Riccardo Crescenzi, Marco Di Cataldo and Andrés Rodríguez-Pose

Government quality and the economic returns of transport infrastructure investment in European regions

Article (Accepted version) (Refereed)

Original citation:
Crescenzi, Riccardo, Di Cataldo, Marco and Rodríguez-Pose, Andrés (2016) Government quality and the economic returns of transport infrastructure investment in European regions. Journal of Regional Science . ISSN 0022-4146
DOI: 10.1111/jors.12264

Government quality and the economic returns of transport infrastructure investment in European regions

Riccardo Crescenzi, Marco Di Cataldo and Andrés Rodríguez-Pose

Department of Geography and Environment, London School of Economics

Houghton St.,London WC2A 2AE, UK.

E-mails: r.crescenzi@lse.ac.uk; m.di-cataldo@lse.ac.uk; a.rodriguez-pose@lse.ac.uk

Please cite as: Crescenzi R., Marco Di Cataldo, M. and Rodríguez-Pose, A. (2016) Government quality and the economic returns of transport infrastructure investment in European regions, *Journal of Regional Science,* DOI: 10.1111/jors.12264

Abstract

Transport infrastructure investment is a cornerstone of growth-promoting strategies. However, the link between infrastructure investment and economic performance remains unclear. This may be a consequence of overlooking the role of government institutions. This paper assesses the connection between regional quality of government and the returns of different types of road infrastructure in the regions of the European Union. The results unveil the influence of regional quality of government on the economic returns of transport infrastructure. In weak institutional contexts, investment in motorways – the preferred option by governments – yields significantly lower returns than the more humble secondary roads. Government institutions also affect the returns of transport maintenance investment.

Keywords: Transport infrastructure, Public capital investment, Economic growth, Institutions, Government quality, Institutions, Regions, Europe

JEL classification: O43, R11, R40, R58

Acknowledgements

This is the revised version of the 3rd Annual *Journal of Regional Science* Special Session paper. The session was held at the 61st Annual North American Meetings of the Regional Science Association International in Washington, D.C, and the presentation of the paper was delivered by Andrés Rodríguez-Pose. We are grateful to Janet Kohlhase, who acted as the discussant for this paper in the session. We would also like to acknowledge the role of the editor in charge, Mark Partridge, and of four anonymous referees in providing challenging, but very useful suggestions during the reviewing process. Multiple suggestions by participants in seminars, workshops, and conference presentations in Ankara, Barcelona, Bialystok, Beijing, Brussels, Heidelberg, Kosice, Las Palmas de Gran Canaria, Palermo, Madrid, Tampa, Utrecht, Warsaw, and Washington, D.C. All errors and omissions are our own.

Generous funding by the European Research Council under the European Union's Seventh Framework Program (FP7/2007-2013)/ERC grant agreement nº 269868 and under the European Union's Horizon 2020 Program (H2020/2014-2020) Grant Agreement nº 639633-MASSIVE-ERC-2014-STG is gratefully acknowledged.

1. INTRODUCTION

Infrastructure investment has always been considered key for economic growth and has been one of the cornerstones of regional development strategies in the European Union (EU) and elsewhere. So intense has the focus on infrastructure been that formerly lagging regions have become leaders in transport infrastructure endowment. After 20 years of intensive European investment in transport infrastructure, Spain had the largest motorway network among the first 15 members of the EU, while Portugal leads in kms per GDP. The United Kingdom came last in the latter two rankings.

However, whether efforts to promote greater economic, social and territorial cohesion by developing new transport infrastructure have delivered the expected economic results has come under considerable scrutiny. Recent scholarly literature has underlined that the returns of transport infrastructure investment have been more limited than that of expenditures in other development axes, such as human capital and innovation (Rodríguez-Pose and Fratesi, 2004; Crescenzi, 2005; Crescenzi and Rodríguez-Pose, 2012). But why this is the case is still unclear.

One possible explanation posits that changes in accessibility deriving from new roads may benefit the economic core at the expenses of the periphery. This concept has been popularized in recent years by New Economic Geography (NEG) theories (Puga and Venables, 1997). A different possibility, which we explore in this paper, is that the returns of infrastructure investment are mediated by the quality of regional government institutions co-responsible for ensuring the selection and realization of specific projects. The local institutional environment in which investments are made will affect the scale and type of new infrastructure investments and, consequently, their economic returns. Poor institutions enhance the opportunities for private gain at the expense of a sound provision of public goods (Acemoglu and Dell, 2010). In weak government quality conditions new investment in transport infrastructure may respond more to political and individual interests than to economic and collective ones (Crain and Oakley, 1995; Henisz, 2002). Institutional failure is at the heart of a greater propensity to finance ‘flagship’ and large-scale transport projects (i.e. motorways, high-speed rail), more appealing to incumbent politicians seeking re-election (Rodríguez-Pose, 2000; Cantarelli et al., 2010), at the expense of less flashy ‘ordinary’ transport investments (i.e. secondary roads, freight railways). It may also lead to a more prominent role of political and business pressure groups, resulting in problems such as collusion at tender-stage, misrepresentation of costs and benefits and of the time needed for implementation (Kenny, 2007; Flyvbjerg, 2009; World Bank, 2011).

The role of institutions and of government quality as mediators of the returns of public policy – while increasingly acknowledged (e.g. Tanzi and Davoodi, 1997; Esfahani and Ramírez, 2003) – has seldom been proven empirically. To our knowledge, there are no analyses which have examined the triple link between quality of government, infrastructure investments, and economic growth for the European regions. We address this gap by analyzing the influence of transport infrastructure on economic growth both independently and in interaction with specific institutional characteristics. Our main hypothesis is that investing in transport infrastructure in poor or inadequate local government institutional conditions can seriously undermine the returns of the investment.

We use the annual variation in the network of motorways and in all other regional roads as our proxy for transport infrastructure investment. Investing in these two infrastructure categories implies significantly different levels of visibility, costs, and potential economic returns. While additional investment in motorways requires a larger financial effort and often aims to improve inter-regional connectivity, investment in other roads tends to be substantially cheaper and generally target local bottlenecks and the strengthening of internal mobility within a region. Similarly, investments in new infrastructure may be preferred to the maintenance of existing infrastructure. Hence, in areas with a weaker quality of government, where the interests of individual actors may prevail over those of society as a whole, motorways – with their greater political visibility and greater corruption opportunities –. may be regarded as a more attractive option than secondary roads or road maintenance expenditure.

We test our hypotheses on a sample of 166 EU regions during the period 1995-2009. Our estimation method (panel fixed effects) controls for unobservable time-invariant regional features and time-specific common shocks, as well as for the key time-varying regional growth determinants, such as innovation capacity, human capital and industrial structure.

The results of the analysis provide little evidence of a positive correlation between regional investments in motorways and economic growth, even if associated with better regional government institutions. In contrast, variations in the endowment of other roads display a stronger connection with regional economic performance in regions with higher quality regional governments. Also the maintenance of transport infrastructure is positively associated with economic growth only in regions with sound government institutions.

2. INFRASTRUCTURE, INSTITUTIONS AND ECONOMIC GROWTH

2.1 Infrastructure and economic growth

A minimum level of public capital investment is essential for economic activity (Button et al., 1995). Infrastructure promotes local accessibility and leads to improvements in the provision of services, to reductions in production costs, to enhanced productivity (Biehl, 1991; Moreno et al., 1997), and to the relocation of economic activity, facilitating economic growth. However, once a necessary basic threshold of infrastructure provision is reached, the impact of additional public investment remains uncertain. A recent report claims that all OECD countries are already beyond that threshold and that additional road expansions will have limited effects on economic performance (OECD, 2009a). Timing is also crucial, as the returns to infrastructure investment tend to be positive when new roads are built, but the positive impact fades away for incremental expansions of existing transport connections (Fernald, 1999).

The notion of a positive linear effect of transport infrastructure investment on aggregate productivity (Aschauer, 1989; Munnel, 1990) has also been strongly challenged by subsequent economic research, both for the US (Holtz-Eakin, and Schwartz 1995; Kelejian and Robertson, 1997) and Europe (Cappelen et al., 2003; Crescenzi and Rodríguez-Pose, 2012). In the case of Europe, single country analyses (Cadot et al., 1999; Stephan, 2000), as well as cross-country investigations (Cappelen et al., 2003; Crescenzi and Rodríguez-Pose, 2012) report much lower elasticities than those found by Aschauer (1989) or even insignificant coefficients.

The explanations as to why the returns of additional investments in infrastructure have not lived up to expectations vary. Some contributions have analyzed the dynamic response over time of regional GDP to public spending in transport infrastructure.

From this perspective, improvements in transport networks represent powerful growth stimuli only at specific moments, but have limited effects in other time periods. Leduc and Wilson (2012) demonstrated that motorway investment in US States had no impact on economic growth while road constructions were underway, an effect which became positive once the new infrastructure became operational. Other studies have shown, however, that most positive growth effects are short-lived. The connection between infrastructure and regional growth in Europe tends to vanish two or three years after it becomes available (Crescenzi and Rodríguez-Pose, 2008; OECD 2009b).

The differential impact of public capital on productivity, wages and employment has also been the center of attention. According to Dalenberg and Partridge (1997), public capital serves as a household amenity that increases labor supply with no impact on productivity. In their view, the weak productivity of US highways is explained by the fact that households may be willing to accept lower wages to live in places where infrastructure is more developed. In this case, the amenity effect may dominate the productivity effect, meaning that infrastructure investment has little or no effect on growth.

Diverse conditions across different types of regions may also affect the returns of infrastructure (Fujita and Thisse, 2002). In particular, NEG analyses have focused on the role of different types of roads. Puga and Venables (1997), Puga (2002) and Ottaviano (2008) have distinguished between the economic effect of long-distance inter-regional transport infrastructure, which affects overall 'accessibility' and provokes further economic concentration, and short-distance or intra-regional infrastructure, that generally facilitates the diffusion of public services and the formation of human capital within peripheral regions. Studies outside the NEG framework focusing on core-periphery differences in factor endowments have reached similar conclusions (Vickerman, 1995; Cappelen et al., 2003; Rodríguez-Pose and Fratesi, 2004).

2.2 Governance and infrastructure investment

One crucial factor behind the returns of transport infrastructure which has so far attracted limited attention is linked to the institutional conditions in each territory. The system of incentives and constraints shaped by local institutions and the efficiency of the local political administration influence the total returns to investment in transport infrastructure (Crain and Oakley, 1995; Henisz, 2002; Acemoglu and Dell, 2010). Political and institutional factors may influence both infrastructure spending and its economic returns at every phase of the investment (Esfahani and Ramirez, 2003). From the planning and selection of transport projects to their implementation, the characteristics of the local governance system play an important role in determining future efficiency. The link between transport infrastructure investment and the planning system, the need for large budgets, the high number of actors involved, and the difficulty in applying effective control mechanisms make the transport sector particularly vulnerable to political interference (Wachs, 1989; Flyvbjerg, 2009; Cantarelli et al., 2010), corruption (Tanzi and Davoodi, 1997; 1998; Kenny, 2006), and collusion (World Bank, 2011). The quality of local institutions determines the risk of moral hazard and, consequently, the capacity of decisions on infrastructure investment to deliver.

In the following subsections, we develop the conceptual and theoretical arguments at the base of our hypothesis at each stage of the infrastructure building process and posit that the economic returns of transport infrastructure investments are deeply affected by the presence of deficient governance. We integrate some significant case-studies drawn from the European context in the discussion.

Investment planning and project selection: political economy factors inflating transport investment

Inadequate political institutions may negatively affect the economic returns to transport infrastructure investment well before the money is actually spent. Governments are directly responsible for appropriate infrastructure planning and rigorous project selection, making transport infrastructure planning and financing fundamentally a political topic. In theory, decision-makers should base their decisions on rigorous cost-benefit considerations. However, decision-making on new transport investment in European countries is “generally politicized, rarely fully transparent, and there is little ex-post analysis on whether projects and policies meet expectations” (Short and Knopp, 2005: 363). Even when the investment is preceded by ex-ante impact studies, the secrecy which frequently surrounds forecasting methods does not guarantee the absence of deliberate cost-benefit misrepresentations (Wachs, 1989; Short and Knopp, 2005; Cantarelli et al., 2010). Incumbent planners may “purposely spin scenarios of success and gloss over the potential for failure" (Flyvbjerg, 2009: 350) of transport projects in order to strengthen their own political positions.

Infrastructure investment is very tangible and highly visible providing policy-makers with excellent opportunities for ribbon-cutting before elections with political considerations prevailing over solid economic valuation (Cadot et al., 2006). Vested political and economic interests can influence the activity of local administrations in weak institutional contexts, making the promotion of new large infrastructure projects preferable from a political perspective to investing in the maintenance of the old transport network or to the promotion of alternative, less 'glitzy' projects (Tanzi and Davoodi, 1997; Kenny, 2007). Special interests and pork-barrel politics can drive infrastructure investment decisions at the expense of social welfare and economic efficiency (Cadot et al., 1999; Kemmerling and Stephan, 2008). In addition, mega-projects are riskier, due to long planning horizons, and more susceptible to cost miscalculations (Flyvbjerg, 2009): collusion and clientelism may also play an important role in this context (Cadot et al., 2006).

Examples of political interest and/or weak local institutions leading to suboptimal infrastructure developments are plentiful. Many of those examples can be found in Spain. Substantial investments in motorways in the 1990s drove the catching-up process in transport infrastructure endowment. Yet, investment in infrastructure increased even further in the 2000s, when the road deficit relative to the countries in the core of Europe no longer existed (Bel, 2010). The wave of investment in motorways before the start of the crisis was mostly realized through toll road concessions that set favorable conditions for private groups (Acerete et al., 2009). The Spanish entrepreneurial sector threw its considerable economic weight in order to inflate investments in new roads, investments which were seldom – if ever – preceded by accurate cost-benefit analyses and by the drafting of financial and economic long-term plans (Bel, 2010). The resulting roads often became 'white elephants' of questionable economic and public utility (Bel, 2010). Such is the case of the toll motorway connecting Madrid and Toledo (AP-41), inaugurated in 2006 with a forecasted traffic intensity of over 25,000 vehicles per day. The actual figures have been nowhere close,[1] as the new motorway has not been able to divert enough traffic

[1] According to an official report from the 'Ministerio de Fomento' of Spain (available at: www.fomento.es/BE/?nivel=2&orden=06000000), the maximum number of daily vehicles was

away from its ‘competitor’, the pre-existing toll-free Madrid-Toledo motorway. The Spanish high-speed railway network can also be considered a rich source of ‘white elephants’ (Albalate and Bel, 2012).

Another highly controversial project is the ‘Vasco da Gama’ bridge in Lisbon (Portugal), which opened to traffic in 1998 and is the longest bridge in Europe. It is the second bridge over the river Tagus, built in theory to alleviate the highly congested ‘25 de Abril’ bridge. The project was financed using government grants, private resources, loans from the European Investment Bank and the Cohesion Fund, with the EU being the main contributor. The project was strongly promoted by the Ministry of Public Works of Portugal, supported by 17 municipal governments of the Lisbon metropolitan area and quickly approved by the European Commission, despite a dedicated commission identifying at least two other alternative and cheaper river crossings connecting more densely populated areas (Bukowski, 2004; Painvin, 2009). Partially as a result of its location the bridge failed to live up to expectations (Melo, 2000; Painvin, 2009). The estimated traffic of 132,000 daily vehicles never materialized, and in the first term of 2013 traffic across the bridge only reached 50,000 vehicles daily (IMT, 2013). The political desire to build the longest bridge in Europe and the need to spend European funds quickly prevailed over the necessity to reduce congestion in the city by using a more suitable alternative location for the project.

Investment planning and project selection: lack of resources, corruption and collusion

Superfluous or wrongly planned infrastructure investment may also be the result of inadequate policy-making and scarce economic resources. In cases when the responsibility for investment planning is decentralized, regional and local authorities may lack sufficient financial leverage to implement investments with higher returns. If political decentralization is not matched by an adequate devolution of economic power, financial instability and coordination problems may arise. In Italy, for example, the 2001 constitutional reform transferred a large share of responsibility for the programming, planning, and managing road development to the regions. However, Italian regional governments have never had sufficient financial resources to properly exercise this role (Casadio and Paccagnella, 2011). As a consequence, the regions have either been forced to further decentralize powers to the provinces or to create

reached in 2008 with 2,800. The number of users has declined since then. The average for the first six months of 2013 was 1,300.

new *ad hoc* organizations for the management and realization of road investments (Marangoni and Marinelli, 2011).

Next to a lack of financing capacity, local corruption is also one of the main factors behind the inefficient planning of public capital spending. In competitive auctions economic efficiency is best ensured when infrastructure projects are contracted to the companies presenting the best bid. This process requires a great degree of transparency. However, the auctions' outcome is often perverted by corruption and collusion. In weak institutional environments bribery can lure government officials to select suboptimal bids or, in cases of limited contractors, collusion may be the outcome.

Several studies have documented the existence of cartels controlling construction bids in European countries. A 2002 enquiry unveiled frauds, unjustified subsidies and bribery of vast proportions from a state-corporate network monopolizing the construction sector in the Netherlands (Van der Heuvel, 2005). In Italy the responsibility for managing auctions[2] on highway and roads concessions belongs to the regions, with construction companies often lamenting a supposed lack of neutrality in the award of contracts. In the South of the country at least one third of projects are contracted to firms with close links to the awarding administration (Bentivogli et al., 2011). Corruption and collusion in the transport sector are severe in many Eastern European countries as well (Kenny, 2006). In Romania a cartel of firms used to raise the price of road construction tenders by up to 30 percent over their market equilibrium level (Oxford Business Group, 2004). Numerous cases of pre-defined tender prices have also emerged in Slovakia (OECD, 2006) and Poland (Cienski, 2013).

Project implementation: cost overruns and delays

Cost overruns and delays tend to be the norm in the implementation of transport infrastructure projects in weak institutional contexts. According to Flyvbjerg et al. (2005), an underestimation of the total costs of large-scale infrastructure projects happens nine out of ten times with cost overruns in road projects on average 20 percent above initial predictions. Political-economic factors are generally regarded as

[2] The national level is responsible for a few projects of national relevance (*grandi opere*), while the regional level manages all other auctions.

the main explanation for cost overruns (Cantarelli et al., 2010). In areas with weak institutions and governance systems, political and economic interest groups often voluntarily misrepresent the costs and benefits of a project in order to facilitate its approval.

Increases in the total costs of infrastructural projects may be also related to distortions taking place at the moment of their execution. Legal disputes – often resulting from clashes between local authorities and the company implementing the infrastructure – can cause severe delays. Finally, additional time and cost overruns can be originated by the incapacity of legal institutions (either national or local) to enforce the project's procurement contracts, and by the lack of appropriate bureaucratic structures monitoring the execution of works.

Such conditions are more prevalent in areas where rent-seeking and/or the presence of organized crime abound. These endemic situations may help transform what initially appear to be feasible projects into 'white elephants', as was the case of the renovation of the Italian 'A3' motorway between Salerno and Reggio Calabria. Works began in 1997 and, at the time of writing, are still underway. Meddling by organized crime – attested by the National Anti-Mafia Commission – together with lengthy court disputes have made costs skyrocket, with the Italian State providing compensation of over 300 million Euros to the private contractors for 'unpredicted costs' (Turano, 2011).

2.3 Infrastructure investment in the periphery

Political meddling, delays, and unexpected cost overruns are frequently much more serious in the European periphery than in the core. As indicated by Charron et al. (2014), government quality in most regions of the European periphery is well below par. Many of the regions in the periphery of Europe have limited experience in project planning, monitoring and evaluation, along with greater problems of corruption, lack of transparency and accountability, inefficient rule of law and, last but not least, low government effectiveness. These conditions are perfect for the prevalence of political and/or individual criteria over economic and/or collective ones when designing, implementing, and exploiting infrastructure projects.

The impact of infrastructure projects in peripheral regions suffers as a result. Political instability, weak accountability, and ineffective governments limit the impact of infrastructure (Crain and Oakley, 1995; Henisz, 2002; Esfahani and Ramirez, 2003), whereas lobbying and corruption inflate expenditures in publicly funded projects (Tanzi and Davoodi, 1997; World Bank, 2011). This is particularly the case of large-scale transport projects that are politically appealing but have the effect of worsening the financial burden of a region, increasing the risk of a default. This risk becomes more serious if corruption is widespread. In these circumstances, the financing of debt is more costly and public investment projects less productive (Ciocchini et al., 2003; Ahlin and Pang, 2008).

Institutional and government failures – more prevalent in peripheral areas – are therefore likely to emerge as barriers for the transformation of transport infrastructure investment into new economic activity and development. However, despite the salience of local institutions and government quality in determining how infrastructure shapes economic performance, only a limited number of empirical studies have attempted to assess the effect of institutions on the economic returns of infrastructure. Research by Tanzi and Davoodi (1997) and Esfahani and Ramirez (2003) uncover a positive role of institutional quality on economic growth, acting through the channel of more efficient and productive investments in infrastructure. These analyses are, nevertheless, conducted at a national level, with no focus on how the quality of regional government shapes the returns of transport infrastructure investments in the regions of Europe.

3. EMPIRICAL MODEL AND REGRESSION RESULTS

3.1 Model specification and data

The aim of the empirical analysis is to test whether the quality of regional government shapes the returns of infrastructure across the regions of Europe. Different typologies of transportation investment are considered. We distinguish between variations in the endowment of motorways and of other regional roads, assuming that this distinction would also reflect a set of structural differences in the investment based on political preferences for different types of roads, the financial effort required to implement them, as well as their potential association with economic growth. The influence of institutions on transport infrastructure is modelled through the inclusion of an interaction term between our two proxies for investment in roads and the regional quality of government. The model takes the following form:

$$\Delta\ln y_{i,t} = \alpha \ln y_{i,t-1} + \beta \Delta\, \boldsymbol{Infr_{i,t}} + \gamma\, \boldsymbol{QoG_{i,t}} + \delta(\Delta\, \boldsymbol{Infr} \times \boldsymbol{QoG})_{\boldsymbol{i,t}} + \eta\, X_{i,t} + \theta_i + \tau_t + \epsilon_{i,t} \quad (1)$$

Where the dependent variable $\Delta \ln y_{i,t} = \ln y_{i,t} - \ln y_{i,t-1}$ is the annual change of the natural logarithm of GDP in region *i* (i.e. the logarithmic approximation of the annual regional growth rate). $y_{i,t-1}$ is the annual lagged level of regional GDP. The main variables of interest in the model – marked in bold – are the growth rate of the regional stock of transport infrastructure, the regional Quality of Government (QoG) index (Charron et al., 2011), and the interaction term between these two variables. $X_{i,t}$ is a vector of independent variables as controls, θ_i are regions-specific unobservable fixed effects, τ_t are year dummies, and $\epsilon_{i,t}$ is the error term. $\alpha, \beta, \gamma, \delta, \eta$ are the parameters to be estimated.

Given the absence of comparable data on regional expenditure for transport projects across countries, we use change in the regional endowment of road infrastructure as our proxy for infrastructure investment. The number of kilometers of roads normalized by thousand inhabitants is our indicator of infrastructure. Crescenzi and Rodríguez-Pose (2012) show that results of growth models assessing the effect of roads infrastructure remain substantially unaltered if alternative standardizations are employed – e.g. kilometers of road divided by regional GDP or by squared kilometers of land. The variable in first difference is assumed to reflect the regional variation in roads resulting from successfully completed new infrastructural investments.

Our variable accounts for all completed and fully functional infrastructure projects that can influence regional economic activity. However, being a measure of the *ex-post* outcome of the investment, it cannot account for time overruns in project construction or for financial waste from unfinished projects. More importantly, it does not capture all investments in road maintenance and improvement, which represent about 30 percent of total transport infrastructure investment in European countries during the 1995-2009 period (OECD, 2011). For this reason, an extension of our work considers a more complete model including a proxy for maintenance investment, only available, however, at the national level.

In order to assess the role of local institutions on transport investment, we interact our infrastructure proxies with the Quality of Government (QoG) index, a survey-based indicator of government quality in European regions compiled by the Quality of Government Institute at the University of Gothenburg in 2009. The index was built on the basis of questionnaires gauging the quality and impartiality of public services and the perception of corruption by local citizens. Responses to the survey have been aggregated at the NUTS1 or NUTS2 level for the EU-27. In a later work, Charron et al. (2014) have extended the QoG index to a longer time-span by integrating it with the World Bank Governance Indicators (WBGI) (Kauffman et al., 2009), identifying in this way four different dimensions of government quality corresponding to the WBGI categories, namely control of corruption, government effectiveness, rule of law, and government accountability.

We make use of the classification by the European Statistical Office (Eurostat) of regional roads into 'motorways'[3] – all dual carriageway roads – and 'other roads' – all other state, provincial, and communal roads. Motorways are more visible, costly to build, and normally connect urban centers across different regions. The development of local roads is much less politically glamorous and less likely to give rise to the same 'hub-and-spoke' effects as motorways.

The vector of controls $X_{i,t}$ includes a number of factors influencing economic growth. In line with the endogenous growth approach and, as customary in the scholarly literature, the model controls for innovation capacity, human capital, and labor market structure (OECD, 2009b; Crescenzi and Rodríguez-Pose, 2012; Parent and LeSage, 2012; Capello and Lenzi, 2014). Transport connectivity improvements determine the potential for a region to absorb and transfer new knowledge and ideas from/to other

[3] Eurostat defines a motorway as a "Road, specially designed and built for motor traffic, which does not serve properties bordering on it, and which: a) Is provided, except at special points or temporarily, with separate carriageways for traffic in two directions, separated from each other, either by a dividing strip not intended for traffic, or exceptionally by other means; b) Has no crossings at the same level with any road, railway or tramway track, or footpath; c) Is especially sign-posted as a motorway and is reserved for specific categories of road motor vehicles".

places. The capability of the regional economy to translate internal and external knowledge and innovation into economic growth, in turn, is deeply affected by the social and institutional conditions of the areas where economic activities take place (Cohen and Levinthal 1990; Fagerberg, 1994; Cooke et al., 1997;). The composition of the labor force, the level of skills, and the quality of regional governments determine the capacity of regions to remain competitive over time by making the best possible use of the available inputs (Rodríguez-Pose and Crescenzi, 2008; Rodríguez-Pose and Di Cataldo, 2015). We account for the main characteristics of the regional socio-economic environment shaping regional competitiveness by including three different control variables: a) the natural logarithm of the number of patent applications per thousand of regional inhabitants, as a measure of innovation capacity; b) the natural logarithm of the percentage of employed people with tertiary education, as a proxy for human capital availability; and c) the share of employed people in the primary sector as a proxy for the upgrading of local skills.

In addition, transport infrastructure investment affects economic performance beyond the geographical boundaries within which it takes place (Cohen, 2010). When a reduction in transport costs helps connecting economic activities with new markets and boost trade new transport infrastructure generates positive spillovers. When new transport connections lead to a loss of productive resources due to the emigration of skilled labor, the spillover effects become negative. We control for spillovers from infrastructure investment in neighboring regions with a spatial lag of the transport investment variable based on Euclidean distance.

All controls are extracted from the Eurostat Regio database for the period 1995-2009 (see Table A1 for the details and sources of the variables included in the analysis).

The study is performed on a sample of EU NUTS1 and NUTS2 regions determined by data availability. Having included in the model measures of regional government quality, we select for all countries the spatial scale with the highest political meaning and reflecting a real capacity to have an influence on infrastructure investment and maintenance decisions. We also consider the regional level with the greatest degree of autonomy for implementing infrastructure projects. This implies using NUTS1 regions for Germany, Belgium, and the United Kingdom and NUTS2 in the remaining countries: Austria, Czech Republic, France, Hungary, Italy, the Netherlands, Poland, Portugal, Romania, Spain, Sweden and Slovakia. The full sample covers 166 European regions. Data constraints (Greece, Denmark, Croatia, Bulgaria) or the absence of regional sub-divisions at the NUTS2 level (Lithuania, Latvia, Estonia, Luxembourg, Malta, Cyprus), or lack of sub-national variation in the QoG Index (Finland, Ireland), prevent us from covering remaining EU countries.

3.2 Descriptive statistics

Table 1 presents the stock of kilometers of motorways and other roads in all countries in the sample at the beginning and at the end of the period of analysis. Spain and Portugal were the countries that witnessed the greatest expansion in their motorway network (Table 1). These two countries already enjoyed some of the most extended motorway network in Europe in 1995. Spain was second only to Austria for number of motorway kilometers per inhabitant. Between 1995 and 2009, Austria and Spain followed very different roadbuilding strategies: while Austria favored the development of secondary roads, Spain invested in motorways. In 2009 Spain was the European country with the highest endowment of motorways per capita: 2.45 times the average of the countries in the sample. Portugal followed with 1.69 times above the average (Table 1). Other countries with significant investments in roadbuilding, such as France, followed a more mixed strategy, combining new investments in motorways and in secondary roads.

Overall, it is the European periphery where the bulk of the investment in motorways has taken place. Less developed regions have added around 1,400 kilometers more than regions of the EU core (Table 1). In more developed regions the transportation effort has been more geared towards secondary roads. Core regions have added more than 100,000 kilometers of secondary roads relative to peripheral regions during the period of analysis (Table 1).

Table 1 also shows the government quality score at the beginning and end of the period. Government quality worsened almost everywhere in Europe. The countries with the lowest endowment of infrastructure in 1995, i.e. Romania, Poland, and Czech

Republic for motorways, and Germany, Romania, and Hungary for other roads, have all seen their QoG score drop in recent times.[4]

[4] If the places that witnessed the greatest improvement in QoG over 1995-2009 were places that historically had low levels of infrastructure and are only now catching up, then the initial stock of infrastructure could be considered an omitted variable in our model, potentially biasing the coefficient of the QoG Index and of the interaction term. However, a lower level of infrastructure endowment at the beginning of the period does not seem to be associated with greater improvements in government institutions. The pairwise correlation coefficient between average QoG growth and infrastructure endowment in 1995 is negative and insignificant for motorways (-0.055) and positive for other roads (0.444).

TABLE 1: Stock of motorways and other roads at the beginning and at the end of the period – countries in sample

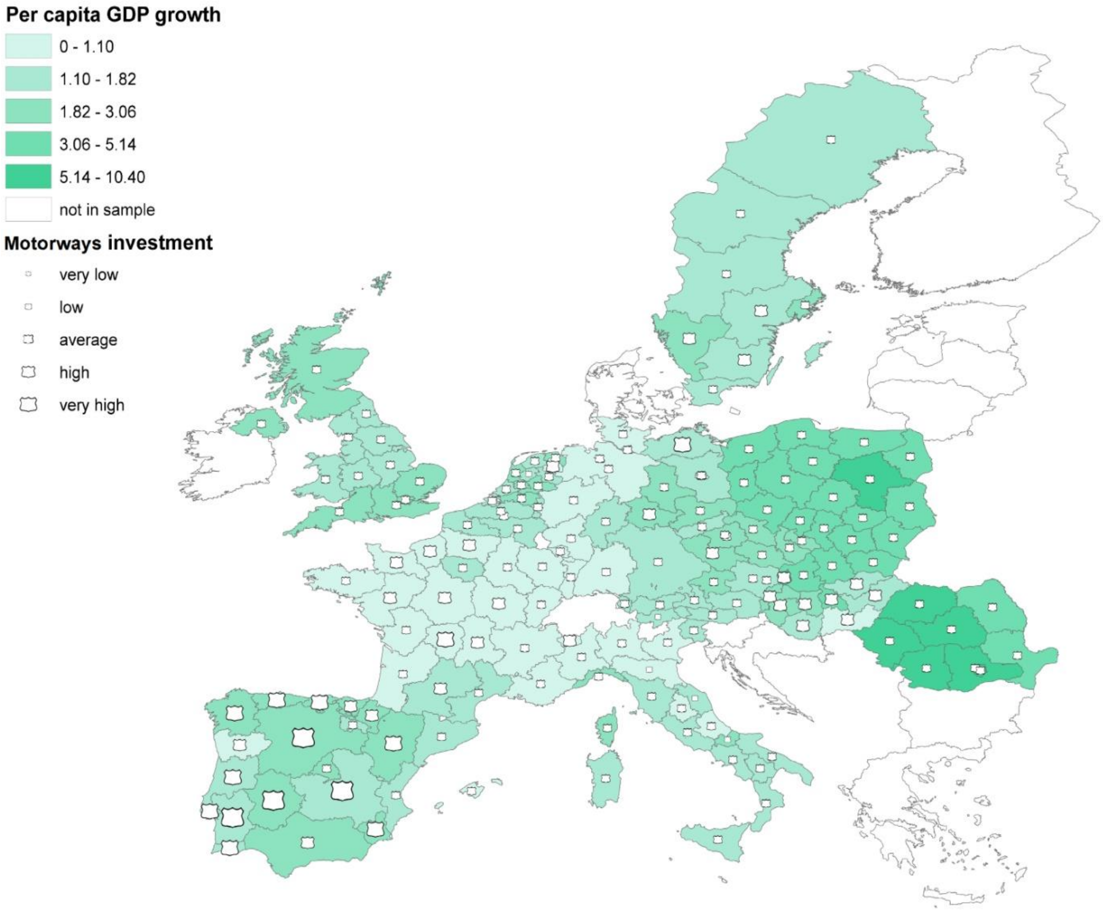
	Motorways					Other roads					QoG Index		
	kilometers			Per thousand inhabitants		kilometers			Per thousand inhabitants				
	1995	2009	Difference	1995	2009	1995	2009	Difference	1995	2009	1995	2009	Difference
Austria	1,589	1,697	108	0.224	0.236	105,193	108,509	3,316	12.61	13.41	1.059	0.975	-0.084
Belgium	1,665	1,764	99	0.135	0.134	139,575	141,901	2,326	11.63	11.59[a]	0.248	0.230	-0.019
Czech Republic	361	730	369	0.032	0.068	55,243	54,990	-253	5.39	5.22	-0.455	-0.510	-0.055
Germany	11,371	12,826	1,455	0.138	0.171	217,590	218,156	566	2.67	2.78	0.948	0.860	-0.088
Spain	6,790	13,806	7,016	0.220	0.402	151,443	147,088	-4,355	5.18	4.71	0.527	0.073	-0.455
France	8,275	11,163	2,888	0.158	0.212	948,963	1,031,114	82,151	21.50	21.67	0.372	0.452	0.080
Hungary	293	1,273	980	0.028	0.137	29,731	29,952[b]	221	3.33	3.41[b]	-0.392	-0.633	-0.241
Italy	6,473	6,661	188	0.159	0.171	159,066	173,946	14,880	5.92	4.57	-0.170	-0.947	-0.776
Netherlands	2,291	2,633	342	0.175	0.185	113,418	134,195	20,777	9.36[c]	10.21	1.183	1.215	0.032
Poland	303	849	546	0.008	0.021	372,233	383,981	11,748	10.65	10.96	-0.520	-0.789	-0.269
Portugal	671	2,705	2,034	0.100	0.278						0.585	0.132	-0.453
Romania	113	321	208	0.004	0.013	72,746	81,392	8,646	3.18	3.80	-1.758	-1.978	-0.220
Sweden	1,279	1,885	606	0.122	0.169	96,713	96,598	-115	15.96	15.41	1.173	1.412	0.239
Slovakia	219	400	181	0.051	0.088	42,388	43,489	1,101	7.25[d]	7.41	-0.954	-0.817	0.136
United Kingdom	3,422	3,674	252	0.058	0.059	407,628	416,002	8,374	7.83	7.60	0.917	0.689	-0.228
All regions	44,375	59,682	15,307	0.119	0.164	2,590,193	2,962,697[e]	372,504	9.72	10.01	0.262	0.061	-0.201
Less developed regions	10,911	19,295	8,384	0.065	0.125	800,276	931,945[e]	131,669	7.61	9.64	-0.257	-0.515	-0.258
More developed regions	33,464	40,383	6,919	0.160	0.190	1,789,917	2,030,752	240,835	11.25	10.26	0.642	0.480	-0.162

Notes: Less developed regions are all regions part of the 'Objective 1' program during 2000-2006; more developed regions are all regions not eligible for 'Objective 1' support; the values are sums in 'kilometers' columns and averages in 'per thousand inhabitants' columns. a / 2007 value. b / 2003 value. c / 1996 value. d / 1997 value. e / for Hungarian regions the sum is made using the 2003 value.

Source: own calculation with Eurostat and QoG Institute data.

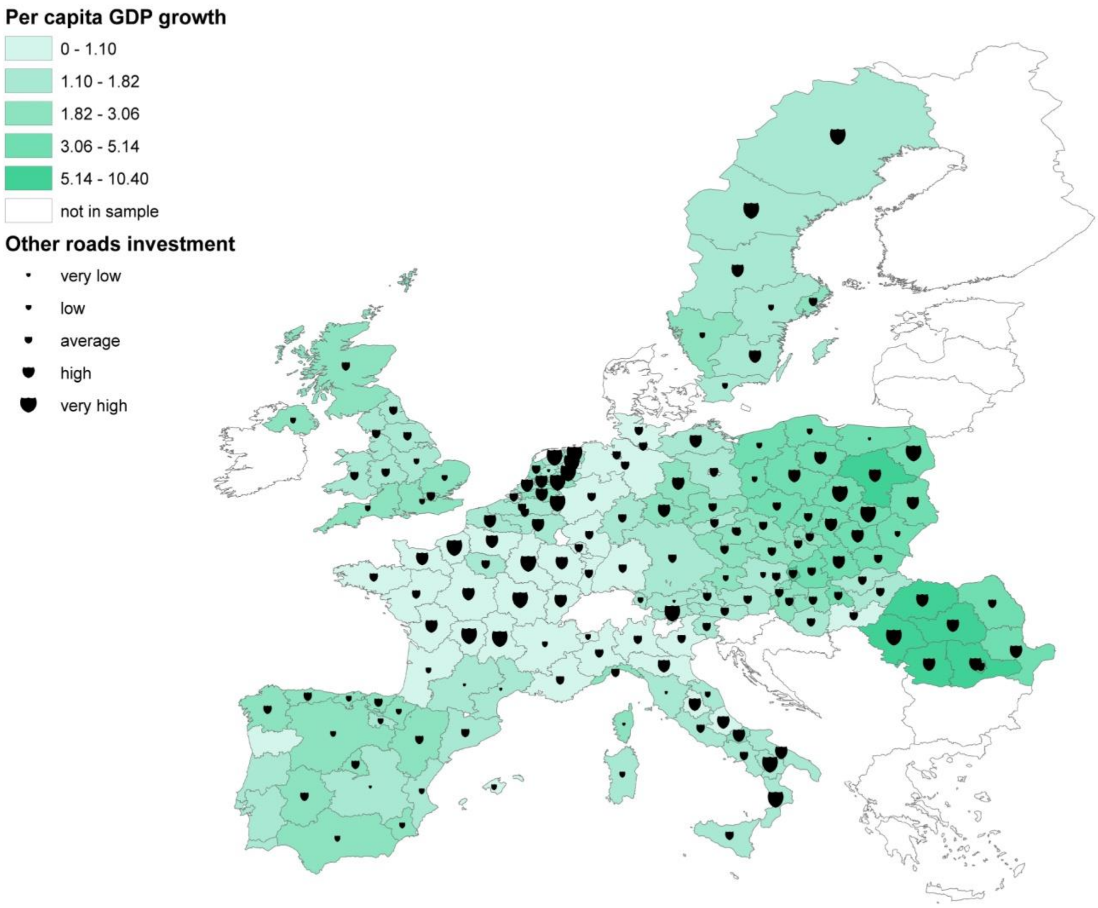
Figures 1 and 2 combine data on transport infrastructure investment with regional economic performance during the period of analysis. Regions are classified according to their average per capita growth rate between 1995 and 2009 and their investment in motorways and other roads respectively. The figures confirm that countries in the Iberian Peninsula recorded the largest increases in motorways, with Hungary following suit. Other regions, such as Limousin in France, Mecklenburg-Vorpommern in Germany, or Småland and the Islands or West Sweden, both in Sweden, also witnessed considerable expansions in motorway endowment (Figure 1). The greatest improvements in secondary roads took place in the Netherlands, Sweden, Poland, Romania, central France, and central and southern Italy (Figure 2). The highest growth rates took place in Central and Eastern Europe and fundamentally in Poland and Romania. The lowest growth happened in France, northern Italy, and western Germany (Figures 1 and 2).

FIGURE 1: Per capita GDP growth and motorways investment in the EU, 1995-2009



Source: own elaboration with OECD and Eurostat data

FIGURE 2: Per capita GDP growth and other roads investment in the EU, 1995-2009



Source: own elaboration with OECD and Eurostat data

3.3 Estimation issues and regression results

The empirical model specified in Equation (1) is estimated by means of fixed effects panel methods with the inclusion of time dummies. Clustered standard errors correct for possible problems of serial correlation and heteroscedasticity. The effect of spatial autocorrelation (i.e., the lack of independence among the error terms of neighboring observations) is minimized by introducing 'spatially lagged' variables among the controls that explicitly take into consideration the interactions between neighboring regions, thereby minimizing their effect on the residuals. The Moran's I test confirms the lack of spatial auto-correlation in the residuals. In the interpretation, we focus on the relative sign and significance of the key coefficients rather than trying to discuss specific point estimates.

Changes in motorway endowment as investment proxy are analyzed first, with the results presented in Table 2. The first column refers to a baseline specification including initial GDP per capita, a control for the regional population, region and time effects. In the following specification (column 2), additional regressors are included to control for other key determinants of regional growth, i.e. the share of employment in the agricultural sector, a measure of regional innovative capacity (patent applications per thousand inhabitants), and a proxy for human capital endowment (the stock of highly educated individuals in the region). The model is completed with a spatially-lagged variable controlling for transport investments in neighboring regions, obtained by weighting the infrastructure variable by means of a Euclidean distance matrix. In the first two specifications of Table 2 the QoG index enters the model in its original form, while in specifications reported in Table A6 in Appendix A it is de-composed into the four quality of government dimensions considered (control of corruption, rule of law, government effectiveness, and government accountability), in order to check if results hold as the governance elements interacted with infrastructure investment vary.

Infrastructure proxy: motorways

The baseline specification presented in Table 2 column (1) shows that both motorway investment and government quality are important drivers of regional growth. The significant and positive coefficient of infrastructure is in line with the neoclassical perspective emphasizing the centrality of public capital accumulation for explaining variations in aggregate productivity (Aschauer, 1989). However, when the model is completed with socioeconomic, educational, and innovation variables (column (2)) the coefficient of motorways investment sensibly reduces its magnitude and loses statistical significance. This is consistent with the hypothesis that development strategies centered on expenditure in new transport infrastructure may not be sufficient to stimulate the growth potential of every region (Vickerman, 1995).

The insignificant correlation between motorways investment and regional growth can be interpreted in different ways. If transport infrastructure is provided optimally in EU regions, the marginal returns of additional expenditures is equal to zero and new investment would have no effects on growth. Another potential explanation it is to assume that new motorway investment attracts individuals willing to accept lower wages to live closer to transport junctions (Dalenberg and Partridge, 1997). In the latter case, the wage decrease may offset any positive economic stimulus derived from the investment, hence determining a zero effect on total productivity. Alternatively, it may be that local development dynamics in some territories may depend less on the construction of new infrastructure and more on regional processes of knowledge generation, the presence of a highly-educated workforce, and socio-institutional conditions (Crescenzi, 2005; Crescenzi and Rodríguez-Pose, 2012). By contrast, the positive and significant coefficient of QoG is not altered by the inclusion of additional explanatory variables, meaning that the quality of regional institutions is strongly correlated to the economic success of European regions.

TABLE 2: Motorways investment, quality of government and regional growth, 1995-2009

Dep. variable: Change of log GDP	Full Sample		Less Developed Regions	
	(1)	(2)	(3)	(4)
Lagged GDP	-0.0302*** (0.0103)	-0.0940*** (0.0130)	-0.0422*** (0.0121)	-0.123*** (0.0201)
Investment in motorways	0.126** (0.0613)	0.0847 (0.0525)	-0.0286 (0.0917)	-0.0478 (0.0773)
Quality of Government (QoG)	0.0318*** (0.00500)	0.0346*** (0.00466)	0.0636*** (0.0107)	0.0603*** (0.00788)
Interaction term **Investment in motorways × QoG**	-0.118 (0.0856)	-0.0663 (0.0739)	-0.184 (0.146)	-0.110 (0.103)
Spatial Weight of investment in motorways		0.784*** (0.162)		0.409** (0.187)
Agricultural employment		-0.00285*** (0.000648)		-0.00292*** (0.000829)
Patent applications		0.00657*** (0.00171)		0.00748*** (0.00279)
Human capital		0.0158*** (0.00469)		0.0417*** (0.0102)
Regional population	-4.46e-05*** (1.21e-05)	-1.53e-05** (7.52e-06)	-3.83e-05* (2.06e-05)	1.14e-06 (1.12e-05)
Region Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Observations	2,293	2,269	960	936
R^2	0.377	0.458	0.361	0.449
NUTS regions	166	166	70	70

Notes: Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Higher scores in the QoG index or its components (see Table A6 in Appendix A where estimates for the individual components of the index are reported) are, however, not associated with increases in the productivity of new motorways. In all specifications the coefficient of the interaction term is not statistically different from zero at the 10 percent significance level. Therefore, while a more effective, accountable and transparent regional government is pivotal in the promotion of successful development policies, it may not suffice for translating new investments in motorways into higher growth. The spatially-weighted variable displays a positive and significant coefficient, implying that being surrounded by regions investing in new motorways generates network externalities which affect local growth positively. However, the results suggest that only some areas may be able to reap the advantages arising from the expansion of the motorway network, while other European regions may see their productive resources being lured away by new investments in motorways.

Peripheral, isolated, and less economically advanced regions are most at risk of losing out from the potential agglomeration of economic activity linked to motorways. Hence, in order to gain a better understanding of how peripheral economies respond to changes in transportation endowment and government quality, we replicate the estimation of the model on a restricted sample of less developed regions – defined as those that were part of the 'Objective 1' of the EU Structural Funds during the period 2000-2006. The less developed regions sample includes 70 NUTS 1 and 2 regions mainly from the Czech Republic, Hungary, Romania, Poland, Slovakia, as well as Eastern Germany, Southern Italy, Southern and Western Spain, Portugal, and Northern Sweden.

Columns (3) and (4) in Table 2 report the estimation results for the less developed sample. Restricting the sample to the regions receiving the bulk of EU Structural Funds can suggest whether financial resources for the promotion of territorial Cohesion among EU regions have been allocated efficiently (Crescenzi, 2009). For many years, the highest share of EU regional development funds was allotted to transport infrastructure (Rodríguez-Pose and Fratesi, 2004). However the belief that growth in peripheral regions is best fostered through investments in 'hard' transport infrastructure connecting isolated and remote areas with the European economic hubs is not supported by our empirical results. New investments in motorways in lagging regions have not been associated with higher levels of growth, as indicated by the negative and insignificant coefficient (column (3), Table 2). In addition, the negative and insignificant interaction term between new motorway investment and government quality highlights that higher investment in motorways is not significantly associated with regional growth, even if promoted by a relatively more efficient regional government.

Consistent with the hypothesis that lagging areas need to strengthen local socio-institutional development pre-conditions in order to stimulate their competitive advantages, column (4) in Table 2 indicates that social and structural factors – including human capital assets, innovation capabilities, and local government quality – are far more accurate predictors of regional growth that investments in motorways. All of these variables display a higher correlation with growth, indicating their importance in regions that, because of their peripherality, tend to be relatively less endowed with a skilled labor force, have a lower innovative potential,[5] and lack a well-functioning institutional system of governance.

Infrastructure proxy: other roads

We now re-estimate the model with the annual change in kilometers of other roads as our infrastructure proxy. As before, we reproduce the estimation first on the full sample of regions (columns (1) and (2), Table 3) and then on the smaller sample of less developed regions (columns (3) and (4), Table 3). The number of observations is reduced to 161 and 66 respectively, due to data availability issues for Portuguese regions. The presentation of the estimation output follows the structure of Tables 2 and is reported in Table 3, while results for the individual components of the QoG index are reported in Table A7 in Appendix A.

In the full sample – and, as was the case for motorway development – when we exclude control variables, infrastructure investments are positively and significantly correlated with economic growth (column (1), Table 3). This effect is, however, not robust to the inclusion of additional growth determinants in the model, providing no statistical evidence that an upgrade in the network of state, regional, and local roads

[5] These results suggest that growth-enhancing factors in lagging regions differ between Europe and the US. In contrast to the results for less developed European regions, the economic dynamism of US lagging areas seems to rely less than that of European regions on elements, such as the proportion of patent applications and the share of high-skilled employment (Stephens et al., 2013).

may independently act as an engine for growth (column (2), Table 3). Conversely, institutional quality is confirmed as a robust growth predictor (Table 3).

TABLE 3: Other roads investment, quality of government and regional growth, 1995-2009

Dep. variable: Change of log GDP	Full Sample		Less Developed Regions	
	(1)	(2)	(3)	(4)
Lagged GDP	-0.0252** (0.0101)	-0.0901*** (0.0140)	-0.0473*** (0.0138)	-0.129*** (0.0218)
Investment in other roads	0.00102** (0.000487)	0.000607 (0.000476)	0.00136 (0.00768)	0.000401 (0.000497)
Quality of Government (QoG)	0.0235*** (0.00484)	0.0246*** (0.00436)	0.0628*** (0.0109)	0.0595*** (0.00801)
Interaction term **Investment in other roads × QoG**	0.00157* (0.000829)	0.00234*** (0.000873)	0.00268** (0.0128)	0.00352*** (0.00118)
Spatial Weight of investment in other roads		0.00366** (0.00155)		0.00299 (0.00204)
Agricultural employment		-0.00352*** (0.000626)		-0.00339*** (0.000834)
Patent applications		0.00534*** (0.00180)		0.00753*** (0.00276)
Human capital		0.0136*** (0.00512)		0.0420*** (0.0134)
Regional population	-4.46e-05*** (1.21e-05)	-1.53e-05** (7.52e-06)	-3.56e-05* (1.78e-05)	5.04e-06 (8.77e-06)
Region Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Observations	2,158	2,134	889	876
R^2	0.387	0.472	0.383	0.472
NUTS regions	161	161	66	66

Notes: Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

As mentioned above, the direct effect of new ‘other road’ infrastructure may not be captured by the data because of how the investment variable is constructed. Another hypothesis, however, is that investments have been successful in some regions, but have had only a limited effect on the aggregate productivity of others. If this is the case, the coefficient of the investment variable may suggest that the resources governments allocated to productivity-enhancing projects were partly offset by interventions that ended up being wasteful and economically inefficient. As widely discussed in section 2, self-interested public officials may take investment decisions that do not represent socially and economically optimizing goals. A sound institutional environment where policy-makers are competent and averse to moral hazard behaviors sets the necessary conditions for transport projects to achieve economic success. The positive and statistically significant interaction term in all specifications of Table 3 suggests that investments in roads other than motorways, if associated with higher quality of government institutions, have a positive correlation with the economic performance of European regions.[6] This confirms that the economic returns from transport investments are conditional on a number of institutional factors including the transparency of the local administrations, a government's political and financial autonomy, the effectiveness of the judicial system, and the risk of corruption.

Our results show that the quality of regional governments may have an influence on the profitability of investments in other roads, but play little role in making motorways investments more productive. It may also be the case that regions with lower government quality and weaker institutions may prefer or – whenever they are not directly responsible for the funding – demand motorways as a more flamboyant, visible, and electorally-rewarding investment than secondary roads. In either case, the outcome is the same: no influence on economic growth. By contrast, regions with better government quality that put greater effort on the overall road network are rewarded by higher levels of growth.

Motorways also represent an important opportunity cost in development terms. Because of their cost, an emphasis in motorways tends to leave limited resources for other types of interventions. The upgrading of local roads, reinforcing the internal connectedness of a region, is generally cheaper and allows greater room for alternative (or complementary) interventions. Hence, the development of transport projects that are embedded in the local economic fabric and contribute to mobilize

[6] A different interpretation of the insignificant coefficient of investment in other roads may be that, at the margin, additional expenditures in secondary roads produce no effect on total output because the level of transport infrastructure in EU regions is already optimal. If this is the case, the positive and significant coefficient of the interaction term may imply that marginal returns are higher in regions with stronger governance because increases in the quality of government determine a more-than-proportional increase in total output. In other words, when investments in other roads are pursued in the framework of supportive institutions, they benefit from increasing returns to scale.

people, goods, and knowledge may truly bring about economic stimuli for all types of economies. When comparing the coefficients of the interaction term in Table 3, the positive effect of a mutual variation in other roads investments and government quality is higher for the sub-sample of less developed regions. This is certainly due to the higher importance of institutions for the economic development of lagging areas than in the core of Europe. These results point to the growth potential of well-targeted investments in secondary roads, which often tend to be disregarded by subnational governments, especially in those peripheral regions of Europe where the quality of government is well below the average.

The control variables maintain the sign and significance reported in the previous version of the model. The coefficients for patent applications and a highly-educated labor force in the less developed regions subset (column (4), Table 3) is higher than the one observed in the full sample, showing that innovative capacity and a good endowment of human capital are more crucial for economic growth in the periphery than in the core of Europe. Quality of government in the periphery of Europe is a far more accurate predictor of regional economic growth than investments in motorways.

Maintenance investment

So far the analysis has considered only the effect of new finished road infrastructure projects on growth. However, a large share (about 30 percent) of total infrastructure investment has been devoted to maintenance and improvements of existing transport networks. The proportion of expenditures for maintenance varies significantly across European countries. Areas where investment decisions have been highly politicized have had a preference for new infrastructure over maintenance spending, due to the higher political returns of newly created roads.

In this section we re-estimate the model including a control for investment in maintenance. In absence of data at the regional level, we resort to the OECD database, providing national-level statistics of annual expenditures for transport infrastructure maintenance subdivided by transport type. We consider two types of expenditures, total transport infrastructure and road maintenance,[7] normalized by

[7] These two variables are available for all countries in the sample, with exception of the Netherlands, Germany, and Spain in the case of total infrastructure maintenance, and Germany and Spain, in the case of road maintenance.

national GDP. As before, we interact the maintenance investment variables with the Quality of Government index, in order to test if the effect of maintenance spending on regional growth varies depending on the local quality of government.

The results of the extended model are presented in Table 4. Panel A (columns (1)-(4)) reports the estimates with the inclusion of total infrastructure maintenance, while Panel B (columns (5)-(8)) focuses on road maintenance. The coefficient of maintenance investment is always negative and, in the case of total transport infrastructure, statistically significant. Although this result may at first seem counter-intuitive, it may be related to the balance between the resources allocated to maintenance relative to new investments. Economists looking at the impact of these two types of investment on growth have argued that a minimum level of maintenance is required in order to display positive growth effects. Rioja (2003) has estimated that for Latin American countries maintenance investments in public infrastructure below 1 percent of GDP would have a negative effect on GDP change. In our case, the average investment in total transport is 0.64 percent of GDP for the full sample, and 0.79 percent of GDP in less developed regions (Table A2). Hence, this result may imply that maintenance investment in all EU regions is still below a minimum critical value.

TABLE 4: Maintenance investment

Dep. variable: Change of log GDP	Panel A Total transport infrastructure maintenance				Panel B Road maintenance			
	Motorways		Other roads		Motorways		Other roads	
	FS	LDR	FS	LDR	FS	LDR	FS	LDR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged GDP	-0.0983*** (0.0172)	-0.152*** (0.0211)	-0.0824*** (0.0182)	-0.152*** (0.0234)	-0.0851*** (0.0160)	-0.119*** (0.0268)	-0.0770*** (0.0175)	-0.125*** (0.0297)
Investment in motorways	0.114 (0.0722)	-0.0415 (0.110)			0.0873 (0.0756)	-0.126 (0.128)		
Investment in other roads			0.000593 (0.000465)	0.000430 (0.000486)			0.000623 (0.000473)	0.000486 (0.000490)
Quality of Government (QoG)	0.0200*** (0.00548)	0.0478*** (0.00905)	0.0148*** (0.00561)	0.0537*** (0.00940)	0.0319*** (0.00553)	0.0613*** (0.00894)	0.0228*** (0.00580)	0.0624*** (0.00984)
Interaction term **Investment in motorways × QoG**	-0.0804 (0.0952)	-0.144 (0.108)			-0.103 (0.0847)	-0.102 (0.119)		
Interaction term **Investment in other roads × QoG**			0.00193*** (0.000703)	0.00353*** (0.00112)			0.00210** (0.000833)	0.00344*** (0.00114)
Spatial Weight of investment in motorways	0.962*** (0.268)	0.602** (0.298)			0.900*** (0.252)	0.571* (0.311)		
Spatial Weight of investment in other roads			0.00136 (0.00153)	-1.31e-06 (0.00212)			0.00230 (0.00154)	-1.29e-06 (0.00215)
Agricultural employment	-0.00273*** (0.000610)	-0.00277*** (0.000806)	-0.00361*** (0.000537)	-0.00337*** (0.000787)	-0.00287*** (0.000792)	-0.00310*** (0.00103)	-0.00385*** (0.000698)	-0.00387*** (0.00100)
Patent applications	0.00911*** (0.00178)	0.0119*** (0.00308)	0.00771*** (0.00192)	0.0126*** (0.00303)	0.00846*** (0.00185)	0.0102*** (0.00318)	0.00670*** (0.00197)	0.0101*** (0.00316)
Human capital	0.0179*** (0.00528)	0.0314*** (0.0112)	0.0148** (0.00613)	0.0343** (0.0154)	0.0206*** (0.00530)	0.0357*** (0.0130)	0.0163*** (0.00608)	0.0373** (0.0179)
Regional population	-3.22e-05*** (1.12e-05)	-0.00013*** (4.04e-05)	-3.88e-05*** (1.19e-05)	-0.000103** (4.13e-05)	-4.10e-05*** (1.23e-05)	-0.000153*** (4.29e-05)	-4.61e-05*** (1.28e-05)	-0.000116** (4.35e-05)
Transport infrastructure maintenance	-0.00521** (0.00234)	-0.00881*** (0.00272)	-0.00405* (0.00240)	-0.00845*** (0.00290)				
Interaction term **Transport infrastructure maintenance × QoG**	0.0176*** (0.00414)	0.0166*** (0.00411)	0.0129*** (0.00405)	0.0130*** (0.00414)				
Road maintenance					-0.00484 (0.00567)	-0.00119 (0.0119)	-0.00181 (0.00571)	-0.00239 (0.0126)
Interaction term **Road maintenance × QoG**					0.00821 (0.00628)	0.00239 (0.0114)	0.00588 (0.00657)	-0.000769 (0.0111)
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,637	710	1,514	650	1,793	710	1,670	650
R^2 within	0.443	0.429	0.443	0.438	0.420	0.395	0.428	0.413
NUTS regions	122	55	117	51	134	55	129	51

Notes: FS = full sample; LDR = less developed regions. Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

A different interpretation is that the investment has limited effect on productivity, because a proportion of the allocated resources is not effectively spent for infrastructure maintenance, but rather controlled by interest groups through corruption or collusion mechanisms. This hypothesis is supported by the fact that the interaction term between government quality and maintenance expenditures is positive and significant for total transport infrastructure, but insignificant for road investment (Table 4, column (8)). The significant interaction term between government quality and total transport maintenance holds both for the full sample and the sample of less developed regions, as well as for motorways and for other roads investment. This means that investing in the maintenance of the overall transport network (total transport maintenance) has more beneficial effects on economic performance, the higher the government quality of the region in which the investment is made. All other coefficients are in line with the ones reported in the previous tables.

Robustness checks

In this section we test the robustness of our estimation results. We consider a number of factors that may affect our estimates: the time-span employed in the empirical analysis, the specification of the model, and the endogeneity of our key variables. The results of the robustness tests are displayed in Tables A3, A4 and A5 in the Appendix.

Changes in time-span. The literature on the relationship between infrastructure and growth has produced different results depending on the different time-spans considered. Our model has been tested on the 1995-2009 time period, but the results may not hold for different periods. We therefore test the robustness of our estimates to a change in time span by excluding the first four and last four years. Table A2 in the Appendix shows the results of the main model for the 1995-2005 and 1999-2009 periods. The results of the analysis are confirmed for both sub-periods. Quality of government is a significant factor behind economic growth and infrastructure investment in other roads is associated with regional GDP growth only in interaction with the QoG index – this result being stronger in less developed regions. The coefficient of the interaction term is larger in magnitude for the 1995-2005 period, probably due to the fact that the marginal returns of the investment are higher when the road network is less developed (Fernald, 1999).

Changes in specification. The model specified in Equation (1) is a dynamic specification where the lagged level of GDP enters as a regressor. This allows to test for convergence and to control for the initial conditions of the regions. Here we present the estimates of a more parsimonious version of the model, excluding the $\ln y_{i,t-1}$ variable. Panel A in Table A4 shows that while the magnitude of the coefficient of some variables changes marginally, the main results are confirmed. Infrastructure investment alone is not significantly linked with regional GDP change; investment in secondary roads is more strongly linked to economic growth in regions with better government quality.

Panel A of Table A4 demonstrates that our results are robust to the exclusion of some regressors. Panel B of Table A4 presents a more complete version of the model in Equation (1), with the inclusion of a new control variable. Models connecting transport infrastructure with economic growth typically rely on Cobb-Douglas production functions including private capital as one factor of production. Our original model does not control for private investment because data for this variable at the regional level is available only from 2000. Adding gross fixed capital formation as a proxy for the stock of private capital does not significantly alter the results (Table A4). One difference is that the coefficient of other roads investment is now positive and significant at 5 percent level.[8] This variable's connection with economic growth becomes stronger if interacted with government quality.

Endogeneity. The estimated effect of transport infrastructure and government quality on economic growth may be imprecise or biased if the direction of causality is running in the opposite way from that assumed in our model: i.e. if infrastructure investment and the quality of institutional structures are the consequences, not the causes, of the economic performance of EU regions.

A vast body of literature has attempted to account for the potential endogeneity of infrastructure capital and institutional conditions by means of instrumental variables. Some studies have addressed endogeneity using time-lags as instruments with

[8] This difference with respect to previous results is not driven by the inclusion of private capital, but by the change in time-span (2000-2009). Estimating the model for this period without private capital produces similar coefficients and standard errors for the variable of other roads investment.

Generalized Methods of Moments (GMM) estimation techniques (Calderón and Servén, 2004; Crescenzi and Rodríguez-Pose, 2012), while others have employed instruments based on historical factors correlated with the endogenous variables but exogenous to current economic conditions (Acemoglu et al., 2001; Tabellini, 2010 for institutions; Duranton and Turner 2011; 2012, for transport infrastructure).

Our model includes two variables of interest which may be endogenous to economic growth, as well as the interaction term between them, making any identification strategy based on 'external' instruments complicated to apply. Moreover, data on historical variables for European regions is not readily available. Hence, in order to minimize endogeneity issues we resort to a dynamic panel analysis through a GMM-system model.[9] The GMM produces estimates in line with the results in Tables 2 and 4 (Table A5). The quality of regional governments remains a significant driver of growth and the interaction term between other roads and government quality is positive and significantly associated with regional economic performance, although only at the 10 percent level. Unlike the fixed effects results, the coefficient of infrastructure investment is not statistically significant, if the control variables are excluded from the model.

This econometric approach is, however, unlikely to fully correct for the endogeneity issues of our model. As government quality is strongly path-dependent, time-lags do not represent valid sources of exogenous variation. Reverse causality, measurement errors and omitted variable remain an issue potentially biasing the results. For this reason, we cannot make any claim regarding the causality of the relationships observed. Hence, our results must be considered as a descriptive analysis of the complex set of relationships between transport infrastructure investment, government quality, and economic growth discussed in the introductory section of this paper.

[9] We choose a GMM-system over a GMM-difference model because it better accounts for the high persistence over time of the variables (Roodman, 2009). To make the number of instruments lower than the number of groups, we only use the second-order time lags as instruments and limit the regressors to the key variables of interest. As this implies excluding population –no longer controlling for 'per capita' effects – we replace the dependent variable with per capita GDP change. The GMM model is estimated for the full sample only because restricting the sample to less developed regions would imply having more instruments than regions.

4. CONCLUSIONS

This paper has investigated the importance of government quality for the economic returns of transport infrastructure investments in the European regions. We assumed that government institutions played a strong conditioning role on the effectiveness of public investments in road infrastructure and that government quality would also affect decisions and the returns of different types of roads: motorways vs. ordinary roads.

The analysis, performed using these two different proxies for infrastructure investment and by interacting them with measures of institutional quality, unveils a very weak or insignificant direct correlation between economic growth and regional investments in either motorways or other roads, but a strong and highly significant connection with regional economic performance if other roads investment is interacted with government quality. The results hold for all different measures of government quality in our dataset. These findings suggest that, as hypothesized, positive rates of returns from infrastructure investment are mediated by the presence of adequate government institutions. Only certain types of transport infrastructure investment are associated with higher growth across the regions of Europe. In particular, improvements in secondary road network in sound government quality conditions are linked to higher growth. By contrast, the highly popular motorway development schemes which have been at the center of development strategies mainly in the periphery of Europe – and in particular in Portugal and Spain – are not associated with the expected economic outcomes, even if promoted by credible, competent and transparent local governments (which is not always the case). Government institutions also help translating investments in maintenance of transport infrastructure into economic growth. Maintenance investment alone is weakly associated to economic performance, and this association may even turn negative, if conducted in environments where corruption and collusion are rife. In all cases, government quality on its own or after controlling for human capital endowments and innovation has been more strongly linked to economic growth than transport infrastructure investment.

These results can be partly ascribed to the differences in the two typologies of road infrastructure considered in our study. The category of other roads includes local and regional roads, whose construction tends to weigh less on public finances if compared to motorways expenditures and is often made to enhance within-region rather than between-region connectivity. This distinction is relevant especially for peripheral areas located far away from the main urban centers and with fewer economic resources at their disposal. Their lower visibility and potential electoral dividends also make this type of investment more likely to respond to real needs and cost-benefit considerations. The glitzier large-scale motorway projects are more visible and generally yield greater electoral returns, but are costlier and may take away vital resources from other key infrastructure interventions or other development axes which could generate greater economic returns.

When discussing the potential policy insights from these results, it is crucial to bear in mind some caveats. First, data constraints limit the possibility of drawing any causal conclusions from the analysis: time-varying omitted variables and reverse causality may still affect our estimates. Second, the time span covered is relatively limited, making it impossible to capture long-term growth trends. Third, our proxies for infrastructure investments are necessarily constrained by data availability: changes in road length of motorways and other roads, as well as national maintenance expenditures can be captured, but we cannot account for broader network effects (linked for example with the interactions between roads and railways or airports), traffic creation, and diversion effects.

Having acknowledged these limitations, our findings still offer relevant insights for economic development policies in Europe. First, the results of the analysis contribute to the increasing number of studies recognizing improvements of local institutions as a necessary prerequisite for efficient public spending, in general, and infrastructure investment, in particular (Acemoglu and Dell, 2010; Rodríguez-Pose and Di Cataldo, 2015; Rodríguez-Pose and Garcilazo, 2015). As Esfahani and Ramírez (2003) put it, “achieving better [economic] outcomes requires institutional and organizational reforms that are more fundamental than simply designing infrastructure projects and spending money on them” (Esfahani and Ramírez, 2003: 471). The re-shaping of institutional structures is a challenging task for policy-makers, as reforms will have to be designed specifically for the environment in which they are to be applied. In any case, our results indicate that ‘institution-building’ needs to be put at the top of the development agenda, if other types of development interventions – and, fundamentally, transport infrastructure interventions – are to become more effective.

A potential way to limit distortions in public investment decisions determined by political interests, pork-barrel politics, or corruption may be to set stricter rules for project evaluation and provide technical guidance to local governments lacking the administrative capacity to select the most profitable projects. Ex-ante and ex-post evaluations, monitoring analyses and appraisals – despite increasing legislation in this respect – are not yet a consolidated practice in all European regions. Highly objective evaluation techniques are unappealing for local politicians regularly trying to exert their influence over the investment's decisions (Short and Knopp, 2005). Regions with weak government institutions require a more thorough following of their transport projects over the full cycle and a greater awareness of project specificities. As argued by a recent US Transportation Research Board (TRB) report, a key capability of infrastructure monitoring agencies is to be able to distinguish between the short-term and the long-term benefits of transport projects. This allows setting timeliness and maintenance-of-effort requirements according to the type of goal to be achieved. Short-term and long-term targets may be assigned specific implementation rules, but a uniform evaluation framework is recommended for each project (TRB, 2014). In the EU enforcing effective evaluation frameworks should require greater levels of enforcement by the European institutions awarding financial resources for infrastructure interventions. One way to do so would be to truly condition the disbursement of EU funds for infrastructure investment to the application of technical regulations for project evaluations.

Other policy implications of our analysis concern the type of transport investment more advisable for peripheral regions. Our empirical results challenge the vision, already disputed in the literature (e.g. Puga, 2002), that one way to foster economic convergence in the EU is to link peripheral locations with the economic heart of the continent through the establishment of a core network of costly long-distance corridors of transport infrastructure. Conversely, our evidence supports the idea that, considering improvements in government quality, economically backward regions should strengthen regional roads in order to facilitate the creation of linkages between key local economic actors. In lagging areas, investing only in long-distance connections may provide incentives for the main economic assets of the region (being them skilled individuals or successful businesses) to re-locate elsewhere. Efforts to improve institutional conditions and promote local accessibility should be accompanied by initiatives targeting other key development drivers, such as education or innovation.

Overall, these policy indications are coherent with the ongoing reform of EU Cohesion Policy, increasingly prone to recognize different institutional capacities as drivers of persistent disparities and as major hindrances for regional convergence in Europe (Barca et al., 2012). Our findings indicate that considering place-based institutions as a key determinant of regional development may be the way forward to ensure effective development support, as long as it implies setting up consistent measures to condition the provision of additional funds on the proof of efficient spending from regional government authorities. Our results also suggest the need to pause and rethink about the interest and viability of many of the transportation policies financed with EU Structural Funds. Under the 2007-2013 budget period, almost half of EU Cohesion expenditures for transport infrastructure development were devoted to the realization of the Trans-European Transport Network (TEN-T), a planned set of road, rail, air, and maritime infrastructure investments that are intended to develop continuous North-South and East-West corridors in the continent. Despite a decline in infrastructure investment, transport infrastructure still attracts a considerable percentage of the almost €352 billion of Cohesion Policy for the period 2014-2020. A very large share of these funds has been or will be spent in lagging areas of Europe, precisely those where our analysis suggests that, unless there are significant improvements in government quality, the association of these funds with economic growth is likely to be limited. A coherent shift to a place-based approach to regional development should induce a thorough rethink of how new transport infrastructure investments can best contribute to future economic development across the regions of the EU.

REFERENCES

Acemoglu, Daron, Simon Johnson, and James A. Robinson. 2001. “The Colonial Origin of Comparative Development: An Empirical Investigation,” *American Economic Review*, 91, 1369–1401.

Acerete, Basilio, Jean Shaoul and Anne Stafford. 2009. “Taking its toll: the cost of private roads in Spain,” *Public Money and Management*, 29, 19–26.

Ahlin, Christian and Jiaren Pang. 2008. “Are financial development and corruption control substitutes in promoting growth?,” *Journal of Development Economics*, 86, 414–433.

Albalate, Daniel and Germà Bel. 2012. *The Economics and Politics of High-Speed Rail*. Lanham: Lexington Books.

Aschauer, David A. 1989. “Is public expenditure productive?,” *Journal of Monetary Economics*, 23, 177–200.

Barca, Fabrizio, Phil McCann, and Andrés Rodríguez-Pose. 2012. “The Case For Regional Development Intervention: Place-Based Versus Place-Neutral Approaches,” *Journal of Regional Science*, 52, 134–152.

Bel, Germà. 2010. “La racionalización de las infraestructuras de transporte en España,” *Cuadernos Económicos del ICE*, 80, 211–228.

Bentivogli, Chiara, Piero Casadio, and Roberto Cullino. 2011. “I problemi nella realizzazione delle opere pubbliche: le specificità territoriali,” in *Le infrastrutture in Italia: dotazione, programmazione, realizzazione.* The Bank of Italy, Workshops and Conferences Vol. 7.

Bukowski, Jeanie. 2004. “Multi-level Networks as a Threat to Democracy? The Case of Portugal’s Vasco da Gama Bridge,” *Journal of Southern Europe and the Balkans*, 6, 275–297.

Button, Kenneth, Scott Leitham, Ronald McQuaid, and John D. Nelson. 1995. “Transport and industrial and commercial location,” *Annals of Regional Science*, 29, 189–206.

Cadot, Olivier, Lars-Hendrik Roller, and Andreas Stephan. 1999. “A Political Economy Model of Infrastructure Allocation: An Empirical Assessment,” CEPR Discussion Papers No. 2336, London.

Cadot, Olivier, Lars-Hendrik Roller, and Andreas Stephan. 2006. “Contribution To Productivity or Pork Barrel? The Two Faces of Infrastructure Investment,” *Journal of Public Economics*, 90, 1133–53.

Calderón, César, and Luis Servén. 2004. “The effects of infrastructure development on growth and income distribution,” World Bank Policy Research Working Paper No. 3400, World Bank, Washington, D.C..

Campos, Nauro F., Ralitza Dimova, and Ahmad Saleh. 2010. “Whither corruption? A quantitative survey of the literature on corruption and growth,” CEPR Discussion Paper No. 8140, London.

Cantarelli, Chantal C., Bent Flyvbjerg, Eric J. Molin, and Bert van Wee. 2010. "Cost Overruns in Large-scale Transportation Infrastructure Projects: Explanations and Their Theoretical Embeddedness," *European Journal of Transport and Infrastructure Research,* 10, 5–18.

Capello, Roberta, and Camilla Lenzi. 2014. "Spatial heterogeneity in knowledge, innovation, and economic growth nexus: conceptual reflections and empirical evidence," *Journal of Regional Science*, 54, 186–214.

Cappelen, Aadne, Fulvio Castellacci, Jan Fagerberg, and Bart Verspagen. 2003. "The impact of EU regional support on growth and convergence in the European Union," *Journal of Common Market Studies*, 41, 621–644.

Casadio, Piero and Marco Paccagnella. 2011. "La difficile programmazione delle infrastrutture in Italia," in *Le infrastrutture in Italia: dotazione, programmazione, realizzazione*, The Bank of Italy, Workshops and Conferences Vol. 7, Rome.

Charron, Nicholas, Victor Lapuente, and Bo Rothstein. 2011. *Measuring Quality of Government and Sub-national Variation*, Report for the EU Commission of Regional Development, European Commission, Brussels.

Charron, Nicholas, Victor Lapuente, and Lewis Dykstra. 2014. "Regional governance matters: Quality of Government within European Union Member States," *Regional Studies*, 48, 68–90.

Ciocchini, Francisco, Erik Durbin, and David T. C. Ng. 2003. "Does Corruption increase emerging market bond spreads?," *Journal of Economics and Business*, 55, 502–528.

Cooke Philip, Mikel Gomez Uranga, and Goio Etxeberria. 1997. "Regional innovation systems: institutional and organizational dimensions," *Research Policy*, 26, 475–491.

Cohen, Jeffrey P. 2010. "The broader effects of transportation infrastructure: Spatial econometrics and productivity approaches," *Transportation Research Part E: Logistics and Transportation Review*, 46, 317–326.

Cohen Wesley M. and Daniel A. Levinthal. 1990. "Absorptive capacity: A new perspective on learning and innovation," *Administration Science Quarterly*, 35, 128–152.

Crain, W. M. and Oakley, L. K. 1995. "The Politics of Infrastructure," *Journal of Law and Economics*, 38, 1–17.

Crescenzi, Riccardo. 2005. "Innovation and regional growth in the enlarged Europe: the role of local innovative capabilities, peripherality and education," *Growth and Change*, 36, 471–507.

Crescenzi, Riccardo. 2009. "Undermining the principle of territorial concentration? EU regional policy and the socio-economic disadvantage of European regions," *Regional Studies*, 43, 111–133.

Crescenzi, Riccardo and Andrés Rodríguez-Pose. 2008. "Infrastructure endowment and investment as determinants of regional growth in the European Union," *EIB Papers*, 13, 62–101.

Crescenzi, Riccardo and Andrés Rodríguez-Pose. 2012. "Infrastructure and regional growth in the European Union," *Papers in Regional Science*, 91, 487–513.

Dalenberg Douglas R. and Mark D. Partridge. 1997. "Public Infrastructure and Wages: Public Capital's Role as a Productive Input and Household Amenity," *Land Economics*, 73, 268–284.

Duranton, Gilles and Matthew A. Turner. 2011. "The fundamental law of road congestion: Evidence from US cities," *American Economic Review*, 101, 2616–2652.

Duranton, Gilles and Matthew A. Turner. 2012. "Urban growth and transportation," *Review of Economic Studies*, 79, 1407–1440.

Esfahani, Hadi Salehi and Maria Teresa Ramírez. 2003. "Institutions, infrastructure, and economic growth," *Journal of Development Economics*, 70, 443–477.

Fagerberg, Jan. 1994. "Technology and international differences in growth rates," *Journal of Economic Literature*, 32, 1147–1175.

Fagerberg, Jan, Bart Verspagen, and Marjolein Caniëls. 1997. "Technology, growth and unemployment across European Regions," *Regional Studies*, 31, 457–466.

Flyvbjerg, Bart. 2009. "Survival of the Unfittest: Why the Worst Infrastructure Gets Built-And What Can We Do About It," *Oxford Review of Economic Policy*, 25, 344–367.

Flyvbjerg, Bart, Mette K. Skamris Holm, and Soren L. Buhl. 2005, "How (In)accurate Are Demand Forecasts in Public Works Projects? The Case of Transportation," *Journal of the American Planning Association*, 71, 131–46.

Fujita, Masahisa and Jacques-Francois Thisse. 2002. *Economics of Agglomeration.* Cambridge: Cambridge University Press.

Henisz, Witold J. 2002. "The Institutional Environment for Infrastructure Investment', *Industrial and Corporate Change*," 11, 355–389.

Holtz-Eakin, Douglas and Amy Ellen Schwartz. 1995. "Infrastructure in a structural model of economic growth," *Regional Science and Urban Economics*, 25, 131–151.

Instituto da Mobilidade e do Transportes (IMT). 2013. *Relatorio de Trafego na Rede Nacional de Auto-Estradas; 1º Trimestre do 2013*. Lisbon: Direção de Planeamiento, Government of Portugal.

Instituto de Infra-Estructuras Rodoviarias (INIR). 2010. *Relatorio de Trafego na Rede Nacional de Auto-Estradas 2010*. Lisbon: Departamiento de Planeamiento, Government of Portugal.

Kelejian, Harry H. and Dennis P. Robinson. 1997. "Infrastructure Productivity Estimation and its Underlying Economic Specifications: A Sensitivity Analysis", *Papers in Regional Science*, 76: 115-31.

Kemmerling, Achim and Andreas Stephan. 2008. "The polito-economic determinants and productivity effects of regional transport investment in Europe," *EIB Papers*, 13, 36–61.

Kenny, Charles. 2006. “Measuring and Reducing the Impact of Corruption in Infrastructure”, World Bank Policy Research Working Paper No. 4099, World Bank, Washington, D.C.

Kenny, Charles. 2007. “Infrastructure, Governance and Corruption: Where Next?” World Bank Policy Research Working Paper No. 4331, World Bank, Washington, D.C..

Leduc, Sylvain and Daniel Wilson. 2012. “Roads to Prosperity or Bridges to Nowhere? Theory and Evidence on the Impact of Public Infrastructure Investment,” NBER Working Paper No. 18042, Cambridge, MA.

Marangoni, Daniele and Giuseppe Marinelli. 2011. “Il crescente ruolo delle Amministrazioni locali nella programmazione e gestione della viabilita stradale”, in *Le infrastrutture in Italia: dotazione, programmazione, realizzazione*, The Bank of Italy, Workshops and Conferences Vol. 7, Rome.

Melo, Joao Joanaz. 2000. “The Vasco da Gama bridge on the Tagus estuary: a paradigm of bad decision-making, but good post-evaluation,” *World Transport Policy and Practice*, 2, 20–31.

Moreno, Rosina, Manuel Artís, Enrique López-Bazo, and Jordi Suriñach. 1997. “Evidence on the complex link between infrastructure and regional growth,” *International Journal of Development Planning Literature*, 12, 81–108.

OECD. 2006. *Annual report on competition policy developments in the Slovak Republic* , Paris: Organisation for Economic Co-operation and Development.

OECD. 2009a. *Infrastructure Investment: Links to Growth and the Role of Public Policy,* in *Economic Policy Reforms: Going for Growth.* Paris: Organisation for Economic Co-operation and Development.

OECD. 2009b. *How regions grow: Trends and analysis*, Paris: Organisation for Economic Co-operation and Development.

OECD. 2011. “Trends in Transport Infrastructure Investment 1995-2009”, International Transport Forum, Organisation for Economic Co-operation and Development, Paris.

Ottaviano, Gianmarco I.P. 2008. “Infrastructure and economic geography: An overview of evidence,” *EIB Papers*, 13, 9–33.

Oxford Business Group 2004. “Emerging Romania”. London.

Parent, Olivier, and James P. LeSage. 2012. “Determinants of Knowledge Production and their Effects on Regional Economic Growth,” *Journal of Regional Science*, 52, 256–284.

Painvin, Nicolas. 2011. *Large Projects, Giant Risks?*, Transportation Global Special Report, Fitch Ratings.

Puga, Diego. 2002. “European regional policies in the light of recent location theories,” *Journal of Economic Geography*, 2, 373–406.

Puga, Diego and Anthony J. Venables. 1997. “Preferential trading arrangements and industrial location,” *Journal of International Economics*, 43, 347–368.

Rioja, Felix K. 2003. “Filling potholes : macroeconomic effects of maintenance versus new investments in public infrastructure,” *Journal of Public Economics*, 87, 2281–2304.

Rodríguez-Pose, Andrés. 2000. “Economic convergence and regional development strategies in Spain: The case of Galicia and Navarre,” *EIB Papers*, 5, 89–115.

Rodríguez-Pose, Andrés and Riccardo Crescenzi. 2008 “R&D, spillovers, innovation systems and the genesis of regional growth in Europe,” *Regional Studies*, 42, 51–67.

Rodríguez-Pose, Andrés and Marco Di Cataldo. 2015 “Quality of government and innovative performance in the regions of Europe,” *Journal of Economic Geography*, 15, 673–706.

Rodríguez-Pose, Andrés and Ugo Fratesi. 2004. “Between development and social policies: The impact of European Structural Funds on Objective 1 regions,” *Regional Studies*, 38, 97–113.

Rodríguez-Pose, Andrés and Enrique Garcilazo. 2015. “Quality of Government and the Returns of Investment: Examining the Impact of Cohesion Expenditure in European Regions,” *Regional Studies*, 49, 1274–1290.

Roodman, David. 2009. “How to do xtabond2: An introduction to difference and system GMM in Stata,” *The Stata Journal*, 9, 86–136.

Short, Jack and Andreas Knopp. 2005. “Transport infrastructure: investment and planning. Policy and research aspects,” *Transport Policy*, 124, 360–367.

Stephan, Andreas. 2000. “Regional Infrastructure Policy and its Impact on Productivity: A Comparison of Germany and France,” *Applied Economics Quarterly*, 46, 327–356.

Stephens, Heather M., Mark D. Partridge, and Alessandra Faggian. 2013. “Innovation, entrepreneurship and economic growth in lagging regions”, *Journal of Regional Science*, 53, 778–812.

Tabellini, Guido. 2010. “Culture and Institutions: Economic Development in the Regions of Europe,” *Journal of the European Economic Association*, 8, 677–716.

Tanzi, Vito and Hamid Reza Davoodi. 1997. “Corruption, public investment and growth”, IMF Working Paper No. 97/139, Washington, DC.

Tanzi, Vito and Hamid Reza Davoodi. 1998. “Roads to Nowhere: How Corruption in Public Investment Hurts Growth,” *IMF Economic Issues,* No. 12. IMF, Washington, D.C.

Tödtling, Franz and Michaela Trippl. 2005. “One size fits all? Towards a differentiated regional innovation policy approach,” *Research Policy*, 34, 1203–1219.

Transportation Research Board. 2014. *Transportation Investments in Response to Economic Downturns,* Special Report No. 312, U.S. Transportation Research Board, Washington, D.C.

Turano, Gianfrancesco. 2011. “Salerno-Reggio Calabria, ci mancava la maxi-multa”. L’Espresso on 24 November, 2011. Available at: http://espresso.repubblica.it/dettaglio/salerno-reggio-ci-mancava-la-maxi-multa/2167177

Van den Heuvel, Grat. 2005. “The parliamentary enquiry on fraud in the Dutch construction industry collusion as concept between corruption and state-corporate crime,” *Crime, Law & Social Change*, 44, 133–152.

Vickerman, Roger W. 1995. “Regional impacts of Trans-European Networks,” *Annals of Regional Science*, 29, 237–254.

Wachs, Martin. 1989. “When Planners Lie with Numbers,” *Journal of the American Planning Association*, 554, 477–479.

World Bank. 2011. *Curbing fraud*, *corruption, and collusion in the roads sector*, The World Bank Group, Washington, D.C.

ON LINE Appendix

TABLE A1: Variables description

Variable	Source	Definition and notes
Change of log GDP	OECD Statistics	First difference of the natural logarithm of regional GDP in current euros, 1995-2009. Data for Romanian regions obtained from Eurostat.
Lagged GDP	OECD Statistics	Natural logarithm of regional GDP lagged by one period.
Investment in motorways	Own calculation using Eurostat data	First difference of the number of kms of motorways, standardized by thousand regional inhabitants.
Investment in other roads	Own calculation using Eurostat data	First difference of the number of kms of regional roads not classified as motorways, standardized by thousand regional inhabitants, 1995-2009. Missing values for all Portuguese regions.
Transport infrastructure maintenance	OECD Statistics	Spending on preservation of the existing transport network and maintenance expenditure financed by public administrations. Data at the national level, 1995-2009. Current euros as percentage of national GDP. Maintenance expenditures for road, rail, inland waterways, maritime ports and airports. Missing values for the Netherlands, Germany and Spain.
Road maintenance	OECD Statistics	Investment and maintenance expenditures for roads as percentage of GDP. Data at the national level, 1995-2009. Current euros as percentage of national GDP. Missing values for Germany and Spain.
Quality of Government (QoG)	Own calculation with QoG Institute data and World Bank Governance Indicators	EU Quality of Government (QoG) index elaborated by the University of Gothenburg, a survey-based index constructed around three main pillars: quality of education, public health care and law enforcement; impartiality in education, public health and legal protection; level of corruption in education, health care and the legal system. This index has been extended to the 1997-2009 period adopting the World Bank Governance Indicators developed by Kauffmann et al. (2009). See Charron et al. (2012) for a detailed explanation on how the index was constructed.

Control of Corruption	Own calculation with QoG Institute data and World Bank Governance Indicators	Section of the QoG combined index based on the calculated score from the answers of its inhabitants to the following questions: 'Corruption is prevalent in my area's local public school system.' (0-10); 'Corruption is prevalent in the public healthcare system in my area.' (0-10); 'In the past 12 months have you or anyone living in your household paid a bribe in any form to: health or medical services?' (y/n); 'In your opinion, how often do you think other citizens in your area use bribery to obtain public services?' (0-10)
Rule of Law	Own calculation with QoG Institute data and World Bank Governance Indicators	Section of the QoG combined index based on the calculated score from the answers of its inhabitants to the following questions: 'how would you rate the quality of the police force in your area?' (0-10); 'The police force gives special advantages to certain people in my area.' (0-10); 'All citizens are treated equally by the police force in my area' (1-4); 'Corruption is prevalent in the police force in my area' (0-10).
Government Effectiveness	Own calculation with QoG Institute data and World Bank Governance Indicators	Section of the QoG combined index based on the calculated score from the answers of its inhabitants to the following questions: 'how would you rate the quality of public education in your area?' (0-10); 'how would you rate the quality of the public healthcare system in your area?' (0-10); 'Certain people are given special advantages in the public education system in my area' (0-10); 'Certain people are given special advantages in the public healthcare system in my area.' (0-10); 'All citizens are treated equally in the public education system in my area.' (1-4); 'All citizens are treated equally in the public healthcare system in my area.' (1-4).
Government Accountability	Own calculation with QoG Institute data and World Bank Governance Indicators	Section of the QoG combined index based on the calculated score from the answers of its inhabitants to the following questions: 'In your opinion, if corruption by a public employee or politician were to occur in your area, how likely is it that such corruption would be exposed by the local mass media?' (0-10); 'Please respond to the following: Elections in my area are honest and clean from corruption.' (0-10).
Spatial Weight of investment in motorways/other roads	Own calculation with Eurostat	Spatially weighted average of first difference of transport infrastructure endowment in neighboring regions, calculated with an Euclidean distance matrix setting the threshold at the minimum distance for each region to have at least one neighbor.
Agricultural employment	Eurostat	Share of regional employment in NACE categories A (Agriculture, forestry and fishing) and B (Mining and quarrying).
Patent applications	Eurostat	Natural logarithm of the number of applications filled for patents of all types per thousand of inhabitants.

Human capital	Eurostat	Natural logarithm of the percentage of employed people (aged 25-64) with completed higher education (ISCED-97 levels 5 and 6).
Regional population	Eurostat	Thousands of residents in the region.
Gross fixed capital formation	Eurostat	Resident producers´ acquisitions, less disposals, of fixed tangible or intangible assets. Hundred million euros of national currency (current prices). Available 2000-2009.

TABLE A2: Descriptive statistics

	All regions			Less developed regions		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Regional GDP	2490	67062	86939	1050	34572	36196
Kms of motorways	2421	321	387	1012	219	374
Kms of other roads	2321	19273	17695	966	14785	9523
Motorways per thousand inhabitants	2459	0.142	0.134	1030	0.093	0.127
Other roads per thousand inhabitants	2321	9.555	8.273	966	8.285	6.586
Change in motorways per thousand inhabitants (investment in motorways)	2293	0.0033	0.012	960	0.005	0.014
Change in other roads per thousand inhabitants (investment in other roads)	2150	0.013	0.272	893	0.029	0.218
Transport infrastructure maintenance	1811	0.644	0.530	809	0.794	0.591
Road maintenance	1967	0.351	0.267	809	0.460	0.263
Quality of Government Index	2490	0.169	0.960	1050	-0.420	1.017
Control of Corruption	2490	0.128	0.924	1050	-0.445	0.908
Rule of Law	2490	0.169	0.938	1050	-0.376	0.982
Government Effectiveness	2489	0.196	1.035	1050	-0.406	1.134
Government Accountability	2489	0.125	0.951	1050	-0.410	1.049
Spatial Weight of investment in motorways	2324	0.0033	0.0054	980	0.0042	0.0065
Spatial Weight of investment in other roads	2312	0.068	0.43	968	0.123	0.613
Agricultural employment	2490	7.807	9.20	1050	13.11	11.92
Patent applications	2490	70.27	93.57	1050	16.76	33.33
Human capital	2454	21.83	9.06	1018	18.06	7.86
Regional population	2490	2639	2470	1050	2248	1533
Gross fixed capital formation	1562	117.67	148.56	682	59.91	71.18

TABLE A3: Robustness checks – Change of time-span

Dep. variable: Change of log GDP	Panel A 1995-2005				Panel B 1999-2009			
	Motorways		Other roads		Motorways		Other roads	
	FS	LDR	FS	LDR	FS	LDR	FS	LDR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged GDP	-0.164*** (0.0181)	-0.213*** (0.0256)	-0.162*** (0.0205)	-0.217*** (0.0277)	-0.101*** (0.0190)	-0.141*** (0.0301)	-0.0977*** (0.0183)	-0.143*** (0.0295)
Investment in motorways	0.127** (0.0606)	0.0435 (0.105)			0.0362 (0.0525)	-0.0994 (0.0733)		
Investment in other roads			0.00124 (0.000883)	0.00182 (0.00172)			0.000745 (0.000464)	0.000840 (0.000508)
Quality of Government (QoG)	0.0366*** (0.00667)	0.0487*** (0.0134)	0.0254*** (0.00576)	0.0483*** (0.0127)	0.0266*** (0.00472)	0.0597*** (0.00787)	0.0263*** (0.00470)	0.0630*** (0.00798)
Interaction term **Investment in motorways × QoG**	-0.113 (0.0874)	-0.185 (0.134)			-0.0775 (0.0781)	-0.123 (0.108)		
Interaction term **Investment in other roads × QoG**			0.00796*** (0.00295)	0.0124* (0.00695)			0.00208*** (0.000782)	0.00365*** (0.00108)
Spatial Weight of investment in motorways	0.627*** (0.155)	0.453** (0.192)			0.510*** (0.165)	0.163 (0.231)		
Spatial Weight of investment in other roads			0.00641*** (0.00168)	0.00426* (0.00222)			0.00346** (0.00151)	0.00296 (0.00200)
Agricultural employment	-0.00298*** (0.000954)	-0.00334*** (0.00124)	-0.00383*** (0.000838)	-0.00377*** (0.00116)	-0.00441*** (0.000736)	-0.00445*** (0.00101)	-0.00437*** (0.000723)	-0.00445*** (0.00102)
Patent applications	0.00506*** (0.00178)	0.00290 (0.00328)	0.00324* (0.00165)	0.00263 (0.00279)	0.00799*** (0.00246)	0.0106*** (0.00326)	0.00943*** (0.00245)	0.0122*** (0.00322)
Human capital	0.0186*** (0.00452)	0.0371*** (0.0102)	0.0157*** (0.00497)	0.0359*** (0.0134)	0.0109 (0.00841)	0.0481*** (0.0147)	0.00960 (0.00849)	0.0467*** (0.0152)
Regional population	-2.17e-05* (1.24e-05)	-1.31e-05 (2.52e-05)	-1.71e-05 (1.19e-05)	6.74e-07 (2.26e-05)	-1.91e-05** (7.67e-06)	1.33e-06 (1.06e-05)	-1.80e-05** (7.64e-06)	9.22e-06 (9.05e-06)
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,625	672	1,496	612	1,798	750	1,754	726
R^2 within	0.218	0.235	0.242	0.264	0.505	0.494	0.506	0.508
NUTS regions	166	70	161	66	166	70	161	66

Notes: FS = full sample; LDR = less developed regions. Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

TABLE A4: Robustness checks – Change of specification

Dep. variable: Change of log GDP	Panel A Estimates without inclusion of lagged GDP				Panel B Control for private capital investment (2000-2009)			
	Motorways		Other roads		Motorways		Other roads	
	FS	LDR	FS	LDR	FS	LDR	FS	LDR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged GDP					-0.142*** (0.0218)	-0.200*** (0.0307)	-0.140*** (0.0213)	-0.203*** (0.0298)
Investment in motorways	0.0616 (0.0564)	-0.0721 (0.0785)			0.0275 (0.0527)	-0.0570 (0.0750)		
Investment in other roads			0.000492 (0.000520)	0.000325 (0.000545)			0.00105** (0.000448)	0.00115** (0.000503)
Quality of Government (QoG)	0.0276*** (0.00336)	0.0414*** (0.00559)	0.0191*** (0.00323)	0.0394*** (0.00537)	0.0308*** (0.00516)	0.0672*** (0.0113)	0.0310*** (0.00514)	0.0712*** (0.0114)
Interaction term **Investment in motorways × QoG**	-0.0606 (0.0773)	-0.100 (0.103)			-0.0772 (0.0769)	-0.0615 (0.114)		
Interaction term **Investment in other roads × QoG**			0.00227** (0.000887)	0.00358*** (0.00106)			0.00231*** (0.000831)	0.00401*** (0.00122)
Spatial Weight of investment in motorways	0.677*** (0.148)	0.454** (0.188)			0.434** (0.171)	0.0876 (0.240)		
Spatial Weight of investment in other roads			0.00421** (0.00168)	0.00415* (0.00217)			0.00264* (0.00154)	0.00194 (0.00196)
Agricultural employment	-0.00122*** (0.000357)	-0.000962** (0.000427)	-0.00187*** (0.000319)	-0.00139*** (0.000440)	-0.00468*** (0.000924)	-0.00445*** (0.00115)	-0.00466*** (0.000906)	-0.00445*** (0.00113)
Patent applications	0.00358** (0.00166)	0.00372 (0.00289)	0.00214 (0.00180)	0.00352 (0.00306)	0.00753*** (0.00271)	0.0121*** (0.00351)	0.00893*** (0.00267)	0.0136*** (0.00344)
Human capital	0.0103** (0.00416)	0.0196** (0.00759)	0.00704 (0.00450)	0.0158 (0.00953)	0.0135 (0.00990)	0.0435** (0.0176)	0.0135 (0.0101)	0.0428** (0.0182)
Regional population	-2.29e-05*** (6.05e-06)	-1.69e-05* (9.57e-06)	-2.59e-05*** (6.04e-06)	-1.33e-05* (7.13e-06)	-3.66e-05*** (1.19e-05)	-0.000110** (4.96e-05)	-3.28e-05*** (1.20e-05)	-9.98e-05** (4.88e-05)
Gross fixed capital formation					7.59e-05** (3.66e-05)	0.000481** (0.000205)	6.99e-05* (3.71e-05)	0.000471** (0.000203)
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,269	936	2,134	876	1,535	662	1,498	642
R^2 within	0.429	0.404	0.445	0.421	0.527	0.521	0.527	0.536
NUTS regions	166	70	161	66	166	70	161	66

Notes: FS = full sample; LDR = less developed regions. Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

TABLE A5: GMM estimates

Dep. variable: Change of log per capita GDP	GMM-system (2nd order lags as instruments)	
	(1)	(2)
Lagged per capita GDP	-0.0305***	-0.0494***
	(0.00499)	(0.00757)
Investment in motorways	-0.0192	
	(0.138)	
Investment in other roads		-0.00452
		(0.00328)
Quality of Government (QoG)	0.00612**	0.00888**
	(0.00310)	(0.00429)
Interaction term	-0.420	
Investment in motorways × QoG	(0.262)	
Interaction term		0.0122*
Investment in other roads × QoG		(0.00724)
Spatial Weight of investment in motorways	0.518*	
	(0.273)	
Spatial Weight of investment in other roads		0.0235***
		(0.00672)
Year Dummies	Yes	Yes
Observations	2,289	2,158
NUTS regions	166	161
Instruments	136	140
AR (2) test (p-value)	0.85 (0.393)	0.36 (0.719)

Notes: Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

TABLE A6: Motorways investment, quality of government components and regional growth, 1995-2009

Dep. variable: Change of log GDP	Quality of Government (QoG) Component							
	Control of Corruption		Rule of Law		Government Effectiveness		Government Accountability	
	FS	LDR	FS	LDR	FS	LDR	FS	LDR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged GDP	-0.0901*** (0.0130)	-0.117*** (0.0215)	-0.0952*** (0.0132)	-0.110*** (0.0204)	-0.0886*** (0.0124)	-0.104*** (0.0187)	-0.0787*** (0.0128)	-0.0890*** (0.0208)
Investment in motorways	0.0640 (0.0496)	-0.0837 (0.0729)	0.0752 (0.0528)	-0.0500 (0.0825)	0.0695 (0.0527)	-0.0353 (0.0647)	0.0707 (0.0511)	-0.0737 (0.0715)
Quality of Government (QoG) Component	0.0254*** (0.00409)	0.0449*** (0.00832)	0.0275*** (0.00394)	0.0347*** (0.00804)	0.0215*** (0.00280)	0.0384*** (0.00460)	0.00611** (0.00273)	0.0121*** (0.00387)
Interaction term **Investment in motorways × QoG**	-0.0703 (0.0736)	-0.0896 (0.103)	-0.0797 (0.0786)	-0.134 (0.110)	-0.0298 (0.0594)	-0.114 (0.0857)	-0.0650 (0.0588)	-0.0334 (0.0632)
Spatial Weight of change in investment in motorways	0.714*** (0.149)	0.439** (0.184)	0.771*** (0.158)	0.291 (0.199)	0.731*** (0.163)	0.524*** (0.188)	0.745*** (0.154)	0.552*** (0.195)
Agricultural employment	-0.00244*** (0.000669)	-0.00248*** (0.000843)	-0.00308*** (0.000655)	-0.00309*** (0.000777)	-0.00293*** (0.000648)	-0.00319*** (0.000826)	-0.00265*** (0.000679)	-0.00308*** (0.000808)
Patent applications	0.00592*** (0.00179)	0.00673** (0.00290)	0.00609*** (0.00177)	0.00584** (0.00267)	0.00624*** (0.00167)	0.00677** (0.00294)	0.00480*** (0.00174)	0.00558* (0.00284)
Human capital	0.0107** (0.00472)	0.0296*** (0.00997)	0.0202*** (0.00459)	0.0348*** (0.00933)	0.0124*** (0.00471)	0.0387*** (0.01000)	0.0132*** (0.00495)	0.0266** (0.0101)
Regional population	-2.33e-05*** (6.54e-06)	-2.41e-05** (9.57e-06)	-1.66e-05** (7.09e-06)	-1.35E-05 (1.06e-05)	-1.25e-05 (7.69e-06)	9.04e-06 (1.19e-05)	-2.54e-05*** (7.20e-06)	-2.43e-05** (1.09e-05)
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,269	936	2,269	936	2,269	936	2,269	936
R^2	0.470	0.430	0.484	0.451	0.481	0.423	0.466	0.409
NUTS regions	166	70	166	70	166	70	166	70

Notes: FS = full sample; LDR = less developed regions. Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

TABLE A7: Other roads investment, quality of government components and regional growth, 1995-2009

Dep. variable: Change of log GDP	Quality of Government (QoG) Component							
	Control of Corruption		Rule of Law		Government Effectiveness		Government Accountability	
	FS	LDR	FS	LDR	FS	LDR	FS	LDR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged GDP	-0.0910*** (0.0142)	-0.131*** (0.0232)	-0.0872*** (0.0139)	-0.109*** (0.0220)	-0.0877*** (0.0135)	-0.109*** (0.0197)	-0.0816*** (0.0139)	-0.0934*** (0.0213)
Investment in other roads	0.000831 (0.000509)	0.000914* (0.000516)	0.000228 (0.000525)	-0.000188 (0.000559)	0.000893* (0.000480)	0.000859* (0.000507)	0.000508 (0.000447)	0.000377 (0.000466)
Quality of Government (QoG) Component	0.0212*** (0.00431)	0.0503*** (0.00953)	0.0132*** (0.00347)	0.0272*** (0.00698)	0.0181*** (0.00257)	0.0375*** (0.00445)	-0.000716 (0.00266)	0.00835* (0.00498)
Interaction term **Investment in other roads × QoG**	0.00195** (0.000965)	0.00374*** (0.00116)	0.00267*** (0.00101)	0.00445*** (0.00151)	0.00212** (0.000816)	0.00273*** (0.000918)	0.00285*** (0.00103)	0.00352*** (0.00116)
Spatial Weight of investment in other roads	0.00351** (0.00159)	0.00402* (0.00214)	0.00342** (0.00154)	0.00320 (0.00194)	0.00346** (0.00149)	0.00200 (0.00194)	0.00317** (0.00147)	0.00317* (0.00186)
Agricultural employment	-0.00324*** (0.000643)	-0.00295*** (0.000889)	-0.00359*** (0.000641)	-0.00367*** (0.000825)	-0.00364*** (0.000610)	-0.00362*** (0.000759)	-0.00346*** (0.000648)	-0.00363*** (0.000805)
Patent applications	0.00491*** (0.00187)	0.00675** (0.00287)	0.00451** (0.00187)	0.00630** (0.00300)	0.00529*** (0.00178)	0.00567** (0.00274)	0.00355* (0.00184)	0.00495* (0.00291)
Human capital	0.0102** (0.00502)	0.0305** (0.0127)	0.0143*** (0.00500)	0.0338*** (0.0127)	0.0111** (0.00496)	0.0338*** (0.0113)	0.00948* (0.00516)	0.0227* (0.0119)
Regional population	-2.33e-05*** (6.54e-06)	-2.01e-05** (7.85e-06)	-1.66e-05** (7.09e-06)	-1.21e-05 (8.12e-06)	-1.25e-05 (7.69e-06)	1.29e-05 (9.26e-06)	-4.46e-05*** (1.21e-05)	-2.19e-05** (8.89e-06)
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,134	876	2,134	876	2,134	876	2,134	876
R^2	0.470	0.460	0.484	0.438	0.481	0.459	0.466	0.431
NUTS regions	161	66	161	66	161	66	161	66

Notes: FS = full sample; LDR = less developed regions. Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.