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Sección ARTÍCULOS

The Relocation of R&D Establishments in France: An Empirical Analysis

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ABSTRACT: This paper analyses the relocation of R&D establishments between French's Zones d'Emploi in the 2008 to 2010 period. We find that small size establishments predominate in these relocations, which occur mostly around major urban areas and in a short distance from the original location (although a negative relation between distance and size seems to exist). Lastly, estimates from a gravity model for origin-destination flows show that the main determinants of the relocation of R&D establishments include agglomeration economies, labour market characteristics, institutional features, transport infrastructures and educational levels. However, there are substantial differences in the way these variables affect intra- and inter-ZdE flows.

JEL Classification: O3; R3; R12.

Keywords: firm relocation; R&D; France.

La relocalización de los establecimientos de R+D en Francia: Un análisis empírico

RESUMEN: Este trabajo analiza la relocalización de los establecimientos de I+D entre Zones d'Emploi francesas en el periodo 2008-2010. Encontramos que los establecimientos de pequeño tamaño predominan en estas relocalizaciones, las cuales se producen principalmente en torno a las principales zonas urbanas y en

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una corta distancia de la ubicación original (aunque una relación negativa entre la distancia y el tamaño parece existir). Por último, las estimaciones de un modelo gravitatorio para los flujos de origen-destino muestran que los principales determinantes de la relocalización de los establecimientos de I+D incluyen las economías de aglomeración, las características del mercado de trabajo, aspectos institucionales, las infraestructuras de transporte y los niveles educativos. Sin embargo, hay diferencias sustanciales en la forma en que estas variables afectan los flujos intra e inter entre ZdE.

Clasificación JEL: O3; R3; R12.

Palabras clave: relocalización de empresas; I+D; Francia.

1. Motivation

The fact that a multinational relocates facilities (headquarters, plants, labs, etc.) to another country often hits the headlines[1]. Job losses are usually the main concern, for the closing down of activities typically implies the termination of a number of employees. However, it is not uncommon to also hear concerns about the transfer of strategic resources and/or the lack of competitiveness of the host country (most commonly when the relocating firm is «national»). In some extreme cases, even accusations of undercutting labour standards or «social dumping» are raised (most commonly when the relocating firm is foreign).

In contrast, the fact that a number of firms relocate their premises to a nearby location within the same country or region goes largely unnoticed by the media. Yet the volume of «internal» or «national» relocations is substantial. According to Lee (2008), for example, in the U.S. manufacturing industry and over the period 1972-1992, «[f]or every 100 new entrants starting operation over a five-year period, more than 10 plants turn out to be relocated from other counties». Also, van Dijk and Pellenbarg (2000) report that the number of Dutch migrant firms has raised from 36,000 to 68,000 between 1987 and 1995. Similarly, the relocation of establishments in France has practically doubled between 2004 and 2010 (from 72,770 to 137,859 according to the *Institut national de la statistique et des* études économiques, INSEE). In particular, out of the approximately 400,000 relocations accounted by the SIRENE database of the INSEE over the period 2008-2010, around one fourth were migrations to another travel-to-work area (*Zones d'Emploi*).

What are the drivers of these «national» or «internal» relocations is still an open question, for the number of empirical studies on the topic is relatively scarce —par-

[1] The examples are countless. See *e. g.* «America's biggest companies continue to move factories offshore and eliminate thousands of American jobs» by R. A. McCormack, *Manufacturing & Technology News*, July 31, 2013; «Alpine firm fearing end to cheap French power eyes Quebec move», by T. Patel, *Bloomberg Business*, January 27, 2015; and «Social dumping - hardly an open and shut case: The arguments about switching jobs between countries are not so simple» by D. Goodhart, *Financial Times*, February 4, 1993.

ticularly when compared to those analysing the location of new firms and establishments—[2]. In this paper we aim to contribute to this literature by focusing on the relocation of R&D facilities. Our focus is motivated by the severe contrast between the importance of this industry and the lack of evidence on (the determinants of) these relocations when they occur within a country or region. On the one hand, this is a key industry for any developed economy, both because of the direct impact that knowledge creation may have on innovation, productivity and/or growth (Cameron, 1996; Mohnen and Hall, 2013) and the positive externalities that may generate (Griliches, 1979). Furthermore, this is an industry that has strong linkages with manufacturing activities (Nadiri and Wolff, 1993), and this interdependence may act as a «vaccine against offshoring»[3]. On the other hand, while there is an extensive (managerial) literature on international R&D relocations (see *e. g.* Rilla and Squicciarini 2011 for an overview), little is known about the internal or national relocation of R&D facilities. In this paper we aim to fill this gap in the literature by analysing the relocation of R&D establishments between French's *Zones d'Emploi* (ZdEs hereafter) in the 2008 to 2010 period.

The French case is particularly interesting because of the relevance of relocations from both empirical and economic policy viewpoints[4]. Nearly one third of French Chief Executive Officers find a relocation likely within the next five years according to a recent survey made by the *Observatoire social de l'entreprise Ipso*[5]. Not surprisingly, then, relocation issues are top-ranked in French policy makers' agendas. In fact, concerns about the spatial mismatch of economic activities have triggered a number of initiatives aiming to provide technical support for firms considering the relocation of their facilities[6]. In particular, the attractiveness of France for international R&D activities is a major issue (Harfi *et al.,* 2007). By providing evidence on (what drives) internal R&D migrations, results provided in this paper may help to address these policy concerns.

The rest of the paper is organised as follows. Next section reviews the relocation literature to show the absence of studies on the R&D industry. In the third section we discuss results from descriptive and spatial analyses. In the fourth section we present the model and discuss the coefficients' estimates. The fifth section concludes.

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[2] See *e. g.* Arauzo-Carod *et al.* (2010) and Manjón-Antolín and Arauzo-Carod (2011) for an overview of recent location and relocation studies, respectively.

[3] These international relocations typically involve the offshoring of plants from developed countries to low-cost countries to benefit from the cheaper production costs at the destination sites (Lampón *et al.* 2014). This may have a positive effect on the competitiveness of the offshoring companies, but it typically also implies substantial job losses in the country of origin.

[4] See *e. g.* Fontagné and Lorenzi (2005) for an analysis of the determinants of firms' relocation in France.

[5] «29% des patrons prêts à délocaliser» by Y. Le Galès, *Le Figaro*, November 12, 2013.

[6] An illustrative example of these initiatives is «Colbert 2.0», a software designed by the *Direction générale de la compétitivité, de l'industrie et des services* to facilitate national relocation decisions (and prevent that firms relocate abroad). In essence, this tool helps firms to address the stay-or-leave decision and, in the case of going for the relocation, suggests the most appropriate locations in France.

2. Related literature

To our knowledge, there is no previous paper investigating the relocation of R&D establishments within a country. The topic, however, is clearly related to three strands of investigations: *i)* on the international relocation of R&D facilities (offshoring and/or internationalisation of R&D activities being alternative denominations); *ii)* on national or internal relocations (*i. e.*, considering a wide range of economic activities); and *iii)* on national or internal location of R&D activities (*i. e.*, focusing on the R&D industry).

Firstly, the international relocation of R&D facilities has been analysed mainly from a managerial point of view (Rilla and Squicciarini, 2011). In particular, these studies have mostly concentrated on investigating two major issues: i) the decision to allocate R&D activities abroad, either theoretically (*e. g.*, Belderbos *et al.,* 2008 and Gersbach and Schmutzler, 2010) or empirically (*e. g.*, Siedschlag *et al.,* 2013); and ii) whether multinational firms enhance their competitive advantage by offshoring their R&D labs (Cantwell, 1995; Le Bas and Sierra, 2002; Filippaios *et al.,* 2009; Castellani and Pieri, 2013). Recent work by Castellani *et al.* (2013), however, analyses the flows of relocations by estimating a gravity model using data on the number of bilateral investments projects in R&D, manufacturing and other business activities.

Secondly, early studies on the relocation behaviour of firms and establishments followed a descriptive approach (Mariotti, 2005). The more recent research, however, seeks to disentangle the factors behind the relocation phenomenon using different econometric methods and data structures (see *e. g.* van Dijk and Pellenbarg, 2000; Pellenbarg *et al.,* 2002a; Pellenbarg *et al.,* 2002b; Brouwer *et al.,* 2004; Holl, 2004 and Manjón-Antolín and Arauzo-Carod, 2011). What is interesting to note here is that most previous studies on the determinants of the relocation flows do not account for both origin and destination features (an important exception being Martínez *et al.,* 2014). Rather, they analyse the determinants of the number of relocations to a set of destinations using the destinations' features as the main explanatory variables. Also, to our knowledge there are no previous relocation studies on specific industries, particularly on the R&D industry.

Thirdly, the main issue in the analysis of the national location of R&D activities is the tendency to be geographically concentrated (Feldman, 1999): R&D activities need and benefit from the proximity to other sources of knowledge generation such as innovative businesses, R&D labs and public and private research centres (Feldman and Florida, 1994). In particular, since knowledge spillovers have a local nature, they tend to arise mainly in major metropolitan areas, as reported by *e. g.* Egeln *et al.* (2004) and Bade and Nerlinger (2000) in Germany, Autant-Bernard (2006) and Autant-Bernard *et al.* (2006) in France and Arauzo-Carod and Viladecans (2009) in Spain. Notice, however, that these analyses focus on the location of new innovative firms or establishments and do not pay attention to the innovative relocations that may occur. Thus, questions such as where these innovative concerns come from and/or what pushes them out of their sites of origin remain unanswered.

3. R&D Relocations in Continental France: An Exploratory Analysis

3.1. The data

We analyse R&D relocations in continental France using data from SIRENE, a data set of the INSEE. In particular, data refers to R&D establishments that relocated their premises between two French ZdEs in continental France between 2008 and 2010[7]. We use ZdEs as the unit of analysis (rather than communes or municipalities, as *e. g.* Houdebine and Schneider 1997 and Rathelot and Sillard, 2008 do) because, as they are defined by economic (rather than administrative) criteria, they help to (partially) control potential MAUP problems (Arbia, 2001). Namely, ZdEs are constructed using commuting data on the geographic area where most of the active population lives and works. Thus, they roughly correspond to French local labour markets, which make them close to the relocating areas that firms or establishments may actually consider.

More specifically, we consider as R&D relocations those involving establishments operating in «Research and experimental development on natural sciences and engineering» and «Research and experimental development on social sciences and humanities» activities (codes 72.1 and 72.2 of the French two-digit SIC classification). In particular, since some establishments changed the industry code after relocating, we have decided to consider only those establishments in the R&D industry at the destination site. This resulted in 514 relocations[8].

3.2. Descriptive statistics: size and distance

Out of the stock of French establishments in 2008, 3.14% were relocations from another ZdE (INSEE). Out of the stock of French R&D establishments in 2008, 15.3% were relocations from another ZdE (Table 1). This difference suggests that R&D establishments faced a larger mismatch between what the sites in which they were located provided and what these establishments required from those sites (and/or more flexibility to relocate when facing such mismatch). Table 1 also shows that most of the relocated establishments in the R&D industry were Self-employed (though this essentially follows from the overall firm size distribution in France). Lastly, relative to the stock of R&D establishments of the same size, Micro-establishments and, to a less extent, Small and Self-Employed establishments, show the largest percentage of relocations.

[7] There were 348 ZdEs in continental France when we constructed the dataset. In June 2012 the INSEE changed the list and composition of the ZdEs, so that they became 322. We use the previous version, the so-called «ZdE 1990».

[8] Only 25 of the 514 establishments were not originally assigned to the R&D industry at the departing site.

Table 1. Establishments' relocation by size (2008-2010)

Size category	*Destination*			*Origin*		
	#	*%*	*% stock*	*#*	*%*	*% stock*
Self-Employed	321	62.45	0.15	369	71.79	0.17
Micro	72	14.01	0.19	79	15.37	0.21
Small	79	15.37	0.19	46	8.95	0.11
Medium	35	6.81	0.11	17	3.31	0.05
Large	7	1.36	0.05	3	0.58	0.02
Total	514	100	0.15	514	100	0.15

Self-Employed include establishments without employees, Micro include establishments with 1-2 employees, Small with 3-9 employees, Medium with 10-49 employees and Large from 50 employees.
Source: own elaboration with data from SIRENE (INSEE).

Table 2 shows that about one third of the relocating R&D establishments slightly changed their size between sites[9]. Of these, most establishments increased their size when moving (24.7% of the relocating establishments), particularly the smaller ones. As a result the size distribution became slightly more skewed to the right: while Self-employed and Micro establishments represented 87.2% of the relocating R&D establishments at origin, they were only 76.5% at destination. Size reductions in the relocation process, on the other hand, were common in all categories but self-employed, and larger the bigger the establishment. Thus, an inverse relationship between size and growth seems to emerge in the data.

Table 2. Number of establishments and size changes during relocation (2008-2010)

Destination	*Origin*					
	Self-Employed	*Micro*	*Small*	*Medium*	*Large*	*Total*
Self-Employed	275	29	8	7	2	321
Micro	38	26	8	0	0	72
Small	40	17	21	1	0	79
Medium	10	7	9	9	0	35
Large	6	0	0	0	1	7
Total	369	79	46	17	3	514

Source: own elaboration with data from SIRENE (INSEE).

Table 3 reports the distance in kilometres between the origin and the destination sites. These distances were computed *i)* assigning a zero value to those relocations

[9] Notice that we only have information about the size categories in origin and destination, *i. e.*, establishments changing size but staying within the same category would remain unnoticed.

that occurred within the same ZdE and *ii)* else using centroid distances between ZdEs. The resulting average distance is 53.3 kilometres. However, in four out of five of the establishments the travelling distance was below the mean. This is because about two thirds of the relocations occurred within the same ZdE and about one out of five in the Île-de-France region (Paris and downtowns, where the mean size of the ZdEs is way below the country mean)[10]. In contrast, 13.2% of the French R&D establishments relocated to a ZdE more than a hundred kilometres away from the original one (*i. e.*, a distance twice the average).

Table 3. Number of establishments and distance travelled during relocation (2008-2010)

Size category	*Distance*					
	0 km (same ZdE)	*Up to 50 km*	*50-100 km*	*100-500 km*	*500-1000 km*	*Mean (km)*
Self-Employed	202	49	17	39	14	67,4
Micro	55	8	1	8	0	37,9
Small	61	9	4	5	0	25,4
Medium	26	7	0	1	1	27,7
Large	4	3	0	0	0	5,1
Total	348	76	22	53	15	53,3

Source: own elaboration with data from SIRENE (INSEE).

It seems thus clear that most R&D relocations involved rather short distances. However, there are important differences between establishments of different size. While smaller establishments tend to relocate far away from the origin (*e. g.*, the mean distance of the self-employed establishments is 67.4 kilometres), larger establishments tend to relocate close by (*e. g.*, the mean distance of the large establishments is 5.1 kilometres)[11].

This pattern of behaviour, however, is at odds with the arguments usually put forward to explain the relocation process (see *e. g.* Hayter, 1997)[12]. Namely, since gathering information about the sites is costly, small concerns will tend to look for potential relocation sites not far away from the original site (which typically would

[10] Empirical evidence from the Île-de-France region reported by Guillain and Le Gallo (2010) shows that R&D activities tend to cluster around Paris and its western suburbs. This is also where an important number of R&D relocations in the Île-de-France region occur.

[11] These differences are more pronounced if distances were computed without considering the relocations that occur within the same ZdE. The resulting mean values (in kilometres) by categories would be: 181.9 (Self-employed), 160.4 (Micro), 111.4 (Small), 107.8 (Medium) and 6.6 (Large).

[12] It is important to stress, however, that previous empirical evidence from France tends to concur with our findings. Benard and Jayet (1996) and Delisle and Lainé (1996), for example, show that *i)* most relocations occur within the same municipality (*i. e.*, they are short-distance relocations) and *ii)* small concerns relocate more far away from the original site than the large ones.

not require large investments in information), while large concerns will consider a wide range of alternatives (including other countries) because they can devote substantial resources to this search. Also, since personal factors play a major role in small concerns' decisions (family, social relationships, etc.), it is more likely that they opt for close by sites when relocating their premises (Stam, 2007).

It has also been argued that while short-distance relocations are mainly triggered by the internal characteristics of the firms (*e. g.*, lack of space due to firm's growth), long-distance relocations are more related to differences in market characteristics and opportunities (sectorial specialisation, agglomeration economies, etc.). Thus, one may expect that those establishments that change size in the relocation process will choose sites that are less distant than those that do not change size (Weterings and Knoben, 2013). Yet we only find supportive evidence of this tenet among Self-employed establishments (and partially in Micro establishments). The breakdown reported in Table 4 suggest that, at least for Small, Medium and Large sized R&D establishments, a change in a critical internal characteristic such as size actually leads to a geographical expansion of the choice set.

Table 4. Mean distance travelled during relocation (2008-2010) considering size changes

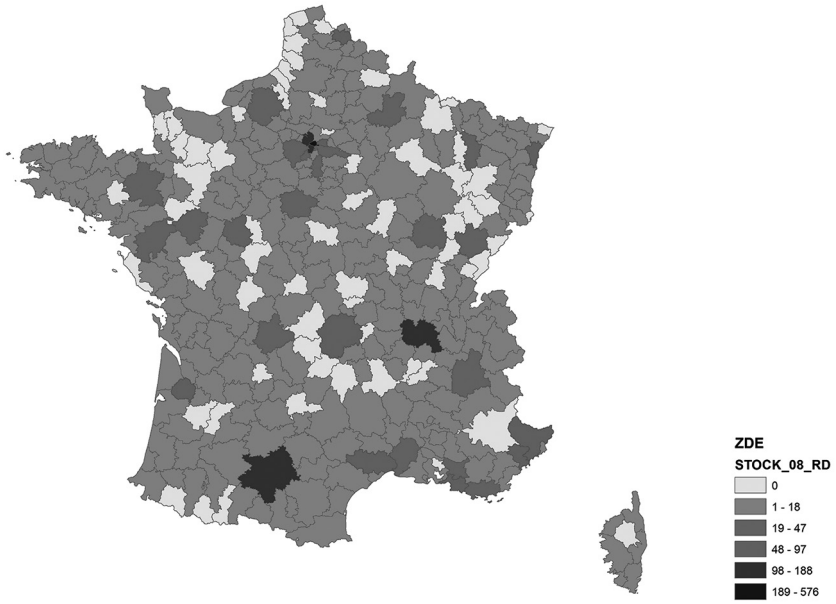
Destination	*Origin*				
	Self-Employed	*Micro*	*Small*	*Medium*	*Large*
Self-Employed	66.9	75.4	26.5	221.7	207.0
Micro	23.8	50.0	97.7	—	—
Small	49.0	11.1	25.3	400.7	—
Medium	15.7	142.3	43.4	46.9	—
Large	12.8	—	—	—	0.0

Source: own elaboration with data from SIRENE (INSEE).

3.3. Spatial Descriptive Analysis

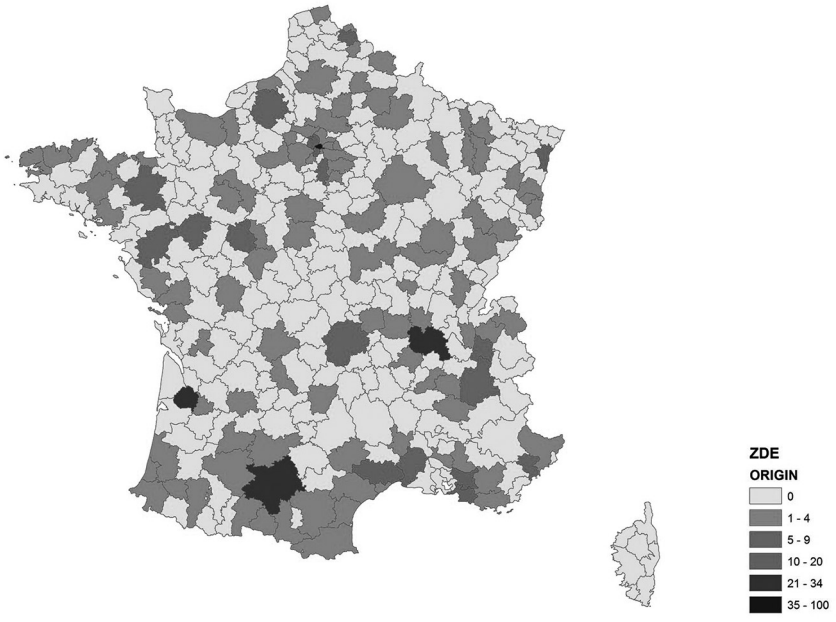
Figure 1 shows that the spatial distribution of the R&D establishments in France is largely concentrated in a few sites. Also, Figures 2 and 3 show that the spatial distribution of the origin and destination, respectively, of the R&D establishments that relocate is similarly concentrated and roughly around the same sites. This means that the spatial pattern of the R&D establishments is quite stable and has barely changed during the 2008 to 2010 period.

Figure 1. Stock R&D establishments (2008)



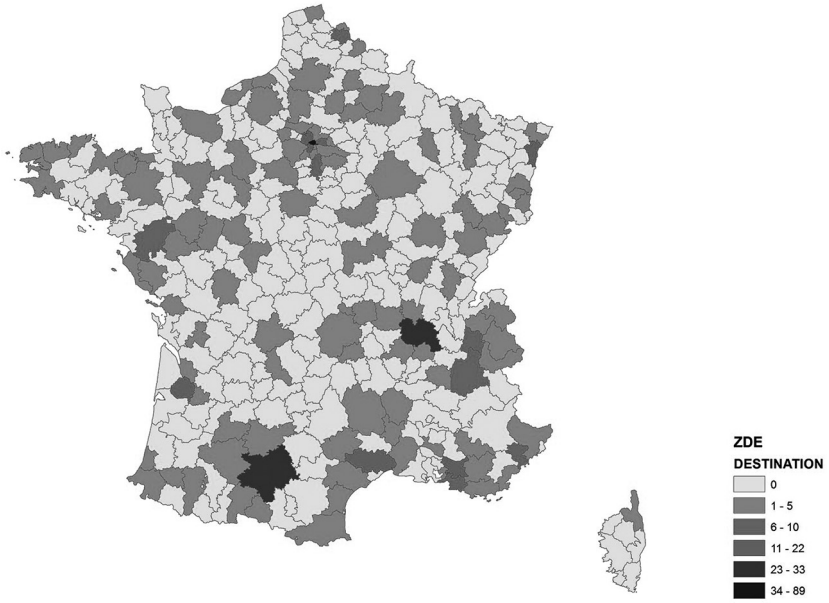
Source: own elaboration with data from SIRENE (INSEE).

Figure 2. R&D relocation by origin (2008-2010)



Source: own elaboration with data from SIRENE (INSEE).

Figure 3. R&D relocation by destination (2008-2010)



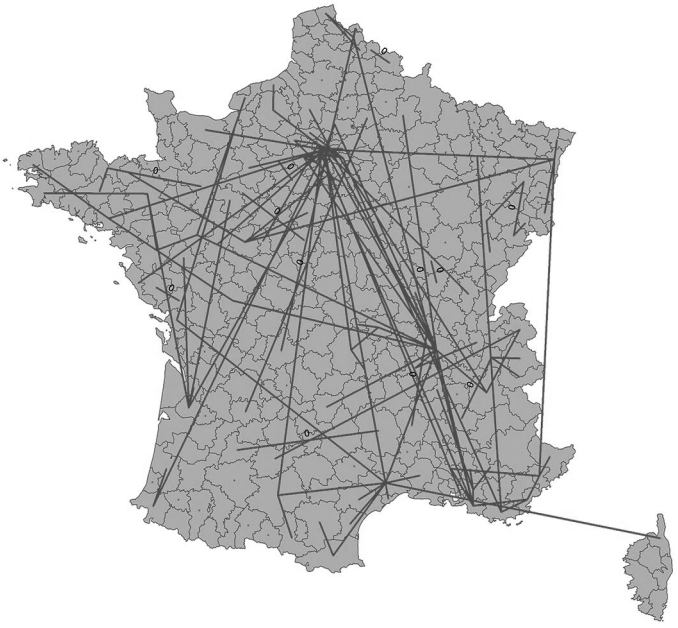
Source: own elaboration with data from SIRENE (INSEE).

The origin - destination flows plotted in Figure 4 suggest that most relocations occur within the same ZdE (particularly around the Île-de-France region). At the same time, however, some relocations involve large distances, and these mostly following the North-South axis (*e. g.*, Paris-Marseille). The other side of the coin of the origin - destination «routes» that emerge in Figure 4 are the large areas that remain neglected. However, it is difficult to find a clear pattern in the regions untouched by the R&D relocations. If any, they seem to mainly correspond to rural areas (*e. g.*, Limousin, Auvergne, south of Centre region, and North and North-Est of Midi-Pyrénées and Aquitaine regions, respectively).

Table 5 provides details on ZdEs in the top tail of the (cumulative) distribution of the R&D relocations. Roughly speaking, the 22-23 ZdEs considered accumulate two-thirds of the relocations of R&D establishments. This means that the spatial distribution of the relocation of R&D establishments is more concentrated that of the whole manufacturing, which spreads all over the whole set of ZdEs. Notice also that these top relocating areas coincide to a large extent with the areas in which most of the R&D activities locate (column % total R&D). On the other hand, we find no clear pattern in the R&D relocations with respect to the R&D specialisation of the ZdEs (column % R&D at ZdE).

In particular, the top origins and destinations include not only the main French urban areas (*e. g.*, Paris and downtowns, Lyon, Toulouse, Bordeaux and Strasbourg), but also some smaller albeit dynamic and research-oriented urban areas (such as *e. g.* Aix-en-Provence, Nanterre, Boulogne-Billancourt and Grenoble). Interestingly, these top origins and destinations are geographically clustered, for we can distinguish between: *i)* urban areas in and around Paris; *ii)* urban areas at Rhône-Alpes and

Figure 4. R&D relocation flows by origin - destination (2008-2010)



Source: own elaboration with data from SIRENE (INSEE).

Provence-Alpes-Côte d'Azur: and *iii)* big urban areas in dispersed parts of the country (*e. g.*, Toulouse and Bordeaux, among others). Also, these three clusters roughly match the *Pôles de Competitivité* created in 2005 by the *Comité interministériel d'aménagement et de développement du territoire* (CIADT) to prevent French manufacturing from being relocated abroad and promote new innovative projects located in these areas (Duranton *et al.,* 2008).

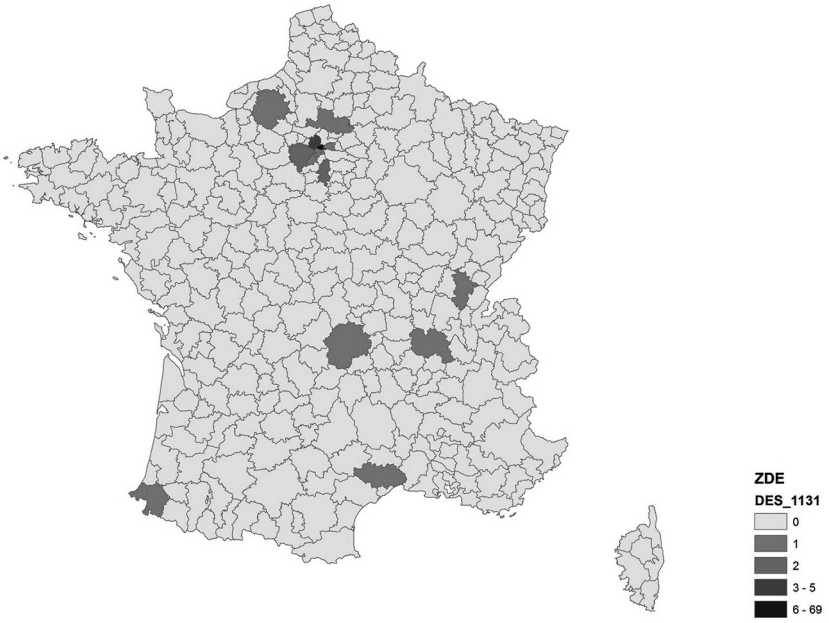
To conclude, in Figures 5 and 6 we zoom down to a particular ZdE: Paris. The first thing to notice is that, as previously shown at the country level, most relocations occur within the same ZdE and close-by ZdEs. Out of the 100 R&D establishments that relocated from Paris in the 2008-2010 period, 69 stayed in the same ZdE. Similarly, out of the 89 R&D establishments that relocated from Paris in the 2008-2010 period, 69 came also from Paris. It is also interesting to note that, although some ZdEs act both as origins and destinations (in the case of Paris, those at the at Île-de-France region and Nimes-Montpelier), in general origins and destinations differ. In the case of Paris, for example, whereas origins include Rouen and Sud-Oise, both in the metropolitan area, some of the R&D establishments relocating in Paris come from Lons-le-Saunier, Clermont-Ferrand, Lyon, Montpellier and Bayonne-Pyrénée. As for the destinations, these include Mortagne-au-Perche-l'Aigle, Caen-Bayeux, Saumur-Bauge, Vendée Ouest, Vannes, Strasbourg, Lyon and Montpellier. Lastly, it is worth noting that these spatial patterns seem to not only arise in the R&D industry but in the whole set of relocations (Omont and Burfin, 2010).

Table 5. Main origin and destination ZdE (2008-2010)

Origin					*Destination*				
ZdE	*%*	*cum. %*	*% R&D at ZdE*	*% total R&D*	*ZdE*	*%*	*cum. %*	*% R&D at ZdE*	*% total R&D*
Paris	19.46	19.46	0.10	17.14	Paris	17.32	17.32	0.10	17.14
Lyon	6.61	26.07	0.18	5.59	Lyon	6.42	23.74	0.18	5.59
Toulouse	5.06	31.13	0.18	3.81	Toulouse	5.45	29.18	0.18	3.81
Bordeaux-Zone-Centrale	4.47	35.6	0.16	2.44	Nanterre	4.28	33.46	0.13	3.93
Nanterre	3.89	39.49	0.13	3.93	Bordeaux-Zone-Centrale	4.28	37.74	0.16	2.44
Montpellier	3.5	43	0.24	2.89	Boulogne-Billancourt	3.31	41.05	0.23	3.24
Strasbourg	2.72	45.72	0.22	1.96	Montpellier	3.11	44.16	0.24	2.89
Boulogne-Billancourt	2.53	48.25	0.23	3.24	Strasbourg	2.92	47.08	0.22	1.96
Aix-en-Provence	2.53	50.78	0.16	1.04	Aix-en-Provence	2.72	49.81	0.16	1.04
Marseille-Aubagne	2.33	53.11	0.12	2.59	Lille	1.95	51.75	0.16	1.76
Lille	1.75	54.86	0.16	1.76	Grenoble	1.95	53.7	0.14	1.40
Grenoble	1.75	56.61	0.14	1.40	Marseille-Aubagne	1.95	55.64	0.12	2.59
Cannes-Antibes	1.75	58.37	0.16	1.87	Nantes	1.56	57.2	0.10	1.28
Angers	1.56	59.92	0.16	0.83	Cannes-Antibes	1.56	58.75	0.16	1.87
Rennes	1.56	61.48	0.12	1.07	Évry	1.36	60.12	0.23	0.92
Chambéry	1.36	62.84	0.05	0.21	Montreuil	1.17	61.28	0.10	1.52
Clermont-Ferrand	1.36	64.2	0.23	1.67	Chambéry	1.17	62.45	0.05	0.21
Nantes	1.17	65.37	0.10	1.28	Rouen	0.97	63.42	0.07	0.62
Évry	0.97	66.34	0.23	0.92	Mulhouse	0.97	64.4	0.07	0.27
Rouen	0.97	67.32	0.07	0.62	Angers	0.97	65.37	0.16	0.83
Tours	0.97	68.29	0.12	0.68	Rennes	0.97	66.34	0.12	1.07
Nîmes	0.97	69.26	0.11	0.77	Saint-Étienne	0.97	67.32	0.07	0.51
Rest of ZdE	30.74	100			Nîmes	0.97	68.29	0.11	0.77
					Rest of ZdE	31.71	100		

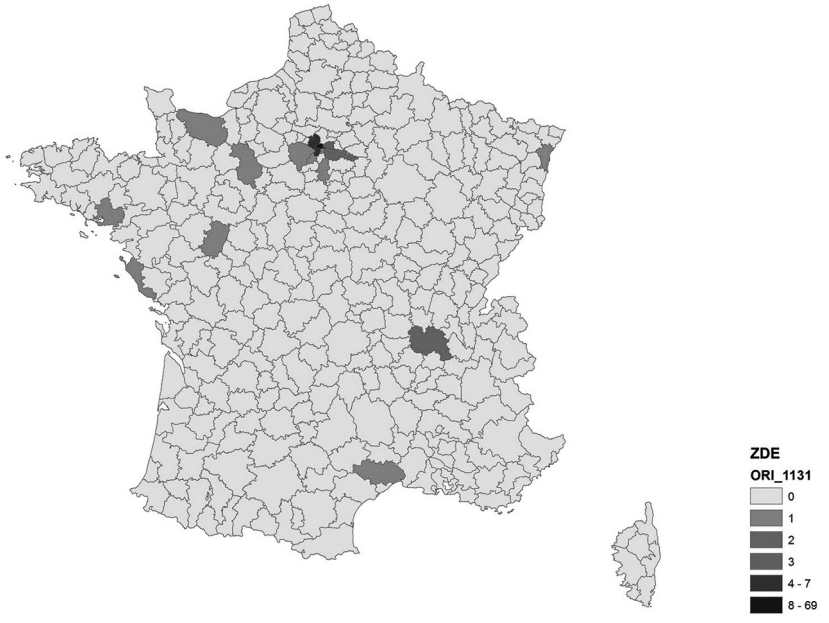
Note: stock data refers to 2008.
Source: own elaboration with data from SIRENE (INSEE).

Figure 5. R&D relocation to Paris ZdE (2008-2010)



Source: own elaboration with data from SIRENE (INSEE).

Figure 6. R&D relocation from Paris ZdE (2008-2010)



Source: own elaboration with data from SIRENE (INSEE).

4. The Econometric model

4.1. A gravity model for origin-destination flows

We seek to analyse the determinants of the number of R&D establishments that move from location $i = 1, 2, ..., n$ to location $j = 1, 2, ..., n$, which we denote by y_{ij}. Thus, the number of observations in our model is n x $n = N$ and the variable of interest, y_{ij}, contains information not only about the flows occurring between different geographical units ($i \neq j$) but also about the flows occurring within the same geographical unit ($i = j$)[13]. As for the vector of explanatory variables, it includes characteristics of the geographical units from which the flows originate (x_i), characteristics of the geographical units to which the flows are destined (x_j), and the (centroid) distances between origins and destinations (d_{ij}). This means that we are following LeSage and Pace (2008) in modelling the relocation process using a gravity model. We differ from them in that we use count-data rather than log-linear specifications (Lambert *et al.,* 2010). In this respect, our model, albeit simpler, is closer to that proposed by LeSage *et al.* (2007) and Martínez *et al.* (2014). More specifically, we depart from LeSage *et al.* (2007) and follow Martínez *et al.* (2014) in that we do not assume that the behaviour of the variable of interest is the same regardless of whether the flows occur within the same location or between different locations.

If one is not willing to impose the assumption that the behaviour of the intra-ZdEs flows of R&D establishments does not differ from that of the inter-ZdEs flows of R&D establishments, then «a separate model for flows from the main diagonal of the flow matrix» is needed (LeSage and Pace 2008: 960). In their analysis of the population migration flows in the US states, for example, LeSage and Pace (2008) use a different function for the conditional expectation of the variable of interest. Yet they assume the same distribution for both intraregional and interregional flows. In our case we consider a more general assumption, namely that the conditional distribution of the flows when $i \neq j$ may be different from that when $i = j$. In maths:

$$\begin{aligned} y_{ii} &\equiv F_1(x,d,\theta_1) \\ y_{ij} &\equiv F_2(x,d,\theta_2) \qquad \text{for } i \neq j \end{aligned}$$

where F_1 and F_2 are appropriate distribution functions, x is an n x K matrix of covariates, d is the $n \times n$ matrix of distances between locations, and $\theta = (\theta_1, \theta_2)$ is a vector of parameters to be estimated. Notice that, depending on the values of θ, this parameterisation still allows for a common behaviour across geographical units as well as for different determinants for inter- and intra-ZdEs flows.

[13] This is an important difference with respect to previous studies on the relocation of firms and establishments, such as *e. g.* Holl (2004) and Manjón-Antolín and Arauzo-Carod (2011). Since they do not have information about the origin of the flows, their dependent variable is the number of establishments that move to location $j = 1, 2, ..., n$ and their number of observations is consequently n.

4.2. Model specification

Given our interest in analysing the determinants of the number of relocating establishments, our model specification employs commonly used distributions for count data (see *e. g.* Cameron and Trivedi, 2013). In particular, we use the Poisson, Negative Binomial and the Inflated versions of these models to model the intra-ZdEs flows (F_1 when $i = j$) and the inter-ZdEs flows (F_2 when $i \neq j$). This means that our model specification, in conditional expectation form, is given by:

$$E\left(y_{ij}\middle|x,d\right) = 1(i=j)(1-\varphi_i)\mu_i + 1(i\neq j)\mu_{ij}(1-\varphi_{ij})$$

with $1(\cdot)$ being an indicator function,

$$\varphi_{ij} = \frac{\exp\left(\gamma_O + x_i\gamma^O + x_j\gamma^D + \gamma^d d_{ij}\right)}{1+\exp\left(\gamma_O + x_i\gamma^O + x_j\gamma^D + \gamma^d d_{ij}\right)}$$

and

$$\varphi_i = \frac{\exp\left(\gamma_0^{OD} + x_i\gamma^{OD}\right)}{1+\exp\left(\gamma_0^{OD} + x_i\gamma^{OD}\right)}$$

being the probability that $y_{ij} = 0$ and $y_i = 0$, respectively, and

$$\mu_{ij} = \exp\left(\beta_0 + x_i\beta^O + x_j\beta^D + \beta^d d_{ij}\right)$$
$$\mu_i = \exp\left(\beta_0^{OD} + x_i\beta^{OD}\right)$$

Notice that, for the sake of simplicity, we have considered the same set of covariates in all the elements of the model. However, in applications the determinants of the probability that the variable of interest is zero may well differ from those of its conditional expectation (see *e. g.* Manjón-Antolín and Arauzo-Carod 2011). Also, one may argue that the determinants of the intra-ZdEs flows may differ from those of the inter-ZdEs flows (see *e. g.* Weterings and Knoben 2013). In any case, including these exclusion restrictions in the previous expressions would only complicate the notation without providing further insights. Lastly, the Poisson and Negative Binomial distributions are accounted by taking $\varphi_{ij} = 1$ and $\varphi_i = 1$ (and a probit rather than a logit function may be used here).

With this in mind, notice that the coefficients of the model are $\theta_1 = [\gamma_0^{OD}, \gamma^{OD}, \beta_0^{OD}, \beta^{OD}]$ and $\theta_2 = [\gamma_0, \gamma^O, \gamma^D, \gamma^d, \beta_0, \beta^O, \beta^D, \beta^d]$. More specifically, γ_0, γ_0^{OD}, β^O, and β_0^{OD}, are the constant terms; γ^d and β^d are the distance parameters; the vectors γ^O and γ^D are the origin and destination parameters of the inflated part of the inter-ZdEs flows model; the vectors β^O and β^D are the origin and destination parameters of the non-inflated part of the inter-ZdEs flows model; the vector γ^{OD} are the parameters of the inflated part of the intra-ZdEs and β^{OD} are the parameters of the intra-ZdEs flows model.

We expect the number of relocations to be decreasing in the distance between origin and destination, so that $\gamma^d \geq 0$ and $\beta^d \leq 0$. Also, β^{OD} can contain both positive and negative parameters. As for the rest of the γ and β coefficients, they can be either positive or negative. In particular, the impact on the volume of flows makes that the sign interpretation of β's and γ's is the opposite: while positive/negative β's would increase/decrease the expected flows, positive/negative γ's would decrease/increase the expected flows.

Following Griffith and Jones (1980), we further expect $\beta^O \times \beta^D \leq 0$ and $\gamma^O \times \gamma^D \leq 0$ for those characteristics that make both origin and destination either more ($\beta^O \leq 0$ and $\beta^D \geq 0$; $\gamma^O \geq 0$ and $\gamma^D \leq 0$) or less ($\beta^O \geq 0$ and $\beta^D \leq 0$; $\gamma^O \leq 0$ and $\gamma^D \geq 0$) attractive for the relocating firm. Similarly, we expect $\beta^O \times \beta^D > 0$ and $\gamma^O \times \gamma^D > 0$ for those characteristics that proxy for the size of the origin and destination, as well as those that either make the origin more attractive and the destination less attractive ($\beta^O < 0$ and $\beta^D < 0$; $\gamma^O > 0$ and $\gamma^D > 0$) or the origin less attractive and the destination more attractive ($\beta^O > 0$ and $\beta^D > 0$; $\gamma^O < 0$ and $\gamma^D < 0$). Notice, however, that this interpretation does not imply that the γ and β coefficients of variables that determine both φ_{ij} and μ_{ij} must show an opposite sign. For example, a variable may act as a proxy for the size of the origin and destination in φ_{ij} ($\gamma^O \times \gamma^D > 0$) while making both origin and destination either more or less attractive in μ_{ij} ($\beta^O \times \beta^D \leq 0$).

4.3. Estimates

Our dependent variable is the number of establishments that relocated their premises within and between continental French ZdEs in 2008-2010. Thus, our sample consists of 348 × 348 = 121,104 observations (348 corresponding to intra-ZdE flows and 120,756 corresponding to inter-ZdE flows). These data come from the INSEE, as do the data on most of the explanatory variables with the exception of the centroid *distance* between ZdEs (in kilometres, from the *Service d'information aéronautique*) and the corporate *taxes* (from the *Ministére de l'économie et des Finances*) [14].

In particular, proxies for the agglomeration economies include the rate between the number of entering establishments in R&D and the stock of establishments in 2006 (*ent rate rd*), the stock of establishments in R&D in 2006 (*stock rd*), the total population in 1999 (*ptot*) and the job density in 2006 (*job dens*) [15]. In addition, we have included the square of job density (*job dens*^{2}) to account for potential dis-economies (Henderson 1997). Moreover, we use unemployment levels in 2006 (*unem*) and net average wages per hour in 2006 (*wage*) to characterise the local labour market and the

[14] Following *e. g.* Houdebine and Schneider (1997) and Rathelot and Sillard (2008), we first compute the corporate tax rate of each municipality as the sum of the following components of the *taxe professionnelle*: *taux communal*, *taux intercommunal*, *taux departemental* and *taux regional*. Since our unit of analysis is the ZdE, we then use the mean values of the municipalities of each ZdE as our measure of corporate tax.

[15] We use the number of entering establishments (*entry*) and the stock of establishments (*stock*) in the inflated part of the model because these variables seem more appropriate to proxy for the size of the units.

percentage of active population employed in industry (*emp ind*) and service sectors (*emp serv*) to proxy for the sectorial specialisation. As for the institutional features, we have considered whether the ZdE is the capital of a region (the dummy *capital*) and whether it is in the Paris region (the dummy *paris*). We have also used dummies indicating whether the ZdE has a TGV station (*tgv*) and an airport (*airport*) as measures of the transport infrastructures. Lastly, the educational level of the individuals living in the ZdE is reflected in the percentage of adult population in 1999 that did not hold a degree (*uneduc*), hold a BEP degree (*bep*) and hold a university degree (*uni*).

Table 6 reports estimates of our gravity model using these data, distinguishing results for intra- and inter-ZdE flows. The model specification for the intra-ZdEs flows corresponds to the zero-inflated Poisson (ZIP) model and, for the inter-ZdEs flows, to the zero-inflated negative Binomial model (ZINB) model. These choices are supported by the fact that the Vuong test rejects the non-inflated models (Poisson and Negative Binomial) in both cases and the α-parameter of the conditional variance is statistically significant in the ZINB model only for the inter-ZdEs flows (see the bottom rows of Table 6 for details).

We start by analysing the results for the intra-ZdE flows. We find that the variables that, *ceteris paribus*, increase the mean number of relocations in the same ZdE (that is, have a significant positive effect) are the agglomeration economies (the rate between the number of entering establishments in R&D and the stock of establishments in 2006 as well as the stock of establishments in R&D in 2006), the sectorial specialisation (percentage of active population employed in industry sectors), the Paris dummy and (through the inflated part) the total population in 1999. It is also interesting to note the existence of (dis)agglomeration effects through the positive sign of the job density and the negative sign of its square. On the other hand, the variables that, *ceteris paribus,* decrease the mean number of relocations in the same ZdE (that is, have a significant negative effect) are labour market characteristics (unemployment levels in 2006 and net average wages per hour in 2006) and (through the inflated part) the corporate taxes.

Next we analyse the results for the inter-ZdE flows. The first thing to notice is that distance shows the expected sign (negative in the mean part of the model and positive in the inflated part) and is statistically significant, thus supporting the gravity model specification. It is also interesting to note the differences that appear with respect to the determinants of intra-ZdE flows[16]. Common determinants only seem to include labour market characteristics and agglomeration economies, although the significance of these variables in the inter-ZdE flows is limited to either the origin or the destination[17]. In fact, the only variable that is statistically significant for both

[16] These differences, along with the differences in model specification previously discussed (ZIP vs. ZINB), reject the assumption that the behaviour of the intra-ZdEs flows of R&D establishments does not differ from that of the inter-ZdEs flows of R&D establishments.

[17] Notice that the sign of the wages in the intra- and inter-ZdEs specifications shows a certain consistency: higher wages reduce relocations in the same ZdE and increase the exit to other ZdEs. In contrast, the sign of the unemployment variable implies a reduction of the relocations in the same ZdE and an increase of the relocations in a different ZdE (rather than a reduction, as in the intra-ZdEs).

Table 6. Estimation of the determinants of the relocation flows (ZIP Model)

	INTRA FLOW(ZIP)		*INTER FLOW (ZINB)*			
Variables	*Estimation*	*S.E.*	*Estimation*	*S.E.*	*Estimation*	*S.E.*
Main equation						
distance			–0.0081***	0.002		
			Origin		*Destination*	
ent rate rd	3.3285***	0.512	0.2662	0.6260	–0.3163	0.662
stock rd	0.0260*	0.015	–0.0317**	0.015	0.0139	0.016
Job dens	1.6600***	0.393	0.7206*	0.433	0.7030	0.663
Job dens2	–0.2405**	0.095	0.1016	0.102	–0.0523	0.113
ptot	–0.0009	0.001	0.0013	0.043	–0.0026*	0.001
unem	–0.1663*	0.101	0.1004	0.061	0.1659***	0.054
wage	–0.5276**	0.232	0.4239***	0.155	0.2161	0.155
emp ind	14.243**	5.786	1.2708	3.510	–3.0924	3.281
emp serv	–0.9413	5.439	5.3969	3.565	–0.6780	3.422
uneduc	10.552	8.041	24.268***	5.471	5.4945	5.226
bep	0.0735	24.49	21.974*	12.46	–0.9168	12.224
uni	1.12	9.31	9.35	6.59	2.62	6.11
capital	0.5134	0.398	0.6687**	0.295	0.5489*	0.318
paris	2.383***	0.753	–0.6881	0.559	–0.5145	0.540
tgv	–0.2502	0.329	–0.5099**	0.256	0.0861	0.240
aeroport	–0.1942	0.365	–0.1838	0.217	0.1853	0.291
taxes	–0.0913	0.074	–0.0436	0.089	0.0660	0.081
Inflated part						
distance			0.0070***	0.002		
			Origin		*Destination*	
entry	–2.6325	5.533	2.3800***	0.855	0.8730	0.780
stock	0.3698	0.554	–0.2292***	0.081	–0.0807	0.074
ptot	–0.0167**	0.007	–0.0018*	0.001	–0.0018	0.002
tax	0.1876**	0.089	0.0220	0.068	0.0813	0.057
α			4.61***			
Vuong test	2.87***		3.87***			
AIC	371.35		2460.89			
LR Test	462.07***		121.46***			

origin and destination is the fact of being capital of a region. In particular, the positive coefficient of the variable *capital* indicates a higher spatial turnover from and to regional capitals. This means that, *ceteris paribus*, there is a larger number of relocations from ZdEs hosting the regional capital to other ZdEs hosting as well the regional capital than to anywhere else.

We also find that the variables that have a significant positive effect on the expulsion of R&D establishments from their ZdE of origin are job density, wages and education (percentage of adult population in 1999 that did not hold a degree and hold a BEP degree) and (through the inflated part) the stock of establishments and the population. As for the variables that have a significant negative effect on the expulsion of R&D firms, we can mention the stock of R&D establishments, the dummy for the TGV station and (through the inflated part) the total number of entering establishments. Lastly, it is worth noting that most of the explanatory variables have no statistically significant effect in determining the flows to destination. Only the unemployment (with a positive effect) and the population (with a negative effect) seem to play a role in the attraction to the destination ZdEs.

5. Conclusions

There has been a number of studies on the relocation of firms and establishments within a country (typically using data at the regional or municipal level). However, most of these national relocations studies neither analyse flow data nor concentrate on a particular industry. In other words, what they typically do is to analyse the determinants of the number of relocations to a region or municipality (*i. e.*, regardless of their origin) using regions' or municipalities' characteristics as the main explanatory variables. Our contribution to this literature is thus twofold. First, we focus on the R&D industry, a key sector in any developed country that, to our knowledge, has never been studied. Second, we use flow data to estimate a gravity model in which the vector of explanatory variables includes characteristics of the geographical units from which the relocations originate, characteristics of the geographical units to which the relocations are destined, and the (centroid) distances between origins and destinations of the relocations. In particular, we provide evidence on the relocation flows of R&D activities in France between 2008 and 2010.

Descriptive and spatial analyses suggest that R&D establishments are already located in areas that provide them with the appropriate environment (in terms of *e. g.* knowledge infrastructures and agglomeration economies that enhance research activities). As a result, the incentives to migrate large distances are limited and most relocating establishments stay close to their original locations (the mean distance being around 50 km). Also, the areas of relocation activity are largely concentrated around some of the major urban areas (*e. g.* Paris, Toulouse and Bordeaux as well as the regions of Rhône-Alpes and Provence-Alpes-Côte d'Azur). Lastly, the lion's share of the relocation activity corresponds to smaller establishments.

Estimates from a gravity model show that the main determinants of the R&D establishments include agglomeration economies, labour market characteristics, institutional features, transport infrastructures and educational levels. However, there are substantial differences in the way these variables affect intra- and inter-ZdE flows. First, agglomeration economies are particularly relevant to determine intra-ZdE flows and to reduce the expulsion of R&D establishments from the ZdEs of origin. Second, unemployment rates and wages foster inter-ZdE's relocations, as they increase migrations from ZdE's with higher wages and to ZdE's with higher unemployment rates. Yet the effect for intra-ZdE's relocations is the opposite, with higher levels of both unemployment rates and wages preventing R&D establishments from relocating within the same ZdE[18]. Third, an R&D establishment located in Paris (Île-de-France region) is more likely to relocate within the same ZdE than another R&D establishment located elsewhere in continental France. Also, the relocation of R&D establishments boosts in the regional capitals, both in terms of departures and arrivals. Fourth, (major) transport infrastructures seem to play a minor role in relocation decisions. Fifth, educational levels do not seem to influence for intra-ZdEs flows. However, lower educational levels foster R&D establishments to leave their ZdEs. Lastly, the statistical significance of the distance between ZdEs supports the gravity model specification.

These results may help French policy makers in their efforts to address the spatial mismatch of economic activities. In the case of the R&D industry, the observed spatial concentration and/or the importance of the regional capitals, for example, suggest it would be misleading to design economic policies that apply uniformly across the territory. Rather, it would be more efficient to concentrate the public efforts in certain geographic and/or administrative areas. It is important to stress, however, that the estimates reported in this paper were obtained under the assumption that the observations are spatially independent. If this assumption does not, the resulting specification error would cause our estimates to be biased. Given the difficulties involved in the construction of a spatial gravity (non-linear) model for origin-destination flows, we leave this issue for future research.

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[18] Notice, however, that the overall effect of wages and unemployment depends on whether these variables proxy for higher labour market standards (*e. g.*, higher levels of wage and lower levels of unemployment) or higher operational costs (*e. g.*, higher levels of wage and lower levels of unemployment). Results reported in Table 7 seem to indicate that the later effect predominates in wages but not in unemployment.

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