguing in favour of the existence of knowledge spillovers bounded in space, there has been a growing criticism with regard to the role of co-location on innovation (Torre and Gilly, 1999; Rallet and Torre, 2000; Breschi and Lissoni, 2001; Boschma, 2005).

Conversely, geographical concentration of innovation might be caused by dynamics within the creation of innovations itself. Innovations involve a cumulative mechanism because people who generate an innovation are often in a good position to use their technological advancement to create further innovations (Lundvall, 1992; Morgan, 1997; Cooke, 2001). As such, if a firm's or region's past investment in innovation affects its technical and organizational capabilities, then those with lower current rates of innovation will find it harder to invest in innovation in the future. As a consequence, knowledge is not equally spread across individuals, firms, and geographical units of observation, such as regions or countries. Moreover, there may not be convergence across regions (in

the context of regions, this problem has been termed the 'regional innovation paradox' by Oughton et al., 2002).

There is some supporting evidence of a path-dependent effect at the regional level. For instance, Cantwell and Piscitello (2005) found that locations that accumulate a wide range of technological competences and develop potential for inter-industry spillovers are more likely to attract R&D investments from multinational firms. At the firm level, studies on firms' innovation persistence also show that past experience in innovation increases the likelihood of innovating (Geroski et al., 1997; Cefis 2003; Roper and Hewitt-Dundas, 2008; Peters, 2009; Raymond et al., 2010; Huergo and Moreno, 2011).

However, studies of firms' innovation persistence across regions are, to our knowledge, almost inexistent. The closest evidence on this topic is on convergence/divergence across regions (Moreno et al., 2005; Drivera and Oughton, 2008). However, they use regions as the unit of analysis, overlooking what is happening at the firm-level within a region. Therefore, this paper attempts to contribute to this topical issue by assessing whether firm-level innovation activities are related to their location. More specifically we attempt to identify empirical regularities relating firms' innovation activities across Portuguese regions and across different types of innovation.

Portugal provides a particularly interesting and useful case for building upon the relationship between firm-level innovation activities and co-location of firms. It is a developed country but, within the context of the European Union (EU), it is a small, open and peripheral economy. These particular features might be challenging to firm's engaging in innovation activities that are based on connections with international innovative networks. This is so because the

openness may guarantee the presence of considerable interactions with the outside world but the peripheral position may refrain them, thus reinforcing the role of geographical co-location. Moreover, EU membership and the creation of the European single market triggered the need for a continuous and persistent innovative focus of Portuguese firms as a way to overcome smallness and the peripheral position.

Therefore, our aim is twofold. First, using survey data from the Community Innovation Survey (CIS), we examine whether co-location of firms is able to foster firm-level innovation, leading to significant regional asymmetries on firm's innovation output. Second, we analyze whether firms' innovation persistence is specific to some locations or evenly distributed. Existing evidence shows that only a small number of firms tend to be persistent innovators and that these firms generate a high-share of all innovative activities (Geroski et al., 1997; Cefis, 2003; Roper and Hewitt-Dundas, 2008; Peters, 2009; Raymond et al., 2010; Huergo and Moreno, 2011). Thus, investigating firms' innovation persistence across regions may help us to understand firms' innovation intensity differences across regions.

The analysis of innovation persistence across regions and types of innovation is important because if persistence and type of innovation are somehow associated with location then public policy should take it into account as there might be different input factors in the innovation production function of each type of innovation. Also, if persistent innovators strongly rely upon spillover effects and geographical proximity, then differences across regions are likely to persist across time and space in a path-dependent way.

The remainder of the paper is organized as follow. The second section reviews the theoretical arguments put forward to explain the agglomeration of innovation activities, the arguments against co-location and the recent empirical evidence sustaining these arguments. The third section reports the data and the empirical findings. The final section provides the concluding remarks and it indicates an agenda for future research.

2. Firms' innovation activities and location

In seeking to understand how geographical location affects innovation, a large number of studies have stressed the importance of region-specific characteristics as key drivers of innovation (e.g., Jaffe et al., 1993; Audretsch and Feldman, 1996; Almeida and Kogut, 1997; 1999; Orlando, 2004; Funke and Niebuhr, 2005; Asheim et al., 2011; Brenner and Broekel, 2011). According to this literature the agglomeration of innovation activities is largely explained by region-specific characteristics that promote knowledge spillovers, attract tacit knowledge and innovation activities, and make firms more or less productive in their innovation activities. Physical proximity is seen as a necessary condition to knowledge exchange when face-to-face contact is needed. It is also a pre-requisite for interactive learning and innovation (see e.g. Howells (2002), Morgan (2004), Aydogana and Lyon (2004), Asheim et al. (2011)).

The geographical dimension of innovation is due to both knowledge spillovers and tacit knowledge, which are perceived as important sources of firms' innovation and are seen as geographically bounded. Tacit knowledge is difficult to exchange over long distances making spillovers limited in space. Moreover, knowledge arises from the social and institutional context in which is produced

which makes social interaction a necessary condition to the production and diffusion of knowledge (Howells, 2002; Morgan, 2004; Aydogana and Lyon, 2004; Asheim et al., 2010).

Yet there is increasing awareness that this view tends to overemphasize the role of spillovers and co-location in the transfer of knowledge between firms and, hence, in innovation activities and output (Torre and Gilly, 1999; Rallet and Torre, 2000; Breschi and Lissoni, 2001; Boschma, 2005). In some cases knowledge is shared on-request or intentionally, thus the knowledge spillover concept has been used to describe other mechanisms of knowledge transfer that have been market-mediated. For instance, firms strategically use R&D alliances as a means to limit knowledge flows and protect competences, rather than to promote knowledge flows (Narula and Santangelo, 2009). Also other studies have been able to identify and measure the role of other knowledge transmission mechanisms besides spillovers, such as social capital (Tappeiner et al., 2008; Akçomak and Weel, 2009; Fitjar and Rodríguez-Pose, 2011), workers mobility (Almeida and Kogutt, 1999; Filatotchev et al., 2011) networks and collaboration (Narula and Santangelo, 2009; Fitjar and Rodríguez-Pose, 2011). In most of those cases, knowledge flows is the result of a conscious and often costly attempt made by firms in order to generate greater innovation and reap economic benefits.

On the other hand, knowledge spillovers are being mistaken by other benefits of agglomeration, such as natural advantages or shared intermediate inputs, that is, pecuniary externalities. Various studies aimed at investigating whether the apparent geographic localization of spillovers from industrial R&D may be an artifact of other agglomerative forces. This evidence is mixed. Some evidence finds that intraregional spillovers are significant and that physical distance also

matters, implying that spillovers decay gradually as regions become farther apart (Duranton and Puga, 2001; Orlando, 2004; Greenstone et al., 2010; Lychagin et al., 2010), while an emerging literature suggests that technological spillovers and demographics are not the main contributing cause of the higher performance observed for firms located within geographic clusters (Smith et al., 2002; Boschma and Wal, 2007; Glaeser and Kerr, 2009).

In line with this last evidence, some authors have argued that physical proximity may not be a necessary condition for knowledge exchange, as other types of proximity, such as cultural proximity (Zeller 2002), organizational and relational proximity (Torre and Gilly, 1999; Torre and Rallet, 2005; Boschma, 2005; Oerlemans and Meeus, 2005), might provide the advantages of physical proximity to firms' innovation activities. The extent of knowledge transfer is shown not to depend exclusively on physical proximity but also on firms' capabilities, absorptive capacity and their ability to renew capabilities over time (Boschma and Wal, 2007).

For instance, Zucker et al. (1998) found that the concentration of startups in the biotechnology industry in the U.S.A. is more the result of a preference of scientists to locate near their home university rather than the result of social ties and meetings between local firms and scientists. Other studies have found that clustering alone is not conducive to higher innovative performance (Beaudry and Breschi, 2003; Boschma and Wal, 2007; Tappeiner et al., 2008; Gilbert et al., 2008), providing evidence in favoring of the view that firm-specific characteristics may be more important for innovation output than firm's location, and that region-specific factors may impact differently on firm's innovation output.

Recently, Fitjar and Rodríguez-Pose (2011) found that innovation in southwest of Norway does not stem from agglomeration and physical proximity, but from other types of proximity, such as cognitive and organizational proximity, rooted in soft institutional arrangements. They argue that the formation of regional hubs with strong connections to international innovative networks may be a way to overcome peripherally in order to innovate.

This mixed evidence and theoretical arguments on the role of firm's co-location on firm-level innovation emphasize the opportunity, usefulness and relevance in researching this topic in Portugal.

3. Empirical analysis

3.1 The dataset

In order to investigate the geographical distribution of innovation output and persistence across different types of innovation, we observed firms over three waves of the Portuguese Community Innovation Survey, covering the time period from 1998 to 2006. The surveys that were used in the analysis are: CIS3 (1998-2000), CIS4 (2002-2004) and CIS6 (2004-2006).

The CIS provides information on firms' innovation activities, like the different types of innovation, the sources of innovation, the effects of innovation and it follows the OECD recommendations published in the Oslo Manual (OECD/Eurostat, 2005). The CIS data has been widely used and the validity of its innovative indicators recognized (see e.g. Kleinknecht et al. (2002), Mairesse and Mohnen (2002)). In a comparative analysis of innovative indicators,

Kleinknecht et al. (2002) showed that the CIS indicators measure innovation input and output more comprehensively and more directly than earlier measures.

The surveys are representative of the Portuguese manufacturing and service industries, hence can be considered globally valid for the manufacturing and services population. Firms with 10 or more employees were sampled randomly by industry and size strata. There are three size-classes: 10–49 employees, 50–249 employees, and 250 or more employees. The industrial stratification is by NACE codes at the 2-digit level. When a stratum size was too small for sampling, a census was done within the specific stratum. The data regarding innovation activities is made up of retrospective answers that cover the three years preceding the survey.

Due to data protection reasons we were not allowed to access data on the location of the firms sampled in the CIS4 and CIS6 surveys. Thus we had to restrict our analysis to the firms that were sampled in the CIS3 survey and showed up in the following surveys. Our final sample comprises 788 firms from both manufacturing and services which we followed over the period 1998-2006.

In order to investigate the geographical distribution of innovating firms across types of innovation we followed the distinction made clear on the questionnaire. That is, *product innovation* was assumed to have taken place when the firm declared it had introduced completely new products or services with important modifications, products with new functions resulting from innovation, or had made changes to the design, presentation, materials or composition of the product, while *process innovation* was assumed to have happened when the firm indicated it had introduced some significant modification in the production process. This modification may involve the

introduction of new machines or new methods of organization, or the introduction of both.

As such, our innovation indicator is an output indicator that takes into account innovation activities that have been introduced in the market over the previous three years. As for the geographical break up, we followed the classification provided by EUROSTAT through NUTS (Nomenclature des Unités Territoriales Statistiques) at the 2-and 3-digit level. Based on this information we constructed our innovation indicators. Previous studies on innovation tend to use R&D expenditures or patents as a proxy for innovation. Yet, it has been argued that R&D expenditures and patents may not be the most adequate indicators to study persistence, since R&D expenditures only relate to input effort and persistence in patenting amounts to persistence in winning the patent race. Thus we overcome these limitations by using as innovation indicator the actual introduction in the market or by the firm of a product or process innovation.

3.2 Geographical distribution and concentration of firms' innovation activities

Our aim is to evaluate whether there are noteworthy regional asymmetries on firms' innovative output. Thus we seek to answer the following questions: Does the geographical distribution of firms' innovation persistence and innovation type differs across Portuguese regions? Do we observe a relationship between the geographical unit, and innovation type and innovation persistence?

3.2.1 Distribution pattern of firms' innovation activities

In order to answer these questions we computed the geographical distribution of innovative firms at the NUTS2 and NUTS3 aggregation level, respectively, over the period 1998-2006, and its breakup by innovation type – product and process - and persistence. For all cases, statistical tests were performed to assess whether there is a statistically significant different distribution of innovation activity across regions and whether there is a statistically significant association between location and firms' innovation output.

As shown in Table 1, the percentage of innovative firms, around of 43% of sampled firms, has remained stable over the period 1998-2006. However, when looking at the data across NUTS2 regions, we observe some differences in the evolution of the regional distribution of innovative firms. For instance, whereas *Alentejo*, *Centro* and *Norte* regions account for an increase in the percentage of innovative firms over time, the *Lisboa* and *Algarve* regions report an opposite evolution, suggesting that region-specific characteristics have an impact on firm's ability and effectiveness of their innovation activities.

[Table 1 here]

The statistical tests Pearson Chi2, the Likelihood-ratio Chi2 and Levene's F statistic confirm that the distribution of innovation intensity differs across NUTS2 regions and the Cramer's V coefficient confirms that there is a statistically significant association between innovation output and the location in which innovation takes place, suggesting that firms' location may have power to explain firms' innovation output. In the following waves only the Levene's F statistic indicates that the variability of firms' innovation output across regions is significantly heterogeneous but we do not observe a strong association between

innovation and location given the low values of the Cramer's V statistic. This result could be interpreted as indicating that knowledge spillovers between regions may occur over time and yield positive effects on firm's innovation activities, regardless its location.

Looking at product innovation and process innovation, we observe that Portuguese firms do more process innovation than product innovation. The distributional pattern is consistent across regions, regardless the geographical aggregation level, indicating that Portuguese firms are using innovation process as a means to increase production. A similar result has been found by Hall et al. (2009) in Italian firms. In both cases, that empirical regularity may be explained by the predominance of low- and medium-technology industries, which tend to focus on process innovations to a considerable greater extent than other industries (Heidenreich, 2009).

Worth noting is that we observe statistically significant differences in the distribution of product innovation across regions as well as a statistically significant association between product innovation intensity and the firms' region. Moreover, there are interesting differences in firms' innovation type over time and across regions. The *Centro* and *Lisboa* regions exhibit a downward trend on the percentage of firms introducing product innovations, while in the other regions it is not possible to identify a clear trend. Regarding process innovation we observe that the *Norte* region is the only one showing an unambiguous and increase in percentage of firms introducing this type of innovation. In brief, the data suggest that initial differences in the distribution of innovation type across regions as well as the strength of the association between innovation type and NUTS2 regions have decreased over time.

Looking at NUTS3 regions, the most relevant change emerging from the data is the increase in the value of the Cramer's V statistic throughout the entire sample period, providing evidence for a clear association between geographical location and innovation, a result that is also valid even when we break up the data by innovation type. In this case, the association is stronger with product innovation than with process innovation. Third, the statistically significant value of Levene's F statistic provides statistical evidence of heterogeneous variability on firms' innovation intensity and innovation type across regions. The increase in the association between innovation and location is consistent with previous evidence as a narrower definition of space is considered (Aharonson et al., 2008).

[Table 2 here]

Specifically, *Grande Lisboa*, a metropolitan region, reports a decreasing percentage of innovative firms, which seems to cast doubt on the hypothesis of the importance of geographic proximity to metropolitan centers to innovative activities. However, the other important Portuguese metropolitan region - *Grande Porto* - reports positive evolution on the percentage of innovative firms. This result was mainly driven by the positive evolution on the percentage of firms that have introduced process innovation, while in the case of *Grande Lisboa* the downward evolution was driven by the evolution on the percentage of firms that have introduced product innovation. Therefore, location appears to matter to firms' innovative activities, as regions differ on the factors that have an impact on firm's innovation activities and performance.

Regarding innovation persistence, Table 3 reveals that only a small percentage of firms are persistent innovators (9.26%), which is in line with previous evidence (Geroski et al., 1997; Cefis, 2003; Roper and Hewitt-Dundas,

2008; Raymond et al., 2010; Huergo and Moreno, 2011). Likewise, the percentage of occasional innovator type 1 firms - those that introduced an innovation once - is larger than the percentage of occasional innovator type 2, 38.71% and 30.71% respectively.

[Table 3 and Table 4 here]

Looking at the distribution of persistent innovators across regions we observe some differences across regions. Specifically, at NUTS2 level, *Lisboa* has the highest percentage of persistent innovators (11.11%), whereas Algarve has none (see Table 3). Yet, only one statistical test (Levene's F) confirms these differences across regions as being statistically significant, irrespectively the geographical aggregation level considered.

When narrower regions are considered (see Table 4), there is a statistically significant relationship between innovation persistence and location. Whereas the Cramer's V statistic does not reveal a relevant association between innovation persistence and location at NUTS2 level, it discloses some strength in the association between these variables. These findings suggest that the degree of physical proximity, evaluated here through the definition of narrower regions, has an association with differences on firms' persistent innovative behavior. This finding is further confirmed through the Moran I test for spatial dependence (see last row in Table 4). The analysis of spatial dependence shows a strong positive spatial autocorrelation for the innovation persistence, regardless the firm's type. This outcome suggests that there is a spatial clustering of innovating firms, which can be interpreted as given support of the view that local learning and knowledge spillovers are important channels for generating innovative firms.

Nonetheless, the strength of the relationship between location and innovation type is stronger than between location and persistence, which suggests that region-specific factors is more likely to have power to explain the pattern of firms' innovation type than to explain the regional pattern of innovation persistence.

3.2.2 Geographical concentration of innovating firms

If co-location of firms has to have impact on firms' innovation activities, the geographical concentration ratio, which describes the proportion of high ranking regions in terms of innovation activities, should reflect it. Comparing data in Table 5, in general, the geographical concentration ratio of innovating firms is higher than the spatial concentration ratio of Portuguese firms, suggesting that the distribution of innovating firms is more uneven than the distribution of firms.

[Table 5 here]

Looking at product or process innovation over the three CIS waves, the differences on geographical concentration ratio are not so noticeable suggesting that concentration on innovation activities follows strictly concentration on firms' locational choices. However, looking at innovation persistence, another interesting and promising outcome emerges. The biggest impact of co-location appears to be on innovation persistence. The four high-ranking regions account for 67.1% of innovating firms that reported having introduced an innovation in all CIS waves (1998-2006). Overall, this seems to imply that firms have no equal probabilities of being persistently innovators, given their previous choice of geographical location. Moreover, this appears to corroborate the argument that

there is some sort of dynamics within the creation of innovation itself (see, e.g., Cooke, 2001), leading to a divergent innovative path across firms and regions.

4. Conclusions

The aim of this paper was to provide empirical evidence on firms' innovative activity by disclosing regularities in the distribution and concentration of innovation activity across Portuguese regions. Using survey data, we contributed to the recent and still scarce literature that investigates innovation by employing novel quantitative indicators of innovative output at firm-level.

Consistent with previous evidence (e.g. Hall et al. (2009)), our data show that innovating firms are more likely to perform process innovation rather than product innovation, which suggests that Portuguese firms appear to be particularly concerned with efficiency gains. Also, a low rate of firms can be classified as persistent innovators.

When looking at the spatial distribution of innovating firms over time we observe a change in innovation intensity across regions and a movement towards convergence, which has been observed by others (Moreno et al., 2005; Driver and Oughton, 2008). Additionally, when looking at the spatial distribution of firms by innovation type and persistent behaviour we find statistical support for both differences across regions in the distributions, and an association relationship between location and innovation. These results are stronger or in some cases only present when a narrower definition of region is considered, which is also consistent with previous evidence regarding the association between location and innovation activities measured by R&D expenses or patents (Aharonson et al., 2008).

We have also found some evidence for differences in the degree of correlation between location and innovation type. Specifically, the statistical tests show that this association is stronger and statistically significant in product innovation but not in process innovation. This result suggests that different types of innovation may have different determinants which are specific to location. One possible explanation could be the McCann's (2007) hypothesis that different types of innovation require different face-to-face contacts, an argument also sustained by Shearmur and Doloreux (2009).

These explorative findings are promising and provide motivation for future research. One possible extension of this research would be to assess which region-specific factors have power to explain firms' innovation activities and effectiveness. Another potentially fruitful extension would be to attempt to investigate the role of region-specific factors on determining different types of firms' innovative output as well as innovation persistence.

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Table 1: Innovation type across Portuguese regions (NUTS2), 1998-2006.

NUTS2		CIS3			CIS4			CIS6		
		1998-2000			2002-2004			2004-2006		
	All firms	Innov[a]	Product[b]	Process[b]	Innov[a]	Product[b]	Process[b]	Innov[a]	Product[b]	Process[b]
	N	%	%	%	%	%	%	%	%	%
Norte	307	43.65	29.32	32.90	41.69	24.43	37.13	44.30	27.36	37.79
Centro	184	39.67	26.09	28.26	39.13	25.00	34.78	43.48	25.54	36.41
Lisboa	261	49.04	33.33	35.25	42.91	24.52	39.46	43.30	21.84	36.02
Alentejo	24	29.17	16.67	25.00	37.50	16.67	33.33	37.50	16.67	37.50
Algarve	12	16.67	0.00	16.67	33.33	16.67	33.33	8.33	8.33	8.33
Total	**788**	**43.65**	**29.06**	**32.11**	**41.24**	**24.24**	**37.18**	**43.02**	**24.49**	**36.42**
Pearson chi2(4)		9.867**	9.814**	4.388	1.113	1.120	1.264	6.417	4.959	4.366
Likelihood-ratio chi2(4)		10.362**	13.130***	4.586	1.123	1.297	1.267	7.708	5.436	5.376
Levene's F (4, 783)		29.760***	20.758***	5.999***	1.479	1.549	1.293	68.809***	6.491***	17.389***
Cramér's V		0.112	0.112	0.075	0.038	0.039	0.040	0.090	0.079	0.074

Source: Authors' own calculations from CIS3, CIS4 and CIS6 data. *Notes*: [a] This is the percentage of innovating firms in the survey. [b] This is the percentage of innovating firms that reported having introduced in the market a product and/or process innovation. The same firm may have reported both types of innovation; hence the sum of the product and process columns may add up to more than 100%. ***, **, * means it is statistically significant at the 1%, 5% and 10% level, respectively.

Table 2: Innovation type across Portuguese regions (NUTS3), 1998-2006.

NUST3 [c]		**CIS3**			**CIS4**			**CIS6**		
		1998-2000			2002-2004			2004-2006		
	All firms	Innov[a]	Product [b]	Process[b]	Innov[a]	Product [b]	Process[b]	Innov[a]	Product [b]	Process[b]
	N	%	%	%	%	%	%	%	%	%
Ave	58	48.28	29.31	37.93	46.55	31.03	37.93	48.28	29.31	43.10
Baixo Vouga	47	42.55	29.79	31.91	42.55	29.79	40.43	46.81	34.04	38.30
Grande Lisboa	176	54.55	36.93	40.34	46.02	27.27	42.05	46.59	23.86	39.77
Grande Porto	145	37.93	28.97	27.59	37.24	18.62	33.79	44.83	26.90	37.93
Total[d]	**788**	**43.65**	**29.06**	**32.11**	**41.24**	**24.24**	**37.18**	**43.02**	**24.49**	**36.42**
Pearson chi2 (25)		35.226*	24.371	28.929	22.235	24.479	16.925	21.358	34.233	23.558
Likelihood-ratio chi2 (25)		36.724*	30.708	29.443	24.198	26.676	18.741	23.497	37.507**	28.675
Levene's F (25, 762)		5.690***	6.962***	3.994***	6.950***	4.519***	5.053***	11.426***	5.387***	11.1889***
Cramér's V		0.211	0.176	0.192	0.168	0.176	0.147	0.165	0.208	0.173
Moran's I test (spatial autocorrelation)			0.163**	0.153*		0.219**	0.197**		0.236**	0.206**

Source: Authors' own calculations from CIS3, CIS4 and CIS6 data. *Notes*: [a] This is the percentage of innovating firms in the survey. [b] This is the percentage of innovating firms that reported having introduced a product and/or process innovation in the market. The same firm may have reported both types of innovation; hence the sum of the product and process columns may add up to more than 100%. [c] There are 28 regions at the NUTS3 aggregation level in Portugal. The final sample only includes 26 regions ('Alto Trás os Montes' and 'Serra da Estrela' are not included), because there are no surveyed firms in the excluded regions.[d] For presentation purposes we just report the regions with the highest number of firms; hence the total row refers to the total sample. The other data is available upon request to the authors. The association tests are performed for the all sample. ***, **, * means it is statistically significant at the 1%, 5% and 10% level, respectively.

Table 3: Innovation persistence across Portuguese regions (NUTS2), 1998-2006.

NUTS 2	**CIS3, CIS4 and CIS6**				
		Innovating firms			Total
	All firms	Occasional type 1[a]	Occasional type 2[b]	Persistent[c]	Innovating firms
	N	%	%	%	%
Norte	307	37.79	31.27	9.77	78.83
Centro	184	39.13	30.98	7.07	77.17
Lisboa	261	41.38	30.27	11.11	82.76
Alentejo	24	25.00	33.33	4.17	62.50
Algarve	12	25.00	16.67	0.00	41.67
Total	**788**	**38.71**	**30.71**	**9.26**	**78.68**
Pearson chi2 (4)		3.761	1.265	4.179	16.387***
Likelihood-ratio chi2 (4)		3.934	1.398	5.488	13.964***
Levene's F (4, 783)		7.640***	2.203*	4.667***	6.227***
Cramér's V		0.069	0.040	0.073	0.144

Source: Authors' own calculations from CIS3, CIS4 and CIS6 data. *Notes*: [a] Occasional innovator type 1 means the firm reported having introduced an innovation once over the period 1998-2006. [b] Occasional innovator type 2 means the firm reported having introduced an innovation twice over the period 1998-2006. [c] persistent innovator means the firm reported having introduced an innovation in all CIS waves. ***, **, * means it is statistically significant at the 1%, 5% and 10% level, respectively.

Table 4: Innovation persistence across Portuguese regions (NUTS3), 1998-2006.

NUTS 3[d]	**CIS3, CIS4 and CIS6**				
		Innovating firms			Total
	All firms	Occasional type 1[a]	Occasional type 2[b]	Persistent[c]	Innovating firms
	N	%	%	%	%
Ave	58	29.31	36.21	13.79	79.31
Baixo Vouga	47	38.30	34.04	8.51	80.85
Grande Lisboa	176	41.48	32.39	13.64	87.50
Grande Porto	145	39.31	31.03	6.21	76.55
Total[e]	**788**	**38.71**	**30.71**	**9.26**	**78.68**
Pearson chi2(25)		23.055	14.947	24.773	51.276***
Likelihood-ratio chi2(25)		27.484	15.265	32.793	48.367***
Levene's F (25, 762)		10.019***	2.229***	4.702***	4.507***
Cramér's V		0.171	0.138	0.177	0.255
Moran's I test (spatial autocorrelation)		0.168*	0.196**	0.152**	0.190**

Source: Authors' own calculations from CIS3, CIS4 and CIS6 data. *Notes*: [a] Occasional innovator type 1 means the firm reported having introduced an innovation once over the period 1998-2006; [b] Occasional innovator type 2 means the firm reported having introduced an innovation twice over the period 1998-2006; [c] persistent innovator means the firm reported having introduced an innovation in all CIS waves. [d] There are 28 regions at the NUTS3 aggregation level in Portugal. The final sample only includes 26 regions because there are no surveyed firms in the excluded regions ('Alto Trás os Montes' and 'Serra da Estrela' are not included). [e] For presentation purposes we just report the regions with the highest number of firms; hence the total row refers to the total sample. The other data is available upon request to the authors. The association tests are performed for the all sample. ***, **, * means it is statistically significant at the 1%, 5% and 10% level, respectively.

Table 5: The concentration ratio of innovation activities in Portuguese regions (NUTS3), 1998-2006 (%).

	CIS3	CIS4	CIS6	3 Waves of CIS6
	1998-2000	2002-2004	2004-2006	1998-2006
Innovating firms				-
Product	61.1	56.5	59.1	-
Process	59.3	56.3	59.2	-
Occasional type 1	-	-	-	54.4
Occasional type2	-	-	-	57.4
Persistent	-	-	-	67.1
Firms in 1998 (population)			56.3	

Source: Authors' own calculations from CIS3, CIS4 and CIS6 data. *Notes*: *Occasional innovator type 1* means the firm reported having introduced an innovation once over the period 1998-2006; *Occasional innovator type 2* means the firm reported having introduced an innovation twice over the period 1998-2006; *Persistent innovator* means the firm reported having introduced an innovation in all CIS waves.

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