

Determinants and Productivity of Regional Transport Investment in Europe

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Abstract

We study the determinants and productivity effects of regional transportation infrastructure investment in France, Germany, Italy, and Spain. We estimate regional production functions for each country, controlling for the potential endogeneity of public infrastructure investment. Two broad categories of determinants of public investment are considered: (1) normative principles, such as efficiency, equity, and redistribution; and (2) political factors, such as electoral competition and electoral rents. The evidence shows that road infrastructure contributes positively to regional production. As to the determinants of infrastructure investment, efficiency and redistribution are uniformly found to be the dominant norms; equity considerations appear to be less important. However, we find remarkable differences across countries regarding the political determinants of infrastructure investment allocation. Which political factors matter for infrastructure investment is related to the different political systems of the various countries.

JEL classification: R10, O40, H54

Keywords: Transportation Infrastructure; Regional Growth; Political Economy

The authors thank Lucio Picci, Federico Bonaglia, and Claudia Cantabene for their help with the Italian infrastructure data, and Cathrin Scupin and the Fundación BBVA as well as Matilde Mas for the Spanish data. They also thank Albert Solé Ollé for sharing his electoral data for Spain and Kerstin Enflo for providing regional capital stock series for comparison. Finally, they thank Timo Välilä, Hubert Strauss and Åke Andersson for comments and helpful suggestions, and gratefully acknowledge excellent research assistance by Nathaliya Fedorenko.

1. Introduction

Considerable effort has been devoted to researching how infrastructure investment contributes to productivity and growth. At present, there appears to be a general consensus on the growth-enhancing effects of public infrastructure investment, although a few studies have found no positive effects (for recent surveys, see Bom and Ligthart 2008; Romp and de Haan 2007; OECD 2007). Even though the *effects* of infrastructure investment are fairly well understood, we know considerably less about the *determinants* of such investment. Most studies treat regional infrastructure investment as an exogenously determined input to private production. However, an increasing number of scholars question this assumption (*e.g.*, Crain and Oakley 1995; Duffy-Deno and Eberts 1991). Kemmerling and Stephan (2002) investigate whether the allocation of infrastructure investment across German cities is influenced by political or by economic concerns. They find that “political congruence,” *i.e.*, same party affiliation of local and higher-tier governments, matters for the *distribution* of federal investment grants. They also find that local governments having a higher probability of reelection have a higher propensity to invest in local infrastructure projects and that, at the federal level, redistributive concerns matter more than the return on the investment.

Cadot *et al.* (2006) propose a simultaneous-equation approach to estimate the contribution of transport infrastructure to French regional growth. Based on a panel of French regions over the period of 1985 to 1992, they estimate not only the contribution of public investment to growth, but also the political determinants of public investment. The empirical findings suggest that electoral concerns and influence activities are indeed significant determinants of cross-regional allocation of transportation infrastructure investment. By contrast, they find little evidence of concern for maximizing economic returns to infrastructure spending after controlling for these political effects. Castells and Solé-Ollé (2005) and Golden and Picci (*fc.*) find political determinants of infrastructure spending for Spain and Italy, respectively. Since these two countries have different political systems, the precise channels of political influence on transport infrastructure are also different between them. Hence, political institutions play an important role in the determination of public investment. Most prominently, federalism and the electoral system have an impact on the political economy of fiscal policies (Persson and Tabellini 2002) and the distribution mechanism of transfers.

In this article, we compare four major European countries and their respective political institutions: France, Germany, Italy, and Spain. All four are similar in population size and GDP per capita but have very different political systems. Germany and Spain are federalist countries; France and Italy are not. Italy and Spain both have proportional voting systems; France and Germany have hybrid voting systems that mix proportional and majoritarian elements. By comparing the four different polities we are able to shed some light on the nature of distribution mechanisms in all four countries and on its impact on the efficiency of public investment in infrastructure. We do this by estimating a system of two equations to allow for mutual endogeneity of productivity effects and political origins of public investment.

In the following section we briefly review the literature on both productivity effects of public capital and its political economy and derive a set of hypotheses to be tested. As

the data collection and operationalization of our key variables are crucial in a four-country comparison, we describe these steps at some length in Section 3. We also provide descriptive evidence of how investment in road infrastructure is regionally distributed. In Section 4 we explain our estimation methodology and describe the results, along with a battery of specification and robustness checks to gauge the validity of our results. The last section concludes with some qualifications to and broader policy implications of our findings.

2. Literature Review and Hypotheses

2.1. Productivity Effects of Public Capital

In this subsection we briefly review the results of empirical studies on infrastructure productivity based on the production function approach, which will guide the following sections of our paper.¹ Early studies such as Mera (1973a, 1973b), Aschauer (1988, 1989a, 1989b, 1989c), and Munnell (1990a, 1990b, 1992) document strong correlation between public capital investment and private sector performance, concluding that public capital is key for economic performance.

However, other studies have reached different conclusions (see, *e.g.*, Tatom 1991). Hulten and Schwab (1991) find that public infrastructure does not have an effect on regional total factor productivity (TFP) growth in U.S. manufacturing. Later studies, mainly dealing with the United States, have resulted in diverse findings. While some find positive and significant effects of infrastructure, others find only negligible or insignificant effects (*e.g.*, Holtz-Eakin 1994; Evans and Karras 1994). Furthermore, the size of the estimated output elasticity of infrastructure capital ε_{YG} differs considerably across the studies (Sturm *et al.* 1996).

For Germany, Hofmann (1996) examines the impact of infrastructure on Hamburg's business sector. In this study, a Cobb-Douglas production function is specified and estimated in a dynamic framework (error correction model). Utilizing data from 1970 to 1992, Hofmann (1996) finds an elasticity of public capital with respect to output that appears to be either insignificant or significant with a negative sign. The result is robust to variations in the econometric specification. In another study at the regional level, using data from 99 German cities from 1980 to 1989, Seitz (1995) finds a positive and significant contribution from infrastructure to private output, with an estimated output elasticity ε_{YG} between 0.08 and 0.19. Finally, Stephan (2002) estimates the impact of public capital on private production using a panel data set from the manufacturing sector of the 11 West German Bundesländer (Federal States) from 1970 to 1996 and finds that public capital is a significant input for production in the manufacturing sector.

Scholars have found a positive contribution of infrastructure investment to growth and productivity for other Western European countries as well. For Italy, Bonaglia *et al.* (2000), among others, find a positive contribution of public capital to regional growth in productivity. Mas *et al.* (1998) find similar effects for Spanish regions. Again, the

¹ For more comprehensive surveys, including studies employing the dual cost or profit function approach, see, for instance, Gramlich (1994), Pfähler *et al.* (1997), or Sturm (1998).

magnitude of the effect and its significance depend not only on the empirical approach chosen, but also on the theoretical framework that provides the foundation for the infrastructure capital model. Considering the various findings of previous studies we formulate our first hypothesis.

Hypothesis 1: The regional transportation infrastructure stock contributes positively to regional production.

We thus hypothesize that infrastructure is an important factor for regional production and growth. In the next section we turn to the determinants of public infrastructure. As argued in the introduction, the link between public investment and the level of regional output clearly hinges on the allocation process of infrastructure investment. It is by no means guaranteed that politicians optimize aggregate social welfare by directing investment in a strictly efficient way.

2.2. Determinants of Public Infrastructure Investment

2.2.1. Economic rationales: Efficiency, equity, distribution

Regarding economic rationales for regional allocation of infrastructure investment, we follow previous research by Mera (1973a), Anderstig and Mattson (1989), Fuente and Vives (1995), Yamano and Ohkawara (2000), and Stephan (2007). Based on this work, we develop three normative principles that politicians may use as guidelines for the distribution of infrastructure investment across regions:

- Efficiency_{*i*} = $\frac{y_i}{g_i}$
- Redistribution_{*i*} = $\frac{y_i}{l_i}$
- Equity_{*i*} = $\frac{g_i}{s_i}$

where y_i denotes regional output, g_i is the regional infrastructure stock, l_i is regional labor force, and s_i is the size of the geographic territory (*i.e.*, the area in square-kilometers.)

Efficiency implies that infrastructure spending should be particularly beneficial for those regions where its impact on growth is expected to be highest. We would expect investment flows to be highest to those regions where its marginal productivity is highest. This allocation of investment would guarantee that the aggregate national income is maximized. Based on a Cobb-Douglas production function, marginal productivity of infrastructure is given by $\alpha y_i / g_i$, where α is the output elasticity of infrastructure capital. We simplify this insight by defining our measure of efficiency as the ratio between the gross domestic product (y_i) and the infrastructure stock (g_i) for region i , and assuming $\alpha_i = \alpha$ for all regions.

Hypothesis 2: According to the efficiency hypothesis, central or regional governments

should direct infrastructure investment to those regions where the marginal productivity of infrastructure is highest.

Redistribution, in our simple terminology, implies that funds are distributed based on the policy of using infrastructure investment as a means of promoting the development of poorer regions. We operationalize this principle as the ratio between output (y_i) and labor (l_i) in a region. If governments follow this logic, infrastructure investment should be targeted at those regions where per-capita GDP is lowest.

Hypothesis 3: If the national government is interested in promoting the development of poorer regions, it may use infrastructure investment as a means of redistribution to spur economic development in such regions. If so, it should target the infrastructure investment at regions with the lowest per-capita income.

The redistribution objective usually conflicts with the efficiency objective. Indeed, we find negative correlation between the ranking of regions according to the efficiency criterion and that according to the redistribution criterion in all countries under investigation.²

Equity, our third normative principle, has to do with the idea of guaranteeing equal living conditions in all regions. We calculate a proxy measure for it as the ratio between infrastructure endowment (g_i) and the geographical size of the region (s_i). For instance, a fundamental norm of German federalism, which is stated in the Constitution, is to guarantee the equality of living conditions in all regions. The German Federal Court is known to base its judicial review of public policy on the basis of such norms. Our criterion measures to what extent a government tries to equalize the public infrastructure endowment (in terms of “infrastructure density”, g_i/s_i). Regional inflows should therefore be inversely related to public capital stocks adjusted for regional geographical differences.

Hypothesis 4: If the national government’s objective is equal infrastructure endowment across regions, it should target its investment at regions with the lowest infrastructure endowment.

2.2.2. Political factors

The four countries under investigation have very different constitutions. Therefore, it is difficult to develop a uniform framework for explaining the political factors behind regional public investment policies across them. To simplify the exposition, we will assume that in all four countries the central government is the decisive political actor. Of course, this is not true for federalist countries, but we will later show the effects of departing from this assumption in a comparison of the federalist countries (Germany and Spain) with the highly centralized countries (Italy and France). There are several hypotheses explaining why politicians consider some regions to be more politically

² A negative correlation of these two criteria is also reported in the case of Japan (Yamano and Ohkawara 2000).

important than others.

The traditional political-science approach to public spending relates transfers to the ideological preferences of parties (*e.g.*, Klingemann *et al.* 1994). The most common example is the idea that left-wing parties have a stronger inclination for spending and “big government” than do right-wing parties. Although the salience of infrastructure investment as compared to other policy areas is not necessarily very high for left-wing parties, preference for high spending usually affects most policy areas. Indeed, there is some empirical evidence for such a proposition in the context of spending on regional infrastructure. Grossman (1994), for instance, finds that U.S. regions in which the Democrats are the dominant party receive more transfers than other regions.

However, the ideological distribution of voters on issues of regional infrastructure is unlikely to be one-dimensionally left *versus* right (Kemmerling and Bodenstern 2006). Regional interests also loom large in the political process so that even conservative parties with a strong regional base will favor a higher level of spending in their regions. Examples of such parties can be found in most European countries: Germany has the regionalist Christian Social Union, Spain has the Catalan and Basque separatist parties, and in Italy there are separatist parties in the northern part of the country. This leads us to our first hypothesis on the political-economy determinants of infrastructure spending.

Hypothesis 5: Infrastructure investment is higher in regions with either strong left or strong regional/ separatist parties.

Another approach to explaining spending does not depend on voter preferences. Infrastructure investment at the regional level is to a large part financed by investment grants from higher-tier governments. Both political and economic studies on intergovernmental grants or transfers have traditionally focused on normative principles, such as those described in the previous subsection (Scharpf 1988; Oates 1999). Yet political economy considerations are important, since in real life the issues of efficiency of investment and its political determinants are mutually dependent: economic efficiency of infrastructure investment depends on its political allocation, and the politicians’ electoral success depend on infrastructure investment and its efficiency. Thus, positive explanations for intergovernmental grants have been sought (*e.g.*, Inman 1988).

Under any approach, however, the fundamental question is why some regions are more successful in receiving grants than others. The politico-economic theory of multi-tiered political systems holds that regions are unlikely to receive equal shares of public transfers or shares when (a) some regions have relatively more political clout to influence the allocation of funds from the central government or (b) national policymakers rely on some regions more than others to muster electoral support. These two claims lead us to our remaining hypotheses on the political factors influencing infrastructure investment.

Starting with the first claim, regions may differ either in their lobbying power or in their institutionalized political clout. Cadot *et al.* (2006), for instance, argue that powerful lobbying groups that depend on road infrastructure, such as big companies, may be more

concentrated in some regions than in others. Regions with stronger lobbies will attract higher transfers since they are able to make campaign contributions to local politicians who, in turn, press for increased grants. A concentration of political power in the hands of a few minority groups can increase the grants (Becker 1983). Moreover, local politicians themselves differ in the extent to which they lobby the national government, as the cases of intergovernmental grants in Norway (Sørensen 2003) and the United States (Grossman 1994) show. Institutional factors that enhance the lobbying power of local politicians are the size and number of seats of an electoral district (Worthington and Dollery 1998) or the voting power of a region (Ansolabehere *et al.* 2002). Finally, channels of influence from lower to higher tiers of government should flow more intensely when reinforced by partisanship. In Germany, for instance, a key factor appears to be partisan congruence between the national and the regional level (Kemmerling and Stephan 2002): in cities where the same partisan composition of government prevails as at the federal level, grant size is significantly higher than in other cities. Since there are many ways of theorizing the political clout of a region, we select the following formulation.

Hypothesis 6: The higher the political clout of a region and, in particular, the higher the political congruence between the regional and the national governments, the higher the infrastructure investment in the region.

The second claim focuses on the preferences of national politicians, rather than on the resources of local politicians. The idea is that national politicians equalize marginal costs—that is, transfers to a region—with marginal benefits, predominantly in the form of higher electoral success. Assuming that central governments depend on local electoral support or money, national politicians will allocate funds to political strongholds (Cox and McCubbins 1986) or to those regions where they can gain the most from additional spending (Dixit and Londregan 1998). Regions in which incumbent politicians have a strong position relative to other parties should benefit most under this theory and, indeed, several studies (Levitt and Snyder 1995; Grossman 1994) find some evidence for the logic of partisan strongholds and incumbency bias in the regional distribution of federal outlays in the United States. Correspondingly, we formulate:

Hypothesis 7: Regional party strongholds of the central government party will receive more public investment than regions in which the central government party is weak.

The alternative and, to some extent, competing hypothesis is that central politicians are more interested in those regions where additional spending has a disproportional effect on the election outcome. The classic version of this argument concerns swing voters, for which there is ample evidence in U.S. first-past-the-post elections (*e.g.*, Jacobsen 1987). Swing voters, those who are as yet undecided, are most important when the race between the two largest parties is very close. If there is a vast difference between the number of votes expected by the two parties, neither will make much of an attempt to attract the swing voters: the most popular party does not need to; the less popular party would be wasting its time (and money) to try. Thus, it is only to regions where swing voters could make a difference in the election outcome that politicians will be motivated to grant money.

One problem with the simple swing-voter hypothesis is that it does not fit all democratic systems. In multi-party or multi-dimensional settings, there will be less chance that there will be “median” voters (because there is a bigger choice), thereby increasing the number of swing voters. This argument therefore is primarily applicable to classic (majority) first-past-the-post electoral systems, in which votes other than for the winning candidate are essentially lost. However, the argument may be extended to other systems, for even in proportional systems, higher electoral competition and more pliable voters should intensify parties’ campaign efforts (McGillivray 2004). Johansson (2003) finds corroborative evidence for a similarly refined version in the Swedish case. There are other factors that raise the marginal gains of central governments in regions. Crain and Oakley (1995) find evidence that voter volatility and legislative stability are important predictors of the size of regional transfers. Castells and Solé-Ollé (2005) use several indicators that “electoral productivity”, *i.e.*, marginal gains in the form of additional seats from marginal increases in votes, is related to public transport grants in Spain. We therefore formulate:

Hypothesis 8: The larger the marginal gains of votes for the central government in a region, and the closer the political race, the larger the infrastructure investment in the region.

This traditional swing-voter hypothesis, however, is not uncontested. Cadot *et al.* (2006), for instance, predict an incumbency effect for infrastructure spending. Those incumbent actors whose chance of reelection is higher will make greater efforts to receive infrastructure investment in their region. This hypothesis is formulated as:

Hypothesis 9: The larger the regional vote share of the incumbent central government, the larger the infrastructure investment in the region.

Hypotheses 8 and 9 may appear to contradict each other, since a central government may be most interested in either very close electoral races *or* races in which it is clearly ahead. In practice, however, it is quite possible that a central government will believe *both* types of races to be more important than those involving a moderate level of competition.

We have now set forth all our major complementary or, in some cases, competing hypotheses on economic and political rationales for the distribution of infrastructure investment and thus proceed to testing them empirically.

3. Data

3.1. Sources

In the following we briefly describe the data and their sources for each country.³

3.1.1. France

³ The level of regional aggregation corresponds to NUTS2 regions for France, Italy. and Spain and to NUTS1 regions for Germany.

The data for France are partially those described in Stephan (2000) and Cadot *et al.* (2006). They include 21 of the 22 French regions for the period 1978–1992.⁴ All values have been converted into ECU at constant 1991 prices. For investment in transport infrastructure, we differentiate between roads, rail, and inland waterways. The infrastructure data for France are also described in Fritsch and Prud’homme (1994) and Fritsch (1995). Road infrastructure investment in France includes both public investment for all road categories and private investment for licensed motorways. The regional capital stocks of road infrastructure are determined from the regional investment series using the “perpetual inventory method” (PIM). The initial capital stock for 1975 for each region is determined as follows. The aggregated transport infrastructure stocks in France as provided by the Federation Nationale des Travaux Publics (FNTP) are allocated proportionally to the individual regions in accordance with the investment proportion of the individual regions. The calculated value is then used as the initial stock for the PIM. For the linear depreciation rate we assume a value of 2.5 percent.⁵

The measures for labor and regional value added data at market prices are taken from the EUROSTAT “New Cronos” database (June 1999 edition). The values for 1979 and 1978 were extrapolated from information on gross domestic product (GDP) for the years 1978 and 1979. The data relating to the regional stock of private capital in France for the period 1978–1991 were provided by Professor Remy Prud’Homme. A description of these data can be found in Prud’Homme (1996).⁶

3.1.2. Germany

For Germany, we separately calculate regional road capital stocks first for roads funded by federal states, districts, and municipalities (*Landes-, Kreis-, und Gemeindestrassen*, district roads), and then for roads financed by the federal government (*Bundesstrassen*, federal roads). In both cases, the PIM is applied based on investment series deflated with the GDP deflator and assuming annual depreciation rates of 0.8 percent for federal roads and 0.6 percent for district roads. These rates are chosen to minimize the difference between the sum of regional road capital stocks that we obtain and the aggregate figures of the stocks for Germany published by the Federal Ministry of Transport (Verkehr in Zahlen, DIW Berlin, 2007). The initial regional capital stocks of road infrastructure for the West German federal states for the year 1970 are obtained from Bartholmai (1973). The information on investment made by the federal, state, and local governments is taken from a publication by the Federal Statistical Office Wiesbaden (*Rechnungsergebnisse des öffentlichen Gesamthaushalts*, Series 14, Section 3.1), which contains road investment figures for different regional-level entities.

As for the additional region-specific variables, the production function data originate

⁴ Corsica was not included due to incomplete statistical information.

⁵ As a control for the capital stocks of road infrastructure obtained with this method, the sum over the individual regions was computed and compared with the aggregated value reported by FNTP. The deviation between the sums of the regional stocks and the national stock is only between 1 and 2 percent.

⁶ The stocks for the year 1992 are computed with PIM using stocks of 1991 and adding regional gross investment in 1992 for all industries, taken from the “New Cronos” database, assuming a linear depreciation rate of 10 percent.

from the series “National Accounts for the Bundesländer” published by the Statistical Office of Baden-Württemberg. Value added is used as a measure for output in the analysis. Private capital in period t is measured as the gross stock of fixed assets in all sectors at the end of year $t-1$ in constant prices of 2000. Labor is measured as the number of employees in all sectors at the regional level of the Bundesländer. For the political data, we use Brancati’s (2007) constituency-level data set and own compilations.

3.1.3. Italy

For Italy, the dependent variable is the public capital stock of roads taken from Picci (2002). We use data for 20 provinces from 1970 to 1998. Picci also uses the PIM to calculate his capital stock data. Data on private capital stocks come from the CRENoS Regio-IT database (Paci and Pusceddu 2000; Paci and Saba 1997), as do the data on other economic variables, which we extract for the years between 1960 and 1996. For the electoral variables, we use Caramani’s (2000) database, which includes electoral results for all major parties in general elections between 1977 and 1996 on a regional level. Retrieving electoral results for individual parties is not of much use, since the Italian party system is notoriously unstable. Therefore, we use the vote share of party families, leading to seven families, of which one reflects the vote share of regional parties, as in Caramani (2000).⁷

3.1.4. Spain

For Spain, we use data on transportation infrastructure investment by the central and regional governments of 17 comunidades autónomas⁸ during the period 1955–1998. The source of data on capital stock and infrastructure investment by government level and region is Fundación BBVA “Stock de Capital en España y su distribución territorial (1964–2000).” These data have been used previously (*e.g.*, Mas *et al.* 1998). We use investment in roads, which constitutes the largest part of overall spending. The stock is calculated using the PIM. Private capital stock data also come from the Fundación BBVA. The other economic variables are taken from the Regional Accounts of the National Institute of Statistics. For the political variables, from Caramani (2000) we extract the vote shares of the Spanish Workers’ Party, the People’s Party, and the communists. The problem of certain regional parties occurring in only one or two regions (such as the Catalan or Bask parties) is addressed by creating a variable that lumps together the vote shares of all the parties that Caramani (2000) denominates as “regional.”

3.2. Political Proxy Variables

The definitions political variables need a little more explanation than do the economic variables and thus we briefly discuss each of them to show how we operationalize our hypotheses on the political economy of transport infrastructure investment. Some of our

⁷ For Italy, the regional level of aggregation (20 provinces) does not match the 32 electoral districts. However, a problem of overlapping occurs for only two constituencies of minor importance.

⁸ This level of aggregation best reflects actual decision-making power even though legal competencies differ greatly across Spanish provinces. It also makes the analysis comparable with that of the other three countries. We exclude the small regions of Ceuta and Melilla as they are hardly comparable with the other Spanish regions.

hypotheses are, of course, only applicable to some political systems. Notably, hypotheses on two-tiered systems pertain only to federal systems (*i.e.*, Germany and Spain).

As mentioned above, there is some debate in the literature on the political economy of regional transfers over whether politicians are more interested in swing constituencies (Dixit and Londregan 1998) or in partisan strongholds (Cox and McCubbins 1986). We operationalize the latter as the regional vote share of the central government party.⁹ Following Johansson (2003), we operationalize the idea of regional incumbency as the difference in number of votes between the two largest parties in a region in national elections. Moreover, we operationalize the concept of electoral race by coding a dummy variable that equals 1 whenever this difference is very small, *i.e.*, less than 5 percentage points. This accounts for a nonlinear effect of the electoral race in cases where the race is very close. Our threshold is arbitrary and alternative operationalizations are possible but we believe that not much is to be gained from a more sophisticated technique. First, such methods may add substantive measurement error to the defined variables. Second, the underlying theory commonly assumes a one-dimensional policy space, which is unrealistic given the politics under investigation. Our version has the merit of being easily interpretable. More important is the theoretical caveat that swing voters should matter more in first-past-the-post voting systems and single-member districts. Thus we expect that the effect of swing voters and electoral tightness should be stronger in majoritarian systems such as France and the open-list system of proportional representation in Italy before 1993 (Golden and Piccific).¹⁰

Finally, for multi-tiered political systems such as Spain and Germany, we use political information at both the central and the regional levels. We compare the partisan makeup of central and regional governments to measure the congruence between them (Kemmerling and Stephan 2002). For Spain, however, we use a simple congruence measure due to lack of information on regional election outcomes. We code a dummy variable that equals 1 if the partisan composition of the regional and the central governments coincide.

Table 1 summarizes our major political-economy variables, their operationalization, and the expected sign of the relationship with public investment in road infrastructure. Following the discussion in Section 2.2, the first three variables capture broad normative

⁹ For France, “incumbent party” is either the Gaullists or the Socialists. For Germany, it refers to sum of vote shares of the coalition of the CDU-CSU and FDP before 1998 and to that of the SPD and Grüne thereafter. For Italy, it is the Democrazia Cristiana for most of the period and for Spain it is the PSOE until 1996 and the People’s Party thereafter.

¹⁰ We also compute complementary measures of the closeness of electoral competition in our tests of robustness. One of these variables is electoral turnout, measured as the number of actual votes in relation to the size of the electorate. Many studies (Levitt and Snyder 1995; Castells and Solé-Ollé 2005) have used turnout as a proxy for the intensity of the electoral campaign and argue that it should be positively related to the size of regional investment. Alternatively, we could expect that the number of effective parties is inversely related to the size of regional investment. In this case, the idea is that more political parties make additional spending less effective for central government parties, since electoral gains are spread over several parties. The number of effective parties has also been used as an indicator for additional veto players, which make political changes in general more difficult (Tsebelis 2002). We follow Laakso and Taagepera (1979) by operationalizing the number of effective parties as 1 over the Herfindahl index of the vote share of parties.

goals in decision making, whereas the latter five focus on the political process and the electoral gains derived from investment in road infrastructure.

[Insert Table 1 about here]

3.3. Descriptive Statistics

Figures 1, 2, 3, and 4 show the mean and standard deviation of the dependent variable of the policy equation, *i.e.*, the growth rate of the regional infrastructure stock. We find increasing growth rates of regional infrastructure stocks in both France and Spain, even though growth rates in Spain have decreased after their peak in the 1990s. In contrast, for Germany and Italy we note a decrease in the average growth rate of regional infrastructure stocks. The standard deviation does not decrease in the same proportion, implying an increasingly heterogeneous growth pattern across regions. Further summary statistics of the dependent and independent variables for the different countries are presented in Tables A1 to A4 in the Appendix. **[ANDREAS: Note that in the Appendix, these are actually labeled Tables A3 to A6.]**

[Insert Figures 1 to 4 about here]

4. Empirical Estimation and Results

4.1. Specification of the Simultaneous Equation Model

Aschauer (1989b) triggered a controversial debate about the contribution of public capital to growth using a simple production function framework with public capital as a factor input to production. Several authors argue that this approach could suffer from a potential endogeneity problem as there might be feedback effects from growth to infrastructure spending. Therefore, a simultaneous-equation approach has been proposed where public infrastructure investment is endogenously and explicitly explained by several variables (Duffy-Deno and Eberts 1991; de Frutos and Pereira 1993; Kemmerling and Stephan 2002; Kawaguchi *et al.* 2005; Cadot *et al.* 2006). Following this line of reasoning, we specify a simultaneous-equation model consisting of two equations: a production function and a policy equation. The two equations are linked through the production function by the definition of the current stock of infrastructure capital (in logs) as $\ln g_{it} = \ln(g_{i,t-1} + \Delta g_{it})$, where Δ is the first difference operator. Assuming a Cobb-Douglas functional form, the logarithmic regional production function can be written as

$$\ln y_{it} = \beta_0 + \nu_i + \lambda_t + \beta_k \ln k_{it} + \beta_l \ln l_{it} + \beta_g \ln g_{it} + \varepsilon_{it}; \quad i = 1, \dots, N; \quad t = 1, \dots, T \quad (1)$$

The GDP of region i at time t (y_{it}) depends on private capital (k_{it}), labor input (l_{it}), and public infrastructure (g_{it}). The production function is estimated in levels and region-specific effects ν_i , and time-effects λ_t are also included.

The policy equation describes the change in regional road capital stocks relative to the

existing stock (*i.e.*, the growth rate of the stock).¹¹ To describe the politico-economic determinants of regional infrastructure stock changes we use the following stylized policy equation

$$\begin{aligned} \Delta \ln g_{it} = & \alpha_0 + \theta_t + \alpha_{eff} \frac{y_{it}}{g_{it}} + \alpha_{redistr} \frac{y_{it}}{l_{it}} + \alpha_{equi} \frac{y_{it}}{s_{it}} \\ & + \alpha_{str} strong_{it} + \alpha_{inc} incumb_{it} + \alpha_{race} elrace_{it} + \alpha_{left} left_{it} \\ & + \alpha_{reg} regional_{it} + \alpha_{congr} congruence_{it} + v_{it}, \quad i = 1, \dots, N, t = 1, \dots, T \end{aligned} \quad (2)$$

The dependent variable of the policy equation is the growth of the infrastructure stock, $\Delta \ln g_{it}$, in region i at time t . The first three terms on the right-hand side of Equation (2) describe the efficiency, equity, and redistribution criteria, respectively. The last terms of Equation (2) correspond to the political variables discussed in the previous section. Note that y_{it} is treated as an endogenous variable in the policy equation, whereas $\Delta \ln g_{it}$ is treated as an endogenous variable in the production function.

As we are analyzing the cross-regional allocation of investment (not the intertemporal within-region allocation), we do not include region-specific dummies but only time effects θ_t in the policy equation. These time effects control for any common shocks at time t so that the remaining heterogeneity in investment allocation captures the differences across regions.

4.2. Econometric Methodology

The endogeneity of the growth rate of the regional road capital stocks in the production function is taken into account by using the nonlinear GMM estimator suggested by Andrews (1991), where the exogenous variables of both equations are used as instruments. The GMM estimator provides consistent estimates of standard errors in the presence of heteroscedasticity and autocorrelation.¹² The results of specification tests on autocorrelation, heteroscedasticity, and stationarity are discussed in the Appendix. Generally, the results support the application of consistent estimators. In the context of simultaneous-equation estimation, a more important issue is instrument validity, *i.e.*, their noncorrelation with the error term. In the context of the GMM estimation, the validity of overidentifying moment restrictions can be tested as proposed by Hansen (1982).¹³

4.3. Estimation Results

¹¹ Note that $inv_{it} / g_{it} = (g_{it} - g_{i,t-1}) / g_{it} \approx \Delta \ln g_{it}$.

¹² Using SAS V9.2 proc model, we specify the GMM estimator using the Parzen kernel. Different kernel/bandwidth choices are tested, but most results are unaffected by these choices.

¹³ The null hypothesis states that instruments and errors are uncorrelated. The test statistic is χ^2 -distributed with $r-s$ degrees of freedom, where r is the number of instruments multiplied with the number of equations and s is the number of parameters.

Table 2 shows the results of the nonlinear GMM system estimation for each country.¹⁴ Both equations are estimated with a good fit, though a large fraction of the fit is likely to be attributable to the region and time dummies and less to the explanatory variables. The region as well as the time effects are significant in both equations for all countries. The choice of instruments in the GMM estimation is appropriate for all countries as the Hansen test does not reject the null hypothesis of valid instruments in any equation at the 5-percent significance level.

[Insert Table 2 about here]

Regarding the results for the production function, we would *a priori* expect estimates of labor elasticity between 0.5 and 0.8 and of capital elasticity between 0.2 and 0.5. Furthermore, we would expect the labor and capital elasticities to add up to 1, implying constant returns to scale in the private inputs. However, the reported production function estimates in Table 2 fulfill these expectations only for Italy and France; the production function results for Germany and Spain appear less plausible with respect to the estimated labor elasticities, which are far below 0.5, particularly in the case of Spain.

Similarly, we find different estimates for the impact of transportation infrastructure on regional GDP. A very low and insignificant contribution is visible for Spain (0.02). France has a much higher and significant coefficient (0.14) and the estimates for Germany and Italy are 0.21 and 0.20, respectively. Hence, according to these estimates, in three out of the four countries road infrastructure contributes to economic output. Our estimates, which range between 0.05 and 0.2, are in general agreement with most previous studies.

The policy equation, however, displays more diverse estimates across the countries. As for the three normative principles, we find that efficiency concerns matter for the growth rates of infrastructure stock in all countries. In addition, the sign of the coefficient for the redistribution criterion is negative and significant, as expected, for three countries, but insignificant for France. This is perhaps not surprising as interregional redistribution does not appear to be a priority in France compared to federalist countries like Germany or Spain. The equity criterion shows a more ambiguous pattern. Here, only France has a significant estimate with the expected sign, whereas the effect for Italy is actually positive, implying that Italian regions with a good endowment of infrastructure receive more investment than those with a poor endowment. To some extent, imprecise estimates or implausible signs may stem from correlation between some of the explanatory variables (see Appendix Table A1).

The effects of the political variables also vary across countries. In general, political influence appears to be relatively moderate. Partisan strongholds do not seem to play a marked role in France or Germany, whereas in Italy and Spain national government party strongholds do indeed receive more investment than other regions. The incumbency effect, *i.e.*, the coefficient for the difference in vote share between the two largest parties, is significant with the expected sign only in the case of Germany.

¹⁴ The results from simple OLS regressions turn out not to be very different from the GMM results in terms of parameter estimates, suggesting that endogeneity is not a serious concern in most of the estimations.

Similarly, the closeness of the electoral race shows an effect in Germany but has an unexpected negative impact in Spain. Furthermore, we find that left-wing parties matter in France and Italy but not in Germany and Spain. Regional parties influence the distribution of public investment significantly only in Italy but not in Spain. Finally, the congruence variable has the predicted effect on the distribution of investment in one of the two federalist countries—Germany—but not in Spain.

Taken together, the findings of our (positive) political variables reveal two interesting patterns. First, the ideological variables—left or regionalist votes—play a role only in a centralized system, arguably because in federalist systems these effects are either politically contained or dominant at the regional level. In contrast, partisan congruence does play a role in one of the two federalist systems (Germany). Second, the variables on electoral incentives show that, as expected, partisan strongholds (H7) and the electoral race (H8) are competing hypotheses, considering the signs of the coefficients for Germany, Italy, and Spain. In addition, we find some evidence for a complementary relationship between the closeness of the electoral race (H8) and incumbency (H9): elections that are either very close or very clear-cut lead to a significant increase in infrastructure spending.

5. Conclusions

In this paper we have investigated the determinants and productivity effects of regional transportation infrastructure investment using a simultaneous-equation approach. The analysis was conducted for four major European economies: France, Germany, Italy, and Spain.

Three of our findings are worth emphasizing. First, the estimates confirm for three out of four countries that regional investment in road infrastructure contributes to regional production. The estimated output elasticities between 10 and 20 percent lie in a plausible range and indicate that the economic contribution of infrastructure to regional development is not by any means trivial. The insignificant estimate for Spain is in contrast to previous studies (*e.g.*, Mas *et al.* 1996; Cantos *et al.* 2005), which use longer time series of the variables.

Second, we establish that normative principles have a large influence on the distribution of investment. In particular, we find that efficiency and redistribution criteria are relevant to the allocation of infrastructure investment across regions, but that equity considerations are of less importance. Again, our findings at least partly contradict previous work. For instance, Cadot *et al.* (2006) do not find that efficiency matters for regional allocation of investment in France. However, their policy equation is differently specified and their period of investigation is shorter than in our case.

Third, our findings show that political factors do influence regional distribution of infrastructure investment but not to a very great extent. As we elaborated in this paper, the results also support the view that political factors have a different impact depending on the country's political system. For example, partisan strongholds and ideological preferences matter more in centralist political systems than they do in federalist countries. The effect of political congruence (same political affiliation of higher- and

lower-tier governments) on the allocation of investment is supported at least for Germany. We also find evidence for a competing relationship between favoring partisan strongholds on the one hand, and favoring very close or very clear-cut electoral races on the other.

A few words on the limitations of our study are in order. First, according to our assessment, the robustness of the results depends less on the sophistication of the applied econometric estimation methods (exemplified by the rather small differences between OLS and GMM estimates) than on the quality of the underlying data. The data for this study were collected from several sources using different definitions, concepts, calculation methods, and so forth. This limits the comparability of figures across countries; however, the data should be consistent for regional comparisons within countries. Second, we are aware that the political proxy variables in particular are somewhat crude measures of the underlying mechanism formulated in the hypotheses. For instance, we presumed a positive influence from electoral competition on infrastructure spending but this can be proxied for only by the outcome of the last election. Certainly, there might be close political competition in a region that is not reflected in the difference of vote shares between the two largest parties in the last election. Third, for two out of the four countries (France and Italy) we cannot distinguish at which level (regional or central government) road investment is administered. Obviously, we would expect a stronger political influence (*e.g.*, from national election outcomes) in cases where the investment is under the control of the national government.

Overall, the approach presented in this paper provides interesting insights into the determinants and productivity effects of regional transportation infrastructure and may serve as an inspiration and starting point for future investigations into these topics.

References

- Anderstig, C., Mattson, L.-G. (1989). „Interregional allocation models of infrastructure investments”. *The Annals of Regional Science*, (23:4), pp. 287-298.
- Andrews, D.W. (1991). “Heteroscedasticity and autocorrelation consistent covariance matrix estimation”. *Econometrica*, (59:3), pp. 817-858.
- Ansolabehere, S., Gerber, A., Snyder, J. (2002). “Equal votes, equal money: Court-ordered redistricting and public expenditures in the American states.” *American Political Science Review*, (96:4), pp. 767-777.
- Aschauer, D.A. (1988). “Government spending and the ‘falling rate of profit’”. *Economic Perspectives*, (12:3), pp. 11-17, Federal Reserve Bank of Chicago.
- Aschauer, D.A. (1989a). “Does public capital crowd out private capital?”. *Journal of Monetary Economics*, (24:2), pp. 171-188.
- Aschauer, D.A. (1989b). “Is public expenditure productive?” *Journal of Monetary*

- Economics, (23:2), pp. 177-200.
- Aschauer, D.A. (1989c). "Public investment and productivity growth in the group of seven". *Economic Perspectives*, (13:5), pp.17-25, Federal Reserve Bank of Chicago.
- Bartholmai, B. (1973). "Regionale Verkehrsinfrastruktur in der BRD". German Institute for Economic Research (DIW), Beiträge zur Strukturforschung no. 26.
- Becker, G.S. (1983). "A theory of competition among pressure groups for political influence". *Quarterly Journal of Economics*, (98:3), pp. 371-400.
- Bom, P. and Ligthart, J.E. (2008). "How productive is public capital? A meta-analysis." CESifo Working Paper No. 2206.
- Bonaglia, F., Ferrara, E.L., and Marcellino, M. (2000). "Public capital and economic performance: Evidence from Italy". IGIER Working Paper 163.
- Brancati, D. (2007). "Constituency-Level Elections (CLE) Dataset". Harvard University, New York, <http://www.people.fas.harvard.edu/brancati/CLE.htm>.
- Cadot, O., Röller, L.-H., Stephan, A. (2006). "Contribution to productivity or pork-barrel? The two faces of infrastructure investment". *Journal of Public Economics*, (90: 6-7), pp. 1133-1153.
- Cantos, P., Gumbau, M., Maudos, J. (2005). "Transport infrastructures, spillover effects and regional growth: Evidence of the Spanish case". *Transport Reviews*, (25:1), pp. 25-50.
- Caramani, D. (2000). "Elections in Western Europe since 1815: Electoral Results by Constituencies", Palgrave, London, UK.
- Castells, A., Solé-Ollé, A. (2005). "The regional allocation of infrastructure investment: The role of equity, efficiency and political factors". *European Economic Review*, (49:5), pp. 1165-2005.
- Cox, G.W. and McCubbins, M.D. (1986). "Electoral politics as a redistributive game". *Journal of Politics*, (48:2), pp. 370-389.
- Crain, W.M. and Oakley, L.K. (1995). "The politics of infrastructure". *Journal of Law and Economics*, (38:1), pp. 1-17.
- De Frutos, R.F. and Pereira, A.M. (1993). "Public capital and aggregate growth in the United States: Is public capital productive?" Economics Working Paper 93-31, University of California.
- De la Fuente, A. and Vives, X. (1995). "Infrastructure and education as instruments of regional policy: Evidence from Spain". *Economic Policy*, (10:20), pp. 11-51.

- Dixit, A. and Londregan, J. (1998). "Fiscal federalism and redistributive politics". *Journal of Public Economics*, (68:2), pp. 153-180.
- Duffy-Deno, K.T. and Eberts, R.W. (1991). "Public infrastructure and regional economic development: A simultaneous equation approach". *Journal of Urban Economics*, (30:3), pp. 329-343.
- Evans, P. and Karras, G. (1994). "Are government activities productive? Evidence from a panel of U.S. states". *Review of Economics and Statistics*, (76:1), pp. 1-11.
- Fritsch, B. (1995). "La contribution des infrastructures au développement économique des régions françaises", Ph.D. thesis, Institut d'Urbanisme de Paris, Université de Paris XII, France.
- Fritsch, B. and Prud'homme, R. (1994). "Measuring the contribution of road infrastructure to economic development in France". Working paper 94-02, Université Paris XII.
- Golden, M. and Picci, L. (fc.). "Pork barrel politics in postwar Italy, 1953-1994". *American Journal of Political Science*, (52:2).
- Gramlich, E.M. (1994). "Infrastructure investment: A review essay". *Journal of Economic Literature*, (32:3), pp. 1176-1196.
- Grossman, P.J. (1994). "A political theory of intergovernmental grants". *Public Choice*, (78:3-4), pp. 295-303.
- Hansen, L.P. (1982). "Large sample properties of generalized method of moments estimators". *Econometrica*, (50:4), pp. 1029-1054.
- Hofmann, U. (1996). *Produktivitätseffekte der öffentlichen Infrastruktur: Meßkonzepte und empirische Befunde für Hamburg*, Europäische Hochschulschriften: Reihe 5, Volks- und Betriebswirtschaft. Frankfurt am Main, Germany.
- Holtz-Eakin, D. (1994). "Public-sector capital and the productivity puzzle". *Review of Economics and Statistics*, (76:1), pp. 12-21.
- Hulten, C.R. and Schwab, R.M. (1991). "Public capital formation and the growth of regional manufacturing industries". *National Tax Journal*, (44:4), pp. 121-134.
- Inman, R.P. (1988). "Federal assistance and local services in the United States: The evolution of a new federalist fiscal order", in Rosen, H. S. (ed.), *Fiscal Federalism: Quantitative Studies*. University of Chicago Press, Chicago, USA, pp. 33-77.
- Jacobsen, G. (1987). "The marginals never vanished: Incumbency and competition in elections to the U.S. house of representatives, 1952-82". *American Journal of Political Science*, (31:1), pp. 126-141.

- Johansson, E. (2003). "Intergovernmental grants as a tactical instrument: empirical evidence from Swedish municipalities". *Journal of Public Economics*, (87:5-6), pp. 883-915.
- Judge, G., Griffiths, W., Hill, W., Lee, T., and Lütkepohl, H. (1985). *The Theory and Practice of Econometrics*, John Wiley and Sons, New York, USA.
- Kawaguchi, D., Ohtake, F., and Tamada, K. (2005). "The productivity of public capital: Evidence from the 1994 electoral reform of Japan". Discussion paper No. 627, The Institute of Social and Economic Research, Osaka University.
- Kemmerling, A. and Bodenstein, T. (2006). "Partisan politics in regional redistribution – do parties affect the distribution of EU structural funds across regions?". *European Union Politics*, (7:3), pp. 373-392.
- Kemmerling, A. and Stephan, A. (2002). "The contribution of local public infrastructure to private productivity and its political economy: Evidence from a panel of large German cities". *Public Choice*, (113:3-4), pp. 403-424.
- Klingemann, H.-D., Hofferbert, R.I., and Budge, I. (1994). *Parties, policies, and democracy*, Westview Press, Boulder (Col.), USA.
- Laakso, M. and Taagepera, R. (1979). "Effective number of parties: A measure with application to West Europe". *Comparative Political Studies*, (12:1), pp. 3-27.
- Levin, A., Lin, C.-F. and Chu, C.-S.J. (2002). "Unit root tests in panel data: Asymptotic and finite sample properties". *Journal of Econometrics*, (108:1), pp. 1-24.
- Levitt, S.D. and Snyder, J.M. (1995). "Political parties and the distribution of federal outlays". *American Journal of Political Science*, (39:4), pp. 958-980.
- Mas, M., Maudos, J., Pérez, F., and Uriel, E. (1996). "Infrastructures and productivity in the Spanish regions". *Regional Studies*, (30:7), pp. 641 - 649.
- Mas, M., Maudos, J., Pérez, F., and Uriel, E. (1998). "Public capital, productive efficiency and convergence in the Spanish regions (1964-93)". *Review of Income and Wealth*, (44:3), pp. 383-396.
- McGillivray, F. (2004). "Privileging Industry: The Comparative Politics of Trade and Industrial Policy", Princeton University Press, Princeton, USA.
- Mera, K. (1973a). "Regional production functions and social overhead capital". *Regional and Urban Economics*, (3:2), pp. 157-186.
- Mera, K. (1973b). "Trade-off between aggregate efficiency and interregional equity: The case of Japan." *Regional and Urban Economics*, (3:3), pp. 273-300.

- Munnell, A.H. (1990a). "How does public infrastructure affect regional economic performance?" *New England Economic Review*, September, pp. 11-32.
- Munnell, A.H. (1990b). "Why has productivity growth declined? Productivity and public investment". *New England Economic Review*, January, pp. 3-22.
- Munnell, A.H. (1992). "Policy watch: Infrastructure investment and economic growth". *Journal of Economic Perspectives*, (6:4), pp. 189-198.
- Oates, W.E. (1999). "An essay on fiscal federalism". *Journal of Economic Literature*, (37:3), pp. 1120-1149.
- OECD (Organisation for Economic Co-operation and Development) (2007). *Transport infrastructure investment and economic productivity*, OECD, Paris, France.
- Paci, R. and Pusceddu, N. (2000). "Stima dello stock di capitale nelle regioni italiane: 1970-1994". *Rassegna Economica, Quaderni di Ricerca*, (4), pp. 97-118.
- Paci, R. and Saba, A. (1997). "The empirics of regional economic growth in Italy, 1951-1993". *Rivista Internazionale di Scienze Economiche e Commerciali*, (45:3), pp. 515-542.
- Persson, T. and Tabellini, G. (2002). *Political Economics. Explaining Economic Policy*, MIT Press, Cambridge (Mass.), USA.
- Pfähler, W., Hofmann, U. and Bönnte, W. (1997). "Does extra public infrastructure capital matter? An appraisal of the empirical literature". *Finanzarchiv*, (53:1), pp. 68-112.
- Picci, L. (2002). "Le infrastrutture in Italia. Le differenze territoriali e l'efficienza della spesa", in Baldassarri, M., Galli, G., and Piga, G. (eds.), *L'Italia nella Competizione Globale - Regole per il Mercato*. Il Sole 24 Ore, Italy.
- Romp, W. and de Haan, J. (2007). "Public capital and economic growth: A critical survey". *Perspektiven der Wirtschaftspolitik*, (8:Special Issue), pp. 6-52.
- Scharpf, F.W. (1988). "The joint-decision trap - lessons from German federalism and European integration." *Public Administration*, (66:3), pp. 239-278.
- Seitz, H. (1995). "The productivity and supply of urban infrastructures". *Annals of Regional Science*, (29: 2), pp. 121-141.
- Sørensen, R.J. (2003). "The political economy of intergovernmental grants: The Norwegian case". *European Journal of Political Research*, (42:2), pp. 163-195.
- Stephan, A. (2000). "Regional infrastructure policy and its impact on productivity: A comparison of Germany and France". *Applied Economics Quarterly*, (46:4), pp. 327-356.

- Stephan, A. (2002). "Assessing the contribution of public capital to private production: evidence from the German manufacturing sector". *International Review of Applied Economics*, (17:4), pp. 399 - 417.
- Stephan, A. (2007). "Zur politischen Ökonomie öffentlicher Infrastrukturausgaben". *Perspektiven der Wirtschaftspolitik*, (8:Special Issue), pp. 116-132.
- Sturm, J.-E. (1998). *Public Capital Expenditure in OECD countries. The Causes and Impact of the Decline in Public Capital Spending*, Edward Elgar, Cheltenham, UK.
- Sturm, J.-E., Kuper, G.H., and de Haan, J. (1996). "Modelling government investment and economic growth on a macro level: A review". Discussion paper, CCSO Series, No. 29.
- Tatom, J.A. (1991). "Public capital and private sector performance". *Federal Reserve Bank of St. Louis Review*, (73:3), pp. 3-15.
- Tsebelis, G. (2002). *Veto Players. How Political Institutions Work*, Princeton University Press, New York, USA.
- Worthington, A.C. and Dollery, B.E. (1998). "The political determination of intergovernmental grants in Australia". *Public Choice*, (94:3-4), pp. 299-315.
- Yamano, N. and Ohkawara, T. (2000). "The regional allocation of public investment: Efficiency or equity?". *Journal of Regional Science*, (40:2), pp. 205-229.

Table 1. Summary of major hypotheses and their operationalization

Hypothesis	Label	Operationalization	Expected sign
H2	Efficiency	y/g	+
H3	Redistribution	y/l	-
H4	Equity	g/s	-
H5	Left/regional parties	vote share of left or regional parties	+
H6	Political congruence (only federal systems)	For Germany: share of governmental party in regional elections for Spain: d=1 if same government on central and regional level, otherwise d=0	+
H7	Partisan strongholds	regional vote share of central government party in national election	+
H8	Electoral race	d=1 if difference of 2 largest parties ≤ 5 percent, otherwise d=0	+
H9	Incumbency	difference in vote shares of 2 largest parties in national election	+

Table 2. Nonlinear GMM system estimation results

	France		Germany		Italy		Spain	
Policy equation	1978–1992		1970–2004		1970–1994		1982–1995	
Dependent variable: $\Delta \ln g$								
Time effects	Included ^(a)		Included ^(b)		Included		Included	
Efficiency	0.0049	(11.97)	0.0005	(3.07)	0.0016	(3.59)	0.7682	(3.22)
Redistribution	-0.0001	-(0.84)	-0.0005	-(2.87)	-0.0011	-(5.27)	-0.0025	-(4.18)
Equity	-7.8559	-(2.16)	0.2294	(0.48)	1.9850	(3.03)	-0.0141	-(1.44)
Partisan strongholds	0.0168	(1.62)	-0.0279	-(1.72)	0.0883	(6.04)	0.0716	(2.05)
Incumbency	-0.0019	-(0.15)	0.0433	(4.19)	-0.0255	-(2.03)	-0.0556	-(1.76)
Electoral race	0.0024	(1.40)	0.0044	(2.64)	-0.0018	-(0.68)	-0.0117	-(2.02)
Left share	0.0217	(2.62)	-0.0206	-(1.21)	0.0413	(3.54)	0.0345	(1.06)
Regional parties share	–	–	–	–	0.0929	(6.25)	0.0120	(0.53)
Political congruence	–	–	0.0172	(2.57)	–	–	0.0018 ^(c)	(0.41)
R ²	0.5269		0.6924		0.4591		0.5000	
Production function								
Dependent variable: $\ln y$								
Time effects	Included		Included		Included		Included	
Region effects	Included		Included		Included		Included	
Log private capital	0.1948	(7.45)	0.0407	(2.09)	0.4253	(14.59)	0.2252	(2.96)
Log labor	0.7287	(10.93)	0.3429	(11.60)	0.6865	(8.31)	0.2092	(2.18)
Log road capital	0.1426	(3.72)	0.2064	(6.33)	0.2008	(5.39)	0.0182	(0.72)
R ²	0.999		0.9997		0.9989		0.9982	
N	315		439		500		255	
No. regions	21		16		20		17	
Hansen test	43.33		42.91		42.83		37.84	

Notes: t-values in parentheses. Hansen test is distributed χ^2 with (r-s) degrees of freedom.

(a) Dummy variable for Île-de-France included, (b) dummy variables for East German Länder included, (c) dummy variable for congruence.

Figure 1: Development of growth rates of regional transportation (road) infrastructure investment in France, 1978–1992

Figure 2: Development of growth rates of regional transportation (road) infrastructure investment in Germany, 1971–2004

Figure 3: Development of growth rates of regional transportation (road) infrastructure investment in Italy, 1970–1994

Figure 4: Development of growth rates of regional transportation (road) infrastructure investment in Spain, 1982–1996

A. Appendix

A1. Specification Tests and Robustness Checks

We performed several specification and robustness checks of the econometric results. A first important issue is multicollinearity. The condition numbers are much higher than 100, which is viewed as a critical value in Judge *et al.* (1985). Thus, imprecise estimates or even implausible signs of parameters might stem from the high correlation between some of the explanatory variables, a problem that is aggravated in cases where the variables do not have much time variation and region-specific effects are included. However, there is no appropriate solution to the multicollinearity issue.

A second issue is heteroscedasticity and autocorrelation in the residuals. The results of specification tests indicate that heteroscedasticity (Breusch-Pagan LM) and nonstationarity of residuals (Levin-Lin panel test)¹⁵ heteroscedasticity is present in both the policy equation and the production function. Autocorrelation is present in both equations as well, according to the Godfrey LM test. Accordingly, application of the nonlinear GMM estimator with consistent estimation of the variance-covariance matrix of parameter estimates is justified.

Finally, the null hypothesis of a unit root in the residuals was tested for using the Levin-Lin test¹⁶ (Levin *et al.* 2002) and rejected in almost all cases for both equations. The only exception is Germany where due to the balance requirement of the Levin-Lin test we had to split the samples to only West German regions from 1970 to 2004 and all regions from 1991 to 2004, including the East German Länder. For the latter sample, the test does not reject the null hypothesis of a unit root in $\ln y$ but the test based on the former sample with only West German Länder does. We are not too concerned about this as the sample from 1991 to 2004 is a small part of the total sample and the power of the test may be limited given the relatively short time series from 1991 to 2004. We also performed an estimation where we allowed for different estimates before and after German reunification for key variables (structural break). The outcome is interesting and yields plausible results, three of them worth mentioning. First, the output elasticity of infrastructure capital is significantly lower after reunification compared to the years before. Second, the efficiency criterion becomes less significant after reunification, whereas both the redistribution and equity criteria gain significance, showing the expected negative sign. Third, the effect of political congruence becomes more important after reunification.

¹⁵ The idea for the stationarity test of the residuals is that if any of the variables in the linear regression equation is nonstationary, due to the definition of residuals as $\varepsilon_i = y_i - \sum \beta_k x_{ki}$, this would lead also to a nonstationarity of the residuals.

¹⁶ The Levin-Lin tests were performed without specifying a time trend and including two lags to account for autocorrelation of order two (except for Germany (a), where a lag of one was specified).

A2. Descriptive Summary Statistics of the Variables

Table A1. Descriptive statistics for dependent and independent variables – France **Error! Bookmark not defined.****Error! Bookmark not defined.****Error! Bookmark not defined.**($n=315$)

Variable	Mean	Std Dev	Min	5 th Percentile	Median	95 th Percentile	Max
$\Delta \ln g$	0.0266	0.0117	0.0032	0.0096	0.0257	0.0471	0.0893
Efficiency	6.7776	1.4124	4.1439	4.4755	6.7055	9.7227	10.9323
Distribution	35.0550	5.0543	23.6208	27.3734	34.7811	42.8373	55.2802
Equity	0.0003	0.0001	0.0001	0.0001	0.0002	0.0005	0.0006
Strongholds	0.4735	0.0676	0.3005	0.3635	0.4724	0.6165	0.6233
Incumbency	0.0999	0.0624	0.0005	0.0042	0.0978	0.2116	0.2231
Electoral race	0.2762	0.4478	0.0000	0.0000	0.0000	1.0000	1.0000
Left	0.4939	0.0739	0.2822	0.3573	0.4943	0.6299	0.6415
$\ln y$	10.2558	0.6729	8.8873	9.4755	10.1792	11.3885	12.5248
$\ln k$	10.4171	0.7048	8.8781	9.5155	10.3532	11.7723	12.5375
$\ln l$	6.7090	0.5942	5.6017	5.9852	6.4977	7.6857	8.5389
$\ln g_{t-1}$	8.3371	0.6770	6.4943	7.4972	8.2962	9.5269	10.1984

Table A2. Descriptive statistics for dependent and independent variables – Germany ($n=439$)

Variable	Mean	Std Dev	Min	5 th Percentile	Median	95 th Percentile	Max
$\Delta \ln g$	0.0298	0.0245	-0.0037	0.0089	0.0231	0.0767	0.2213
Efficiency	5.1188	2.4311	2.5566	2.7446	4.2469	10.9511	12.1032
Distribution	46.7350	9.8070	24.2491	30.6071	46.8987	62.2887	74.6434
Equity	0.0029	0.0046	0.0001	0.0002	0.0006	0.0166	0.0213
Strongholds	0.4738	0.0881	0.2363	0.3131	0.4885	0.6160	0.6568
Incumbency	0.1062	0.0815	0.0000	0.0070	0.0955	0.2521	0.3333
Electoral race	0.3235	0.4683	0.0000	0.0000	0.0000	1.0000	1.0000
Left	0.4439	0.0806	0.2678	0.2936	0.4413	0.5874	0.6434
Congruence	0.4234	0.0973	0.1048	0.2277	0.4246	0.5882	0.6519
$\ln y$	11.2383	0.9673	9.1516	9.6959	11.1741	12.7983	13.0715
$\ln k$	12.8103	0.9596	10.8946	11.3233	12.7429	14.3866	14.6084
$\ln l$	7.4170	0.9029	5.8856	5.9410	7.3286	8.8798	9.0491
$\ln g_{t-1}$	9.6665	1.0927	7.2834	7.9073	9.7035	11.2912	11.4391

Table A3. Descriptive statistics for dependent and independent variables – Italy ($n=500$)

Variable	Mean	Std Dev	Min	5 th Percentile	Median	95 th Percentile	Max
$\Delta \ln g$	0.0225	0.0251	-0.0069	-0.0023	0.0156	0.0770	0.1436
Efficiency	4.4906	2.9407	0.9578	1.1698	3.5627	10.6820	14.1450
Distribution	46.0254	8.6157	24.2825	32.7750	45.4300	61.1102	69.5105
Equity	0.0018	0.0024	0.0001	0.0002	0.0007	0.0078	0.0135
Strongholds	0.2773	0.1410	0.0000	0.0523	0.3073	0.4884	0.5407
Incumbency	0.1305	0.0821	0.0016	0.0131	0.1233	0.3146	0.3627
Electoral race	0.1720	0.3778	0.0000	0.0000	0.0000	1.0000	1.0000
Left	0.3984	0.1195	0.0000	0.1893	0.4100	0.5773	0.6063
Regional parties	0.0450	0.1111	0.0000	0.0000	0.0005	0.3441	0.4980
$\ln y$	10.3938	1.0998	7.7470	8.1236	10.4088	11.8595	12.5048
$\ln k$	12.0140	0.9751	9.5125	10.0324	12.0723	13.3624	14.0462
$\ln l$	6.5824	1.0299	3.9627	4.4161	6.5201	7.9306	8.3082
$\ln g_{t-1}$	9.0740	0.6525	7.2465	7.7457	9.1976	9.8550	10.2246

Table A4. Descriptive statistics for dependent and independent variables – Spain ($n=255$)

Variable	Mean	Std Dev	Min	5 th Percentile	Median	95 th Percentile	Max
$\Delta \ln g$	0.0480	0.0431	-0.0186	-0.0094	0.0385	0.1415	0.2072
Efficiency	1.5775	0.9920	0.3356	0.5602	1.2989	3.8287	4.7869
Distribution	30.7125	5.4250	15.1243	21.3953	30.5139	39.3054	42.7330
Equity	0.2388	0.3384	0.0147	0.0239	0.0967	1.3300	1.6265
Strongholds	0.3945	0.1103	0.0183	0.1470	0.4018	0.5416	0.6070
Incumbency	0.1284	0.0988	0.0014	0.0141	0.1101	0.3252	0.3875
Electoral race	0.2941	0.4565	0.0000	0.0000	0.0000	1.0000	1.0000
Left	0.4759	0.0911	0.2428	0.3133	0.4704	0.6388	0.6691
Regional parties	0.0781	0.1483	0.0000	0.0000	0.0000	0.4928	0.6000
Congruence	0.6275	0.4844	0.0000	0.0000	1.0000	1.0000	1.0000
$\ln y$	16.5236	0.9087	14.5997	14.9980	16.4343	18.0740	18.2571
$\ln k$	16.0945	0.8350	14.1620	14.5537	16.0288	17.3941	17.8424
$\ln l$	6.2078	0.8857	4.3621	4.5031	6.1134	7.5546	7.7433
$\ln g_{t-1}$	13.8876	0.8111	12.0718	12.3517	13.9654	15.0901	15.5591

