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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 productivity effects with regional production functions for each country controlling for the potential endogeneity of public infrastructure investment. In analyzing the determinants of public infrastructure investment two broad categories are considered: First, the normative principles such as efficiency, equity, and redistribution; and second, political factors such as electoral competition and electoral rents. The evidence shows that road infrastructure positively contributes to regional production. As to the determinants, efficiency and redistribution are consistently found to be the dominant norms while equity considerations appear to be less important. However, we find remarkable differences across countries regarding the political determinants. Which political factors matter for infrastructure investment is related to the different political systems of the various countries.

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The politico-economic determinants and productivity effects of regional transport investment in Europe

1. Introduction

Considerable research efforts have been devoted to measure the contribution of infrastructure investment to productivity and growth. There appears to exist a consensus by now about the growth-enhancing effects of public infrastructure investment, even if some studies have not found positive effects at all (for recent surveys, see Bom and Ligthart 2008, Romp and de Haan 2007 and OECD 2007). Compared to its consequences, we know considerably less about the determinants of regional infrastructure investment. Most studies treat regional infrastructure investment as an exogenously determined input to private production. However, more and more scholars have questioned 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 with a higher probability of re-election show a higher propensity to invest in local infrastructure projects and that, at the federal level, redistributive concerns matter more than the return on investment.

Cadot *et al.* (2006) propose a simultaneous-equation approach to estimate the contribution of transport infrastructure accumulation to French regional growth. They estimate not only the contribution of public investment to growth but also the political determinants of public investment in a panel of French regions from 1985 to 1992. The empirical findings suggest that electoral concerns and influence activities are indeed significant determinants of the cross-regional allocation of transportation infrastructure investment. By contrast, they find little evidence of concern for the maximization of economic returns to infrastructure spending after controlling for these political effects. Castells and Solé-Ollé (2005) and Golden and Picci (2008) find political determinants of infrastructure spending for Spain and Italy, respectively. Since the political systems in these countries are rather diverse, the precise channels of political influence on transport infrastructure differ from country to country. 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 focus on a comparison of four major European countries and their respective political institutions: France, Germany, Italy, and Spain. All four countries are similar in population size and GDP per capita but have very different political systems. Germany and Spain are both federalist countries, whereas France and Italy are not. Italy and Spain both have proportional voting systems, whereas 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 onto the nature of distribution mechanisms in the four countries and on their impact on the efficiency of public investment in infrastructure. This is done 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. We derive a set of hypotheses to be tested later on. 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 give some descriptive evidence of how investment in road infrastructure is regionally distributed. In Section 4 we explain our estimation methodology



Achim Kemmerling



Andreas Stephan

and describe the results. We also present 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) or Munnell (1990a, 1990b, 1992) have documented 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, for example 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 carried out mainly for the US have also found rather diverse results. 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 elasticity of output with respect to infrastructure capital (ϵ_{YG}) differs considerably across 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 finds an elasticity of output with respect to public capital that appears to be either insignificant or significant with a negative sign. This result turns out to be 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 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 eleven West German *Bundesländer* (federal states) from 1970 to 1996 and finds that public capital is a significant input for production in the manufacturing sector.

The estimated impact of public capital on output tends to be positive in studies using a production function.

Also for the other Western European countries scholars have found a positive contribution of infrastructure investment to growth and productivity. 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 magnitude of the effect and its significance depend not only on the empirical approach chosen but also on the theoretical framework in which the productivity effect of infrastructure capital is modeled. Considering the various findings of previous studies we formulate our first hypothesis.

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

This first hypothesis claims 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 hinges on 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).

allocation process of infrastructure investment. It is by no means granted that politicians optimize aggregate social welfare by strictly directing investment in an efficient way.

2.2 Determinants of public infrastructure investment

2.2.1 Economic rationales: Efficiency, redistribution, and equity

Regarding the economic rationales for the 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). Along the lines of these scholars 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 output in region i , g_i the regional infrastructure stock, l_i the regional labour force, and s_i the size of the geographic territory (*i.e.*, the area in square-kilometres).

Efficiency implies that infrastructure spending should be beneficial particularly for those regions where its expected impact on growth is highest. We would expect investment flows to be highest to those regions where its marginal productivity is highest. This allocation of investment would ensure 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 elasticity of output with respect to 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 target infrastructure investment to those regions where the marginal productivity of infrastructure is highest.

Redistribution implies in our simple terminology that the distribution of funds follows the principle of using infrastructure investment as a means of regional policy to promote the development of poorer regions. If governments follow this logic, infrastructure investment should be targeted on those regions where per-capita GDP is lowest.

Hypothesis 3: If the national government is concerned about promoting the development of poorer regions, it should target the infrastructure investment on regions with the lowest per-capita income.

It should be noted that the redistribution objective is in most cases in conflict 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

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

The government may favour regions with high infrastructure productivity, low income or low endowment in allocating funds.

Equity, our third normative principle, refers to 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 territory (s_i) of a region. 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 has the objective of equal infrastructure endowment across regions, it should target its investment on regions with the lowest infrastructure endowment.

2.2.2 Political factors

The four countries under inspection have very different constitutions. Therefore it appears difficult to develop a uniform framework for explaining the political factors behind regional public investment policies across countries. To simplify the exposition we assume that the central government is the decisive political actor in all four countries. Of course, this is not true for federalist countries but it is possible to show the effects of departing from this assumption by comparing the results with those for the highly centralized countries Italy and France. There are several hypotheses explaining why for central politicians some regions are politically more important than others.

Regions ruled by left parties are traditionally expected to spend more on infrastructure due to a ‘big-government’ bias.

The traditional political-science approach to public spending relates transfers to 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 to spending and ‘big government’ than 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 were the dominant party received more transfers than other regions.

Yet the ideological distribution of voters on issues of regional infrastructure is unlikely to be one-dimensionally left-versus-right (Kemmerling and Bodenstein 2006). Regional interests also loom large in the political process so that even conservative parties with a strong regional base will favour higher level of spending in their regions. Examples of such parties can be found in many European countries. In Spain, for example, there are the Catalan and Bask separatist parties, and in Italy there are separatist parties in the northern part of the country. This leads to our first hypothesis on the political-economy determinants of infrastructure spending.

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

Another approach to the explanation of more spending does not depend on any notion of voters’ 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

politicians' electoral success depends on infrastructure investment and its efficiency. Thus more and more positive explanations for intergovernmental grants have been sought (e.g. Inman 1988).

Again, the fundamental question of these new approaches is why some regions are more successful in receiving grants than others. The politico-economic theory of multi-tiered political systems holds it that regions are unlikely to receive equal shares of public transfers or shares in accordance with equity or efficiency considerations if (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 on others to muster electoral support. These two claims allow deriving all our remaining hypotheses on the political factors influencing infrastructure investment.

Some regions receive more funds from the government because of strong political clout or high importance in general elections.

To start 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 lobby groups such as big companies depending on road infrastructure may be concentrated in some regions more 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 at the national level. 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 of an electoral district and the number of seats allocated to it (Worthington and Dollery 1998) or the voting power of regions (Ansolabehere *et al.* 2002). Finally, channels of influence from lower to higher tiers of government should be easier when reinforced by partisanship. In Germany, for instance, it rather seems to be the partisan congruence between the national and the regional level (Kemmerling and Stephan 2002) that matters: 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 modeling the political clout of a region, we select the following formulation of

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 is infrastructure investment in the region.

The second claim focuses on the preferences of national politicians rather than 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 alternatively to those regions in which they can gain the most from additional spending (Dixit and Londregan 1998). Several studies (Levitt and Snyder 1995; Grossman 1994) found some evidence for the logic of partisan strongholds and incumbency bias (see below) in the regional distribution of federal outlays in the US. Correspondingly, we formulate

Hypothesis 7: Regional strongholds of the central government party 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 in which additional spending has a disproportionate effect on the election outcome. The classic version of this argument is the one about swing voters for which there is ample evidence in US first-past-the-post elections (e.g. Jacobsen 1987). The simplest version of the swing-voter idea is equivalent to the closeness of the political race between the two largest parties, since the larger

the distance of the major opposition party, the less likely it is that this party gains the constituency. Hence, central politicians lose interest in constituencies where they either dominate or have no chance of winning. One problem with the simple swing-voter hypothesis is that it does not fit all democratic systems alike. In multiparty or multidimensional settings, a median voter is less likely to exist, thereby increasing the number of swing-voters. It is therefore primarily an argument for the classic (majority) first-past-the-post electoral system, in which votes other than for the winning candidate are essentially lost. Nevertheless, the argument may be extended to other systems, for even in proportional systems higher electoral competition and more pliable voters should enhance parties' campaigning efforts (McGillivray 2004). Johansson (2003) finds corroborative evidence for a refined version of the swing-voter hypothesis in the Swedish case. There are also other factors that raise the marginal gains of central governments in regions. Crain and Oakley (1995) have found evidence that voter volatility and legislative stability are important predictors of the size of regional transfers. Castells and Solé-Ollé (2005) use several indicators of 'electoral productivity', *i.e.*, the marginal gains in form of additional seats from marginal increases in votes, in their relationship to public transport grants in Spain. We therefore formulate

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

The swing voter idea has not remained uncontested, however. Cadot *et al.* (2006), for instance, predict an incumbency effect for infrastructure spending. The underlying idea is the margin of incumbency, that is, the lead of the incumbent political party over other parties. Those incumbent actors with a higher chance of reelection are expected to 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 compared with the major political opposition party, the larger is infrastructure investment in the region.

Investment may be higher in 'swing states' and in regions with strong incumbents but lower in regions with intermediate levels of electoral competition.

One might think of Hypotheses 8 and 9 as competing, since a central government may care for either very tight electoral races or races where it is clearly ahead. In practice, however, one may also think of a non-linearity such that the central government holds both races in higher esteem than a race with a moderate level of competition.

We have now gathered all major complementary and in some cases competing hypotheses on the economic and political rationales for the distribution of infrastructure investment and can proceed to the measurement of their empirical relevance.

3. Data

3.1 Sources

In the following we briefly describe the data and their sources for each country.³ The data for France are partly the same as 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

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

⁴ Corsica was not included due to incomplete statistical information.

prices. For investment in transport infrastructure we are able to 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 in the following way. The aggregated transport infrastructure stocks in France as given by the Fédération Nationale des Travaux Publics (FNTP) are allocated proportionally to the individual regions in accordance with the investment shares 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 have been taken from the Eurostat 'New Cronos' data base (June 1999 edition). The values for 1979 and 1978 were extrapolated using GDP data for these years. The data relating to the regional stock of private capital for the period 1978-1991 have been provided by Professor Prud'Homme. A description of these data can be found in Prud'Homme (1996).⁶

For Germany we calculate regional road capital stocks separately for roads funded by federal states, districts and municipalities (*Landes-, Kreis-, und Gemeindestrassen*, district roads) on the one hand and roads financed by the federal government on the other (*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 so as to minimize the difference between the sum of our regional road capital stocks and the nationwide figures of the stocks estimated for the government by the German Institute for Economic Research (DIW 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 regarding investment made by the federal, state and local governments is taken from Statistisches Bundesamt (2005). It contains the road investment figures of the different bodies at the regional level.

As for the additional region-specific variables, the production function data originate from the regional accounts published by Statistisches Landesamt Baden-Württemberg. Value added is used as a measure for output. 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. Labour is measured as the number of employees in all sectors at the level of the federal states. For the political data we use Brancati's (2007) constituency-level data set and own compilations.

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 data base (Paci and Pusceddu 2000; Paci and Saba 1997). This also holds for the other economic variables, which we extract for the years between 1960 and 1996. For the electoral variables we use Caramani's (2000) data base. This data set includes electoral results for all major parties in general elections between 1977 and 1996 at the regional level.⁷ Retrieving electoral results for individual parties is not of great use, since the Italian

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. It turns out that 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' data base, assuming a linear depreciation rate of 10 percent.

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

party system is notoriously unstable. Therefore we use the vote share of party families. This leads to seven families of which one reflects regional parties as in Caramani (2000).

For Spain we use data on transport infrastructure investment by the central and regional governments of 17 comunidades autónomas⁸ during the period 1955-1998. The data on capital stock and infrastructure investment by government level and region come from the Fundación BBVA (Mas *et al.* 2003). 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 we again extract information from Caramani (2000). We extract the vote shares of the Spanish Workers' Party, the People's Party and the communists. The problem of regional parties anchored 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 parties Caramani (2000) denominates as 'regional'.

3.2 Political proxy variables

The relevance of individual political factors depends on relationships between levels of government and on electoral systems.

Unlike most of the economic variables, the definitions of the political variables need careful explanation. This subsection shows for each of them how we operationalize our hypotheses on the political economy of transport infrastructure investment. Some of the hypotheses only make sense for some political systems. Notably, hypotheses on two-tiered systems are only useful for federal systems such as Germany and Spain.

As mentioned above, there is some debate in the literature on the political economy of regional transfers on whether politicians are disproportionately interested in swing constituencies (Dixit and Londregan 1998) or partisan strongholds (Cox and McCubbins 1986). We operationalize the latter as the regional vote share of the central government party.⁹ Furthermore, we operationalize the idea of regional incumbency as the difference between the two largest parties in a region in national elections following Johansson (2003). Moreover, we operationalize the concept of electoral race by coding a dummy variable that equals one whenever this difference is very small, *i.e.*, less than 5 percentage points. This allows capturing nonlinear effects of the electoral race in cases where the race is really tight. Our threshold is arbitrary and alternative operationalizations are possible but we believe that not much is gained from more technical sophistication for our purpose. 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 Picci 2008).¹⁰

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

9 For France 'Incumbent party' refers to either the Gaullists or the Socialists. For Germany it refers to the 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 robustness tests. 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

Finally, for multi-tiered political systems such as Spain and Germany, we use political information both at the central and the regional level. We compare the partisan constellation of central and regional governments to compute a measure of congruence between both levels (Kemmerling and Stephan 2002). For Spain we use a simpler congruence measure due to the lack of information on regional election outcomes. We code a dummy variable that equals one if the partisan composition of the regional and the central government 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 goals in decision-making whereas the latter five focus on the political process and the electoral gains derived from investment in road infrastructure.

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	+

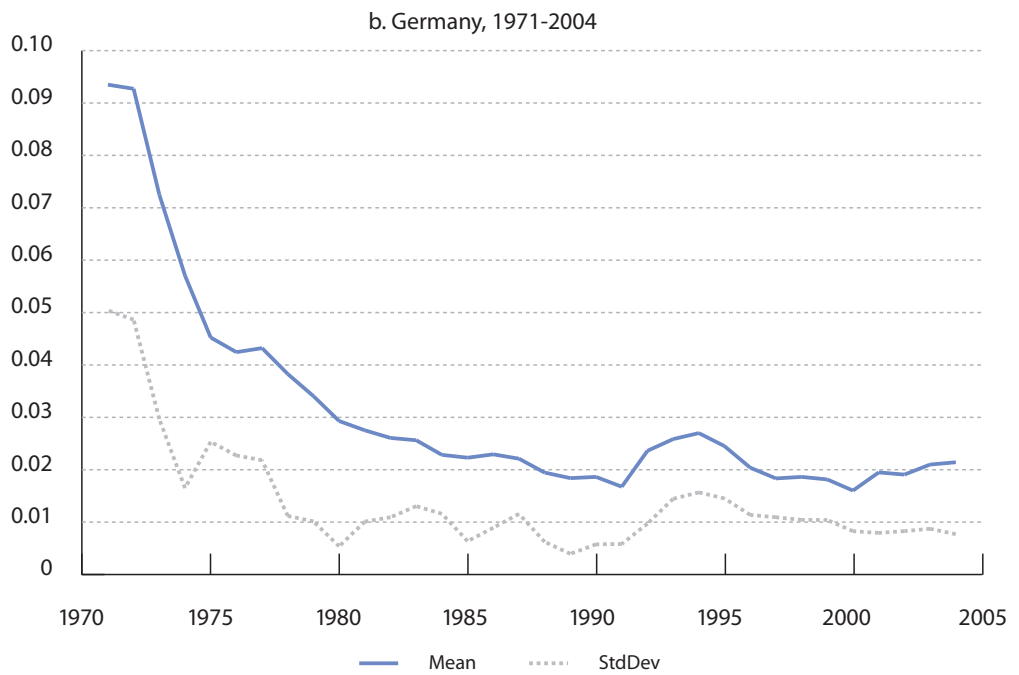
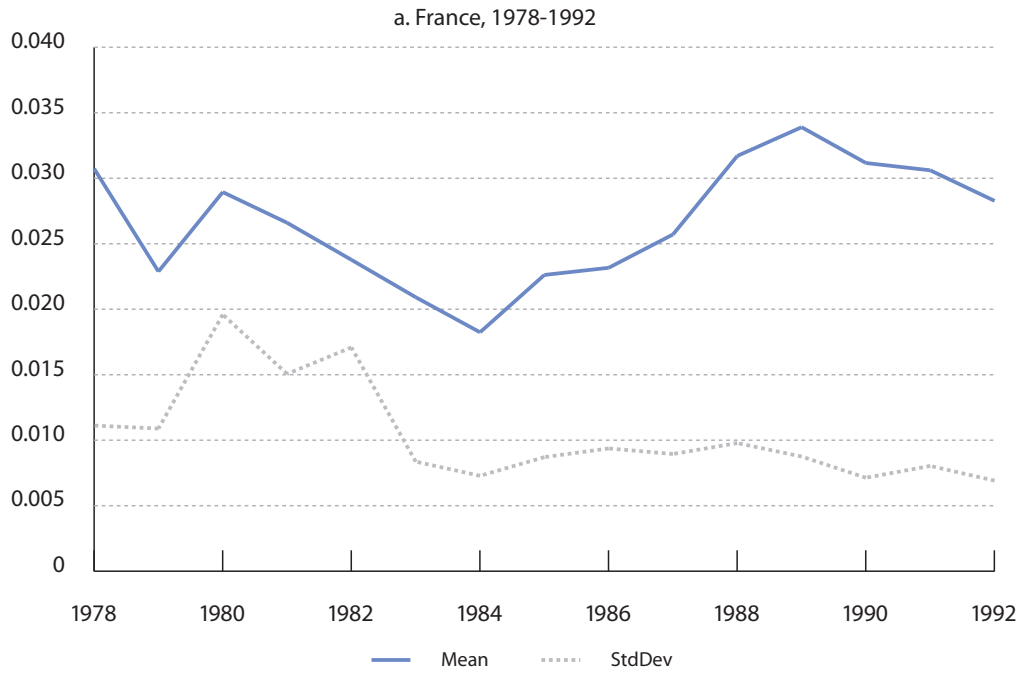
3.3 Descriptive statistics

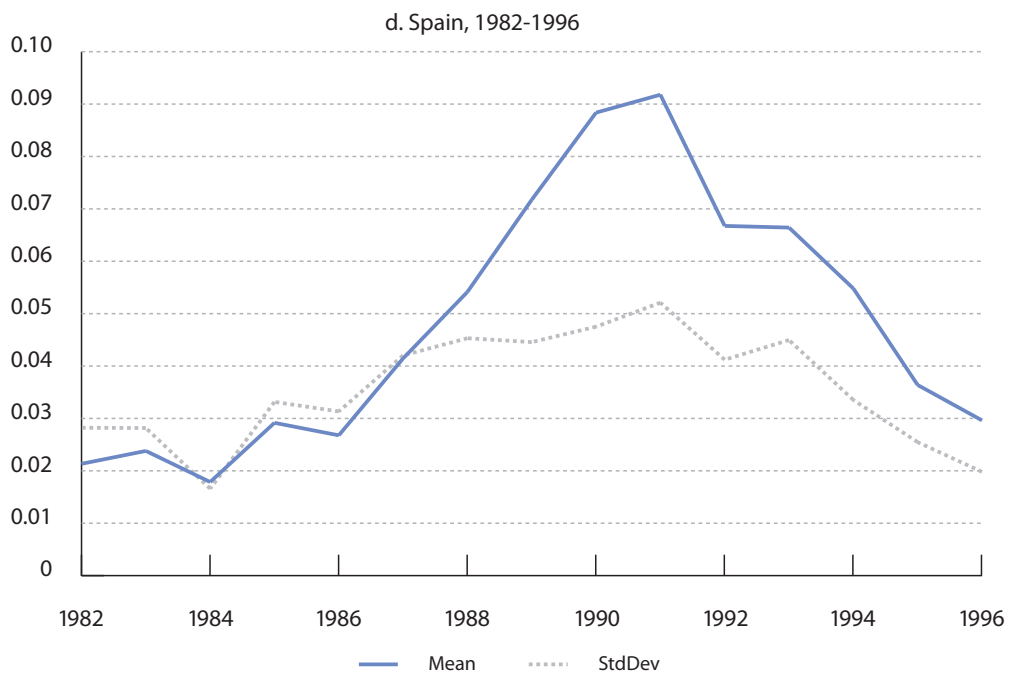
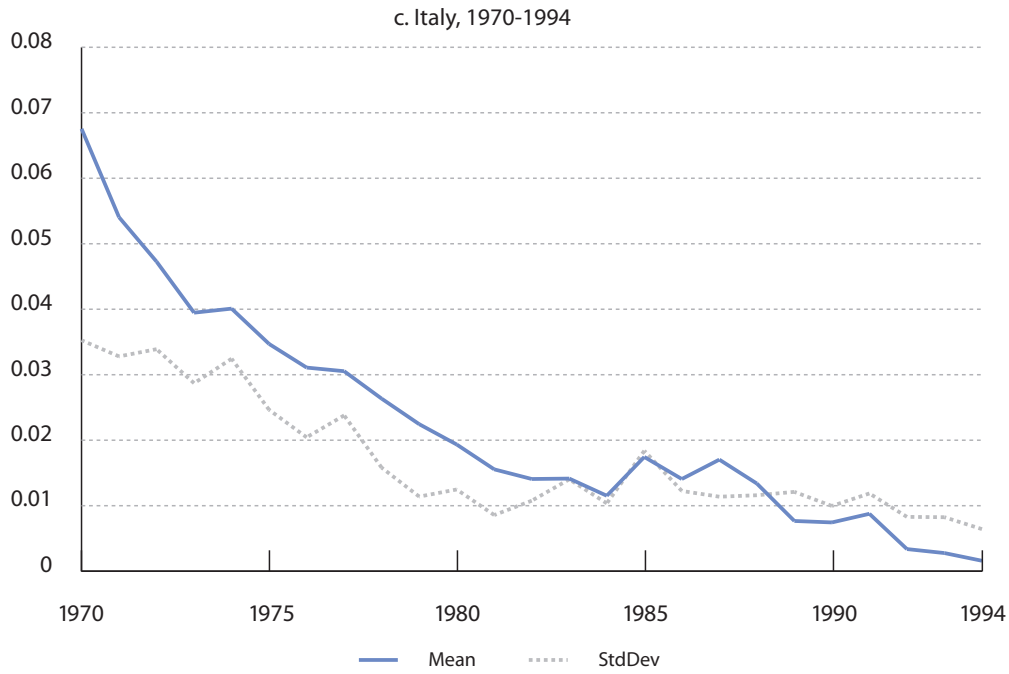
Figure 1 shows the mean and standard deviation of the growth rate of regional infrastructure stocks, the dependent variable of our policy equation. We find increasing growth rates of regional infrastructure stocks both in France and in Spain even though growth rates in Spain have decreased after their 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 heterogenous 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 Annex.

Average growth of regional infrastructure stocks decreased in Germany and Italy but increased in France and Spain.

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 one over the Herfindahl index of the vote share of parties.

Figure 1: Development of growth rates of regional transportation (road) infrastructure investment





4. Empirical estimation and results

4.1 Specification of the simultaneous equation model

Aschauer (1989b) has triggered a controversial debate about the contribution of public capital to growth using a simple production function framework with public capital as factor input to production. Several authors have argued that this approach could suffer from an 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:

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

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 v_i as well as time-effects λ_t are included.

The policy equation describes the change in the regional road capital stock 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:

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

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, redistribution, and equity criteria, respectively. The last terms 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 aim to analyze the cross-regional allocation of investment (and 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 captures differences across regions.

4.2 Econometric methodology

The endogeneity of the growth rate of regional road capital stocks in the production function is taken into account by using the non-linear GMM estimator proposed by Andrews (1991) whereby

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

Regional output and transport infrastructure investment are jointly determined by the production function and the policy equation.

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 Annex A1. They support the application of consistent estimators in general. When estimating simultaneous equations an issue that is even more important is the validity of instruments, *i.e.*, their non-correlation 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

Table 2 shows the results of the non-linear 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 so 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 backed 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.

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 one, implying constant returns to scale in the private inputs. The reported production function estimates in Table 2 are in line with these expectations only for Italy and France whereas the production function results for Germany and Spain appear to be less plausible with respect to the estimated labor elasticities, which are far below 0.5, in particular for Spain.

Similarly, we find different estimates for the impact of transportation infrastructure on regional GDP. A very low and insignificant contribution is seen 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, in three out of four countries we find that road infrastructure contributes to output. In light of most previous studies our estimates lie in a plausible range from 0.05 to 0.20.

Transport infrastructure is found to foster output, except for Spain, with the elasticity ranging from 0.05 to 0.20.

The policy equation, however, displays more diverse estimates across countries. As for the three normative principles, we find that efficiency concerns matter of the growth rates of the 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 appears not to be a priority in France in contrast 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 negative sign whereas the effect is even positive for Italy. This implies that Italian regions with a good endowment of infrastructure receive more investment than those with a poor endowment. To some extent imprecise estimates or even implausible signs may stem from correlation between some of the explanatory variables (see Annex A1).

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.

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.

Table 2. Non-linear GMM system estimation results

Policy equation Dependent variable: $\Delta \ln g$	France 1978-1992		Germany 1970-2004		Italy 1970-1994		Spain 1982-1995	
	Included /1		Included /1		Included		Included	
Time effects								
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	—	—	—	—	—	—	0.0018	(0.41)
R ²	0.5269		0.6924		0.4591		0.5000	
Production function Dependent variable: $\ln y$								
Time effects								
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 /2	43.33		42.91		42.83		37.84	

Notes: t-values in parentheses.

/1 Dummy variables included in the policy equations of France (Ile-de-France) and Germany (East German Länder).

/2 Hansen test is distributed χ^2 with (r-s) degrees of freedom.

Also the effects of the political variables vary across countries. In general, the political influences appear to be relatively moderate. Partisan strongholds do not seem to play a major role in France or Germany whereas in Italy and Spain regions where strongholds of the national government party are located indeed receive more investment than others. The coefficient of the difference between the two largest parties (incumbency effect) is only significant with the expected sign in the case of Germany. Similarly, the tightness of the electoral race shows an effect in Germany but has an unexpected negative impact in Spain. Furthermore, we find that left parties matter in France and Italy but not in Germany and Spain. Regional parties influence the distribution of public investment significantly 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, *i.e.*, 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 – only play a role in a centralised 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 capturing 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, for Germany we find evidence of a complementary relationship between the tightness of the electoral race (H8) and incumbency (H9): Elections that are either very tight or very clear 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 has been conducted for four major European economies: France, Germany, Italy, and Spain.

Three major findings of the study are worth being emphasized. First, the estimates confirm for three out of four countries that regional investment in road infrastructure has contributed 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 trivial at all. 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 can establish that normative principles guide the distribution of investment to a large extent. In particular, we find that efficiency and redistribution criteria are relevant for the allocation of infrastructure investment across regions whereas the equity criterion is less important. These findings are also partly in contrast to previous work. For instance, Cadot *et al.* (2006) do not find that efficiency matters for the regional allocation of investment in France. However, their policy equation is differently specified and the period of investigation is shorter than in our case.

Third, our findings show that political factors influence the regional distribution of infrastructure investment but are generally less important than anticipated. As we have elaborated in this paper, the results also support the view that political factors have a different impact depending on the political system at hand. For example, partisan strongholds and ideologic preferences matter to a greater extent for centralist political systems compared to federal ones. 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 of a competing relationship between favouring partisan strongholds on the one hand, and favouring very tight or very clear electoral races on the other.

Efficiency and redistribution concerns drive regional infrastructure investment more than political factors.

***Data quality is an issue
for the robustness of
the results, econometric
sophistication is not.***

A few words on the limitations of our study are in place. 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 have been 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 in particular the political proxy variables are sometimes rather crude measures of the underlying mechanism formulated in the hypotheses. For instance, we have presumed a positive influence from electoral competition on infrastructure spending but this can only be proxied for by the outcome of the last election. Certainly, there might be tight political competition in a region, which 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 administrated. 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 here provides interesting insights into the determinants and productivity effects of regional transport infrastructure and may serve as an inspiration and starting point for future investigations into these topics.

Annex

A1. Specification tests and robustness checks

We have performed several specification and robustness checks regarding the econometric results. A first important issue is multicollinearity. The condition numbers are much higher than 100, which is seen 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, which is even exaggerated in cases where the variables do not have much time variation and region-specific effects are included. However, there is no applicable solution to the multicollinearity issue.

A second issue is heteroscedasticity and auto-correlation in the residuals. The results of specification tests indicate that heteroscedasticity (Breusch-Pagan LM) and non-stationarity of residuals (Levin-Lin panel test)¹⁵ are present both in the policy equation and the production function. Autocorrelation is also present in both equations according to the Godfrey LM test. Accordingly, the application of the non-linear 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 is tested for and can be rejected in almost all cases for both equations using the Levin-Lin test¹⁶ (Levin *et al.* 2002). The only exception is Germany where due to the balancedness 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 *lny* but the test based on the former sample with only West German *Länder* rejects it. We are not too much concerned about this outcome 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 have also performed an estimation where we allow for different estimates before and after the German reunification for key variables (structural break). The outcome is interesting and yields plausible results, and three of them are worth mentioning. First, the elasticity of output with respect to 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 non-stationary, this would also lead to non-stationarity of the residuals due to the definition of residuals as $\varepsilon = y - \sum \beta_i x_i$.

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, where a lag of one was specified).

A2. Descriptive summary statistics of the variables

Table A3. France ($n=315$)

Variable	Mean	Std Dev	Min	5 th Percentile	Median	95 th Percentile	Max
ΔIng	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
Iny	10.2558	0.6729	8.8873	9.4755	10.1792	11.3885	12.5248
Ink	10.4171	0.7048	8.8781	9.5155	10.3532	11.7723	12.5375
InI	6.7090	0.5942	5.6017	5.9852	6.4977	7.6857	8.5389
Ing_{t-1}	8.3371	0.6770	6.4943	7.4972	8.2962	9.5269	10.1984

Table A4. Germany ($n=439$)

Variable	Mean	Std Dev	Min	5 th Percentile	Median	95 th Percentile	Max
ΔIng	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
Iny	11.2383	0.9673	9.1516	9.6959	11.1741	12.7983	13.0715
Ink	12.8103	0.9596	10.8946	11.3233	12.7429	14.3866	14.6084
InI	7.4170	0.9029	5.8856	5.9410	7.3286	8.8798	9.0491
Ing_{t-1}	9.6665	1.0927	7.2834	7.9073	9.7035	11.2912	11.4391

Table A5. 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 A6. 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

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