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Regional Spillovers of Transport Infrastructure Investment: A Territorial Cohesion Analysis

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Territorial cohesion is a routine part of the job of spatial planners. However, it has not always been measured using a valid and solid methodology. This paper addresses conceptually how regional spillovers of transport investments of the Spanish master plan (''Plan Estratégico de Infraestructuras y Transporte'' 2005–2020) affect territorial cohesion. Different periods undergo analysis using the ''extraction method''. We calculate regional spillovers by accessibility gains measured in economic potential units (gravitational method using GDPs for each centroid under analysis). Two different typologies of regional spillovers are given, according to the direction of the effects: upstream and downstream. We conclude that the 'Plan Estratégico' favours territorial cohesion of Spain, but the degree of territorial cohesion produced by each region is not uniform. The end of the paper raises a number of suggestions for further research on the interaction of regional spillovers with territorial cohesion.

Keywords: Regional spillovers; transport infrastructure; accessibility; territorial cohesion; Spain

1. Introduction

The European Commission (EC) has, since its inception in 1957, devoted much discussion to the future of the European Union's cohesion policies (CEC, 2004, CEC, 1998). In fact, the European Cohesion Forum, held by the Commission on 21 and 22 May 2001, concluded that cohesion must not be a matter for structural policy alone, and other European Union organisations - in particular those for agriculture, rural development, the environment and transport - must make

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policies that more effectively contribute to it. Among the policies named to play that role are the European Common Transport and the Trans-European Transport Network (TEN-T). The TEN-T Policy aims to provide the infrastructure for smooth functioning of the internal market and achievement of the objectives of the Lisbon Agenda on Growth and Jobs (CEC, 1998). It also sets out to help ensure accessibility to transport throughout the EU and to boost economic, social and territorial cohesion (CEC, 2009).

So far, the EU has invested €400 billion in a network that was established by decision of the European Parliament and the Council in 1996, and last amended in 2004. This investment has helped to complete a large number of projects of common interest, interconnecting national networks and overcoming technological barriers across national borders. . Articles 154-156 of the Treaty on European Union define TEN-T policy and its role in achieving the objectives of smooth functioning of the internal market. They include social and economic cohesion for the benefit of all its citizens, economic operators, and regional and local communities, inter alia by targeting EU action to promote interconnection and interoperability of national networks, and access to such networks.

All the national transport master plans in the EU follow these premises and, in principle, they are expected to promote regional cohesion at the national level. This in keeping with the view of policymakers and researchers, such as Nijkamp et al. (1990), who suggested that cohesion effects should be studied in any relevant integrated policy analysis. Because of existing policy, the treatment of cohesion effects of transport infrastructure investments tends to be even and common (Grant-Muller *et al.*, 2001).

Ex-ante cohesion effects of transport investments are difficult to analyse, because all transport investments in a region affect not only the internal boundaries of the region but other regions situated in the vicinity. These effects are usually termed 'regional spillover effects'. Regional spillovers are the main drivers of the cohesion policies in transport master plans, because some of the accessibility gains achieved by a region are consequences of regional transport investments made in others. In practice, some important benefits of transport investments of less developed regions could be reaped by the most developed regions of the country in the form of regional spillovers, leading to an increase in regional disparities.

In this paper we aim to analyse how regional spillovers of road transport investments in the Spanish transport master plan (Ministerio de Fomento [2004], ''Plan Estratégico de Infraestructuras y Transporte,'' 2005–2020; PEIT) can affect the territorial cohesion of Spain. Planners usually concentrate transport investments in those regions with less income, in order to promote territorial cohesion. However, this behaviour is myopic because new investments benefit both their own regions and neighbouring ones. For this reason, it is necessary to analyse how regional spillovers produced by transport investment affect territorial cohesion. The analysis of spillovers could help to disentangle the real investments of the transport master plan in each of the regions. To our knowledge, this exercise has not been performed in the past, so this paper expands the current state-of-the art, analysing how the objective of territorial cohesion is affected by the impact of regional spillovers from transport infrastructure investments.

2. Background

In this paper, the analysis of regional spillovers is conducted by looking at regional distribution of accessibility gains of each regional transport investment. We use geographic information system (GIS) technology, which can be considered a complementary tool to any conventional cost-benefit analysis. As stated earlier, it is well known that transport investments in a region affect the accessibility of the region itself and the rest of the regions considered in the study. This is especially true for some major motorways, which connect different regions of a country. Thus,

if we have a motorway that connects two developed regions through a third, less developed one, then the investments in this third region could more intensely favour the two developed regions than the middle region. This critical issue has been scarcely studied and, as we will show, it is relevant in order to evaluate the transport master plans from the point of view of cohesion. The evaluation cannot only be based on the economic figures invested in the less developed regions of a territory, because part of these benefits are transferred to other regions and, as suggested earlier, positive cohesion effects of transport master plans can be blurred by spillovers. Thus, when we analyse the cohesion effects of any transport master plan, then regional spillovers play a determinant role: A plan will produce more cohesion when regional spillovers are harvested by the less developed regions (downstream effects). On the contrary, if regional spillovers are harvested by the developed regions (upstream effects), then cohesion will not be favoured.

Some earlier papers deal with the possible existence of regional spillover effects. Munnell (1992)[4] found that the elasticities of output with respect to public capital formation obtained with state-level data tend to be lower than those obtained with aggregate data, a finding she conjectured to be due to the existence of spillover effects. In studies of spillover effects, the methodologies and empirical results are usually based on the estimation of aggregated production functions (Boarnet, 1998; Holtz-Eakin and Schwartz, 1995; Cantos *et al.*, 2005). Pereira and Roca-Sagalés (2003) captured the spillover effects of public capital formation, estimating region-specific VAR models which include both public capital spent in the region itself and public capital spent outside the region. Thus, they estimated the marginal products for each region both for the public capital spent in the region itself and for the public capital located elsewhere (spillover effects of public capital). Their empirical results suggest that spillovers account for over half of the aggregate effects of public capital formation.

To date, the importance of spillover effects on regional cohesion has been elusive. We hypothesize that by using GIS technology to extract new regional features, our approach improves on the conventional ones that use more aggregate data, and for that reason are not particularly suitable to differentiate the intensity of spillover effects over all the regions of a country. In an earlier study, Ozbay, Ozmen-Ertekin and Berechman weighted investments according to two criteria: neighbouring regions that are closer and those that are farther away (Ozbay *et al.*, 2007). They concluded that the magnitude of regional spillovers to neighbouring counties is strongest near the investment location.

Gutiérrez *et al.* (2009), using a different methodology - one based on the analysis of accessibility indicators - calculate matrices of investments flows among all the Spanish regions. These matrices serve to differentiate two important cases:

- upstream effects are regional spillovers which are transferred from less developed regions to developed regions;
- downstream effects are regional spillovers which are transferred from developed regions to less developed regions.

This matrix allows us to know how much of the direct investment in each region is transferred to other regions, and it is especially important to differentiate whether these transfers take an up- or downstream direction. Assessing these figures adequately can be crucial to determining whether the regional spillovers do favour territorial cohesion.

It is evident that underpinning this approach is the strong relationship between accessibility, on the one hand, and economic growth and development, on the other. Governments of all the EU countries dedicate important budgets to investing in transport infrastructures, confident that better accessibility will provide an adequate framework for economic growth and better welfare

[4]Mas et al. (1996), Moreno et al. (1997) and Ezcurra et al. (2005), using panel data techniques, found possible indirect evidence of regional spillovers along the lines suggested by Munnell (1992).

for individual citizens. Analogously to what has been previously cited regarding the imbricate relationship between public capital in special highways or transport infrastructure and economic growth and development, some studies have shown that accessibility and economic growth and development also have a strong direct relationship (Forslund and Johansson, 1995; Vickerman *et al.*, 1999; Ozbay *et al.*, 2003 and 2006).

2.1 Transport infrastructure, accessibility and economic growth

Transport infrastructure can be considered as one more input into the production process. Increasing the stock of infrastructure, like increasing any other stock of capital, should lead to an increase in the rate of economic growth. Underlying this view are a large number of econometric exercises that estimate aggregate production functions with public capital as an input (Puga, 2002). The assumption behind this production function is that regions that provide higher levels of infrastructure will have higher output levels, and that regions that provide cheap and abundant transport infrastructures will produce more transport-intensive goods (Wegener and Bökemann, 1998). There are many examples of regional production functions, including transport infrastructure indicators (see, for example, Aschauer, 1989; Munnell, 1992; Moomaw and Williams, 1991; Holtz-Eakin, 1994, Mamatzakis, 1999; Ozbay *et al.*, 2007).

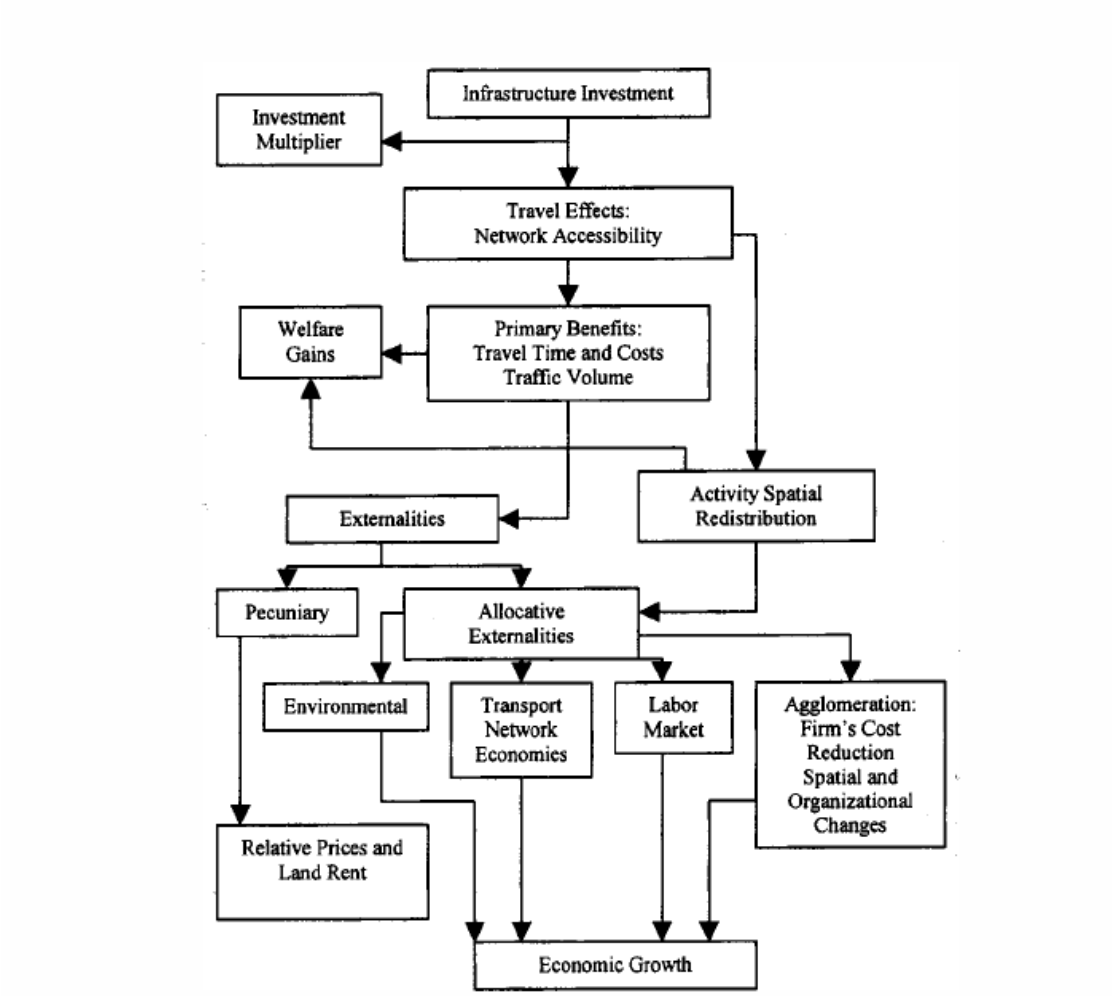

Figure 1. Framework representing the relationship between accessibility and economic growth (Banister and Berechman, 2000)

However, indicators of infrastructure endowment used as an input in production functions have been criticized because they are not a satisfactory measure of the utility of the network, rather only of the quantitative properties of the infrastructure (for example, kilometres of motorway). The interaction between regions and cities cannot be easily explained by these aggregate indicators without considering how cities are connected. Responding to this criticism, some researchers have substituted infrastructure endowment indicators with accessibility indicators in the analysis of production functions (Forslund and Johansson, 1995; Wegener and Bökemann, 1998; Ozbay *et al.*, 2003 and 2006). In this view, improving accessibility implies an increase in potential production. Figure 1 shows the mechanisms that explain the relationship between accessibility and economic growth.

2.2 Transport infrastructure, regional spillovers and territorial cohesion

Spillover effects of transport infrastructure are understood as the benefits that one region experiences as the consequence of transport investments made in others (Pereira and Roca-Sagalés, 2003). These effects are especially relevant in the case of transport infrastructure plans and projects because network effects spill over into distant regions (Martín *et al.*, 2007). Studies carried out on the importance of infrastructures in productivity gains using a subnational scale (states, regions or metropolitan areas) obtain lower elasticities for infrastructures than studies at a national level (the Munnell paradigm). The elasticity result shows that the infrastructures of a region affect not only on that region, but also other regions connected by a transport network (Hulten and Schwab, 1991).

A unified planned transport network is essential to achieving better integration of the subnational areas. Cohesion between these areas will remain a basic prerequisite in designing transport master plans to facilitate free movement of goods and people. In Spain, the Ministry of Development, in designing 'the "PEIT", recognized the necessity of reducing gaps in opportunity among all the regions and sought to give the outlying parts of the Spanish territory greater access to the central backbone of the nation (Madrid-Barcelona-Valencia). This plan is especially relevant, not only because of its magnitude (€32,105 million and 6129 km of new motorways), but also because of the decentralized nature of Spanish government.

'Territorial cohesion' is an ambiguous term, and the concept is used distinctly in different fields. According to Davoudi, ''such obscurities often occur when a term is translated from one language to another while leaving behind its wider systems of meaning. The notion of territorial cohesion, translated from the French original, Cohesion territoire, is a victim of such a process'' (2005, p. 433). However, despite its ambiguity the concept generally has a positive connotation; thus 'territorial cohesion' has spread around rapidly and become a routine feature of spatial planning (Schön, 2005).

Faludi (2004) and Davoudi (2004) attempted to trace the origin of 'territorial cohesion', with the aim of providing a deeper understanding of the concept's meanings and applications. They outlined some important and particular events as well as publications that have given it political notoriety. It is clear that territorial cohesion gained widespread use at the European level after its appearance in the proposed EU Constitution, which states that ''in order to promote its overall harmonious development, the Union shall develop and pursue its action leading to the strengthening of its economic, social and territorial cohesion. In particular, the Union shall aim at reducing disparities between the levels of development of the various regions and the backwardness of the least favoured regions''. (Conference of the Representatives of the Governments of the Member States, 2004, Article 220).

The Third Cohesion Report was the first attempt to shed some light on and extend the concept of territorial cohesion beyond the borders of social and economic cohesion[5]. Until then, indicators of cohesion had been mainly related to equality and, to a smaller extent, disparities between regions. This was a narrow approach because territorial cohesion was only studied via certain socioeconomic variables at a certain administrative level (country, region or municipality). In this context, some cohesion reports illustrate that although cohesion in this narrow sense between the EU member states was increasing, the disparities between the regions were also growing.

Hamez (2005) concluded that it is important to define 'territorial cohesion' broadly to avoid reducing it to the analysis of the regions facing economic weaknesses or geographical limitations, such as islands, mountainous areas or peripheral zones. A broader version of the concept combines several dimensions, including (p. 401):

- a multisectoral dimension: in terms of the promotion of not just economic, but also social and environmental, cohesion;
- a territorial dimension: in terms of different spatial levels, from the EU to the local level, and concerning both disparities and access to services (see Third Cohesion Report);
- a temporal dimension: in terms of a concern not just with present disparities but also the likely changing relative situation.

Territorial cohesion has been previously analysed in other studies using GIS technology. In most of the cases, the approach is based on the analysis of changes in the spatial distribution of accessibility values (e.g., Schürman *et al.*, 1997; Martín *et al.*, 2004; López *et al.*, 2008). The studies use different equality indices to analyse whether territorial cohesion (equity) is increased or not using two different scenarios: ex-ante –ie, before the construction of transport infrastructure; and ex-post – ie, after the construction of all transport investments. In this paper, we use a different approach: analysing the effects on cohesion by comparing regional spillovers. Therefore, the analysis described in this paper extends the state of the art in two different directions:

- First, for each region examined, the accessibility regional changes caused by the new motorways investments are obtained for three different scenarios. Then accessibility indices are used to analyse the results, and those are compared. Thus, we will compare the scenario ex-ante, the scenario ex-post (PEIT) and the regional scenario which describes the PEIT without any investment in a specified region ("extraction method"). In this way, we can conclude whether the regional investments in each of the regions promote territorial cohesion.
- Second, when analysing the matrix of regional spillovers, we consider whether these spillovers are part of the upstream set.

In summary, we have developed a method in which the focus has been placed on territorial cohesion instead of economic cohesion, overcoming the availability of data which has been cited as the major constraint when this type of study is carried out using GIS technology. This method satisfies the second and third characteristics proposed by Hamez.

[5] The concept of territorial cohesion extends beyond the notion of economic and social cohesion by both adding to and reinforcing it. In policy terms, the objective is to help achieve more balanced development by reducing existing disparities, preventing territorial imbalances and making both more coherent both sectoral policies which have a spatial impact and regional policy. The concern is also to improve territorial integration and encourage cooperation between regions (CEC, 2004).

3. An Accessibility Indicator Methodology to Calculate Regional Spillovers

In this section, some aspects of the methodology in which the calculus of regional spillovers is based will be briefly explained. (See Gutiérrez *et al.*, 2009 for further details.) Regional spillovers are calculated for the 'PEIT', which covers the period of 16 years, from 2005 to 2020, and allocates funds for the new construction of 6,129 km of motorways with a total cost of €32,105 million in the peninsular territory of Spain.

The GIS model includes the main road network of the 15 Spanish peninsular regions (Figure 2), Portugal and the South-Western French regions (Aquitaine, Midi-Pyrénées and Languedoc-Roussillon) for 17 different scenarios – 2005 (ex-ante plan), 2020 (ex-post plan) – and 15 scenarios for 2020 without considering regional investments in region *i*. Thus, regional spillovers from new motorway investments foreseen in the PEIT are calculated according to the net gains on accessibility (measured by economic potential[6]). The accessibility gains are obtained using the regional extraction method (Figure 3). The logic behind this procedure resembles the works that use the extraction method on the basis of an input-output table with multiple regions. In order to consider the isolated effects of a hypothetical region *i*, it is usual to extract the region under analysis from the multiple-region model (Dietzenbacher *et al.*, 1993).

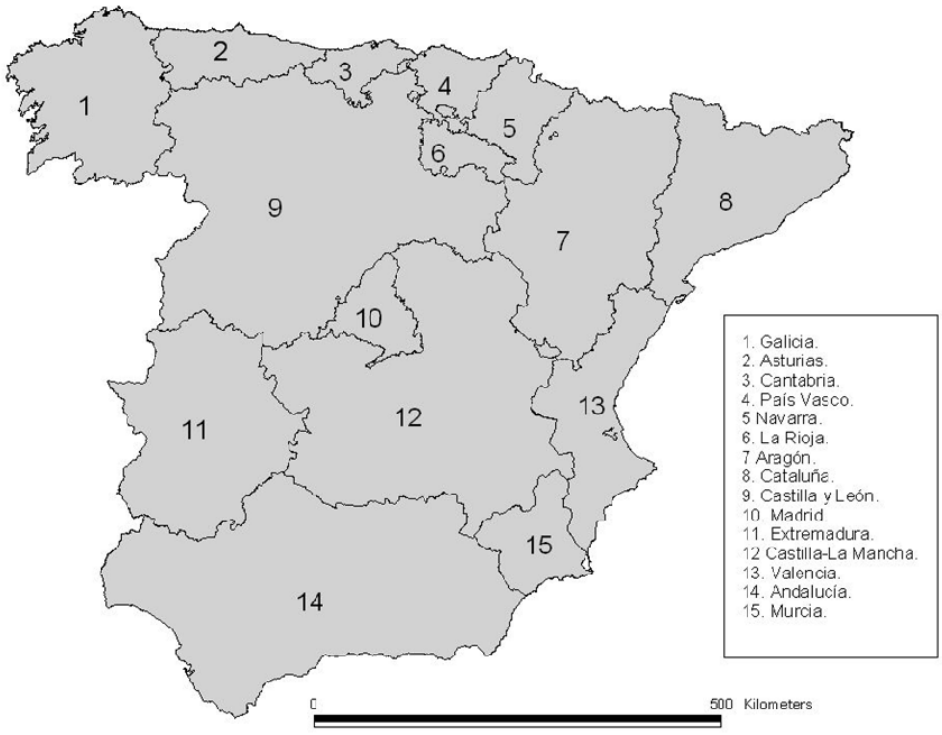

Figure 2. Spanish autonomous regions

The difference in accessibility gains between the ex-post (PEIT) scenario and the scenario simulating the extraction method of region *i* gives a good approximation of the accessibility gains that these investments produce in all the regions of Spain. Part of these effects are absorbed for the region itself (inner effects), but the rest of the gains correspond to benefits exported to other regions in the form of regional spillovers.

[6] Economic potential can be interpreted as the volume of economic activity to which a region has access, after the cost and time of covering the distance to that activity has been accounted for (Dundon-Smith and Gibb, 1993).

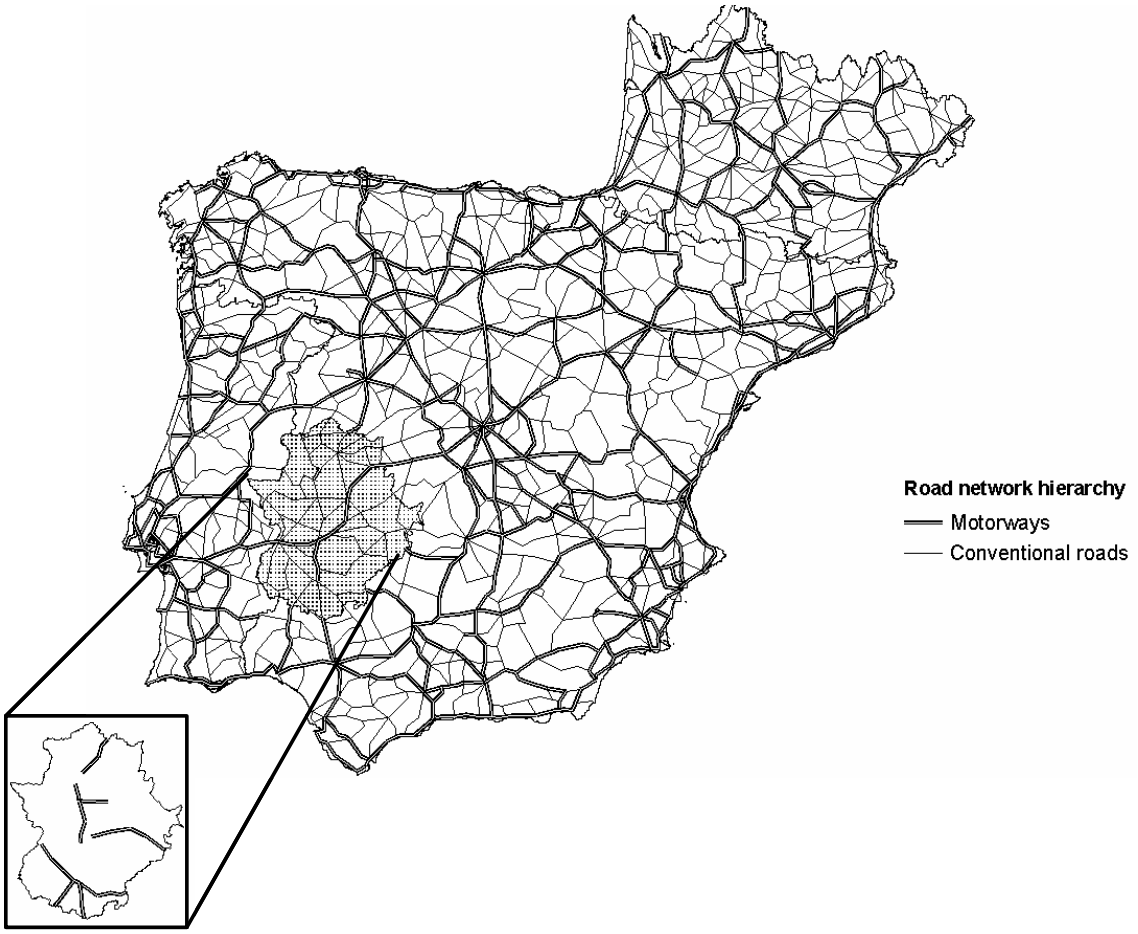

Figure 3. The regional extraction method (example of the extraction of the new motorways planned for Extremadura)

For each of the 17 scenarios, the study area was divided into 815 transport zones with their respective centroids. This large number of zones was justified because accessibility indicators were more accurate and realistic than if other aggregated spatial units, such as provinces (47) or regions (15), had been used. Besides, it was necessary to correct the problem known as self-potential - which refers to how much the internal accessibility of each zone contributes to total accessibility - discussed in Bruinsma and Rietveld (1993) and Frost and Spence (1995). If not corrected, self-potential problems can bias the results of accessibility measures, most strongly in zones that are highly populated or have a large area.

Once the GIS model has been stored in a database, calculating the economic potential accessibility indicator is relatively straightforward. First, it is necessary to calculate the minimum paths through the network in order to determine the access time from each node to the different centroids included in the analysis, and then the accessibility indicator for each node can be obtained. Second, some results are interpolated using raster analysis (IDW - inverse distance weighted interpolation).

Thus, comparing the results obtained for the scenarios ex-post (all the investments foreseen in the PEIT) and each of the regional scenarios using the extraction method, it is possible to analyse all accessibility gains, differentiating which part is retained by the region itself (inner benefits) and which is exported to other regions (regional spillover effects) (Table 1). We can see, for example, the regional spillovers measured in potential units produced by the construction of the motorways in Extremadura. As expected, the greatest economic potential gains correspond to the

region itself, ie inner benefits (7261 economic potential units). However, there are also significant spillovers in other neighbouring regions, such as Andalusia (2311), Castilla y León (1017) and Castilla–La Mancha (788). The regional spillovers on farther regions of Spain are almost negligible, for example, Catalonia (19) and Aragón (58). Table 1 also shows that the regional distribution of spillover effects is clearly asymmetric. For example, the foreseen investments in Andalusia increases the economic potential in Asturias by 195 units , whereas the road investments made in Asturias increases the economic potential in Andalusia by only 1 unit.

Table 1. Accessibility spillover matrix (in potential units)

To From	Andalusia	Aragón	Asturias	Cantabria	Castilla-La Mancha	Castilla y León	Catalonia	Extremadura	Galicia	La Rioja	Madrid	Murcia	Navarra	Basque Country	Valencia	Produced benefits
Andalusia	4271	94	195	162	1051	354	135	2871	197	144	371	941	105	137	520	11549
Aragón	196	7773	419	902	796	608	1479	310	156	2296	809	958	4705	2350	2189	25947
Asturias	1	9	1285	353	3	29	6	2	838	17	4	1	27	181	2	2760
Cantabria	22	3	114	2996	44	248	0	54	8	11	67	18	1	79	12	3677
Castilla-La Mancha	1317	817	344	119	9490	754	473	1653	271	192	1175	2554	149	115	2164	21586
Castilla y León	429	2945	2079	4921	1280	7957	1379	1601	1284	5505	1792	327	4961	1363	393	38215
Catalonia	101	1355	135	216	294	187	4494	183	71	337	413	337	583	358	628	9691
Extremadura	2311	58	624	547	788	1017	19	7261	510	368	300	361	158	435	329	15087
Galicia	9	22	1292	400	25	324	12	27	2475	115	34	13	96	220	13	5077
La Rioja	6	85	40	26	3	291	29	31	47	1470	7	1	664	23	1	2724
Madrid	4	23	13	19	230	62	8	59	9	2	27	19	0	12	24	512
Murcia	602	220	10	11	228	18	300	31	8	72	35	5180	131	38	763	7647
Navarra	18	287	218	415	67	173	274	28	34	3339	86	34	4248	937	101	10259
Basque Country	11	16	0	1	17	109	0	27	16	153	42	4	74	354	5	829
Valencia	29	1143	51	156	281	114	203	44	27	586	131	534	595	354	3885	8133
Received benefits	9327	14852	6819	11243	14596	12247	8811	14183	5951	14607	5294	11282	16496	6958	11028	163693

Source: Gutiérrez *et al.*, 2009.

4. Regional Spillovers and Territorial Cohesion

This section analyses the results obtained by the aforementioned methodology from the perspective of territorial cohesion using inequality indices. Thus, a comparison between the regional scenarios with respect to both scenarios - ex-ante and ex-post - will be made in order to evaluate whether the motorway investments in each region contribute positively to the aim of territorial cohesion in Spain. This exercise belongs to the literature of territorial cohesion because the effects are measured by accessibility indices, extending the analysis beyond simple economic measures that do not take into account important regional spillovers.

We did not develop a specific methodology to quantify accessibility disparities. Rather, we calculated and compared different inequality measures frequently used in the income inequality literature (Cowell, 1995), using the following inequality indicators: Gini, Atkinson (0.5), Theil (0) and the coefficient of variation of the accessibility indicator that has been calculated in the previous section for all seventeen types of scenarios.

Table 2 presents the inequality accessibility indices. (Because the indices are well known, we are going to omit discussion of their basic characteristics and their mathematical representation.) These indices may be considered a policy tool for comparing the evolution of regional accessibility disparities in the different scenarios analysed. Their use will allow planners to discuss whether the impacts of the PEIT and individual regional investments serve to reduce or increase regional accessibility disparities. The reason to choose different inequality indicators for all the scenarios is twofold. First, it is well known that some inequality indices are quite sensitive to the presence of outliers in the distribution, so the analysis is more robust if we use different indices. Second, we study the economic potential differences associated with the different scenarios under analysis, in order to study the complexities of regional spillovers.

From table 2 we can conclude that regional cohesion will be achieved after the completion of the PEIT. It can be seen that all inequality indices are lower in the PEIT scenario. This result is consistent with the master plan, an objective of which is completion of the national interurban motorways in a way that makes more eastern and western links, favouring spatial interaction of the nodes without considering the hierarchy of Madrid. The Spanish national motorway system was based on the central location of the nation's capital, and most links of the national motorway system pass through Madrid. However, PEIT was developed with the assumption that the grid of the existing centre-periphery axis would be completed. In summary, it can be concluded that PEIT's overall performance on accessibility is very successful.

Table 2. Accessibility inequality indices

Scenarios (extraction method)	Gini	Atkinson (0.5)	Theil (0)	Coefficient of variation
Ex-ante (without plan)	0.0780	0.0057	0.0118	0.1601
Ex–post (PEIT 2020)	0.0764	0.0053	0.0110	0.1532
Andalusia	0.0774	0.0054	0.0112	0.1545
Aragón	0.0759	0.0053	0.0110	0.1537
Asturias	0.0769	0.0054	0.0111	0.1539
Cantabria	0.0768	0.0054	0.0111	0.1538
Castilla–La Mancha	0.0753	0.0052	0.0108	0.1524
Castilla y León	0.0772	0.0055	0.0113	0.1554
Catalonia	0.0756	0.0052	0.0108	0.1524
Extremadura	0.0781	0.0055	0.0113	0.1554
Galicia	0.0773	0.0054	0.0112	0.1544
La Rioja	0.0764	0.0053	0.0110	0.1534
Madrid	0.0764	0.0053	0.0110	0.1532
Murcia	0.0766	0.0053	0.0110	0.1536
Navarra	0.0767	0.0054	0.0110	0.1539
Basque Country	0.0765	0.0053	0.0110	0.1532
Valencia	0.0759	0.0053	0.0109	0.1531

Focusing on the partial scenarios for each region (the extraction method), the results show that regional cohesion for all the hypothetical scenarios is improved when the comparison is done with respect to the scenario of the PEIT without any investment in a specified region. In other words, if the investments of a particular region could not be foreseen, the regional cohesion would be improved independently from the rest of investments. However, this situation is not so uniform when the comparison is done with respect to the scenario of the complete PEIT. It is not surprising that extraction scenarios are better in terms of equity for these particular regions: Aragón, Castilla–La Mancha, Catalonia and Valencia (each of their individual figures is lower than the figure in the Ex–post [PEIT] row). It is clear that the PEIT investments favour the most accessible territories, with the exception of Madrid. The extraction of Madrid, the Basque Country and La Rioja is almost negligible because the investment in these regions called for by the PEIT is really low.

5. Interaction of Regional Spillovers and Territorial Cohesion

The results in Section 4 allow policymakers and planners to evaluate globally the effects of each regional transport investment on territorial cohesion. However, the interaction between the individual regional spillovers and territorial cohesion is not well resolved. In this section, a further step is presented to analyse the individual behaviour of regional spillovers in terms of territorial cohesion. This analysis uses an innovative approach: studying individual regional spillovers according to their direction: upstream effects (when regional spillovers move towards less accessible regions – periphery to more accessible regions – core) and downstream effects (the opposite direction).

5.1 Regional Spillovers: Core and Periphery Effects

In this section, the direction of all the regional spillovers is analysed according to when the accessibility gains are produced in less accessible regions by investments in more accessible regions (downstream effects). The opposite direction is considered as the upstream effects, which are characterised by investments in less accessible regions which produce accessibility gains in more accessible regions. These regional spillovers can be named 'periphery-core' or 'core-periphery' effects. For these terms, the convention of location analysis has been followed, where the core consists of the most accessible regions in terms of economic potential, and the periphery consists of the complementary set. To differentiate the regional spillovers in these two categories, without loss of generality, we consider the downstream regional spillovers as positive because for territorial cohesion these values are preferred. Analogously, the values of upstream regional spillovers are considered negative. As we are only analysing the effects of regional spillovers on territorial cohesion, the values of the inner effects are changed to zero. Thus, Table 3 shows the regional spillovers according to the direction of accessibility gains measured in potential units.

Table 3. Accessibility spillover matrix (in potential units): Up and downstream effects

From \ To	Andalusia	Aragón	Asturias	Cantabria	Castilla-La Mancha	Castilla y León	Catalonia	Extremadura	Galicia	La Rioja	Madrid	Murcia	Navarra	Basque Country	Valencia
Andalusia	0	-94	195	-162	-1051	-354	-135	2871	197	-144	-371	-941	-105	-137	-520
Aragón	196	0	419	902	-796	-608	-1479	310	156	2296	-809	958	4705	-2350	-2189
Asturias	-1	-9	0	-353	-3	-29	-6	-2	838	-17	-4	-1	-27	-181	-2
Cantabria	22	-3	114	0	-44	-248	0	54	8	-11	-67	-18	-1	-79	-12
Castilla-La Mancha	1317	817	344	119	0	754	-473	1653	271	192	-1175	2554	149	115	2164
Castilla y León	429	2945	2079	4921	-1280	0	-1379	1601	1284	5505	-1792	327	4961	-1363	-393
Catalonia	101	1355	135	216	294	187	0	183	71	337	-413	337	583	358	628
Extremadura	-2311	-58	624	-547	-788	-1017	-19	0	510	-368	-300	-361	-158	-435	-329
Galicia	-9	-22	-1292	-400	-25	-324	-12	-27	0	-115	-34	-13	-96	-220	-13
La Rioja	6	-85	40	26	-3	-291	-29	31	47	0	-7	1	664	-23	-1
Madrid	4	23	13	19	230	62	8	59	9	2	0	19	0	12	24
Murcia	602	-220	10	11	-228	-18	-300	31	8	-72	-35	0	-131	-38	-763
Navarra	18	-287	218	415	-67	-173	-274	28	34	-3339	-86	34	0	-937	-101
Basque Country	11	16	0	1	-17	109	0	27	16	153	-42	4	74	0	-5
Valencia	29	1143	51	156	-281	114	-203	44	27	586	-131	534	595	354	0

Source: Own elaboration

Table 4 shows that downstream effects (61.1%) are greater than upstream effects (38.9%). The average value and the asymmetry coefficient are also positive. Thus, we can conclude that regional spillover interaction points in the direction of territorial cohesion. This conclusion is similar to the one previously obtained in the literature. It is also coherent with the asymmetric behaviour of accessibility when this is studied by a gravity economic potential indicator (Figure 4). Bruinsma and Rietveld (1998) and Gutiérrez (2001) showed that when there is an improvement in the transport connection between two regions, the less accessible region is the one which is more favoured by this improvement as larger markets are closer to the latter region.

Table 4. Accessibility regional spillovers: Up- and downstream effects

Average	106.2
Median	-0.1
Standard deviation	995.7
Coefficient of variation	937.7
Coefficient of asymmetry	2.3
Maximum	5505
Minimum	-3339
Downstream effects	61411.1 (61.1%)
Upstream Effects	-39113.7 (38.9%)

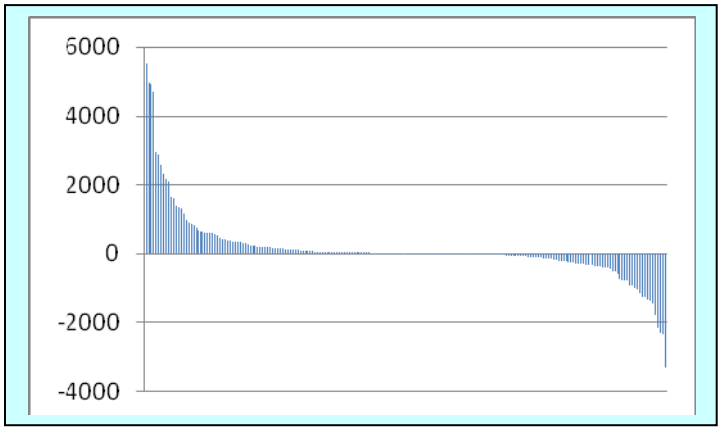

Figure 4. Distribution of accessibility regional spillovers: Up- and downstream effects

6. Summary and Conclusions

The notion of territorial cohesion was clearly established at the European level after its appearance in the proposed EU Constitution. In Spain, the PEIT recognized the necessity of reducing the gaps in opportunity among all the regions, bringing the outlying parts of the Spanish territory closer to the central backbone of the nation (Madrid-Barcelona-Valencia).

The Third Cohesion Report was the first attempt to shed some light on and extend the concept of territorial cohesion beyond the borders of social and economic cohesion. Hamez (2005) concluded that territorial cohesion studies should treat this concept broadly and should not be reduced to the analysis of the regions facing economic weaknesses or specific geographical limitations.

In this paper, we have used the suggestions proposed by Hamez in our extraction method in order to analyse the state of territorial cohesion in Spain after implementation of the transport

master plan in 2020. We have studied how the interaction of regional spillovers affects territorial cohesion, measuring it by the gains in accessibility. Two characteristics of Hamez's recommendations are part of our methodology:

- A territorial dimension (815 transport zones) has been used to measure both accessibility gains with respect to the status quo scenario - no plan - for 16 different scenarios (extraction method for each region and the whole plan) and to what extent the regional spillover is part of downstream effects.
- A temporal dimension has been used out of concern not just with present disparities but also the likely changing relative situation. In this case, we have studied the temporal dimension, comparing the present situation (ex-ante without any investment of the plan), the likely changing relative situation produced by the whole transport master plan (ex-post scenario) and 15 individual regional situations without foreseen investments.

To calculate regional spillovers derived from the PEIT 2005–2020, we employ the familiar extraction method to estimate region-specific spillovers, which are based on the comparison of the accessibility gains for all the scenarios listed in item 2 above. This approach allows us to estimate the marginal contribution for each region. Our empirical results, obtained from using a more general regional approach based on accessibility measures suggest, that regional spillovers account for a significant figure in all the cases.

The analysis of the partial scenarios for each region (the extraction method) has shown that regional cohesion for all the hypothetical scenarios is improved when the comparison is done with respect to the ex-ante scenario – no plan. If the investments in infrastructure could not be built in a particular region, regional cohesion would be improved by the rest of the investments. However, this situation is not so uniform when the comparison is done with respect to the scenario of the complete PEIT. It is not surprising that extraction scenarios favouring the most accessible territories are better in terms of equity for their respective regions.

We have shown that downstream effects (61.1%) are greater than upstream effects (38.9%). We also conclude that regional spillover interaction points in the direction of territorial cohesion. This conclusion is similar to the one which was obtained by the analysis of disparities on accessibility for all the different scenarios.

Although our results on regional spillovers are interesting in themselves, they may be used to show why previous literature has been so elusive, partly due to the difficulties behind models that treat regional spillovers as the effects of public capital with aggregated variables at the regional level. This literature has typically failed to affirm the importance of regional spillovers. This oversight is explained by the fact that past research has largely ignored or confounded spillover effects. Indeed we suggest that for future research, GIS technology can be used to overcome some of the difficulties of previous works, which are based on the lack of good and reliable data.

On a different level, promising future research on regional spillovers and territorial cohesion can address the role of the demarcation area, the size of transport areas and the parameter used in the impedance function of the gravitational model to explain robustness or differences of results.

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