Measuring Regional Variation of Corruption Induced Inefficiency in Public Roads Construction, using German Data

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(Dated: May 15 2006)

The goal of this project is to measure inefficiency in government spending on infrastructure, and thereby provide insight on regional variation in political corruption across Germany. The index is calculated as the ratio of physical quantities of public roads over the normalized, cumulative capital stock spent on roads. A greater prevalence of political corruption is believed to exist in regions where the ratio of the physical infrastructure to spending is low. This paper emulates the indexing procedure used by (Golden and Picci 2005), who measure overall infrastructure over aggregate public spending to proxy political corruption in Italy. However, this paper focuses specifically on roads and controls spending data more extensively. Although the empirics are straightforward, data collection is by far the most difficult aspect of this paper. Fortunately, at this time the majority of the data have been collected and formatted and what remains to be collected is still feasible. The index is still calculated for demonstrative purposes. Following the preliminary results, is a proposal for how this index may be employed in future research.

I. INTRODUCTION

Rent extraction from the provision of infrastructure is one form of corruption, common both to developing and developed countries (Rose-Ackerman 1999). This occurs when public officials use their privileged position in order to benefit themselves at the cost of public welfare. Efficiency losses result, since such distortions in resource allocation increase the cost of providing public goods. The means by which scholars observe and recommend solutions for this phenomena vary greatly. The literature falls predominantly under one of five general themes: the study of the impact of corruption on efficiency, the impact of corruption on growth, variation across nations in magnitude of corruption, efficacy of policy initiatives in reducing corruption and incentives for reducing corruption (Bardhan 1997). This project falls within the first category, for it measures one aspect of inefficiency brought about by political corruption, namely political corruption reduces the rate of return of public spending (Tanzi 1997). Considering the importance of understanding this effect, there is relatively little work on measuring the magnitude of public funding lost to political corruption across geography. The goal of this paper is to systematically measure the impact of political corruption on public infrastructure development, and furthermore, to illustrate its variation across German regions.

The purpose of this paper is to extend and improve upon the original proposal for indexing corruption across sub-national regions, first introduced by Golden and Picci (Golden and Picci 2005). They generated a proxy for corruption as the ratio of quality, for a broad spectrum of public infrastructure, to its corresponding cumulative spending. This paper emulates this procedure, but advances a residual based method for assessing political corruption. The residual based approach is embraced in the public and health economics literature as a means to estimate relative quality or efficiency in various applications. It is argued that this residual based approach better estimates the rate of return to public spending.

The allocation of public funds for specific public services is not a reliable indicator of the actual quality of public services (Dehn et al. 2003). A measure is needed to compare what is spent to what is delivered. This paper emulates the Golden and Picci method of indexing corruption as a "rate of return" to government spending (Golden and Picci, 2005). The procedure compares the existing endowment of public infrastructure (more specifically, roads) to the cumulative capital investment, normalized by various cost controls. The deviation from efficiency may be understood as a loss associated with government rent seeking (Krueger 1974). The index does not determine the exact amount of Deutsch Marks (now Euros) leaked from individual construction projects, but provides evidence on which regions have historically mishandled these finances. This paper indexes inefficiencies in the construction of public roads only. Indexing roads rather than all forms of infrastructure is more tractable and results in more precise cost controls. This paper asserts that regions that mishandle money in public roads projects are also likely to experience lower cost efficiency for other forms of infrastructure and possibly even experience higher rates of other forms of corruption.

This paper is organized as follows: section II. provides a definition of political corruption and evaluates the various methods for measuring and interpreting the phenomenon. Section III., Data and Procedure, describes the procedure used to index political corruption and how the data are collected and formatted. The residual analysis procedure is proposed as a preferred alternative to Golden and Picci's ratio. Section V. presents the findings for Germany's corruption index. Finally, the appendices at the end of the paper are dedicated to more thorough discussion of the various data and methodological concerns.

II. GENERAL LITERATURE REVIEW ON CORRUPTION

What is Political Corruption?

Rent extraction in public infrastructure spending is a principal form of political corruption. The "activities surrounding public works construction are the classic locus of illegal monetary activities between public officials and business" (Golden 2005, p.41). Public infrastructure suffers quality reduction and misallocation as fraud, mismanagement and embezzlement in public works contracting become more prevalent. This results in higher public spending with lower return. Empirical work shows that higher corruption alters the composition of government expenditures (Mauro 1998) in favor of those projects that are more susceptible to corruption. Corrupt public officials have been known to favor large public infrastructure projects, such as roads, since they are easier to extract rents from. Thus, one would expect that regions suffering from political corruption would overspend with little to show for it.

The definition and operationalization of political corruption is complex. Political corruption is broadly defined as "the misuse of public trust for private gain". For the purposes of this study, political corruption is operationalized as the distance between the "efficient" and actual delivery of public services. Still, this requires further clarification. One may interpret this distance as the rate of return to government spending (Golden and Picci 2005). This efficiency approach does not address political corruption in policy formation or during budget allocation. This project does not distinguish between misallocated infrastructure projects (i.e. highway to nowhere) and those that equitably serve the public. What it does illuminate, is that when a certain quantity of government funding is allocated to public roads projects, roughly how much of the money is actually spent on the intended projects. Developing a proxy for the rate of return in public spending will illustrate political corruption, since corrupt government rent seeking is directly proportional to the rate of return on public spending (Kreuger 1974).

Assessing and Measuring Political Corruption

Since political corruption is a highly concealed and varied activity, it is exceedingly difficult to gather adequate information on this topic. What follows is a review of various methods used in the literature to gauge corruption in public spending. These include national and micro-level surveys, case studies, and relative efficiency indices. These various research designs have unique advantages and flaws; with each approach tackling the topic with varying foci. Some are better suited for determining the exact channels by which public monies are siphoned away, while others are better suited at ascertaining the magnitude of waste resulting from corruption. Surveys and indicies are intended more for comparisons whereas case studies are intended to pick up on area specific particularities of corrupt activities. This review of the various research design currently used to investigate political corruption is accompanied by a brief explanation for why corruption indexing was the method of choice for this project.

Surveys

The Transparency International's Corruption Perceptions Index (CPI), produced by Transparency International, is the most prominent survey-based measure of political corruption. Transparency International, an organization devoted only to researching and combating corruption, ranks countries in terms of the degree to which corruption is perceived to exist among public officials and politicians. This results in an index, which defines corruption as "the abuse of public office for private gain." This composite index draws upon corruption-related data from expert surveys carried out by various institutions. Those who are surveyed consist of business people, analysts and local experts. For what this research agenda gains in scope, it looses in precision. These indices are not intended to measure specific types of corruption or compare similar regions, but to broaden awareness of a more general problem.

The World Bank formulated a similar country level indicator for corruption in "Governance Matters" Washington DC, 1999-2004. This measures national governments' "control of corruption," using mostly surveys. The agency uses successively less precise measures of governance, mostly surveys, and weighs them accordingly in order to develop the corruption indicator. The confidence intervals are huge, making cross-country comparisons dubious (World Bank, 2004. p. 9).

Macro-level indices have the advantage of being expansive, yet are often criticized for imprecise sampling procedures. These perception indices are often generated from survey responses which are typically taken from foreign experts' assessment of the overall corruption in the country. The survey responses may not be very informative since questions about the degree of political corruption are both ambiguous and complex. Furthermore, there may be a bias in the response rate towards those who believe they are less liable to penalty for participation in the survey, and thus, less informed. Perception bias is yet another concern when using survey implementation. People may have preconceived notions about the degree of corruption in a particular country, which are independent from the actual value. The time at which the surveys take place may be an issue. For instance, after corruption scandals break in the media, people are more apt to view corruption as severe. However, the very existence of media coverage may be the mark of improvements, as law enforcement and the general public becomes more reactive. In actuality, those countries that do not report on corruption, may in fact, be the most corrupt. Micro level surveys have an advantage over macro level surveys in that they are more specific, and often, more extensive.

Micro level surveys have been employed to study the mechanisms responsible for the capture of public funds (Reinikka and Svensson 2003). Here, surveys are used to gauge the percentage of public expenditures diverted by corrupt officials in Ghana, Peru, Tanzania and Zambia. One benefit of these surveys is that survey respondents provide information on how these funds were diverted. For instance, in the Reinikka & Svensson's survey respondents indicated that monies were diverted into patronage politics and the funding of political activities rather than direct theft for private use. In another survey-based analysis on corruption in public service delivery, respondents claimed that the majority of public monies are siphoned out at the contracting stage (Davis 2003). Contractor cartels and political influence "subvert fair and honest contracting" (Davis p.57). Like other uses of survey research methodology, the study runs the risk of artificially forcing respondents to formulate opinions, thereby masking the complexity of conflicting views and unconscious biases within each respondent. Although consumers of survey research in the field of corruption must be aware of these concerns, the benefits of this research should not be written off.

Case studies

Case studies may provide credibility not achieved in small sample studies or institutional reviews. Because the scope is more narrow, field work often employs various methodology to more thoroughly measure and understand the causal pathways of political corruption. Since case studies on political corruption often combine surveys with expenditure tracking, researchers are able to assess the mechanisms responsible for misallocations of funds. The pitfall of case studies is that they may be too specific to the particularities of the region studied, and therefore, add little to the theoretical and comparative study of corruption. Cross-country comparison of corruption case studies are often dubious, due to the difficulty in measuring and observing these phenomena. Often, factors which may be independent of the actual degree of corruption render comparisons unsatisfactory. Within country analysis of corruption is more promising. The influence of these unobserved factors is reduced in within country analysis. As of late, the literature is moving away from the use of country level corruption estimates toward more micro level observations (Golden & Picci 2005, Olken 2004).

Public expenditure tracking surveys (PETS), have recently been implemented in the developing world to assess political corruption in public service delivery. This research involves field work to thoroughly investigate provision of public services, such as schools or hospitals, in a specific region. PETS are based on both surveys conducted within the region and reviewing government accounting sheets. A recent study conducted in Bangladesh, used PETS methodology coupled with investigative work to gauge service delivery in the health care sector (Chaudhury and Hammer 2003). In order to discover absentee rates in medical providers, Chaudhury & Hammer made unannounced visits to various health care clinics distributed throughout Bangladesh. The study discovered that doctors on government payrolls had absentee rates as high as 74 percent in rural districts (Dehn et al 2003, ch.9 p.191). The study also concluded that absentee rates are dependent upon whether the medical provider lives near the health facility, has access to a road, and has electricity. Such results may spur direct policy change. The PETS methodology is particularly useful in analyzing delivery of more subjective goods, such as healthcare [1]. There is a missing link between the allocation of spending and its transformation into public services (Dehn et al 2003). In Bangledesh's health care sector money was not used to line the pockets of politicians, but was misappropriated to poorly supervised employees. Fortunately, the proposed focus on roads allows considerably less complexity in measuring quality of the goods delivered. At the time a public road project is completed, it is delivered[2]. Once it has been determined that the road is cost effectively built and not misallocated (i.e. highway to the mayor's summer cabin), then there is no further need to assess political corruption.

Benjamin A. Olken, in his 2004 paper "Monitoring Corruption: Evidence from a Field Experiment in Indonesia", employs randomized field experimentation to assess political corruption in public service delivery. Olken's field experiment, on political corruption of village road projects in Indonesia, employs a research methodology that holds considerable advantages over the one used in this paper. Whereas this work proxies the missing expenditures in government road projects due to corruption, Olken is able to measure it directly. Olken hires independent engineers to estimate the prices and quantities of inputs used in 600 village road projects, and then compares those estimates to the local government's official expenditure reports. This procedure allows one to determine the efficiency loss in public administration with considerable precision. There are, however, two drawbacks in applying Olken's research methodology to measure political corruption. The act of randomly selecting a particular region may impact the outcome, as when the local government realizes that it is under audit, they may improve their accountability. This is not a concern for his research design, since he was measuring the impact of these audits on behavior over time. Yet, if the main goal is to measure political corruption, these other factors must be ruled out. Furthermore, this project is limited to the study of only very recent projects. By analyzing

[1] A credence good is a good where the consumer will not know the quality of the good "ex ante of the purchase" ; and is unlikely to know ex post. Health care is the textbook example of a credence good.

[2] Unless one considers the possibility that the road is captured by looting party, etc. However, this is extremely unlikely in Germany.

long run accumulation of infrastructure and capital expenditures, my paper may provide more definitive inference on cross-regional variation within the country. Finally, although Olken's research methodology has many advantages, its implementation is too demanding for this current project.

Corruption Induced Inefficiency Indexing

This paper employs the corruption indexing methodology. Corruption indexing involves measuring the ratio of inputs and outputs in public service delivery. This project's ambition is to gauge the magnitude of corruption induced inefficiency, not to observe the exact avenues of corruption. Although it is important to investigate the mechanisms behind political corruption in public service delivery, providing information on efficiency deviation is also valuable. Government rent seeking plays a role all societies, and may be viewed as the deviation between optimal service delivery and actual service delivery (Krueger 1974).

Corruption indexing involves the cross-regional within-country mapping of "corruption" estimates. The index is calculated as the ratio of cumulative infrastructure over the normalized and cumulative capital stock. Put more simply, it is the ratio of what a region has over what it spent. This ratio does not represent the exact amount of money siphoned via corruption, but allows one to determine where such waste is more extreme (Golden and Picci 2005). Showing which regions are more inflicted by the phenomenon may encourage governments and organizations to adopt anti-corruption laws and to implement programs accordingly.

One advantage of corruption indexing is that the procedure may be consistently reproduced in various institutional environments. Indexing is quite straight forward, albeit the country level expertise needed to collect meaningful controls. The corruption index, which Golden and Picci employed in their paper is simply the ratio of all public infrastructure over the cumulative capital stock said infrastructure. The cumulative capital stock is the public spending on infrastructure divided by the regional cost of cement and sand in the year 2001. This paper employs the same ratio procedure, but extends the procedure by analyzing the residuals from a cost model. The cost model takes into account various controls that are specific to the cost of road construction in order to produce a vector for normalized spending

Roads are chosen over all other forms of public infrastructure because they are the quintessential public good. Roads are ubiquitous, measured easily and are fixed-asset public goods. In other words, the quality of roads endowment can more easily be observed than other public goods (such as health care and public schooling). It is also relatively less complicated to employ statistical controls for the variation in cost, not associated with corruption. There are numerous reasons that a school in one region could be more expensive than the other, that are not related to differences in corruption and quality. The technology and standards for roads construction are more uniform throughout Germany, thus making the index for the return to government spending in road construction is more tractable.

III. DATA AND PROCEDURE

The Data and Procedure section details the methodology and statistics used to compile the political corruption index for Germany's public works administration. Again, this paper is emulating the "measure of corruption in public works" index for local governments in German districts that Prof. Miriam Golden and Prof. Lucio Picci employed for Italian regions (Golden & Picci 2005). This project is unique in that it uses geographic information systems (GIS) and spatial data analysis techniques. Since the sole purpose of the index is to understand variation across geography and these various data input vary in their degree to which they are geographically disaggregated, GIS is a solution to a potential "mixed-n" problem [3].

Units

This project is accomplished using the Nomenclature of Territorial Units for Statistics (NUTS) developed by the European Union. These units are the geocode standard for referencing the administrative division of European states for spatial statistics[4]. There are three degrees of desegregation in Germany's regions, NUTS 1, NUTS 2, NUTS 3. NUTS 1 corresponds to Germany's 16 Länder, NUTS 2 corresponds to the administrative level of the 41 Regierungsbezirke (equivalent to districts) and NUTS 3 level data references Germany's 439 local governments.

Figure 1. on the following page employs a boundary file for Arc/GIS with NUTS2 level regional units to illustrate the capital stock across districts. These smaller districts correspond to the larger NUTS 1 regions. The uniformity of these administrative units and their direct fit into NUTS2 and NUTS1 units, makes the spatial calculations simple. It is worth noting that some of the NUTS1 and NUTS2 regions are identical [5]. For example, the city state of Hamburg is both a Land and a district. As long as these re-

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[3] To understand what is meant by "mixed-n" consider the following example: Cement prices are constant within 8 separate regions in Germany and infrastructure endowment is measured across 38 regions. http://www.icpsr.umich.edu/training/summer/biblio/1996/anselin.html

[4] NUTS is thus in some extent similar to the ISO 3166 standard, as well as the FIPS standard of the United States. See below for further information http://en.wikipedia.org/wiki/-Nomenclature_of_Territorial_Units_for_Statistics

[5] The overlapping regions include, Berlin, Brandenburg, Bremen, Hamburg, Mecklenburg-Vorpommern, Rheinhessen-Pfalz, Saarland, Schleswig-Holstein and Thringen.

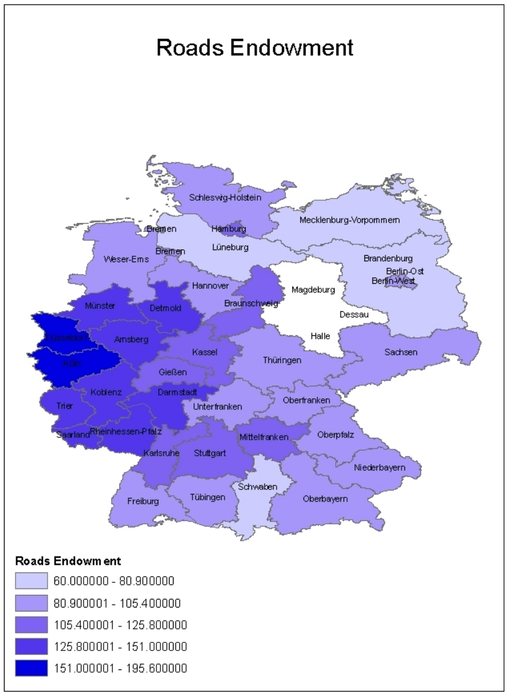

FIG. 1: Germany's Regional Public Road Endowments, NUTS 2 level index values. Darker regions have greater roads endowment, given the normalization procedure employed by Ecoter Statistical Agency

gions are layered accordingly in the ARC software, this overlap does not pose any serious problems for the index.

Variables

Physical Public Capital

The first of the two components that make up the corruption index is drawn from a preexisting measure of physical infrastructure in Germany. These data are collected directly from Ecoter, a French statistical agency commissioned by the EU to provide indepth statistical information on the quality of various public infrastructure in France, Germany, Spain, Great Britain, and Italy[6]. Within this Ecoter report are specific data on the overall ranking of the quality of infrastructure in each subregion, as well as, individualized data on specific forms of infrastructure. Ecoter comprehensively reviews the quality of roads in order to compute each region's relative index value. Ecoter provides data on road quality for all 38 of Germany's districts (NUTS2;Regierungsbezirke). These values have been normalized with a mean 100 and indexed at the EU level, allowing one to compare across Germany and the entire EU.

The Ecoter study categorized infrastructure into "main," "intermediate" and "elementary" infrastructure categories at the NUTS2 level NUTS2, regions UE5[7]. This study employs data taken from the category Transportation and subcategory Roads. Dieter Biehl of Ecoter generated a within country rank of road endowment quality for regionally built public roads, both main and provincial, in Germany [8]. The endowment level has a normalized mean of 100 over all of Europe. See Figure 1 below, notice that the level of roads endowment is highest in Germany's Western districts and lowest in Magdeburg, Dessau and Halle. From this we would expect that Western German districts have historically spent more on public roads than in their Eastern counterparts.

Because roads are "space serving" public infrastructure, they are normalized according to the area of the geographic unit [9].

Cumulative Government Infrastructure Spending

The second half of the corruption index is comprised of cumulative government spending on infrastructure, calculated by the Permanent Inventory Method (PIM) and normalized using residual analysis. The spending on public infrastructure makes up the denominator of the corruption index. The ratio of infrastructure quality over cumulative spending was first introduced by Golden and Picci as a means to proxy political corruption (Golden and Picci 2005). What is unique here, is how the spending is normalized by more extensive controls.

Spending Data

The spending data are collected from the German statistical agency Destatis, which gather and disseminates statistics for the German government [10]. They keep detailed government records on the amount spent annually

[6] The study was carried out by a working group including experts from all the Countries considered and was coordinated by Ecoter together with Confindustria. In particular, the expert responsible for Germany is Dieter Biehl and the coordinators were Maurizio Di Palma and Claudio Mazziotta (Ecoter) and Giuseppe Rosa (Confindustria).

[7] For example, Communication: Telephones: Office telephone links or Transportation: Airports: Principal Airports (surface area of runways mq).

[8] The aggregation of elementary indicators to synthetic intermediate and main level is not straightforward. For a detailed description of the process by which subcategories of roads are weighted, consult "Analysis of the Infrastructure Endowment in Main European Countries: Synthesis of the Final Report." http://europa.eu.int/comm/enterprise/library/lib-competition/doc/infrastructure_endowment.pdf

[9] see Appendix A for further discussion on normalization

[10] http:www.destatis.de/themen/d/thm_prodgew.htm

FIG. 2: Cumulative Government Spending on Roads Infrastructure: this figure illustrates the relative aggregate spending patterns of the 10 western Laender. The spending is aggregated as a perpetual inventory (PIM:11:0) of eleven years and zero percent depreciation rate. Note: These spending data are not yet normalized for cost.

on road construction at the NUTS 1 level. The data represent the total public expenditure, in real terms, for new roads from the "National Budget and Public Accounting Data" for Germany's federal budget (years 1980-1995). These annual accounting books are massive, containing several volumes and thousands of pages, from which I extracted the publication, "National Budget and Public Accounting Data", subject series 14 Issue 3.1, Section 8 Articles 1052-1056 lines: 4140 - 4544. This document provides comprehensive annual accounting on public construction expenses for federal, state, county, local and rural roads. The official cost records for road construction, are independent from the maintenance costs and costs of land procurement. As these data are not currently available electronically, they were entered manually.

Perpetual Inventory Method (PIM)

Corruption is measured as the ratio of infrastructure to aggregated spending. This spending is aggregated according to the perpetual inventory method (PIM). PIM calculates gross capital stock as the sum of gross fixed capital formation in previous years, for which the service life is not yet expired. This gross capital stock represents an "historically cumulative measure of the price government paid for public investments" (Golden and Picci 2005, p. 8).

This paper presents the results that employ the same version of PIM used in (Golden and Picci 2005). This, more basic, PIM assumes that the total investment of a particular asset does not deteriorate during the expected service life. Other versions of this method account for deterioration in the value of the capital investment over time. For instance, if the value is believed to deteriorate by five percent per year, an investment of 1000 euros on a road ten years prior will contribute roughly only 600 euros to today's asset. The other versions of PIM have also been tested and do not alter the resulting corruption index. These alternative results are provided in the Appendix C. It appears that the deterioration rate of PIM method does not effect the robustness of my results.

According to an OECD report, "Methods used by OECD countries to measure stocks of fixed capital" the service life for all public German roads is 11 years [11]. This means that if the Hamburg government spent 4 million Deutsch Mark on city roads in 1992, these roads would no longer exist today. Thus, spending data is only required 11 years prior to the year that public infrastructure index for roads was generated. This is one of the advantages of focusing the project solely on public roads for this project, since most other forms of public infrastructure have varying service lives of 20-50 years.

Thus far, the methods described in the Data and Procedure are the same as those employed in Golden and Picci's paper. This is the point at which the approaches, to creating an index of political corruption based on relative efficiency in infrastructure investment, diverge. The cost controls described in the section that is to follow are more extensive. The normalization procedure is more extensive and robust since it is tested in the cost control model.

Cost Controls

Various intervening factors may explain regional variation in the cost effectiveness of public road construction, which have nothing to do with corruption. Thus, controlling regional differences for these factors is crucial. Golden and Picci normalized their measure of public capital stock by controlling for regional variation in cement and sand prices. Since Germany is very different than Italy and this study focuses solely on public roads, it is important to test other controls. The controls employed in this paper include: bioclimatic data, topographic features and cement prices. Labor costs may be ruled out since wages in public sector construction are set at the

[11] OECD (1993) presents an overview of service lives applied in a number of OECD-member states. (http://www.oecd.org/dataoecd/13/58/2552337.pdf)

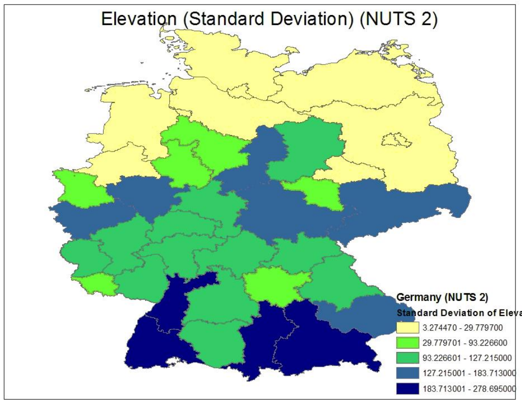

FIG. 3: Variation in Elevation (variable name is logstdelev); employed to control for variation in spending attributable to variation in terrain, which is not associated with political corruption.

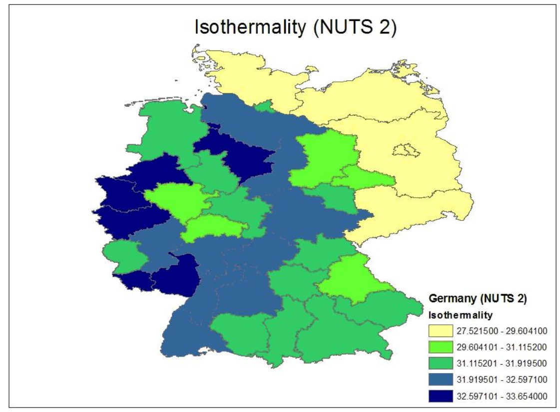

FIG. 4: Isothermal Variation (logmeanbio3); employed to control for variation in spending attributable to weather variability.

national level. Fortunately, seismicity is not a concern, as there has not been a single earthquake in the past 103 years and low grade seismic activity in Germany is negligible (Maples 2006).

Topographic Features

Roads built in mountainous regions are more expensive to build than in flat regions. In order to control for the added cost attributed to building roads on difficult terrain, elevation data is acquired which is observed at the square km latitude/longitude level. The km square unit observations are grouped by their NUTS2 regions in order to match these data with the district level unit of analysis. The standard deviation of sq.km elevation is computed to illustrate cross-regional topographic variation. The NUTS2 regions are sufficiently large in area, and therefore, have enough observations to provide a robust calculation[12]. As shown in Figure 3., there is considerable variation in topography in Germany. Consider the Länder Sachsen and Bremen, with the standard deviation in regional elevation of 291 and 4 respectively. It is likely that building a kilometer of standard two lane road in Bremen is less expensive, ceteris paribus.

Bioclimatic data

Weather severity may also explain variations in public expenditures for equal level road endowments. Severe weather may cause construction delays and require additional logistical support [13]. For this reason, the various bioclimatic data are tested for their significance in determining cost variation. The variables are formatted in ARC to fit the NUTS 2 regional level and include: annual mean temperature (logmeanbio1) , isothermality (logmeanbio3)[14] and annual precipitation (logmeanbio12). These variables are used to normalize spending[15].Worldclim organizes these bioclimatic variables globally across several decades and supplies them in 1 sqkm units formatted for Arc Software. These data have been reorganized to fit Germany's NUTS2 regions, by taking the average within each boundary file. Figure III represents the degree to which regional sub governments experience volatile weather patterns. Note, in Figure III, that Northeastern regions of Germany have less isothermal variation. This indicates that the there is less reason for weather related construction delays and additional support. Other variables, such as Minimum Annual Temperature, may also significantly explain cost variation independent of corruption

Isothermality is the ratio of the Mean Diurnal Range over the Annual Temperature range:

$$\frac{\frac{1}{12}\sum(\max(monthlytemp) - \min(monthlytemp))}{\max(annualtemp) - \min(annualtemp)} \tag{1}$$

Building Materials

[12] calculations across the of sq km

[13] As far as I know there is no general rule regarding the relationship between weather severity and construction costs. Suggestions are welcome. However, if two correlated variables are significant, the variable with greater explanatory power will be used.

[14] Isothermality is the ratio of the Mean Diurnal Range over the Annual temperature.

[15] Other versions of the model that contain a combination of the 3 variables are also tested to check the robustness of the residual model. see appendix C

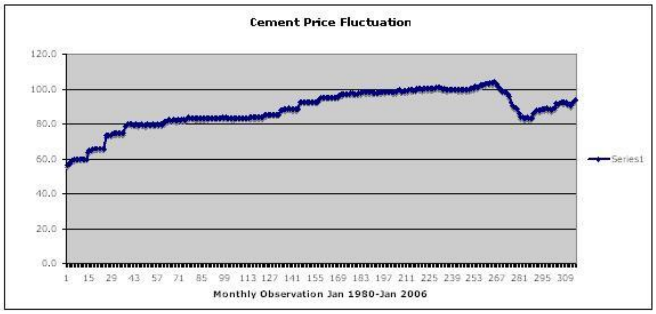

FIG. 5: Price of Cement in Germany (raw material for concrete). The price fluctuation data are used to control for variation in building material costs over time.

Building materials are a significant determinant of the cost of infrastructure construction. Therefore, the index must account for cross-regional and temporal variation in the price of building materials.

Modern roads are paved either by asphalt, concrete or some combination of the two. Asphalt, more specifically named asphalt-concrete, is widely used in road construction because of its low cost. However concrete is preferable for major road projects since it is more durable, less polluting, more skid-resistant and is less reactive to extreme weather[16].

Concrete and cement are often falsely treated as synonyms. Cement is the most important ingredient in concrete. Cement is a closely controlled chemical combination, containing mostly lime and silica (cement.org). There are few cement suppliers in the world, making cement prices across Germany constant. The road building materials are therefore more or less expensive depending on the process by which cement is used to make concrete. Cement is mixed with various forms of gravel and sand to make up concrete.

The ultimate strength of concrete is determined by its water to cement ratio. Higher ratios are not desirable and indicate that cheaper materials were mixed in with the cement. The recipe is dictated by the design, and the government allows a two percent tolerance on the components that they purchase. If too little cement is used, the material costs are reduced, but the final product is less durable. Moral hazard plays a role at the point at which concrete is mixed and sold to the government. Fortunately, it is very easy for consumers to observe if concrete is not made according to the specified mixture. For this reason, the government officials do not unwittingly pay high prices for poor concrete mixtures. It is, however, possible that officials turn a blind eye or receive bribes. There is considerable potential for corruption to enter at the stage of concrete or building contracting.

New York City in the mid-eighties is an excellent case study of how corruption leads to higher spending on public construction. Until the crime families were convicted, all but the smallest city's concrete related construction projects were controlled by an illegal operation (Owen 2003). Five major crime families ("The Commission") were able to rig concrete contracting, allowing only a small Mob-controlled group of contractors and suppliers to win these projects. In addition to rigging these deals, the Commission collected a two percent tax on all concrete work. The absence of competitive bidding and the corruption tax led to dramatic increases in the cost of public construction (Owen 2003).

Again, this paper will not pinpoint the exact channel by which public funds are lost. However, the index will illuminate suspicious regions. Since cement prices are constant, one would expect that concrete contracting would be relatively uniform throughout Germany. However, organized crime in concrete contracting will lead to relatively higher final construction costs. Such inefficiency will surface in the final index since this region will experience higher spending for equal quality infrastructure, ceteris paribus.

The price of cement also varies over time (see Figure 5). It is therefore necessary to weigh the annual spending data by its corresponding cement price. Consider by example what would occur if this procedure is not employed. Take region A and region B, where A builds the majority of its roads in 1986 and B builds in 1992.The price of cement is higher in 1986 than in 1992. Raw spending data will be higher for A, and without controlling for cement prices, A will seem deceptively more corrupt than B. Therefore it is imperative that variation in cement prices is controlled for [17].

Final Note on Controls

The spending data must also be controlled for by population and surface area (sq.km). Golden and Picci did not explicitly mention that they controlled for both size and population for roads spending in their study. They listed roads as a "space serving" form of infrastructure and therefore controlled for area. It seems more reasonable to treat roads as both "space" and "population" serving since as the size and population of a given region increases, the magnitude of spending will too. For more detail on the population density controls, please consult Appendix A.

Although the purpose of this paper is to further our understanding of political corruption by proxying the rate of return in public spending in Germany, this project requires knowledge of civil engineering that is beyond the scope of a political scientist. One concern in particular is how service life is calculated. Is it really appropriate

[16] (cement.org)

[17] I am waiting on the data for Asphalt. These data are from the same source and will be formatted and employed using the same control technique.

Source	SS	df	MS	
Model	15.6262464	6	2.6043744	Number of obs = 11
Residual	1.75523288	4	.43880822	F(6, 4) = = 5.94
Total	17.3814793	10	1.73814793	Prob > F = 0.0533
				R^2 = 0.8990
				Adj R^2 = 0.7475
				Root MSE = 0.66243

Indep. Variable	Coef.	Std. Err.	t	P > |t|	95 % Conf. Interval
logmeanbio1	-1.197326	6.375952	-0.19	0.860	-18.89981 16.50516
logmeanbio12	10.2088	6.951131	1.47	0.216	-9.090631 29.50824
logmeanbio3	-30.02439	17.99465	-1.67	0.171	-79.98554 19.93676
logstdelev	1.820301	.859979	2.12	0.102	-.5673839 4.207985
logsqkm	-.4380477	.3377539	-1.30	0.264	-1.375803 .4997075
logpop	.7155878	.43408	1.65	0.175	-.4896115 1.920787
cons	19.61581	33.42131	0.59	0.589	-73.17664 112.4083

TABLE I: **Significance Test of Control Variables and Normalization of Capital Stock**

to follow OECD convention and employ the same service life for all German roads? These concerns are detailed in Appendix B, where it is demonstrated that changing the rate of deprecation does not alter the results significantly.

Residual Analysis of Infrastructure Spending

The procedure used for controlling spending differs from that introduced by Golden and Picci, who divide spending by the geometric average of regional cement and sand costs (Golden and Picci 2005; p.50). This paper employs a residual based method for controlling cumulative spending by cost. The procedure advocated here provides three distinct advantages over the Golden and Picci index. First, the study is limited to roads and therefore allows for a more legitimate comparison across across infrastructure. Second, the residual analysis provides more information on the significance of variation in return to spending. Finally, this procedure is based on a model for costs in road construction and as such demonstrates how well the assumptions fit the data, whereas Golden and Picci assert that their cost controls are sufficient.

Residual-based approaches for indexing relative qualities or efficiency levels is present in the public and health economics literature. Research used by epidemiologists for the inter-hospital comparison of mortality rates is particularly germane. This procedure was first introduced in the late 1970's (Duckett and Kristofferson 1978) and continues to be used in modern work. Other notable research involving the use of residuals to index quality may be found in the economics literature. For instance, Berry, Levinsohn and Pakes employ a variation of this procedure in the context of demand estimation; see Berry (1995) and Berry, Levinsohn and Pakes (1995). The procedure employed by Duckett and Kristofferson to measure hospital quality is most applicable for this project. Their procedure involves creating a model to predict mortality rates based on observable factors that are believed to predict mortality. Once the model is found to fit the data well, the regression residuals are analyzed Residuals that are found to be statistical outliers are given further attention since they represent hospitals that have mortality rates above or below what is expected. Finally, the residuals are ranked to provide an index of hospital quality. This distance from the prediction line represents the quality of health care that cannot be directly measured (Ansari et al. 1999). This paper adapts this procedure and models government spending rather than mortality.

A model is first created to predict the level of spending on new road construction in Germany, matching the time series for the quality assessment and the life of the road. The dependent variable is the cumulative infrastructure spending. The independent variables are the cost controls that predict how much money "ought" to be spent on these roads projects. [18] The model presented in this paper employs the logged average annual precipitation, logged standard deviation of elevation, logged square kilometer and logged population. Each of these variables are believed to contribute to higher spending on road construction.

The fit of the model is strong, indicating that a large portion of the variation in spending is associated with variation in the cost controls. The residuals are then extracted and interpreted as the deviation above or below what would be expected, given our observable indicators for cost variation in road construction. The closer the data fit the model overall, the more emphasis one may place on the results (Ansari et al. 1999).

The regression results of the cost model are provided in Table 1. above. The Adjusted R-squared value of .747 indicates that the model explains the variation in the dependent variable reasonably well. The F statistic of 5.94 indicates that the regression is nearly significant at the five percent level. The direction of coefficients are also as expected. The model displayed above is not actually the closest fitting specification tested. The cost model that predicted depreciated log spending (loge1105) has a

[18] Several variations of this model are provided to test for the robustness of the final index to model specification and may be viewed in Appendix C.

FIG. 6: The map above illustrates the relative levels of normalized spending. These are calculated by estimating the regression residuals for the roads spending model presented in Table 1. Darker regions indicate that actual spending is above the prediction line and lighter regions fall below.

stronger overall fit. The F statistic is 8.71 and the regression is significant at the 2 percent level. Fortunately, the final index calculation is the same regardless of which of the two models are chosen. The model with zero depreciation, shown in Table 1 above, is chosen since it more closely matches the assumption that Golden and Picci make regarding PIM. Several other cost model specifications are provided in Appendix C along with a sensitivity analysis on how choice of model effects the final index ranking.

The logarithm of district population is the only indicator variable that is significant at the 5 percent confidence level and log standard deviation of elevation is nearly significant. The positive coefficients indicate that higher populations and greater variation in altitude (i.e. rough terrain to build roads) are positively associated with higher road construction costs. This cost model is robust to different specifications of the depreciation rate. These other specifications are provided in Appendix C.

The normalized spending values, displayed in Figure 6 above, are calculated by estimating the regression residuals for the roads spending model presented in Table 1. The darker regions are those where the actual spending fall above the prediction line. This does not mean that they are less efficient or more corrupt since higher roads quality could explain this deviation. Likewise, lighted shading is used to illustrate regions where predicted spending is above actual spending.

The residual analysis procedure rests on the critical assumption that regional cost variations do not significantly shift the demand for road construction. This is a valid assertion since the demand for road construction is rather inelastic, particularly due to the constitutionally mandated requirements that the standard of infrastructure be equalized across German Länder ("Ausgleichsmalzahl"). If this were not true, then the regions where infrastructure is more expensive could curtail their spending and the resulting infrastructure quality would suffer. This does not appear to be the case, since high cost regions do not appear to have lower spending patterns [19]. Such a scenario would require simultaneous equation modeling. This is not necessary due to the fact that this is a model for a homogenous good, where cross product substitution is not significant (i.e. they won't build an ice rink instead of a road). Thus, the change in variation in cost inputs does not decrease aggregate output and the model does not need to account for endogenous demand decisions based upon marginal prices (Berry 1994).

The residual analysis presented here is preferred to Golden and Picci's method because it provides more information about the relative cost efficiency in public spending across regions. The Golden and Picci index allows one to create a relative ranking of the ratio of inputs to outputs. However, Golden and Picci's procedure does not tell us much about why certain regions score poorly. They also provide no information on how well the two cost controls that they employ predict spending. It seems infeasible that the cost of cement and sand in 2001 will strongly predict cumulative spending on all forms of public infrastructure (i.e. schools, roads, telecommunications) over the span of several decades. Variation in Italian spending relative to measured quality could result from unobserved cost inputs that are not accounted for in a model nor associated with political corruption. Perhaps the reason that the Golden and Picci procedure is well received is because the results validate an existing opinion about differences between northern and southern Italy. However, a more robust procedure is required to test for variation in the rate of return to public spending in Germany without strong apriori knowledge.

The Final Index

At this point the final index may be generated. This final indexing procedure is very simple. First the two data for roads infrastructure and capital stock are in-

[19] In the extreme cast that demand is very elastic, the relationship between cost and spending is inverted.

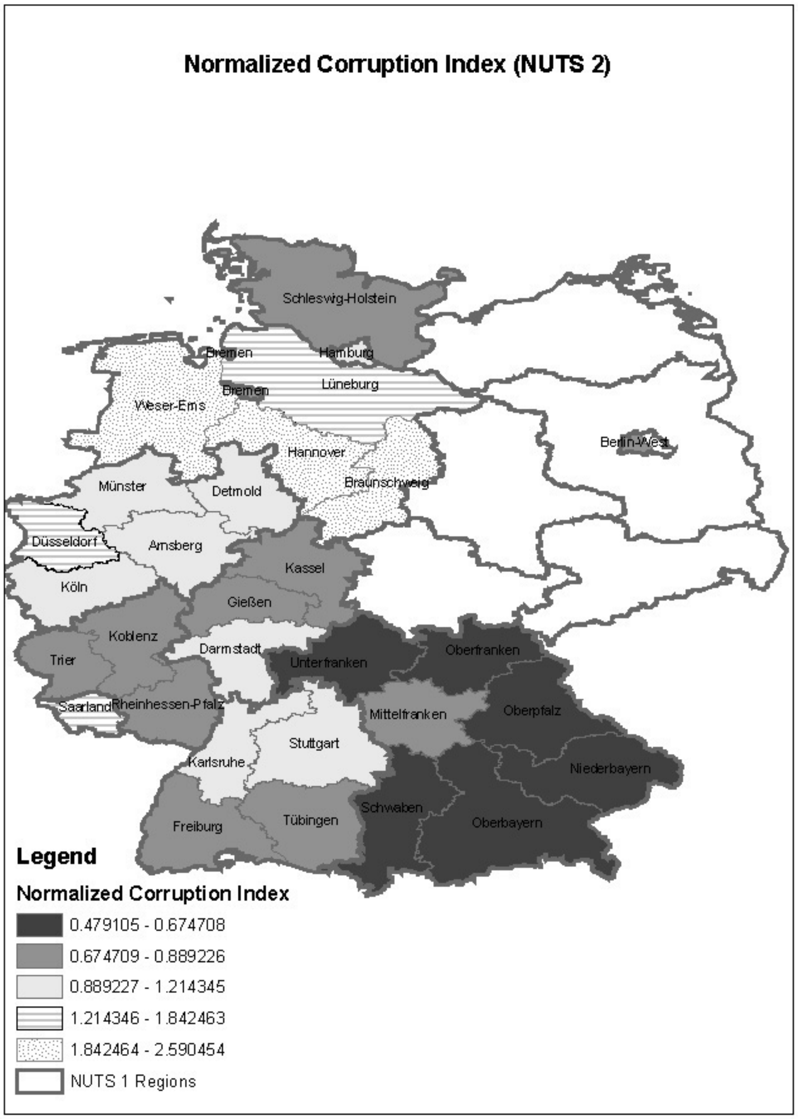

FIG. 7: **EFFICIENCY INDEX (1995)**: Golden-Picci style corruption index estimated with German fiscal data 1984-1995.

dexed with a mean set equal to 1 and standard deviation equal to .5. Second, the index for infrastructure is divided by the index for spending (residuals from the cost model). This ratio makes up the final political corruption index[20].

A potential critique of this final index is that it could be

[20] Note that there are 11 Länder employed as units in the spending analysis, whereas there are 32 district level observations in the final index. This is because the Ecoter infrastructure quality index provides a ranking across all 38 of Germany's districts. The 6 East German districts are removed from the index for the same reason described before. These districts map onto the Länder perfectly since they are subunits. These districts quality data are simply matched to their corresponding Länder spending data to comprise the final index http://www.icpsr.umich.edu/training/summer/biblio/1996/anselin.html

heavily driven by the chosen model specification. Therefore, the index procedure is tested with various other models to insure that the final ranking does not change dramatically as a result of reasonable changes to the model design. This does not alter the fit of the data substantially, nor the direction of coefficients. Most importantly, the final index estimation does not markedly change. The final index is also robust to alternative Perpetual Inventory Method (PIM) calculations for the aggregate spending data. In other words, dropping the assumption employed by OECD that there is no depreciation in capital stock over the course of the service life does not alter the findings. The model is estimated with varying depreciation rates and the final index rank does not change. The final index is also tested for robustness against alternative construction cost controls. Finally, changing the independent variables in the spending model does not markedly alter the final index. All of these robustness checks are detailed in Appendix C. To summarize, these checks show that the relative residuals extracted from the cost model estimation do not change drastically as a result of reasonable changes to the model's assumptions.

The results of this data project illustrate the rate of return to public investment in road construction across German districts. This procedure would be improved if a greater number of observations were tested in the cost model. The current estimation is limited because the cost model is predicting Länder spending, for which there are only eleven units. One possibility is to extend collect on spending data to the district level. Recall that as there are no electronic data for national level statistics over the relevant time period and that the data for this project were collected by hand. Collecting further disaggregated spending data will require extensive archival work.

IV. FINDINGS

Following the precedent set by Golden and Picci,one would infer from this index that regions with lower return to infrastructure spending harbor greater political corruption (Golden and Picci 2005). Notice that the southwest regions of Germany are darkly shaded and therefore less efficient. The regions with the lowest return to spending, denoted by darker colors, are considered to be less accountable.[21]. This means that a kilometer of public road was relatively more costly in Land of Bavaria than in northwestern Niedersachsen, although costs inputs are accounted for.

What is certain is that the darkly shaded regions are those wherein measured spending is higher relative to output. However, the observation that some regions are less efficient than others does not necessarily indicate that they are corrupt. In another paper, I argue that this relative inefficiency across regions reflect the asymmetric fiscal incentives set by the Federal Constitution. The paper argues that strong variation in political corruption is unlikely. Rather, that this regional variation illustrated in Figure 7. reflect the differing incentives created by Germany's fiscal equalization policy, whereby wealthy Länder are required to transfer public funds to less prosperous regions.

[21] The dark gray lines denote the Länder boundaries. Notice that although the index is calculated at the district level, there is little within Land variation in how the sub-governments score on this index. Again, the East German Länder are omitted from this index due to historical discontinuity. The index calculates the cumulative capital investment in roads, beginning in 1984 which is well before Germany's reunification.

Appendix A: concerns about population density

Ecoter's procedure for normalizing "space serving" public infrastructure does not directly mention controls for population. This is rather disconcerting, since regions with higher population will have more roads, with more lanes. Since Germany obviously does not have a uniform distribution of population density, this could bias the quality of road infrastructure towards more densely populated regions. Interestingly, the measurements that Ecoter has normalized by population relate more to population density than roads endowment rankings.

In Figure 8 the population density is estimated for each region and then plotted against its corresponding "infrastructure endowment". This index, which is not used for this paper, includes all public infrastructure (schools, hospitals, telecommunications etc). This shows that there is a positive relationship between population density and overall infrastructure ranking. However, Ecoter claims that the majority of the sub indices that make up the overall infrastructure rankings are in fact normalized by population (Ecoter 1999).

Note, there is a difference between normalizing by population verses population density. Given that they have normalized by population, the relationship above may illustrate that small rich metropolitan provinces have better infrastructure regardless of the area and number of people are served. This is definitely an indication that the ranking may be biased towards metropolitan regions. Correl = - 0.5738, That as population density increases, the rank will improve.

Fortunately for this study, population density does not seem to be as great a factor in road infrastructure endowment. The correlation between population density

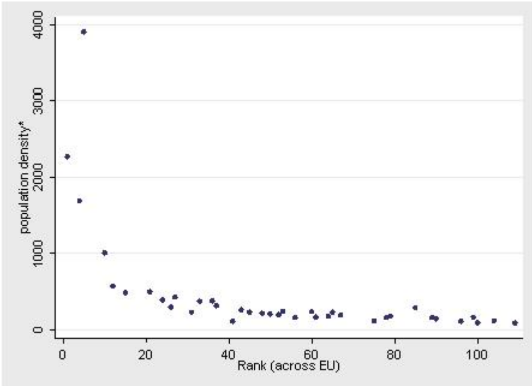

FIG. 8: Overall endowment

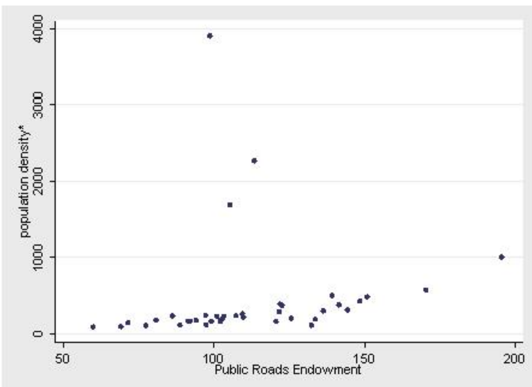

FIG. 9: Public Roads Endowment against Population Density

and roads endowment is reasonably close to zero, (Correl =0.1215). Figure 10 demonstrates that there is a positive relationship between the size of the region and the quality of roads infrastructure (Correl = -0.6087). This negative correlation signifies a positive relationship since lower ranking numbers indicate higher quality. The greater the surface area, the greater the road endowment. This could offset the relationship between population density and road infrastructure, since Germany's smallest regions are most densely populated (i.e. Hamburg, Bremen, Berlin).

Appendix B: Concern about PIM

The very simplicity of the PIM method for this paper is what opens it to criticism. Although the information on asset service lives is well documented, the rate of road retirement is not an exact science. Service lives may change over time, in reaction to technological change or business cycles (Meinen, Verbiest and deWolf 1998). The version of PIM used by Golden and Picci does not account for degradation of roads.

The spending statistics used to compile the value of capital stock include only spending on new roads and excludes spending on ordinary maintenance expenses. This

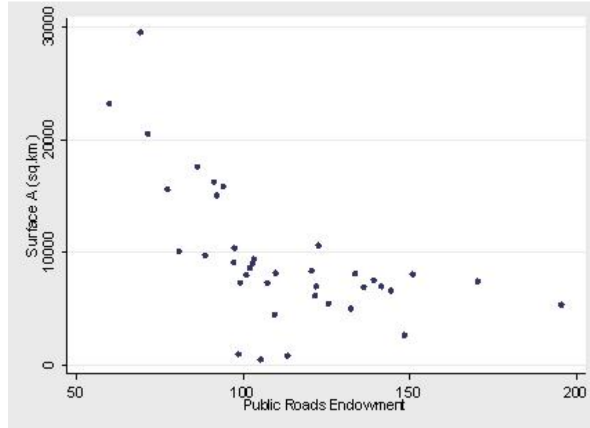

FIG. 10: Public Roads Endowment against Surface Area of Regions

is not necessarily a problem so long as one critical assumption holds: that the quality of maintenance must not effect the service life. Regardless, this is only a problem if some districts systematically differ in terms of their maintenance expenditure and replacement rate.

There are various questions that must be answered. The service life used for this analysis is optained from the OECD. At this point, I do not have any information on whether different service lives for each region exists. If this can be obtained, the maintenance question will be resolved.

So long as no extreme differences in maintenance procedures across states exist, it appears that the choice of PIM model is not problematic. In Appendix C, Figures 1 and 2, you will find that changing the depreciation rate does not effect the overall index score.

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