

Holl, Adelheid; Rama, Ruth

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Economic crisis and innovation: Do regions matter?

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Economic crisis and innovation: Do regions matter?*

Adelheid Holl

Institute of Public Goods and Policies (IPP)
CSIC - Consejo Superior de Investigaciones Científicas
C/ Albasanz, 26-28; 28037 Madrid, Spain
a.holl@csic.es

Ruth Rama

Institute of Economics, Geography and Demography (IEGD)
CSIC - Consejo Superior de Investigaciones Científicas
C/ Albasanz, 26-28; 28037 Madrid, Spain
ruth.rama@cchs.csic.es

Abstract: Drawing on a large sample of Spanish manufacturing and service sector firms we analyze the changes in firms' innovation expenditures that have taken place since the onset of the 2008 crisis and the relationship between such changes and the location of the company. We specifically focus on firms in the Basque Country. Compared to other Spanish regions, the Basque Country differs in terms of its fiscal status, its earlier experience of crises, its innovation performance and its greater focus on innovation-related policies. Our results show that the crisis has indeed not had the same impact on firms' innovation expenditures in the Basque Country than in comparable Spanish regions. Even after controlling for sectoral differences and detailed firm level characteristics, firms with R&D employment in the Basque Country showed a significantly lower probability of having abandoned innovation activities and even a somewhat higher probability of having increased their innovation effort. This regional effect has been especially important for SMEs.

Key words: regions, innovation investment, economic crisis, resilience.

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1. Introduction

There is broad agreement among economists and policy makers that economic growth is nowadays largely driven by the capacity of firms to innovate. Most advanced countries have therefore developed public support programmes to promote innovation-related activities among firms.

The financial and economic crisis that started in late 2007 has had a far reaching impact on countries around the world. Spain has been one of the countries worst affected. As a result of the economic crisis, the government has reduced public funding in R&D. At the same time, the continued credit crunch has dramatically worsened the possibilities for financing new ideas and projects. One of the consequences of the economic crisis is that many companies have reduced their innovation-related activities; however, some firms have been more resilient than others (Filipetti and Archibugi, 2011 and Archibugi et al., 2013b provide evidence in this regard for European countries). Filipetti and Archibugi (2011) furthermore show that there are important differences across countries regarding the degree to which the economic crisis has affected firms' innovation investment. They argue that national institutional settings and the structural characteristics of national innovation systems have played an important role in shaping how firms have responded to the crisis. With very few exceptions (Eickelpasch, 2014), this quantitatively rooted literature on the crisis has largely overlooked the role of the regional location of firms. However, learning processes underlying innovation are localised and locally embedded, and regional innovation systems (hereafter, RIS) may play a role too.

The empirical literature based on quantitative data rather than on qualitative information has not yet looked at the effects of the current economic crisis on the innovation strategies of firms located in specific regions. There are a few exceptions, e.g. Madrid-Guijarro et al. (2013) on SMEs in the Murcia region of Spain and Antonioli et al. (2013) on firms in Emilia-Romagna in Italy. However, it is difficult to put their results into perspective, since no comparison is provided with similar regions within the same country. Though these studies provide important insights, it is difficult to tell from them whether the behaviour, pro cyclical or anti cyclical, of firms located in Murcia or Emilia-Romagna differs from that of firms located, respectively, in comparable Spanish or Italian regions. Other regional studies about the crisis have tended to adopt a descriptive and discursive rather than a statistical approach. These studies have utilized relatively small samples and followed predominantly case studies methodologies. Without denying the clear relevance of

previous research work, we claim that there is still a strong need for quantitative studies that put analyses of regional firms into a perspective.

We argue that firms located in certain regions may have been more likely to maintain and even increase their innovation activities during the crisis. This is a departure from previous studies in the business cycle literature since these analyses have focused on firm-specific characteristics as almost the only explanation for the persistent innovative activities of firms faced to crises.

Spain provides an interesting setting for the analysis; as stated, it is one the countries worst hit by the crisis. It is also a country with a highly decentralized unitary state with a unique framework of territorial administration. Spanish regions have very diverse economies and also different degrees of fiscal and political autonomy. They vary greatly in terms of their innovation performance as well as regarding their regional innovation and technology policies. Moreover, their responses to the economic crisis in terms of regional policies have not been the same. We will use the case of the Basque Country to illustrate our point. Compared to other Spanish regions, the Basque Country shows some distinct characteristics. It enjoys a special fiscal status, earlier experience of crises, a higher innovation performance and it has a greater focus on innovation-related policies. We are especially interested in small and medium sized enterprises (SMEs) since they have displayed great vulnerability during the Spanish downturn. It is important to understand the possible differences of firms that locate their R&D activities in the Basque Country because these firms seem to show a success story and it is here that comparative analysis has a role to play.

Our analysis contributes to the literature with its use of a large national data base. Specifically we use a detailed micro-data set that allows us to test whether the crisis has differently affected firms' innovation processes in the Basque Country as opposed to firms in the most comparable Spanish industrial regions; namely in Madrid and Catalonia. Our approach contributes empirically to a better understanding of the phenomenon of resilience of innovative activities at the regional level. Even after controlling for sectoral differences and firms' structural characteristics, we find that firms in the Basque Country show a significantly lower probability of having abandoned innovation activities and even a somewhat higher probability of having increased their innovation effort. This regional effect seems to mainly influence SMEs.

Section 2 presents the literature review and the hypotheses to be tested. Section 3 describes the data used in the econometric analysis and presents some descriptive statistics.

Section 4 displays the model specification. Section 5 offers the results and discussion. Section 6 concludes.

2. Literature review

In order to develop a coherent framework for the analysis, three building blocks must first be put in place. In what follows, we briefly review the literature on business cycles and innovation, organizational and regional resilience, and RIS.

2.1. Business cycles and innovation

The impact of business cycles on innovation at the company level is still a controversial issue. Analysing Finnish firms in low tech sectors, Makkonen et al. (2014) conclude that, as proposed by neo Schumpeterian theories, adoption of new technologies is more likely in recession periods, due to lower opportunity costs, than in boom periods. In periods of heavy demand, engineers and scientists are likely to be shifted from firm laboratories to the industrial plant, a situation that tends to reduce innovation by unit value of sales during a growth period (Branch, 1974). In a sample of Spanish companies, recession in the market in which the focal firm operated was negatively associated with both product and process innovation (Martinez-Ros, 2000). Analysing Spanish data for 1991-2010, López García et al. (2014) found similarly that the behaviour of corporate R&D was counter-cyclical. They argue that during crises enterprises tend to substitute short term productive investment with investment which is likely to improve their long term performance, such as R&D. However, they found an important exception: in credit rationed firms, recessions may induce a reduction of R&D expenditures, especially in medium tech industries. Antonioli et al. (2013) found that companies located in Emilia-Romagna (Italy) preferred to implement process innovation to cope with the current crisis.

The evidence provided by most analyses of previous crises seems, however, to support the idea that innovation tends to be pro-cyclical. Analysing UK data for 1948 to 1983, Geroski and Walters (1995) conclude that fluctuations in demand lead to variations in innovative activities, as measured by major innovations and patents. These authors contend that the demand pull impact on innovation includes changes in consumers' preferences, the competitive structure of markets and other factors influencing the ability of inventors to appropriate the benefits of their inventions. Harfi and Mathieu (2009), focusing on the 1987-2006 period, found similar results. They noted that in OECD

countries, the R&D and innovative activities of firms were rather pro-cyclical, as such activities tended to increase in growth periods and to decrease in periods of recession. This may also be the case during the current crisis. Analysing manufacturing SMEs in Murcia (Spain), Madrid-Guijarro et al. (2013) found that reported innovative activities decreased from 2005 to 2009. Paunov (2012), analysing Latin American firms during 2008-2009, found that their innovation behaviour was largely pro-cyclical. Studying the most important European Union R&D performers, Cincera et al. (2011) observed a deceleration of innovative activities during the current crisis and reported a sharp drop in these companies' R&D investment in 2008-2009. Based on analysis of a large sample of British firms, Archibugi et al. (2013a) found that the current crisis substantially reduced their innovation expenditures. Arvanitis and Woerter (2014) noted that, over 1999-2009, the R&D behaviour of Swiss manufacturing firms was more pro-cyclical than anti-cyclical.

Cincera et al. (2011) believe that inconclusive results on whether R&D is counter cyclical or not might be attributable to different companies reacting differently to crises. Actually, the literature has reported on the heterogeneity of firms in this respect. Differences concerning size of industrial plant, sector, previous innovative experience or access to credit may contribute to explaining the resilience of firms in matters of innovation activity (Arvanitis and Woerter, 2014; Paunov, 2012). In addition, some studies suggest that the capacity of firms to counteract the business cycle depends, in part, on the availability of public funding for innovation. Analysing eight indigenous and foreign multinational enterprises (MNEs) operating in France, Laperche et al. (2011) found that these companies had not reduced their R&D expenditures during the current crisis, while some firms had actually expanded them. An important reason for this was that companies were able to secure public funding aimed at stimulating innovation. Eickelpasch (2014), studying German manufacturing companies, observed that their R&D behaviour was counter cyclical in 2008-2009, since the expansion of R&D expenditures was greater than changes in demand. He attributes the low volatility of R&D staff in these enterprises, at least in part, to the provision of short-time working allowances by the Federal Employment Agency to companies during the crisis and "the massive increase in the volume of the R&D schemes funded by the Federal Ministry of Economy and Technology" (p. 19). Apparently, even in one of the EU countries least hit by the crisis, policies may have played a substantial role in helping firms to preserve and even increase the level of their innovation expenditures. Qualitative evidence on several European regions seems to back

this finding regarding the role played by public policies during the crisis, (see, for instance, Gebhardt, 2012; Rodrigues and Melo, 2012).

To our knowledge, this literature has not yet examined whether the regional location of companies within a country may have affected the level of their R&D expenditures during the crisis. An exception is Eickelpasch (2014), who observed that companies in West Germany were more likely than companies in East Germany to engage in R&D during 2009 and 2010. This result suggests that, within a country, firms located in a specific region may display pro-cyclical behaviour while firms located in another region may display counter-cyclical behaviour even when firm-specific features are controlled for.

2.2. Resilient firms and resilient regions

Related to the previous discussion, some authors in the management tradition have elaborated on the concept of resilient organizations (Gilly et al., 2014). They maintain that the resilience of firms is determined by their capacity to: i) absorb, anticipate and resist an external shock and ii) generate new technical and organizational solutions. However, the concept of resilience has more often been used as a framework to analyse the effects on localities of a broad set of phenomena, such as business cycles, technology life cycles and globalization. The literature provides at least two definitions of regional resilience: i) the ability of firms in a region or country to remain in their current state in spite of changes, shocks and perturbations and ii) their ability to adapt to change and move ahead, beyond just recovery (for reviews of the resilience literature, see Davies, 2011 and Simmie and Martin, 2010). As noted by Navarro-Espigares et al. (2011), while the first definition suggests a static notion of resilience, the second understands it as an ongoing process. Recent contributions to the regional resilience literature have emphasised the role of the state, institutions, social and political agents, power relations and network structures, and policy interventions for understanding regional differences in resilience (Pike et al., 2010; Bristow, 2010; Davies, 2011; Bailey and De Propris, 2014; Bristow and Healy, 2014). However, these concepts have still been rarely assessed in empirical studies on regional resilience.

The empirical literature has attempted to evaluate the resilience of regions faced with crises by measuring rates of growth and changes in output or employment (Davies, 2011, Groot et al., 2011; Navarro-Espigares et al., 2011; Lee 2012; Musil, 2014). Research results suggest that reasons for regional resilience may be sought in a variety of factors

(such as, for example, large shares of high tech industries, industrial diversification, workforce skills, as well as in different government responses).

What emerges from the regional resilience literature is that there are not exclusive recipes for regional resilience. Diametrically opposed measures have proved successful. Adjustment or adaptation after a shock has often been seen as the regional capacity to withdraw from traditional sectors towards promising “new” sectors. In contrast, Treado and Giarratani (2008) analysing the steel technology cluster in Pittsburgh, argue that the resilience of a region can be demonstrated by its ability to rescue key elements of its traditional industries within an evolving global industry. More importantly, success stories may not be the direct consequence of “ad hoc” policy implementation but also of historical trajectories (Crespo et al., 2013).

The literature also suggests that organizational resilience and regional resilience may be interrelated phenomena. The strategies of leading firms may contribute to the strengthening of the competitive advantages and capabilities of other local firms and, hence, to sheltering an agglomeration or region during crises (Carbonara, 2002; Rama and Ferguson, 2007). Conversely, embeddedness in regions or sub regional localities may help companies threatened by a financial crisis or by neo-liberal reform to enhance their firm specific advantages. During downturns, some localities may negotiate territorially based social pacts, which include local enterprises, trade unions, business associations, governments, universities, etc. (Dei Ottati, 2002).

However, the literature also offers examples of territories unable to find solutions to crises (Cassiolato et al., 2002). What might have failed in some of these cases is the capacity of the region to organise collective learning processes (Gilly et al., 2014). An efficient RIS may contribute to the resilience of innovative activities at company level.

2.3. Regional Innovation Systems

RIS have been defined as the “*. wider setting of organisations and institutions affecting and supporting learning and innovation in a region*” (Asheim and Isaksen, 2002). Regions may differ in terms of their different innovative strengths and weaknesses, as well as their industrial, and science and technology (S&T) strategies. Different innovative actors, different distribution of S&T funding and different intensity of linkages between innovators are some of the reasons explaining differences among RIS, even within the same country. These three aspects may be illustrated with studies on the Spanish case. Analysing 35 different variables through factor analysis, Buesa et al. (2006) identified several distinct RIS

and highlighted their distinctive strengths. The Madrid system relied mainly on public R&D expenditure; the Catalan system on the regional and productive environment for innovation, such as a large regional market; and the Navarre system on the role of universities. The Basque Country system, in contrast, was organized around innovative firms (e.g. high internal R&D expenditures as percentage of GDP, large share of corporate R&D employees as compared to the active population; high annual income of technological centres) according to Buesa et al. (2006).

Another reason for differences between RIS is that some may be mainly “entrepreneurial”, while others may be mainly “institutional” (Cooke, 2009). Analysing the distribution of the S&T funding of five Spanish regions, Sanz-Menéndez and Cruz Castro (2005) identified two different strategies. They noted that Andalusia, Catalonia and Madrid were clearly academically oriented, while Galicia was in a transition from an academic oriented to a business oriented system. Basque Country, however, had made a clear choice for a business oriented system, emphasizing support to: R&D corporate activities, clusters, and private technology centres that catered to the needs of regional firms, especially SMEs.

The literature has clearly established that knowledge spillovers are geographically mediated (Feldman, 2000). Regional interactions between firms and between firms and institutions seem to be essential to define the emergence of an RIS (Cooke et al., 1997). For instance, Riba Vilanova and Leydesdorff (2001), based on 1986-1995 scientometric data, have argued that Catalonia cannot be considered an RIS because its academic system and its industrial system interact at the national and international level, but seldom interact locally. Networking for innovation has been pointed out as a factor contributing to the resilience of industries and companies in the face of crises (Storper, 1992; European Commission, 2013). At the regional level, differences between RIS may result in very different innovation performances.

3. Data

Our main data source is the Spanish Technological Innovation Panel (Panel de Innovación Tecnológica, PITEC), a survey carried out by the Spanish Statistical Office (INE). The PITEC includes information on the technological innovation activities of all the main sectors in the Spanish economy, including services and manufacturing, and provides consistent innovation information for the 2004-2012 period. PITEC provides detailed information on the regional location of the companies' R&D employees. Specifically, firms are asked to state the number of R&D employees in each of the 19 autonomous regions of

the country. This allows us to identify all firms with R&D employment in the Basque Country as well as in other regions. Specifically, we include regional dummies for the three main industrial areas in Spain: Madrid, Catalonia and the Basque Country. The principle of residence used by some studies may pose difficulties if one attempts to understand the technological capacity of regions because, in the case of multi-plant companies, R&D activities are attributed to the headquarters of the firm or to the residence of the company which applies for a patent (Evangelista et al., 2001). This criterion may underrate the capacity of some regions. Here, instead, the regional dummies are based on the location of the firms' R&D facilities. For our 2008-2012 comparison, we have a sample of 4,697 manufacturing and service firms that responded in both 2008 and 2012 and that reported R&D employment in 2008. Since our regional dummies are based on the location of the firms' R&D employees, we only include firms that in 2008 had R&D personnel. By including only firms with R&D employees, our analysis is focused on innovative-active firms before the onset of the economic crisis.¹

4. Motivation

3.1. Innovation performance

In 2008-2012, the Innovation Union Scoreboard (European Commission, 2013) classified Spain as among the “Moderate Innovators”. This is a group of countries displaying a performance below that of the EU-27 (i.e. between 50% and 90% of the performance of the EU-27). The decline of the Spanish growth performance was especially noteworthy, for example, in finance and support of innovation, innovative linkages. Spain's Gross Domestic Expenditures on R&D (GERD) are also below the EU-27 average and the gap has even increased since 2008. In 2008-2012, GERD increased from 1.96% in 2008 to 2.06 % in the EU-27 but decreased from 1.35 % to 1.30 % in Spain.² Note that in Ireland, another peripheral European country strongly hit by the crisis, GERD increased from 1.45% to 1.72 %. In Spain, the part accounted for by the business sector also fell, from 0.71 % of GDP in 2007 to 0.69 % in 2012, while in Ireland it rose from 0.85% to 1.20%. Unlikely many other OECD countries (e.g. Germany, Portugal, Norway), Spanish strategies for recovery have not explicitly focused on R&D or innovation (Guellec and Wunsch-Vincent, 2009).

¹ Note, however, that our main results are unchanged when we include these firms in our analysis. In this case, firms that did not report R&D employees in 2008 but had innovation expenditure in the years between 2004 and 2008 are included in the control group.

² http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/introduction

According to PITEC data, the percentage of innovative-active firms has dropped in Spain by about 9% between 2008 and 2012, with this drop being particularly marked among SME's. In contrast, among the largest firms, the percentage of innovative active firms remained rather stable. Both the percentage of patenting firms as well as the percentage of turnover due to new products has also dropped.

The innovative performance of regions is far from homogeneous. Spain is actually one of the EU countries displaying greater regional diversity in this regard (European Commission, 2013). In our analysis, we focus on firms with R&D employment in the Basque Country and compare those firms to firms with R&D employment in Madrid and Catalonia, the two other large Spanish industrial regions. Each of these three regions are characterised by high shares of industrial production and high levels of per capita income, population density and human capital. These three regions hold “first-order innovation systems” and concentrate around 70% of Spanish corporate innovation activity (Herrera and Nieto, 2008). They also concentrate high tech economic activities and employ more qualified human capital than other Spanish regions.

TABLE 1

These three regions have a greater R&D intensity compared to the country average according to their Gross Expenditures on Research and Development (GERD) as a percentage of GDP (Table 1). The Basque Country is, however, the only region that has increased its total intramural R&D since the onset of the economic crisis. When we look at the different sectors of R&D expenditure we see that in the Basque Country the business enterprise sector largely maintained its level of expenditure, while in other regions business investment in R&D declined. With the economic crisis, public funding in R&D and in education has undergone severe cuts in Spain. However, in Catalonia and, to an even greater extent, in the Basque Country, R&D expenditure in the government sector has increased. In the higher education sector, the Basque Country is also the only region which increased its R&D expenditure since the onset of the economic crisis. The region seems to be following a pro innovation response to the crisis, similar to that followed at the national level by countries such as Finland and Korea (Guellec and Wunsch-Vincent, 2009) in the 1990s, when those countries faced severe crises and boosted their respective education expenditure and public R&D budgets.

The latest Regional Innovation Scoreboard (European Commission, 2014) classifies the Basque Country together with Navarre as the only two “Innovation Follower” regions in Spain. Madrid and Catalonia are classified as “Moderate Innovators”. In fact, Madrid and

Catalonia have lost the “Innovation Follower” ranking that they enjoyed before the onset of the economic crisis (European Commission, 2012). These performance groups are built with data on 11 indicators. Table 2 shows some of these indicators for the three regions. The Basque Country stands out for R&D expenditure in the business sector and for the four indicators displaying the innovative activities of regional SMEs (SMEs innovating in house, innovating SMEs collaborating with other, SMEs introducing product or process innovation, and sales of new to market and new to the firm innovation in SMEs).

TABLE 2

3.2. Policies

Spanish regions have a considerable degree of autonomy and fiscal prerogatives, and develop their own spatial programmes. This system has been referred to as a “non institutional federalism” (Colomer, 1998). While R&D and innovation-related policies are shared between regional governments and the national government, education and public universities are under the competence of regional governments. Regional funding amounts to a substantial share of the funding obtained by Spanish firms for their R&D activities, especially in SMEs (Huerigo Orejas and Rojas Pizarro, 2014). However, the share of funded regional SMEs varies substantially (Otero et al., 2014).

By the early 1990s, new ideas, such as the importance of industrial clusters, the networking of firms or local cooperation for innovation as avenues to regional development were in the air both in the academia (Porter, 1990) and in the European Commission. Everywhere, new regional policies were hotly debated. Facing a devastating crisis of its traditional industries during the late 1980s and early 1990s, the Basque Country put in practice some of these ideas earlier and boldly than comparable Spanish regions. A possible reason is that Spain enjoyed an expansive phase in 1986-1990 (Rodríguez-Pose and Fratessi, 2007); consequently, policy changes may have been perceived as less pressing than more specifically, in the Basque Country.

While all over the world many regions facing shocks have reoriented their industrial structure, the Basque Country, instead, implemented since the early 1990s policies tending to strengthen some of the old regional industries (e.g. machine-tools, high quality steel) and on supporting their clustering (Aranguren and Navarro, 2003). Adopting a similar line of reasoning than Treado and Giarratani (2008), we interpret that this strategy denotes the ability of the Basque Country to rescue key elements of its traditional industries. At the same time, the Basque Country developed “a regional R&D structure from scratch in a short period of time (15-20 years)”, well ahead of the current crisis (Moso and Olazaran,

2002). Its regional innovation and technology policy has been highly industry orientated and clearly aimed at innovative SMEs (Aranguren et al., 2009).

The Basque experience has also been anticipatory concerning policies to stimulate local inter-firm linkages. Such linkages can facilitate knowledge sharing and save on resources that the firm may subsequently use for innovation. Catalonia had implemented similar policies but these were less ambitious than the Basque's and mainly resulted in temporary local networks (Ahedo Santisteban, 2006). Basque policies concerning, more specifically, R&D cooperation have been furthermore both precocious and SMEs-related. High levels of R&D cooperation may contribute to regional resilience because access to externalities on the part of companies is facilitated. Again, the available data appear to suggest that the Basque Country is different. Not only the share of innovative SMEs collaborating with other companies and institutions over the total number of regional SMEs is higher there (Table 1) but it also increased during the current crisis. In 2007-2012, the share of collaborative SMEs decreased in Madrid and Catalonia from 20% to 16% and from 23% to 18%, respectively (European Commission, 2014). In contrast, in the Basque Country it increased from a higher point of departure, from 35% to 37%; and most of these linkages seem to be intra-regional and policy supported (Castro Spila et al., 2010). As stated, starting in the early 1990s, the region put in place cluster policies around economic activities in which it already displayed some international competitiveness (Ahedo Santisteban, 2006). Technology transfers from local private technology centres to regional SMEs have been generously funded by the regional government (Olazaran et al., 2009). This policy has been a substantial departure from the national strategy concerning technology centres. According to Ybarra (2009), in Spain, *public* technological centres have been converted to quasi-profit centres that, consequently, tend to cater mainly to large regional companies.

As compared to otherwise equivalent Spanish regions, the Basque Country seems to differ in terms of better innovative performance, earlier experience of crises and greater focus on innovation-related policies.

4. Empirical specification

We are interested in how firm location and structural characteristics relate to decisions on innovation expenditure after the onset of the economic crisis.

We construct two dependent variables. First, we analyse the decision of firms to stop spending on innovation. We define the variable *STOPPER* as taking on value 1 if the

firm has ceased to report innovation expenditure since the year 2008 and 0 otherwise. Second, we analyse the decision of firms to increase innovation expenditure since the year 2008. We define the variable *Re&Drise* as taking on value 1 if the firm has increased its innovation expenditure between 2008-2012 by more than 10% and 0 otherwise. Given the binary character of the dependent variables, we estimate two sets of bivariate probit models with *STOPPER* and *Re&Drise* as dependent variables respectively. Estimations include our three regional dummies for Madrid, Catalonia and the Basque Country, the remaining areas serving as reference group. Below we describe our control variables.

Firm-specific control variables

Size. The Schumpeterian hypothesis proposes that large firms are more likely to be innovative because they have the capacity to overcome capital market imperfections and to spread innovation costs over many units (Cohen, 1995). Concerning the possible effect of size on resilience, the empirical evidence is not conclusive. Paunov (2012) found that, in 2008-2009, small Latin American firms were more likely to abandon ongoing innovative projects owing to their difficulties obtaining finance. Apparently, the behaviour of European SMEs has been different. Antonioli et al. (2013) found that, in Emilia-Romagna (Italy), SMEs were more likely to cope with the crisis by implementing innovation, especially organizational innovation; they argued that SMEs displayed more flexibility, permitting them to react rapidly to a downturn. In a sample of British firms, Archibugi et al. (2013a) found that during the crisis, a large size was negatively associated with increased investment in innovation, meaning that small firms were more likely to increase such investments.

Productivity. High productivity is an aspect of economic performance which may encourage firms to continue with their innovative projects in spite of the crisis (Antonioli et al., 2013).

Export status. According to Paunov (2012), Latin American exporters were less likely to abandon R&D projects during the crisis. In contrast, Archibugi et al. (2013a) found no association between the exporting activities of British companies and their propensity to increase innovation activities during the crisis.

Innovation level. Other studies point to pre-crisis innovation level as a factor contributing to explaining why some firms have been able to use innovation to cope with the current crisis, arguing that “innovation calls innovation” (Antonioli et al., 2013). At the same time, the literature on the dynamics in firms’ innovation behaviour has shown that there is high persistence in innovation, suggesting that “success breeds success” (Archibugi

et al., 2013a; Cefis and Orsenigo, 2001). This might imply that “old” innovators are more likely to maintain or expand their innovation activities during crises. In order to account for firms’ pre-crisis innovation level we include the following controls: First, we control for technological leadership status. To calculate firms’ technology status at sector level, we follow Berry’s (2006) methodology. Specifically, we include a dummy for technological advanced firms. This dummy takes the value 1 if the firm is in the top quartile in its technological sector in terms of the number of R&D employees per total sales in their respective technology sector and year, and 0 otherwise. To classify firms, OECD technology levels were used.³ The second variable is the number of patents the firm has registered in the pre-crisis period. This is also an indicator of the innovativeness of the firm in the pre-crisis period. Archibugi et al. (2013a) found in a sample of British firms that high innovation intensity is likely to predict increased investments in innovation during the crisis and that firms which had applied for a patent or registered a design have been more likely to go on with their innovative activities during the crisis. In contrast, Cincera et al. (2011) observe that highly R&D intensive EU firms tended to reduce their R&D investment in 2008-2009 (size, sector and other variables checked in their model).

Newly created firm. A review of the literature points to the association of innovation and entry (Cohen, 1995); new entrants may tend to invest in radical innovation and enjoy greater R&D productivity (Henderson, 1993). These results suggest that new firms may be involved in more ambitious projects that are usually planned for the long run. However, in a sample of Latin American firms, Paunov (2012) found that “young” companies in 2008-2009 were more likely to abandon ongoing projects because they had more difficulties accessing finance.

Multinationals. Foreign affiliates are able to draw upon the internal capital market of the parent, whereas local firms often face financing constraints, especially during crises (Desai et al., 2008). As foreign affiliates may suffer less financial pressures, they may be more able than domestic firms to maintain or increase their innovation activities during the crisis. Foreign affiliates are defined as companies belonging to a business group with its headquarters outside Spain.

³ We classified the manufacturing industries in which the plants operate into three groups according to the R&D intensity (average R&D/turnover) of the industry. In doing so we used the OECD classification, which establishes the following cut-off points for average R&D/turnover: 0.9; 3; and 5 per cent. The cut-off points define low, medium, and medium high and high technology industries. Following the EUROSTAT classification, service firms were classified into three categories: high-tech services, low tech services and other services.

Sectors: Previous studies have shown that industrial structure matters for resilience (Groot et al., 2011; Arvanitis and Woerter, 2014). For instance, Davies (2011) found that unemployment rose in most Spanish regions in 2010, but poorer southern regions with high percentages of persons employed in construction were less resilient than northern manufacturing regions, due to the continuing impact of the housing crash. We include industry dummies based on the sector aggregation provided in PITTEC, which is an aggregation of the CNAE (the Spanish acronym for Spain's National Classification of Economic Activities) classification of 44 sectors. These detailed sector dummies account for differences in the sectoral composition of regions and control for industry-specific dynamics that affect firms' innovation behaviour and their response to the economic crisis in terms of innovation expenditure.

Appendix Table A1 provides a summary description and summary statistics of our explanatory variables. Appendix Table A2 presents the correlation matrix.

5. Results and discussion

Results in Table 3a show the probability of firms abandoning innovation expenditures since the onset of the economic crisis. Column (1) only includes our three regional dummies. Column (2) includes industry fixed effects as controls. In column (3) firm-specific characteristics are added. Without control for firm-specific characteristics, firms located both in Madrid and in the Basque Country appear as having a lower probability of having abandoned their innovation activities. However, conditional upon firms' pre-determined characteristics, only for firms in the Basque Country is a significantly lower probability observed. Column (4) presents the marginal effects of estimates in column (3).⁴

TABLE 3a

Turning to the firm-specific control variables, our results also indicate that innovation activities have been discouraged mainly in smaller companies (*Size*) with lower productivity (*Prod*) and in non exporters (*Export*). At the same time, more innovative firms (firms with more patent applications - *Patnum*) show a lower probability of having abandoned their R&D efforts since the onset of the economic crisis. Export status has been a stimulus for Spanish firms maintaining their innovation activities during the crisis. In our sample, new firms (*New*) and firms belong to multinationals (*Multi*) were neither

⁴ Marginal effects (dy/dx) are computed at sample means. For dummy variables, the marginal effect corresponds to the discrete change from 0 to 1.

more nor less likely to abandon innovation. Foreign ownership does not seem to guarantee that a firm maintains its innovation effort during the crisis.

Given that the crisis has especially hit SMEs, in Table 3b we split our sample in order to analyse whether regional effects influence the innovation behaviour of small, medium sized and large firms in a similar manner. We find different regional effects by size stratum. The *Basque Country* variable displays negative, statistically significant coefficients in both the sub samples of small and medium sized firms, while it is not statistically significant in that of large firms. In none of the sub samples are the coefficients for the other two region dummies statistically significant, except for the *Madrid* variable, which is tangentially significant in the sub sample of large firms. Our key result shows that the influence of location on the probability of maintaining innovation activities during times of crisis is highest for SMEs located in the Basque Country .

TABLE 3b

Table 4a shows the results regarding firms' decision to increase their innovation expenditure. Again, column (1) only includes our three regional dummies. Column (2) includes industry fixed effects as controls and in column (3) we further add firm-specific characteristics. Column (4) again shows the marginal effects for the specification in column (3). The regional dummies in all three specifications (column 1-3) show a statistically significant difference only for firms located in the Basque Country. Location of R&D facilities in this region indicates that these companies have been better able not only to maintain but even to increase their innovative activities during the crisis.

TABLE 4a

As for our firm-specific characteristics, we now largely observe the opposite picture to Table 3a. The probability of having increased innovation expenses since the onset of the economic crisis is higher in larger firms. However, productivity and export market participation show no significant effect. Interestingly, a significant negative coefficient for technologically advanced firms is observed. This indicates that the most technologically intensive firms have not increased their innovation effort. Instead, it has been firms of lower technology intensity that were more likely to increase their innovation expenditure. The number of patents is now not significant. However, the results also indicate that relatively new firms (*New*) show a higher probability of having increased their innovation effort since the onset of the economic crisis. This suggests that during the crisis, a proportion of innovation activities has been rooted in a group of new companies

established in 2004-2008, who may be contesting the market of incumbent firms. Our results indicate that rather than established technology leaders, young firms seem to be a source of new innovation effort during times of crisis. These results provide support for the findings in Filipetti and Archibugi (2011) and Archibugi et al., (2013a, b). Similarly to our results, Filipetti and Archibugi (2011) found that the most innovation intensive firms - in terms of their turnover invested in innovation - have been less likely to have increased their innovation expenditure with the onset of the economic crisis, while Archibugi et al., (2013a, b) have stressed the role of new entrants, and fast growing new entrants in particular, in the dynamics of recovery. Again, in Table 4b we split our sample by size of the firm (small, medium sized and large firms). In the sub sample of small firms, the coefficient for the *Basque Country* variable is positive and statistically significant. In the sub samples of medium sized and large firms, in contrast, the coefficient for the *Basque Country* variable is not statistically significant. In none of the three sub samples (small, medium sized and large firms) are the coefficients for the other two location variables, *Madrid* and *Catalonia*, statistically significant. Location in the Basque Country in contrast is clearly associated with the probability that a small firm increases its innovation expenses during the crisis. Our results indicate a statistically significant role of the regional context. In contrast, most of the previous quantitative literature on business cycles has virtually ignored regional effects.

TABLE 4b

The reasons for the greater persistence of innovative activities in firms, and more specifically in SMEs, with R&D employment in the Basque Country clearly needs to be examined but are not the primary focus of our article. The discussion presented in Section 4 suggests that the Basque Country differs from otherwise comparable Spanish regions as concerning its historical experience of crises and its long-termed emphasis on innovation policies. The response to the crisis has also differed. As shown by Table 1, the Basque Country R&D expenditure in the regional government sector even increased during the current crisis. This seems to support previous findings that public spending may counteract the effects of cyclical trends at the company level (Eickelpasch, 2014; Paunov, 2012). Strong regional innovation systems seem to make a difference in firms' resistance to crises. Even in one of the European countries worst affected by the crisis, this question may have contributed to the probability of Basque firms maintaining and even expanding their innovative activities. Proactive regional policies may have been able to trigger dynamism even in the innovative behaviour of companies that are especially vulnerable to the crisis

and the credit crunch, i.e. SMEs. Local and regional finance for innovation received by Basque SMEs has been substantial, even during the crisis (Otero et al., 2014). Analysing data of the Spanish Statistical Office (INE) the abovementioned authors find that, in 2010, 83% of Basque SMEs received local and regional funding for their innovative activities, against 64 % of all Spanish SMEs and only 38% of Catalan SMEs. Regional finance may have been crucial to encourage the continuation and even the increase of Basque SMEs' R&D spending during the crisis.

Reasons behind regional public spending are clearly beyond the objectives of this article. They deserve, nevertheless, a brief analysis. Owing to redistributive territorial flows between richer and poorer regions, the most affluent Spanish regions display a fiscal deficit while poorer regions display a fiscal surplus (De la Fuente et al., 2014). An exception are Navarre and the Basque Country, rich regions which enjoy a special fiscal status, a remnant of medieval fiscal exemptions (*"fuero"*). In 2011, they had positive fiscal balances amounting, respectively to 5.2% and 7.0% of their GDP. In contrast, owing to their fiscal solidarity with poorer regions, Madrid and Catalonia, which are also rich regions, displayed deficits amounting to - 0.7% of their respective GDP. In other words, Navarre and the Basque Country had relatively more funding at their disposal, as compared with other regions. This circumstance may have helped firms located in the Basque Country to obtain resources, in comparison to those located in Catalonia and Madrid. In our view, however, this may be part of the explanation but it is not likely to be the whole story. In robustness checks we have added a dummy to our model for Navarre, which also enjoys fiscal exemptions and is, in many respects, a region oriented towards higher education and R&D. The dummy for Navarre turns out insignificant and our main findings are unchanged.⁵

While we do not deny the importance of the availability of financial resources at the regional level, our results suggest that proactive strategies and regional characteristics may play a crucial role in explaining the resilience of Basque firms during the crisis. Further research is clearly needed to assess the relevance of these explanations.

6. Conclusions

We argued that regional effects may have played a role regarding the innovative behaviour of firms during the crisis. We used the case of the Basque Country, Spain, to illustrate our point. We analysed characteristics of companies in the pre-crisis period, with

⁵ Results available upon request.

special attention given to their regional location, and their relation to changes in innovation behaviour since the onset of the 2008 crisis.

Our results show that the impact of the crisis on firms' innovation expenditure has not been the same in the Basque Country than in comparable Spanish regions. Companies located in the Basque Country reveal a greater probability of having maintained and even expanded their innovation expenditures during the crisis and this has been especially the case for SMEs. The counter cyclical policies adopted by the Basque Country may help manufacturing and service companies that perform R&D in the region to overcome the crisis more rapidly than those in the rest of Spain. This circumstance may put the local economy on a stronger path once the crisis is finished. In the aftermath of the crisis, the Spanish geography of corporate innovation and competitiveness may be quite different than in the pre crisis period. Our results suggest the need to take into account the regional dimension in analyses of business cycles.

While our results show a significant regional impact in the case of the Basque Country, even after controlling for sectoral and detailed firm-specific characteristics, we can only speculate about the factors that could account for the greater persistency of SME's innovation activities in the Basque Country. Further research should provide a detailed analysis of the regional factors that may have enabled firms to maintain or even increase their innovation expenditure since the onset of the economic crisis; for example, the role played by Basque fiscal status, regional institutions, human resources, cooperative arrangements and regional R&D subsidies. This would be an important avenue for future research.

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Table 1: Regional expenditures in R&D

	Madrid		Catalonia		Basque Country		Spain	
	2008	2012	2008	2012	2008	2012	2008	2012
GERD as a % of GDP	2.01	1.85	1.64	1.55	2.03	2.25	1.35	1.30
Total GERD (million euros)	3892.1	3433.7	3286.4	2991.0	1345.6	1431.1	14701.4	13391.6
GERD in the business enterprise sector (million euros)*	2245.5	1886.5	2007.3	1672.9	1088.8	1085.6	8096.7	7094.3
GERD in the government sector (million euros)	996.8	908.3	554.6	614.3	64.0	97.3	2672.3	2556.6
GERD in the higher education sector (million euros)	649.9	633.0	724.4	694.6	192.8	246.3	3932.4	3715.6

Source: INE (2014). * includes the private non-profit sector.

Table 2. Regional innovation indicators, 2012

	Basque Country	Madrid	Catalonia
R&D expenditure in the public sector ⁽¹⁾	0.313	0.500	0.410
R&D expenditure in the business sector ⁽¹⁾	0.525	0.445	0.405
SMEs innovating in house ⁽²⁾	0.404	0.278	0.349
Innovating SMEs collaborating with others ⁽²⁾	0.365	0.155	0.177
EPO patent applications ⁽³⁾	0.242	0.202	0.258
SMEs introducing product or process innovations ⁽²⁾	0.422	0.287	0.371
Employment in knowledge intensive activities ⁽⁴⁾	0.654	0.794	0.328
Sales of new to market and new to firm innovations ⁽⁵⁾	0.615	0.437	0.480

Source: Regional Innovation Scoreboard 2014

Notes: (1) As percentage of regional GDP. (2) As percentage of regional SMEs. (3) Per billion regional GDP.
(4) Employment in medium tech and high tech manufacturing and knowledge intensive services as percentage of total workforce. (5) As percentage of turnover (only for SMEs).

Table 3a: Firms decision to abandon R&D

	(1)	(2)	(3)	(4) (dy/dx)
<i>Regions</i>				
Madrid	-0.190*** (0.064)	-0.182*** (0.070)	-0.015 (0.074)	-0.003
Catalonia	-0.073 (0.052)	-0.024 (0.053)	0.061 (0.056)	0.012
Basque Country	-0.276*** (0.070)	-0.275*** (0.074)	-0.265*** (0.078)	-0.045***
<i>Firm-specific characteristics</i>				
SIZE (log)			-0.181*** (0.020)	-0.034***
PROD(log)			-0.598* (0.371)	-0.114*
EXPORT			-0.217*** (0.060)	-0.044***
TEC. ADVANCED			0.023 (0.061)	-0.004
PATNUM			-0.082*** (0.027)	-0.016***
NEW			-0.087 (0.105)	0.016
MULTI			-0.035 (0.088)	0.007
<i>Industry fixed effects</i>				
	N	Y	Y	
Number of observations	4697	4691	4690	
Log likelihood	-1944.0	-1874.5	-1785.5	

Notes: (1) Robust standard errors are presented in parentheses; ***, **, * = statistically significant at the 99, 95 and 90% levels. (2) Industry fixed effects are based on 43 unreported sector dummies (3) all estimations include a constant.

Table 3b: Firms decision to abandon R&D in small, medium, and large-sized firms

	Small firms	Medium sized firms	Large firms
<i>Regions</i>			
Madrid	0.032 (0.098)	0.060 (0.156)	-0.318* (0.185)
Catalonia	0.053 (0.077)	0.095 (0.105)	-0.076 (0.148)
Basque Country	-0.286*** (0.099)	-0.372** (0.169)	0.270 (0.198)
<i>Firm-specific characteristics</i>			
SIZE (log)	-0.196*** (0.045)	-0.209* (0.122)	-0.186*** (0.070)
PROD(log)	-0.670 (0.465)	-0.992 (0.843)	1.061 (1.018)
EXPORT	-0.134* (0.076)	-0.489*** (0.130)	-0.058 (0.168)
TEC. ADVANCED	0.009 (0.084)	-0.159 (0.119)	0.215 (0.218)
PATNUM	-0.090** (0.043)	-0.020 (0.026)	-0.483*** (0.180)
NEW	-0.107 (0.115)	0.190 (0.318)	
MULTI	0.141 (0.170)	0.007 (0.151)	-0.038 (0.161)
<i>Industry fixed effects</i>			
	Y	Y	Y
Number of observations	2247	1283	904
Log likelihood	-1041.2	-434.2	-245.4

Notes: (1) Robust standard errors are presented in parentheses; ***, **, * = statistically significant at the 99, 95 and 90% levels. (2) Industry fixed effects are based on 43 unreported sector dummies (3) all estimations include a constant. (3) Note, that for the large firm sample there are very few newly created firms and the variable is dropped from the model because it predicts failure perfectly.

Table 4a: Firms decision to increase R&D spending

	(1)	(2)	(3)	(4) (dy/dx)
<i>Regions</i>				
Madrid	0.060 (0.053)	0.066 (0.057)	-0.022 (0.059)	-0.007
Catalonia	0.101** (0.045)	0.055 (0.046)	0.019 (0.047)	0.006
Basque Country	0.154*** (0.055)	0.143*** (0.058)	0.120** (0.058)	0.042**
<i>Firm-specific characteristics</i>				
SIZE (log)			0.085*** (0.016)	0.029***
PROD(log)			0.079 (0.315)	0.027
EXPORT			0.067 (0.052)	0.023
TEC. ADVANCED			-0.156*** (0.051)	-0.053***
PATNUM			-0.001 (0.001)	-0.001
NEW			0.203** (0.087)	0.073**
MULTI			-0.010 (0.065)	-0.003
<i>Industry fixed effects</i>				
	N	Y	Y	
Number of observations	4697	4697	4696	
Log likelihood	-2858.1	-2825.9	-2790.5	
Notes: (1) Robust standard errors are presented in parentheses; ***, **, * = statistically significant at the 99, 95 and 90% levels. (2) Industry fixed effects are based on 43 unreported sector dummies (3) all estimations include a constant.				

Table 4b: Firms decision to increase R&D spending: small, medium, and large-sized firms

	Small firms	Medium sized firms	Large firms
<i>Regions</i>			
Madrid	0.059 (0.091)	-0.100 (0.127)	-0.030 (0.110)
Catalonia	0.084 (0.072)	-0.075 (0.087)	0.022 (0.095)
Basque Country	0.218*** (0.086)	0.127 (0.111)	0.047 (0.124)
<i>Firm-specific characteristics</i>			
SIZE (log)	0.057 (0.044)	0.052 (0.095)	-0.114** (0.049)
PROD(log)	-0.158 (0.443)	-0.084 (0.619)	0.551 (0.677)
EXPORT	0.171** (0.072)	0.070 (0.112)	-0.111 (0.122)
TEC. ADVANCED	-0.246*** (0.074)	0.077 (0.090)	-0.018 (0.139)
PATNUM	-0.014 (0.021)	-0.012 (0.010)	0.004* (0.002)
NEW	0.196** (0.101)	0.221 (0.232)	0.613 (0.439)
MULTI	-0.106 (0.162)	0.020 (0.112)	0.033 (0.100)
<i>Industry fixed effects</i>			
	Y	Y	Y
Number of observations	2257	1343	1069
Log likelihood	-1040.6	-825.1	-670.8

Notes: (1) Robust standard errors are presented in parentheses; ***, **, * = statistically significant at the 99, 95 and 90% levels. (2) Industry fixed effects are based on 43 unreported sector dummies (3) all estimations include a constant.

Appendix Table A1. Explanatory variable description and summary statistics

Variable	Definition	Mean	Std. dev.
SIZE	Log (total number of employees) in 2008	4.16	1.56
PROD	Log (turnover/total number of employees) in 2008	2.47	0.08
EXPORT	Dummy variable taking on 1 if the company reports sales in international markets between 2006-2008 and 0 otherwise.	0.73	0.44
TEC. ADVANCED	Dummy variable taking on 1 if the company is in the top quartile in terms of the number of R&D employees per total sales in its respective technology sector in 2008.	0.50	0.50
PATNUM	Number of patents applied for between 2006-2008	1.21	15.1
NEW	Dummy variable taking on 1 if the company was newly created between 2004-2008	0.06	0.24
MULTI	Firms belonging to a multinational company (at least 50% of foreign capital participation) in 2008	0.11	0.31
Madrid	Dummy variable taking on 1 if the company reports R&D employees in the Madrid region in 2008.	0.17	0.37
Catalonia	Dummy variable taking on 1 if the company reports R&D employees in the Catalonia region in 2008.	0.29	0.45
Basque Country	Dummy variable taking on 1 if the company reports R&D employees in the Basque Country in 2008.	0.15	0.36

Appendix Table A2. Correlation matrix

	Stopper	Size	Prod	Export	Tec. Advanced	Patnum	New	Multi	Madrid	Catalonia	Basque Country
Stopper	1										
Size	-0,138	1									
Prod	-0,041	0,279	1								
Export	-0,099	0,182	0,277	1							
Tec. Advanced	0,091	-0,350	-0,350	-0,132	1						
Patnum	-0,028	0,070	0,016	0,037	-0,006	1					
New	0,000	-0,221	-0,182	-0,118	0,128	-0,006	1				
Multi	-0,054	0,254	0,188	0,128	-0,166	0,060	-0,049	1			
Madrid	-0,033	0,145	-0,005	-0,052	-0,048	0,019	0,000	0,054	1		
Catalonia	0,001	0,051	0,117	0,165	-0,058	0,005	-0,065	0,091	-0,173	1	
Basque Country	-0,049	-0,026	0,003	-0,047	-0,002	0,030	0,059	-0,032	-0,125	-0,240	1