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Is There an Optimal Structure for Decentralized Provision of Roads?

*Frannie Humplick**Azadeh Moini-Araghi*

Generally, local maintenance of roads is more efficient than centrally controlled maintenance. For road construction, contracting procedures and competitive bidding are more important than issues of decentralization. Central governments should regulate safety and other network externalities.

Summary findings

Humplick and Moini-Araghi empirically investigate how decentralization affects the efficiency of road provision from the viewpoint of the local goods provider and the road user. The theoretical model: a double-cost hidden level of effort. For accurate estimates, they found it important to include both user and provider concerns in determining the optimal level of decentralization.

Using four different model specifications and three data sets, they find that 100-percent decentralization of maintenance functions (where there is no central regulation on quality standards) produces the most efficiency gains, as quality roads are provided at lower unit costs. There is little justification for central government to be involved in road maintenance. In fact, as Germany's example shows, uniform standards combined with decentralized maintenance remove the incentive to reduce costs and erode most of the efficiency gains from local maintenance. Maintenance is by definition a local activity and should reflect user preferences.

Central governments should regulate safety and other network externalities by having a stake in the financing

of road administration and in such functions as planning, policy setting, and regulation of safety and other network externalities. Central governments should finance no more than 10 percent of administrative costs.

As for construction, it depends on the country. It may be better to ensure that contracting procedures in a country are efficient before suggesting the decentralized provision of roads. It is easier for local governments than for central governments to incorporate user preferences in their spending decisions. Similarly, determining where to make investments, deciding how to procure works, and monitoring the quality of construction and maintenance is often done more efficiently locally — except when local capacity to carry out road works is limited.

The results point to the benefits of decentralized provision of roads, but many countries contract out maintenance and provision. In that case, it may not matter whether local competitive bidding is carried out by a central or local agency.

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Is There an Optimal Structure for Decentralized Provision of Roads?¹

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1 This paper—a product of the Policy Research Department—is part of a larger research study in the Agriculture and Natural Resources Department to develop a strategy for rural development. The research study is jointly funded by the Norwegian and Swiss Special Studies Trust Funds and by the Bank's Research Support Budget under the research project "Decentralization, Fiscal Systems, and Rural Development" (RPO 679-68).

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1. Introduction

Decentralization programs are increasingly being adopted by developing countries around the world. Sixty three out of seventy five transitional and developing countries with populations exceeding five million are in the process of granting more economic and political powers to lower levels of government (Prudhomme, 1995). The transfer of competencies and responsibilities has been based on grounds that there are gains to be made from decentralization. These benefits, it is contended, stem from improvements in allocative and productive efficiencies. Allocative efficiency is improved by decentralization because local councils have a better understanding of the local demand for public goods and services, and are able to allocate scarce resources to better match this demand, thereby increasing satisfaction and welfare. Productive efficiency also is improved in many cases, because local governments are able to deliver goods at a lower cost than national bodies.

Whether the above benefits have materialized in practice is not quite clear. In some countries, the decentralization experience has been positive, whereas in others, decentralization has failed to deliver the gains promised. In response to the problems faced by decentralized operations and in the search for a better understanding of the decentralization process, the World Bank has initiated a comprehensive research project, entitled "Decentralization, Fiscal Systems and Rural Development". The study focuses on the processes through which services are delivered; to learn about the economic, political and institutional factors that influence the outcome of decentralization efforts, and to the extent possible to quantify the impact of decentralization on rural service delivery. In the recognition that decentralization outcomes and objectives may be country specific and sector specific, the study conducts sector and country specific examination of these issues. Our study contributes towards the understanding of country and sector specific effects of decentralization.

To date, many governments have used decentralization as a common strategy to revitalize and rebuild road networks and to strengthen their systems of administration and maintenance. Twenty four out of a sample of thirty countries are found to have decentralized; particularly those countries with increasing trends towards motorization have relied on decentralization as a way to improve their road operations (see figure 1). From 1982-1986, the average degree of decentralization for roads, measured as the share of local government in total expenditures for roads, increased about 20 percent. The debt crisis could have been a major breakpoint for the transfer of responsibilities to lower levels of government (figure 2) since between 1982 and 1986, the share of local government spending in roads grew faster than the ratio of debt to GDP. Faced with severe financial deficits, decreasing levels of exports, rising prices of energy and diminishing foreign assistance, central governments regarded decentralization as an optimal strategy to use limited resources more effectively. Figure 2 shows that the trend towards decentralization declined slightly since 1990, although the average share of local government spending on road works in 1992 has leveled off at forty three percent, a share much higher than that of 1982 which was thirty two percent.

The above discussion shows that it is quite important to study the effects of decentralization on the road sector. Most recently, Humplick and Estache (1995) provided an analysis of the impact of decentralization on roads with a focus on maintenance. Their results indicate that the decentralization of road maintenance leads to an improvement in the general condition of roads, more paved roads and a reduction in maintenance backlogs. They also find, however, that decentralization leads to higher unit costs and expenditure on maintenance. Moreover, it leads to greater differences in quality across regions. These conclusions demonstrate that decentralized satisfaction of local preferences is costly; in fact, they draw our attention towards the need to gain a better understanding of the underlying factors that influence decentralization outcomes in the road sector. This is the aim of this study.

Expanding on Humplick and Estache's study (1995), this research examines the effects of decentralization on road service delivery to gain an understanding of the forces that promote centralization and those that encourage decentralization in the road sector. The study develops a conceptual framework and analytical basis for understanding both the influencing factors (institutional and economic) of decentralization for the road sector and for evaluating empirically the impact of decentralization on road service delivery. It treats the provision of road services within a multi-product framework of decentralized provision. An interesting feature of the study is its focus on various types of fiscal decentralization, mainly decentralization disaggregated by activity: decentralization of construction, maintenance and administrative activities. This form of decentralization may serve as a proxy for functional decentralization since it indicates how much expenditure local governments actually have control over for the three main activities related to road provision.

The paper is organized as follows. Section two introduces the general and extended theoretical frameworks of the study. Section three is an empirical analysis which first introduces the data, then the results of a cross-country econometric analysis, and the limitations of using a cross-country panel. To test the robustness of our results from panel data, we conduct a longitudinal analysis of the impact of decentralization on road provision for the case of Korea which is presented in section four. To further test the effect of the depth of decentralization (to state and local governments as well as a function of the number of governments) we measure the impact of decentralization on road service performance for Germany. The analysis of performance is expanded in this case to include measures of safety and participation of users in financing road works. The three empirical investigations in sections two, three and four, are compared in a cumulative fashion, wherever data availability permits, to verify the findings of the previous data set. Finally, in section six we draw some policy conclusions from the analysis.

2. Theory

This section presents the conceptual framework which has been developed to analyze the links between decentralization and road service delivery. In our model, decentralization is defined in terms of how it relates to efficacy of service delivery or performance. As a measure of performance, we employ an extended double cost approach, which was first developed by Buchanan and Tullock (1962) and has since then been extended by others for application to a variety of issues.³ We distinguish between two categories of costs: i) *resource costs*, which are simply the costs of provision, administration, and management of roads (input costs); and ii) *preference costs*, which are defined as costs incurred by road users (local and transit users)⁴ due to poor performance of road infrastructure. In line with economic theory, a suitable social objective is to minimize total cost, which is the sum of preference costs and resource costs. We recognize that differing *levels of effort* can be applied to achieve the same level of service delivery.⁵

To formalize the double cost concept described above and to make it applicable to the case of providing road services, we adopt a modified representation developed by Laffont and Tirole (1993) for efficiency of producing goods in a multiproduct framework, where the production type and level of effort affect the quality of the product. The multiproduct framework is relevant because a given level of government typically supplies road services with variable and verifiable quality at an observable cost of provision. The outputs can thus be measured as the *quality* of roads and the unit *costs* in \$ per km of producing the given levels of quality. Furthermore, the condition of roads is variable across locations and the variation in quality is verifiable through physical measures.⁶ Following Laffont and Tirole, “verifiable dimensions of quality can be treated as quantities of fictitious outputs and are thus amenable to the multiproduct analysis” (Laffont and Tirole, 1993: 165).

³ See Biehl (1994), who has applied an extended version of the double cost model as a reference scheme to determination of optimal federal constitutional structures.

⁴ Local users are those who live in the jurisdiction under consideration and who drive on roads and move goods and people from one place to another. They are the beneficiaries who demand that enough roads exist for them to travel within the jurisdiction and who would like roads to be reliable (no congestion or seasonal failures, wide lanes) and in good quality (primarily paved), to minimize vehicle operating costs and make traveling more comfortable. The second group of users include transit users (national or international), whose economic activity depends primarily on roads. Generally, transit users depend on the road network because they are moving inputs to production plants, or for taking products to other locations in domestic or foreign markets. Similar to local users, transit users are interested in the state of road services. The two kinds of road users differ in the degree to which they express their demand for reliability and better road quality and in turn the level of government that is most responsive to their demands.

⁵ This term is borrowed from economics of the firm, where it is defined as the degree of attention paid by a manager to reduce costs or improve performance (see, Laffont and Tirole (1993), p.168).

⁶ For an overview of quality and quantity measures for public services, see Hirsch, W., “The Supply of Urban Services”, *Issues in Urban Economics*, based on papers presented at a conference in January 1967.

We combine Laffont and Tirole with Buchanan and Tullock to arrive at a double cost model where resource costs are represented by the unit expenditures in construction, maintenance and administration and preference costs are measured by a proxy of user vehicle operating costs which is the percentage roads in bad condition. Our main departure from the Laffont and Tirole model is that we assume both cost and quality to be observable and verifiable. However, we maintain their assumption that effort is an increasing function of the provision type (in our case the degree of decentralization), but we propose measures of revealed level of effort, as we are concerned with the level of productivity under different degrees of decentralization. To estimate the optimal level of decentralization, we use results from proofs provided by Olsen and Torsvik (1995) to develop the model specification. We provide justification for these assumptions in the following section.

Outputs from a Road Agency

An agency j , which may be centralized or decentralized, having responsibilities for roads within a well-defined jurisdiction, produces road services through undertaking production and/or management of some or all of the following three activities: (a) major construction works on new road links to expand access to the network or improve the connectivity of the network as well as rehabilitation and reconstruction of existing road links to improve their transitability; (b) maintaining existing road links in passable conditions by performing necessary repair works as well as carrying out preventive maintenance activities to prolong the life of existing assets; and (c) administering day to day operations on the network such as managing contracts for roadworks in the case where such works are contracted out to another agent, dealing with emergencies such as landslides and road accidents, and undertaking any planning, coordination and regulatory responsibilities that relate to the provision of roads.

The agents (central government, local governments) producing road services generate a vector of outputs q measured in terms of the quality profile of road services provided across the jurisdictions they are responsible for. Quality is measurable in scalar terms by the percentage of roads in good or bad condition, and verifiable by the degree of satisfaction road users have for a provided quality of road.

At each time period t , we can observe the expenditures on roads by the agent, classified according to the three key activities above, which we denote by a cost C and the quality of produced road links which we denote by q . The costs are expressed in \$ per km in order to remove effects of scale⁷ and are allowed to vary by the type of function i (construction, maintenance, administration), the type of agent j (centralized or decentralized), and the time period t . Quality is measured as the percentage roads in bad

⁷ We do not control for different road sizes as measured by number of lanes and width of lanes. Neither do we control for the type of materials, and presence or absence of roadside furniture.

condition, a measure that users are sensitive to. We explicitly include time to capture both the static and dynamic efficiency of different degrees of decentralization.

The agent receives transfers τ^k from three main types of principals k : (i) the central government ($k=1$) providing financial allocations on a periodic basis to the agent to carry out road works which may be generated from taxes or external borrowing; (ii) road users ($k=2$) paying user charges such as tolls, licences, fees and taxes for road usage; and (iii) non-users ($k=3$) who make allocations--in addition to the contributions to the central government in terms of general taxes which may be used to finance roads--to the agent as a result of being neighbours to the road infrastructure. Some of the transfers the non-users allocate cannot be measured in monetary terms as they are in the form of non-monetary costs such as noise, emissions, land-degradation, and other effects from the presence and usage of the road.

The responsibilities of the agent depend on the degree of decentralization with respect to the provision of roads, which we denote by a provision type parameter β . In the special case of fiscal decentralization, with which we are concerned, the degree of decentralization is defined by the ratio of own-source generation of funds towards road provision to the total expenditures on roads. So that, for any agent j , at a fixed time period, we can define the degree of fiscal decentralization as $\beta = 1 - (\tau^1 / C)$. Since it is difficult to measure τ^1 , we use the inverse of the central government's direct contribution to road works as a measure of degree of decentralization. The parameter β ranges from 0 percent where all expenditures are made by the central government denoted by "completely centralized" to 100 percent where all expenditures are made by local government denoted by "completely decentralized".

Resource Costs

Let us consider the first category of costs; mainly the resource costs:

$$RC = C + \Theta \quad (1)$$

which are made up of observable (C) and unobservable (Θ) components. The observable component C is defined as:

$$C = C(e, q) \quad (2)$$

where C is the observable cost of producing road services, which we measure ex-post in the three dimensions of expenditures defined earlier all measured in \$ per km of roads under the jurisdiction of an agent, such as a unit of government. The total cost of producing road services is the sum of the expenditures made in construction, maintenance, and administration as seen in figure 3.

In producing road services at quality q an agent can use a low ($e=e_{\text{low}}$) or high level ($e=e_{\text{high}}$) of effort, for a fixed degree of decentralization β . We further assume that this level of effort is unobserved and affected by non-quantifiables such as governmental, fiscal, and institutional structures as well as societal objectives, all of which are specific to the decision-making unit of analysis. However, while the degree of effort expended e is not directly observable, it is driven by two major factors: efficiency and voter satisfaction objectives. Two units of government with the same level of fiscal decentralization may exert different levels of effort, thus realizing different performance in terms of resource cost savings.

We postulate that under fiscal decentralization, agents such as local governments receive transfers (τ^l) from the central government which may or may not be earmarked for producing road services.⁸ Such an agent attempts to meet local preferences through expenditures (C) and level of effort (e). At low levels of fiscal decentralization a government will meet all or most of its road expenses by using the transfers from the central government (τ^l) since they may have no incentive to reduce costs by expending more effort. Some local governments who have closer ties to the voting public, may try to reduce (C) by expending more (e), so as to use the transfer (τ^l) to meet more or other demands⁹. We can thus derive a disutility of effort which we define as:

$$U = \tau^l - \psi(e) = (1-\beta)*C - \psi(e) \quad (3)$$

The term $\psi(e)$ is a function representing the hidden cost of effort for the agent (a unit of government at the local level) to: i) reduce resource costs; ii) meet more preferences at the same level of effort; or iii) raise revenues internally to meet the costs of satisfying more local preferences rather than depending solely on the transfers.¹⁰ From (3) we see that the degree of decentralization is a noisy proxy for the level of effort. Using a proof from Olsen and Torsvik (1995) we suppose that the level of effort actually expended under a provision type β to produce road quality q at cost C , is an increasing function of β .

⁸ The transfers to a local government can be measured as a function of the total expenditures in the road sector. However, since each country has a different formula for allocating these transfers as well as different rules on earmarking we treat them as unobservable.

⁹ This argument only holds when the transfers are not earmarked for road activities.

¹⁰ Note that in this paper the view of the public sector is different from the traditional bureaucratic view, where the objective function of public officials clashes with the citizenry's interests. In models of public choice, as represented by Niskanen (1971), Brennan and Buchanan (1980), Romer and Rosenthal (1979), only the government knows its cost function which it deliberately misrepresents to make its case for the largest possible appropriation for its budget. The public sector has a monopoly and is seen as a single monolithic agent that seeks systematically to exploit its citizens through maximization of tax revenues that it extracts from the economy. Although this is a widely known view of the public sector, it has been subject to lively debate and numerous expansions. Oates (1972), for example, emphasizes that the public sector is not just one big monolithic unit and when talking about the government, it is important to differentiate between various levels of government. In accord with this view, in this paper we see the public sector consisting of several units, acting in representation of their voters' interests.

The observable expenditures on roads in (2) as well as the unobservable level of effort in (3) reduce to a resource cost function for producing road services under a given structure of provision:

$$RC(q) = C(\beta, q) + \Theta(e, q) \quad (4)$$

Factors affecting the unobservable level of effort may be specific to a country and could be captured by a country-specific fixed effect which can be estimated explicitly. We revisit this point in later sections of the paper. Resource costs can also vary over time and across conditions of a particular jurisdiction, for a fixed provision type β , depending on institutional, political, and geographic factors. We expand on this point in later sections of the paper.

There are two possible hypotheses that can be drawn from theory. The first hypothesis assumes that observable resource costs C vary by “provision types”, increasing initially with increasing degrees of decentralization, then declining after a maximum point is reached as follows:

$$\begin{aligned} \partial C / \partial \beta &> 0 & \forall & \beta_L < \beta < \beta^{\max} \\ \partial C / \partial \beta &< 0 & \forall & \beta^{\max} < \beta < \beta^H \end{aligned}$$

where:

$\beta^{\max}$ = level of decentralization which maximizes resource costs;
 β_L = initial level of decentralization assumed to be zero; and
 β^H = maximum level of decentralization feasible, assumed to be 100 percent.

A second hypothesis is a refinement of the first, assuming that observable resource costs decrease with increasing degrees of decentralization in a non-linear fashion (convex) but they decline at a decreasing rate or even increase after a certain level of decentralization as economies of scale are lost.

$$\begin{aligned} \partial C / \partial \beta &< 0 & \forall & \beta_L < \beta < \beta^H \\ \partial^2 C / \partial^2 \beta &> 0 & \forall & \beta_L < \beta < \beta^H \end{aligned}$$

We draw the main justification for the two hypotheses above on the structure of the model from the following: initially, the central government has important economies of scale in the provision of roads and the initial fragmentation of central government may result in loss of scale economies (both administrative and technological) with a consequent increase in cost of provision, administration, and management of roads (Buchanan and Tullock, 1962)¹¹. However, it seems reasonable to suppose that costs

¹¹ We assume for purposes of simplicity that the government unit, central or local, does everything by itself, through force account. In practice, much of the works are contracted out to the private sector (except in countries where the private sector is underdeveloped) so that the scale issue is less important.

increase at a decreasing rate or even start to decline as decentralization advances. Two economic arguments are put forward in support of these assumptions: i) first, there may be important diseconomies of scale resulting from inefficiencies inherent in big administrative units, and ii) second, at higher levels of decentralization, expenditure decisions may be tied more closely to real resource costs¹² (Oates, 1972: 87, Hirsch, 1968:495) and are hence expected to be lower.

We also draw justification for a non-linear impact of the degree of decentralization on the costs of producing public goods from a paper by Olsen and Torsvik (1995), where it was shown that the degree of decentralization has a dynamic impact on the level of productivity of an agent which may be positive or negative depending on the importance of the future relative to the present. In this study, we explicitly test these assumptions for the case of roads, as we have no prior reason to expect one functional form over the other.

Preference Costs

The second category of costs is the cost resulting from lack of responsiveness of government to demand for roads. It is the cost incurred by road users due to the inability of a unit of government to meet user preferences (local residents and transit users) of road quality. Preferences of local residents and transit users derive from the perceived social value associated with the production of road quality q and can be defined as follows:

$$P(q) = \varphi_i P_{ii}(\beta, r(e, C)) + \varphi_j P_{ij}(\beta, r(e, C)) \quad (5)$$

where:

P_{ii} = local residents expressing preferences for local goods; and

P_{ij} = transit users expressing preferences for local goods in a transit jurisdiction.

The term $P(q)$ is the perceived value of the quality of roads defined as a disutility of bad roads, a function increasing with the decline in road quality q . Preference costs are affected by the degree of decentralization β and the process of transforming expended resource costs C and level of effort e , denoted by the transformation function $r(e, C)$.

The following cases can be distinguished:

$\varphi_i = \varphi_j$ when road provision is centralized and there is full and equal representation of both local residents and transit users;

¹² This is one of the arguments that Oates (1972) put forward in favor of decentralization of provision of public goods. Assuming that higher degrees of decentralization imply greater autonomy in expenditure decision-making, he argues, local governments will operate more efficiently because local people weigh the benefits of a service versus its costs.

$\phi_i > \phi_j$ where there is no representation of transit users; and
 $\phi_i < \phi_j$ in a jurisdiction where transit transport is important and transit users have more voice than local residents.

We consider the special case where the preferences of transit users are expressed and met by local governments. We, therefore, do not need to distinguish between the two types of road users. Preference costs are therefore expressed by:

$$P(q) = P(\beta; r(e, C)) \quad (6)$$

We can define two basic assumptions from theory. First, preference costs may initially decrease with increasing degrees of decentralization but increase after a certain optimal level of decentralization.

$$\begin{aligned} \partial P / \partial \beta < 0 \quad \forall \quad \beta_L < \beta < \beta^{\min} \\ \partial P / \partial \beta > 0 \quad \forall \quad \beta^{\min} < \beta < \beta^H \end{aligned}$$

where:

$\beta^{\min}$ = the level of decentralization which minimizes preference costs;
 β_L = minimum level of decentralization assumed to be zero; and
 β^H = maximum level of decentralization assumed to be 100 percent.

The second hypothesis assumes preference costs decrease with increasing degrees of decentralization in a non-linear fashion (concave) but they decline at a decreasing rate or increase after a certain level of decentralization as costs of collective decision-making increase.

$$\begin{aligned} \partial P / \partial \beta < 0 \quad \forall \quad \beta_L < \beta < \beta^T \\ \partial^2 P / \partial^2 \beta > 0 \end{aligned}$$

The expected decrease in the two hypotheses above follows simply Musgrave's (1959 and 1965) allocative efficiency argument that decentralized units of government are closer to the people and can better tailor the supply of roads to demand or preferences of local residents. The expected increase follows Oates' (1972) diversity argument that diversity in demand is best met through decentralization.

Preferences of local- and transit-users and the social value associated with the production of road quality q can be defined in terms of the disutility of the individual user, which we defined earlier as a preference cost, and denote as $P(q)$. The disutility $P(q)$ may arise from a user who is a local resident, fully represented in local decision-making processes, or from a transit user with no direct impact on local decision-making. The mobility of road users following Tiebout (1956) model is a crucial qualifier for achieving efficiency in meeting user preferences. We assume that transit users in addition

to being totally represented in the choice of quality levels by local decision-making units are perfectly mobile.

Optimal Level of Decentralization

The social welfare function can be written as the difference between the social value associated with the production of road quality $V(q)$ and the resource costs of meeting quality demands $RC(q)$:

$$W = V(q) - RC(q) \quad (7)$$

Assuming that local preferences associated with the production of road quality completely meet the social valuation associated with this good and recalling that preference costs represent a negative value, we can write:

$$W = -P(q) - RC(q) \quad (8)$$

$$W = -\{P(\beta; r(e, c))\} - \{C(\beta, q)\} - \{\Theta(e, q)\} \quad (9)$$

To maximize welfare would mean to minimize the sum of preference costs and resource costs:

$$\max W = \min [\{P(\beta; r(e, c))\} + \{C(\beta, q)\} + \{\Theta(e, q)\}] \quad (10)$$

In terms of decentralization, it is to find the β^* that maximizes W , or minimizes preference and resource costs.¹³ By employing welfare maximization as a function of minimizing preference and resource costs, we can examine the effects of decentralization on road service delivery and discuss various choices of rules in terms of optimal location of provision (central government versus decentralized level of provision). The concepts, so far, are illustrated in more detail in figure 4. In this paper we provide empirical evidence of the optimal level of decentralization independently for preference and resource costs, and jointly for the total effect of decentralization.

¹³ Note the interdependency of preference and resource costs in equation (10). Both cost categories are determined by the level of decentralization and the unobserved level of effort (e). Depending on the type of decentralization, preference and resource cost minimization are driven by the degree of voter's awareness. Particularly with respect to the road sector, with fiscal decentralization and no ear-marking of revenues, voters are unaware of the opportunity cost of production of road quality and resource cost efficiency. Under functional decentralization with absence of fiscal decentralization, voters do not care about resource cost efficiency but are clear about preference costs. In contrast, when there is fiscal and functional decentralization with ear-marking, voters are highly clear about resource and preference costs. The presence of transit users who do not vote in a jurisdiction whose roads they are using complicates the maximization of welfare. We assume perfect mobility of such users in the Tiebout (1956) sense, whereby they can make route selections to meet their preferences. These concepts will be discussed more in detail in section 4 where we relax the assumption of unobservability of (e).

Measuring the Impact of Decentralization

We now depart from the general representation of resource and preference costs to introduce three special cases: (i) resource and preference costs are independently determined by separate agents; a unit of central government which allocates expenditure budgets for resource costs across jurisdictions and a local government which decides on the quality level to provide, respectively; (ii) resource and preference costs are jointly and simultaneously determined by the same agent; and (iii) resource costs and preference costs are recursively determined by a single or multiple agents, with preference costs leading and resource costs following and vice versa.

Without loss of generality and for ease of exposition we redefine the models developed thus far as linear-in-variables specifications for the three cases above. The models described thus far reduce to the following specification.

$$c_{ijt} = a_{i0} + a_{i1}\beta_{ijt} + a_{i2}q_{ijt} + a_{i3}T + a_{i4}D_j + \mu_{ijt} \quad (11)$$

$$q_{ijt} = b_{i0} + b_{i1}\beta_{ijt} + b_{i2}Z_{jt} + b_{i3}D_j + \varepsilon_{ijt} \quad (12)$$

where we introduce three sources of variation in resource and preference costs defined by the following:

- $j = 1, \dots, J$ = the number of distinguishable jurisdictions by the existing level of decentralization;
- $i = 1, \dots, I$ = the type of road function, where $i=1$ for construction, $i=2$ for maintenance, $i=3$ for administration; and
- $t = 1, \dots, T$ = time measured in years.

Preference costs q_{ijt} and resource costs c_{ijt} are allowed to vary across jurisdictions j , time t , and by the additional dimension of the type of road function i . Similarly for the level of fiscal decentralization β_{ijt} which is allowed to vary across road function i , jurisdiction j , and time t .

We introduce three control variables defined by Z_{jt} which is the level of income in jurisdiction j at time t , measured by per capita GNP; D_j which is a dummy capturing the jurisdiction-specific fixed effect; and T which denotes a specific year of analysis to capture the time-varying fixed effects. The random terms ε_{ijt} and μ_{ijt} are as expected, defined across the three main dimensions of variation.

The three special cases mentioned above can be summarized as follows:

- Resource and preference costs are independently determined by separate agents when the following conditions both hold:
 - $a_{i2} = 0$; and
 - ε_{ijt} and μ_{ijt} are not correlated.

- Resource and preference costs are jointly and simultaneously determined when the following conditions both hold:
 $a_{i2} = 0$; and
 ε_{ijt} and μ_{ijt} are correlated.
- Resource costs and preference costs are recursively determined when the following conditions both hold:
 $a_{i2} \neq 0$; and
 ε_{ijt} and μ_{ijt} are correlated.

From these cases we define four models: (a) Model 1 estimates equation (11) independently assuming $a_{i2}=0$; (b) Model 2 estimates equation (12) independently; (c) Model 3 estimates equations (11) and (12) simultaneously assuming $a_{i2}=0$; and (d) Model 4 estimates equations (11) and (12) recursively with the estimated value of q in (12) feeding into equation (11).

We explicitly test the hypotheses described so far in order to conclude on the impact of decentralization on resource and preference costs. We undertake the detailed analysis of observed differences in model specifications in a companion paper which develops the same concepts using detailed case studies, where the actual nature of determining resource and preference costs is known (see Humplick and Azadeh, 1996).

For empirical analysis, defining basic local good units entails normally serious problems since it is difficult to make units of output and input measurable or operational.¹⁴ For our analysis, the measure of preference costs is based on Lancaster's (1966) abstract-product approach, which allows us to define demand for roads indirectly in relation to certain of its attributes.¹⁵ For roads, the condition of the network can serve as a proxy for demand for roads.¹⁶ Resource costs are measured in terms of unit costs of road activity. It follows that unit cost is just the first derivative of cost with respect to quantity of roads provided, which serves as a basic measure of efficiency of road provision.

As a measure of decentralization (the variable β), we employ both the aggregate definition of total decentralization and the disaggregated one, which distinguishes between various types of decentralization by function. As already mentioned, this disaggregation is important because depending on the technology, road works may require the involvement of various entities. Further, it allows us to develop both measures of fiscal and functional decentralization. We distinguish between: a) total decentralization

¹⁴ Hirsch (1968) provides a survey on measurable units of outputs and inputs for public services. Hirsch, W. (1968) "The Supply of Urban Services", Issues in Urban Economics; based on papers presented at a conference in January 1967.

¹⁵ Lancaster, K. "A new Approach to Consumer Theory", Journal of Political Economy, vol. 74 (April, 1966). p. 132-57.

¹⁶ Ben-Akiva et al (1993) develop a framework for substituting the condition of roads as a proxy for user costs while utilizing roads of a given condition.

(percentage local government involvement in road service delivery); b) decentralization of construction (percentage share of local government in construction activities); c) decentralization of maintenance (percentage share of local government in maintenance); and d) decentralization of administration, which is a proxy for deconcentration¹⁷.

An important econometric issue arises in estimating the equations (11) and (12). The terms (μ and ϵ) represent random effects deriving from the unmeasured levels of effort expended by each country at a given period of time.¹⁸ Using panel data, the omitted variable problem arises when we have country specific and time-invariant portions of our error term ($\mu_{ijt} = \rho_{ijt} + v_{ijt}$).¹⁹ A possibly important country omitted variable could include differences in various institutional and governmental structures that are difficult, if not, impossible to quantify. This specification treats (v_{ijt}) as a country specific omitted variable (fixed effect) that may be correlated with the included regressors. Country dummies are included to eliminate country specific effects and OLS is applied to the data.²⁰ To the extent that the country specific omitted variables are correlated with included regressors the parameter estimates obtained by OLS method without country dummies may be biased and inconsistent.

3. Empirical Analysis

Data

The empirical analysis employs three data sets: (a) cross-country panel including observations in 35 countries over 10 years; (b) time series data for the case of Korea from 1968 to 1992; and (c) a panel data set across eight states and their respective districts from 1980 to 1992 in Germany. With these three data sets we investigate the impact of decentralizing road provision at three levels of analysis: jurisdictions are countries and we are looking at the share of local government financing of road works--the cross-country

¹⁷ Rondenelli (1983) provides a definition distinguishing between major forms of functional decentralization, mainly devolution, deconcentration, and delegation. Devolution involves the transfer of functions or decision-making authority to legally incorporated local governments, such as states, provinces, or municipalities. Delegation involves the transfer of functions to regional or functional development authorities, parastatal organizations, or special project implementation units that often operate free of central government regulations and act as agents of the state in performing prescribed functions with the ultimate responsibility remaining with the central government. Deconcentration involves the transfer of functions within the central government hierarchy through the shifting of workload from the central government to field offices, and the shifting of responsibilities to local administrative units that are part of the central government structure. Parker (1995) introduces the "soufflé" theory of decentralization that incorporates three main ingredients: political, functional, and fiscal elements. Like a soufflé that requires just the right combination of milk, eggs, and heat to rise, he argues that a successful program of decentralization must include just the right combination of these three ingredients.

¹⁸ We will revisit this term later when introducing country specific effects.

¹⁹ We don't address ρ_{ijt} since it is assumed iid. Further, if Oates' diversity argument holds, we may expect correlation between the error term μ and the level of decentralization (no corrections are made for heteroskedasticity).

²⁰ The dummy coefficients are not reported in the results.

panel; jurisdictions are time periods within a single country where there have been changes in local government participation in financing road works--the case of Korea; and jurisdictions are state and local governments within a single country--the case of Germany.

The cross-country panel is taken from the International Road Federation (IRF)²¹ Statistics, which provide yearly an extraordinarily rich set of information on roads disaggregated by level of government. We are able to distinguish between central and local government expenditures, where the latter encompasses all levels of government (local and regional governments) other than the central government. From this data set, it has been possible to develop a continuous measure of decentralization disaggregated by level and type of road activity. Additional information includes data on costs also by level and type of activity and the condition of the network. The panels are not balanced because some of the observations are missing. We arrive at a total of 262 observations for measuring the effect of different levels of decentralization on resource and preference costs.

A cross-country panel was selected because it has pre- and post- decentralization data for a variety of countries which decentralized or centralized over time (e.g., Korea, Indonesia, and Colombia) as well as countries which did not change their levels of decentralization over the period of analysis (e.g., Switzerland, Germany, and Tanzania). The pre-decentralization data serves as a control for the post-decentralization data so that the impact of decentralization as a continuous variable can be estimated. This data set is employed to verify the validity of the double-cost hidden level of effort approach to measuring the impact of decentralization on performance. With the country level panel we determine whether there are optimal levels of decentralization for provision of roads and estimate empirically the impact of decentralization on road performance. Table 1 displays the information contained in the cross-country data set.

The data set for Korea is also derived from the IRF source although the analysis is longitudinal and covers a wider period of time, from 1968-1992. With this data set we are able to measure the country-independent impact of switches between levels of decentralization on resource and preference costs. In the 25 year period analyzed, the level of fiscal decentralization across road functions in Korea fluctuated as shown in Table 2. Korea was selected as a case study because it has a high level of decentralized construction and maintenance, but a low level of decentralized administration of road functions, in a fiscal sense.

The analysis of the impact of decentralization in Germany relies on state and local government panel data which was obtained from eight German states (Baden-Wuerttemberg, Hessen, Bayern, Niedersachsen, SchleswigHolstein, Nordrheinwestfalen, Saarland and Rheinlandpfalz). Data on roads disaggregated by activity was gathered by requesting that the responsible road authorities at the state and local levels provide

²¹ We recognize that the quality of the IRF statistics is questionable and rely on the time series data for Korea and the original data collection we conducted in Germany to qualify whatever findings we have from the cross-country panel.

information of both a general and a specific nature. The state government data was provided by the Deutsche Strassen Liga, a non-governmental institute.²² The local government data was collected from the yearly Finanz Bericht and from interviews with road experts and officials in seven states. In addition, technical experts in Germany were contacted and interviewed to obtain the necessary information. Tables 3 and 4 display the information contained in the panel data set. Germany was selected as a case study because it has a high level of decentralized administration and construction and a low level of decentralized maintenance, in a fiscal sense.

The Impact of Fiscal and Functional Decentralization from Cross-Country Data

We use the double cost approach and hidden level of effort framework to measure the impact of fiscal decentralization on road provision using the cross-country panel. We estimate the four models defined in the last section, testing the various hypotheses postulated in the theory section. The estimation results are presented sequentially by model and comparisons of findings are done cumulatively across models.

Model 1: The Independent Impact of Decentralization on Resource Costs.

The independent impact of decentralization on resource costs from the cross-country panel is summarized in Table 5a while the impact of the control variables is presented in Table 5b. We find that after controlling for country-specific effects, income as measured by per capita GNP, and time, increasing the level of decentralization has a significant impact on resource costs. The impact of decentralization varies depending on the type of road function.

Table 5a: Independent Impact of Decentralization on Resource Costs

Variable	Partial Effects of Functional Decentralization			Total Effect of Decentralization
	Construction	Maintenance	Administration	
fiscal decentralization ¹	4.33 (0.74)	1.63 (2.04)	0.44 (1.35)**	9.71 (1.67)
fiscal decentralization ²	-0.03 (-0.26)	-0.03 (-1.59)*	-0.03 (-2.72)	-0.19 (-1.57)*
fiscal decentralization ³	0.001 (0.32)	0.0001 (1.15)	0.0003 (3.80)	0.001 (1.12)
R-squared	0.72	0.82	0.81	0.76
Observations	261	261	261	261

Fiscal decentralization is measured separately as the percentage local government contribution to construction, maintenance, administration, and road provision in general in the first, second and third order respectively.

Shaded portions significant at 90% level of confidence.

²² The Deutsche Strassenliga brings together professionals working in different areas on roads. Members come mainly from the private sector but the agency is in close cooperation with the state and federal governments. It promotes the development of roads in Germany.

* significant at 85% level of confidence.

** significant at the 80% level of confidence.

Decentralizing administration results in a reduction of resource costs initially, followed by an increase (but at a slower rate) as the coefficient for the second order effect is negative and significant while that of the third order effect is positive and significant but smaller than the second order effect. So the subsequent increase in resource costs does not totally offset the initial gains, and the overall effect of decentralization is to reduce resource costs. Tests on the shape of the function (convex and then concave) are accepted at a 99% level of significance. The optimal degree of decentralization of administration functions, defined as the point achieving the least unit costs of administration, is found to be between more than 50 and less than 90 percent local government contribution to financing administration functions (see figure 7).

The opposite is true with respect to maintenance where decentralization was found to result in a slight initial increase in unit costs of maintenance. The subsequent decrease in maintenance costs with increasing levels of decentralization (second order effect) was found to be larger but significant only at the 85% level of confidence. It may be that decentralized units of government undertake more expensive maintenance technologies to provide better quality of roads. This conclusion cannot be made from the model specification in table 5a and we need to compare the findings of other model specifications as shown in figure 8.

Using the results of the cross-country panel and the assumption that resource costs and preference costs are independently determined (i.e., decisions to maintain a road or construct a new link are made independently of the decision to allocate a specific expenditure budget for that activity), we find decentralization to be neutral with respect to unit costs of construction.

From Table 5b we see that the country-specific fixed effects are jointly and independently (for most countries) significant. These effects are relative to the USA which is used as a normalizing country for comparison purposes. Korea is the only country whose unit costs of construction are significantly higher than those in the USA. Countries which have similar unit costs of construction as the USA measured in \$ per km are Japan, Canada, and Saudi Arabia. All other countries have unit costs significantly lower than those in the USA with respect to construction. These results suggest that the majority of countries are spending significantly less per km of road on construction than the USA.

With respect to maintenance, there are fewer countries with significant differences relative to the USA. The notable exceptions are Japan, Denmark, Finland, UK, Netherlands, Sweden, Austria, and Switzerland which spend considerably more than the USA and Hungary and Poland which spend considerably less than the USA.

All countries spend significantly more on road administration per unit km of roads than the USA except Hungary, Ireland, Poland, Switzerland, and Canada, which spend about the same as the USA.

Table 5b: Country-Specific Effects of Decentralization on Resource Costs

Variable	Construction		Maintenance		Administration		Total Effect	
	coeff	t-stat	coeff	t-stat	coeff	t-stat	coeff	t-stat
Cameroon	-220	-1.58	-9	-0.89	15	2.36	-100	-1.14
Ethiopia	-265	-1.91	-10	-0.67	15	2.59	-163	-1.59
South Africa	-192	-2.52	-11	-1.17	31	6.92	-58	-1.02
Argentina	-300	-3.16	-7	-0.42	22	3.37	-245	-2.52
Bolivia	-296	-2.09	-26	-1.56	28	4.12	-199	-1.80
Brazil	-285	-2.06	-19	-1.26	13	2.21	-195	-1.91
Chile	-256	-2.03	-7	-0.41	16	2.43	-152	-1.51
Colombia	-310	-3.32	-18	-1.13	28	4.41	-249	-2.68
Costa Rica	-273	-1.94	-13	-0.82	13	1.95	-178	-1.66
Indonesia	-230	-1.63	-14	-0.89	14	2.22	-253	-2.70
Japan	-6	-0.06	33	2.41	11	2.52	136	1.51
Korea	155	1.89	14	0.97	43	7.49	259	3.03
Philippines	-229	1.62	-0.4	-0.02	15	2.30	-118	-1.11
New Zealand	-316	-3.40	-16	-1.02	14	2.26	-247	-2.71
Denmark	-318	-3.53	36	2.80	42	7.92	-86	-1.13
Finland	-273	-3.08	55	3.52	33	5.58	-105	-1.15
Germany	-192	-2.13	-5	-0.34	54	14.33	10	0.12
UK	-271	-3.10	44	4.85	22	3.78	-69	-0.83
Netherlands	-309	-3.34	28	1.76	15	2.60	-222	-2.44
Spain	-293	-3.39	2	0.11	12	2.04	-210	-2.37
Sweden	-356	-4.16	25	1.72	11	1.95	-247	-2.83
Austria	-284	-3.30	46	3.13	34	5.83	-97	-1.09
Belgium	-290	-2.44	-12	-0.53	40	4.19	-237	-1.89
Hungary	-226	-3.04	-37	-2.10	11	1.50	-205	-2.66
Iceland	-327	-3.68	-14	-1.02	23	3.65	-248	-2.76
Ireland	-256	-2.08	-13	-0.88	-0.61	-0.15	-249	-2.68
Italy	-173	-1.77	112	6.46	48	9.01	134	1.37
Poland	-398	-4.27	-47	-2.78	8	1.29	-341	-3.62
Switzerland	238	6.20	103	13.43	-4	-1.05	310	7.77
Uganda	-239	-1.68	-28	-1.60	14	2.15	-261	-2.69
Zaire	-257	-1.62	-10	-0.43	13	1.37	-158	-1.17
Canada	-14	-0.34	9	1.08	-2	-0.63	2	0.05
Saudi Arabia	48	0.33	20	1.18	23	3.51	187	1.73
Bahrain	-289	-2.06	11	0.65	17	2.56	-167	-1.53
Time	11.24	6.20	3.87	9.43	0.87	5.03	16.14	7.74
GNP/capita	0.001	0.32	0.0007	0.93	-0.0001	-0.34	0.004	0.89
Constant	-22072	-6.11	-7680	-9.40	-1731	-5.07	-31888	-7.72

Shaded portions significant at 90% level of confidence.

* significant at 85% level of confidence.

** significant at 80% level of confidence.

The total effect of fiscal decentralization is less sensitive to country-specificities than the partial effects. Korea, Switzerland, and Saudi Arabia spend significantly more than the USA; while the other countries spend about the same or less than the USA. It is interesting to note that country-specific fixed effects are more significant in the case of construction and administration than in the case of maintenance.

The other control variables of time and income have the same effect across road functions; time is significant and positive indicating that unit costs have been increasing over time and the income variable is not significant across all road functional specifications.

Model 2: The Independent Impact of Decentralization on Preference Costs.

Model 2 investigates the country effects more thoroughly by looking, in addition to the impact of decentralization on road quality (a measure of preference costs); whether the countries which spent more or less than the USA achieved any better quality of roads than the USA. Tables 6a and 6b show the estimated results for the case of preference costs as measured by the percentage roads in bad condition. Decentralization of maintenance reduces preference costs initially (first order effect), but then they increase at a faster rate (second order effect), then decrease again at a slower rate (third order effect). Therefore, the overall effect of decentralizing maintenance functions is to reduce preference costs, and the optimal degree of decentralization of maintenance activities is 100 percent; where local governments are fully responsible for financing maintenance.

Table 6a: Independent Impact of Decentralization on Preference Costs

Variable	Partial Effects of Functional Decentralization			Total Effect of Decentralization
	Construction	Maintenance	Administration	
fiscal decentralization ¹	-0.15 (-0.36)	-0.55 (-2.17)	0.25 (1.09)	-0.41 (-1.33)
fiscal decentralization ²	0.002 (0.26)	0.01 (2.44)	0.0006 (0.10)	0.004 (0.71)
fiscal decentralization ³	-1.87e-06 (-0.03)	-0.0001 (-2.29)	-0.00002 (-0.51)	1.27e-06 (0.03)
R-squared	0.97	0.97	0.98	0.97
Observations	261	261	261	261

Fiscal decentralization measured separately as the percentage local government contribution to construction, maintenance, administration, and road provision in general in the first, second and third order respectively.

Shaded portions significant at 90% level of confidence.

* significant at 85% level of confidence.

** significant at the 80% level of confidence.

Decentralizing other functions such as construction and administration is neutral with respect to preference costs. The total effect of decentralization on preference costs is negative but not very significant as can be seen in Table 6a; indicating that decentralization tends to result in lower preference costs.

Country specific effects of decentralization on preference costs in Table 6b are large and significant. Most countries have road conditions that are significantly worse than the USA with the exception of Denmark, Germany, UK, Netherlands, Austria, Belgium, Ireland, Italy and Switzerland. However, when looking at the country fixed effect when administrative functions are decentralized, then we see that countries like Japan have lower preference costs and Indonesia is no longer superior to the USA. The latter result also holds for the case of total effects of decentralization on preference costs.

Countries can be grouped into four main categories with respect to the efficiency of their construction and maintenance activities relative to the USA; (a) efficient provision when both the resource and preference costs are low relative to the USA; (b) inefficient provision when both the resource and preference costs are high relative to the USA; (c) countries with insufficient spending when the resource costs are low relative to the USA but the preference costs are higher; and (d) countries with high standards when the resource costs are high relative to the USA but the preference costs are lower.

Figures 5 and 6 plot the estimated fixed effects for the countries which have a significant difference compared to the USA for the case of construction and maintenance respectively. We focus the reader's attention to two specific cases: Germany which has efficient construction activities; and Korea which is not significantly different from the USA in terms of preference costs but has high resource costs for both construction and maintenance. These two countries are used in later sections of the paper to measure the effects of decentralization independent of country-fixed effects.

Table 6b: Country-Specific Effects of Decentralization on Preference Costs

Variable	Construction		Maintenance		Administration		Total Effect	
Variable	coeff	t-stat	coeff	t-stat	coeff	t-stat	coeff	t-stat
Cameroon	55	5.53	50	15.61	59	13.36	54	12.03
Ethiopia	35	3.52	29	6.08	39	9.17	32	5.94
South Africa	31	5.81	26	8.69	25	7.84	32	10.89
Argentina	35	5.09	28	5.17	25	5.45	40	7.80
Bolivia	60	5.96	54	10.25	64	13.40	56	9.70
Brazil	54	5.48	48	10.17	58	13.81	50	9.32
Chile	49	5.45	45	8.68	52	11.08	48	9.08
Colombia	53	7.92	52	10.20	44	9.85	59	11.96
Costa Rica	49	4.89	44	8.48	53	11.62	46	8.18
Indonesia	-3	-0.25	-9	-1.84	1	0.29	4	0.81
Japan	2	0.35	-7	-1.55*	-7	-2.33	19	3.98
Korea	3	0.53	-0.65	-0.14	0.79	0.20	24	5.27
Philippines	47	4.64	41	8.01	51	11.13	45	8.19
New Zealand	8	1.15	3	0.55	9	2.07	12	2.57
Denmark	-37	-5.70	-46	-11.22	-46	-12.17	-32	-8.11
Finland	7	1.13	3	0.61	9	2.09	17	3.59
Germany	-37	-5.78	-40	-7.90	-41	-15.31	-28	-6.79
UK	-35	-5.67	-45	-15.51	-35	-8.50	-28	-6.49
Netherlands	-24	-3.62	-30	-5.99	-22	-5.20	-17	-3.60
Spain	-5	-0.81	-13	-2.72	-4	-0.86	0.47	0.10
Sweden	-5	-0.88	-7	-1.61*	-4	-0.95	-2	-0.39
Austria	-36	-5.86	-39	-8.32	-37	-8.95	-27	-5.72
Belgium	-33	-3.88	-39	-5.38	-41	-6.10	-27	-4.03
Hungary	10	1.81	10	1.68	15	2.99	11	2.69
Iceland	49	7.79	47	10.30	43	9.77	55	11.43
Ireland	-34	-3.80	-42	-8.63	-41	-14.11	-27	-5.45
Italy	-34	-4.86	-42	-7.58	-43	-11.24	-19	-3.79
Poland	4	0.53	-2	-0.29	6	1.25	5	1.04
Switzerland	-44	-16.24	-43	-17.73	-43	-16.25	-35	-14.94
Uganda	44	4.36	42	7.72	48	10.22	51	9.95
Zaire	58	5.17	53	7.31	62	9.32	56	7.94
Canada	10	3.52	9	3.27	9	3.21	11	4.78
Saudi Arabia	18	1.79	13	2.42	22	4.68	26	4.63
Bahrain	-12	-1.19	-18	-3.44	-8	-1.72	-15	-2.61
Time	-0.76	-5.87	-0.69	-5.30	-0.78	-6.34	-0.25	-2.08
GNP/capita	v.s.	-0.22	v.s.	-0.24	v.s.	-0.23	v.s.	0.05
Constant	1548	6.00	1422	5.46	1578	6.49	549	2.26

Shaded portions significant at 90% level of confidence.

* significant at 85% level of confidence.

** significant at 80% level of confidence.

Model 3: The Impact of Decentralization when Resource and Preference Costs are Simultaneously Determined

Table 7 summarizes the estimation results for the model specification which assumes that resource and preference costs are jointly determined. We use this model specification to better capture the impact of autonomy of decentralized units on efficiency of road service provision. We see that the model specification does not fit the data as well as the specification on independent determination of resource and preference costs. This may be that the countries in the data base fall mostly in the category where these two costs are indeed independently determined. The effect of decentralized maintenance with this specification is the same as that for model 1, where resource costs initially increase, then decrease as the level of decentralization increases (second order effect less significant). In the case of decentralized administration costs, the effect is also the same as that in model 1 in terms of the shape; resource costs decreasing non-linearly (second order effect) and then increasing at slower rate (third order effect).

Table 7: Simultaneous Determination of Resource and Preference Costs

Variable	Construction		Maintenance		Administration	
	Resource	Preference	Resource	Preference	Resource	Preference
fiscal decentralization ¹	1.71 (0.17)	0.25 (0.12)	2.01 (1.79)	-0.59 (-0.52)	0.37 (0.94)	0.66 (0.60)
fiscal decentralization ²	0.03 (0.14)	-0.01 (-0.31)	-0.06 (-1.28)*	0.02 (0.74)	-0.02 (-2.06)	0.002 (0.95)
fiscal decentralization ³	-0.001 (-0.50)	0.0001 (0.46)	0.0004 (1.06)	-0.0001 (-0.79)	0.0002 (2.83)	-0.0001 (-0.58)
R-squared	0.70	0.38	0.76	0.51	0.77	0.54
Observations	261	261	261	261	261	261

Fiscal decentralization measured separately as the percentage local government contribution to construction, maintenance, administration, and road provision in general in the first, second and third order respectively.

Shaded portions significant at 90% level of confidence.

* significant at 85% level of confidence.

'em significant at the 80% level of confidence.

Construction costs are neutral with respect to decentralization, as in the case of model 1, and preference costs, unlike the case in model 1, are not affected by any type of decentralization. The results with the respect to the impact of decentralization on resource costs are very robust, whereas those with respect to preference costs are sensitive to model specification.

These results point to a very important issue: when road provision activities are decentralized and the decentralized units have authority for both spending and quality standards they spend more on maintenance, have more efficient administration than

centralized units, and are as efficient in construction as centralized units. The impact of decentralization on preference costs is not measurable in such a case.

Model 4: The Impact of Decentralization when Resource and Preference Costs are Recursively Determined

In Table 8 we show the estimated results for the specification where preference costs determine resource costs. We see that for this specification, decentralized maintenance results in higher resource costs while decentralized administration results in lower resource costs (second order effect) which increase with increasing degrees of decentralization but at a lower rate than the initial decrease (third order effect).

The shape of the estimated functions changes with this model specification for the case of administration (see figure 7). We see that the justification for the role of the central government is no longer there, when the preferences of users are explicitly used to make decisions on spending in the road sector (i.e., when quality standards are set first then resource costs are determined in order to meet these standards). Decentralized units spend more than centralized ones for the same level of quality, but they spend less in administration of road activities. This is an important finding which may also be indicating that when uniform and/or high standards are regulated, the efficiency gains of decentralized provision may be offset by the regulated quality levels. In these cases, it may be more efficient to manage the provision of quality services centrally, as predicted by models 1 and 3. Germany is a good case which demonstrates this effect as shown in the following sections.

Table 8: Recursive Determination of Resource Costs from Preference Costs

Variable	Construction	Maintenance	Administration
fiscal decentralization ¹	4.31 (0.74)	1.67 (2.09)	0.44 (1.37)
fiscal decentralization ²	-0.03 (-0.25)	-0.03 (-1.61)	-0.03 (-2.72)
fiscal decentralization ³	-0.0003 (-0.47)	0.0001 (1.16)	0.0002 (3.79)
R-squared	0.72	0.85	0.81
Observations	261	261	261

Fiscal decentralization measured separately as the percentage local government contribution to construction, maintenance, administration, and road provision in general in the first, second and third order respectively.

Shaded portions significant at 90% level of confidence.

* significant at 85% level of confidence.

** significant at the 80% level of confidence.

Summary of Findings from Cross-Country Panel

The results of models 1 through 4 are summarized in table 9 and compared in figures 7 and 8. In figure 7 we see that models 1 and 3 both estimate that the lowest resource costs for administration are achieved at more than 50 percent and less than 90 percent decentralization of the financing responsibilities for administering road provision. Those of model 4, when preference costs determine resource costs recursively, estimate the optimal level of decentralization to be 100 percent. These results are quite robust and indicate that, when there is a high representation of local governments in the fiscal decisions concerning roads (measured in terms of their participation in the financing of road administration as a percentage of total administration costs) resource costs are lower. However, there seems to be a need for some presence of the central government (less than 10 percent share) to ensure that low costs are maintained. Such findings point to the need for coordination and regulation at the central level for some administrative functions.

Consistent with Oates' theory the relationship between resource costs and decentralization is highly non-linear and mostly concave (see figures 7 and 8), with the exception of construction costs. Thus, at higher levels of decentralization for maintenance and administration, local governments are more efficient producers and providers of road services. The country dummies are significant for all model specifications, indicating that there are strong country specific forces at work that capture the effect of decentralization on performance. This means that, the extent to which benefits of decentralization can be realized in terms of reduced costs of provision and improved quality of service, will depend on the conditions of the country in question.

Construction costs in all model specifications are not affected by the degree of decentralization, in a linear or non-linear form. This result may be due to the fact that decentralized levels of government are limited in their capacity and do not possess economies of scale. Further, construction is an activity that is very sensitive to geography as well as the efficiency of contracting-out arrangements. Since even countries with centralized provision of roads do use contracting out, it may be that this effect is confounded in the country specific effects and cannot be generalized at a cross-country level. The case studies on Korea and Germany in the following sections demonstrate the country-independent effect of decentralization on unit costs of construction.

When the impact of various types of decentralization on preference costs using the cross-country panel is considered independently (model 2), the results show that only decentralization of maintenance bears a significant effect (decentralization of construction and administration are not significant). The coefficients with respect to maintenance are significant and negative initially (first order effect), implying that condition of roads improves with increasing degrees of decentralization. The second order effect for decentralized maintenance costs is positive and significant, indicating that the relationship between preference costs and maintenance decentralization is convex,

and that the optimal point may very well be less than 100 percent decentralization (see Figure 13).

Table 9: Summary Results

Model	Estimated Results	Decentralization of Construction	Decentralization of Maintenance	Decentralization of Administration	Total Effects of Decentralization
Model 1	Resource Costs (1st order, independent effect)	neutral	increase*	neutral	increase*
	Resource Costs (2nd order, independent effect)	neutral	decrease**	decrease*	decrease**
	Resource Costs (3rd order, independent effect)	neutral	neutral	increase**	neutral
Model 2	Preference Cost (1st order, independent effect)	neutral	decrease*	neutral	neutral
	Preference Cost (2nd order, independent effect)	neutral	increase*	neutral	neutral
	Preference Costs(3rd order, independent effect)	neutral	decrease*	neutral	neutral
Model 3	Resource Costs (1st Order, joint effect)	neutral	increase*	neutral	
	Resource Costs (2nd order, joint effect)	neutral	decrease**	decrease*	
	Resource Costs (3rd order, joint effect)	neutral	neutral	increase**	
	Preference Cost (1st order, joint effect)	neutral	neutral	neutral	
	Preference Cost (2nd order, joint effect)	neutral	neutral	neutral	
	Preference Costs (3rd order, joint effect)	neutral	neutral	neutral	
Model 4	Resource Costs (1st order, recursive effect)	neutral	increase*	neutral	
	Resource Costs (2nd order, recursive effect)	neutral	decrease*	decrease*	
	Resource Costs (3rd order, recursive effect)	neutral	neutral	increase**	

(*) significant at 90% level of confidence.

(**) significant at 85% level of confidence.

The country dummies are significant for all types of decentralization, implying that individual country effects are important determinants of preference costs. We can capture these country effects in more depth by studying countries' experiences with decentralization to see how they perform and how preference costs relate to the level of decentralization in these countries (this is done in section 4). However, we find that road conditions, a proxy for preference costs, seem quite independent of the degree of decentralization, except for maintenance. This result is consistent with that in Humplick and Estache (1995) where the percentage roads rated in good condition were used as a measure of preference costs and found road conditions to be positively correlated to the degree of decentralization.

Theory and the Limitations of the Modeling Approach

Models 3 and 4 indicate that the impact of various types of decentralization on performance can be captured through resource costs, but only when resource costs are expressed as a function of preference costs. The impact of decentralization, in effect, even though initially expressed by user preferences for good or bad road quality, is eventually observable through resource costs, with user preferences translated in an efficient or less efficient manner, depending on the structure of institutions within the country. Therefore, measuring resource costs alone is not sufficient and we qualify empirically the theoretical assumptions in Laffont and Tirole (1993). It is important to measure the cost of provision as a function of quality, except in cases (as assumed in model 4) where user preferences are completely included in the spending decisions. Hoxby (1995) measures the impact of decentralization of education on costs and quality of education using the Laffont and Tirole model, without controlling for quality. We find that this assumption is valid in the USA for the case of education in some jurisdictions, because most user preferences are completely included in the spending decisions. This assumption would not be valid for the case of roads even in the USA.

The empirical discussion suggests that the impact of decentralization on road performance is also strongly driven by country specific factors. The country dummies are significant for all estimations. This means that the gains(losses) from decentralization that we see, are despite the variations in country specific effects. In the following section, we control completely for the presence of country specific effects by looking at one country longitudinally. The idea is to see whether there is a change in the measured effects when we focus on only one country, mainly Korea.

4. Decentralization of Road Functions in Korea

Korea is used as a case study to measure the impact of changes in the level of decentralization or road performance. We replicate the estimations of models 1, 2, and 3 in the previous section, as presented in tables 10, 11, and 12 respectively, and summarize

the results in Table 13. We do not look at model 4 as we have seen that the results are quite robust across model specifications and this model requires a larger number of observations to meet the degrees of freedom requirements. Because we are dealing with time-series data, we test for the presence of serial correlation, and use the Cochrane-Orcutt procedure to correct for these effects when present.

Consistent with the analysis in section 3, we find decentralization of maintenance has the strongest impact on resource costs (see table 10). The coefficients for decentralization of maintenance are significant and negative (first order), then positive (second order) and negative (third order), implying that resource costs decrease with increasing levels of decentralized maintenance. The effect of decentralization on unit costs of construction is mostly linear, since the first order effect is the only significant variable of decentralization. Furthermore, we see that economies of scale are lost as these costs increase with increasing degrees of decentralization. The effect of decentralization on unit costs of administration in Korea is not very significant, although the overall effect is to reduce these costs, as was found earlier. However, total decentralization has a strong non-linear impact on resource costs. The overall effect is to reduce the total costs of providing roads (since the negative second order coefficient dominates).

Table 10: Impact of Decentralization on Resource Costs--Case of Korea

Variable	Construction	Maintenance	Administration	Total Effect
year	29.55 (2.71)	1.16 (1.89)	1.09 (1.57)**	31.34 (2.92)
per capita GNP	16.89 (2.99)	2.28 (6.88)	0.96 (1.70)	22.05 (3.62)
fiscal decentralization ¹	8.86 (1.61)*	-1.22 (-2.49)	0.22 (0.49)	15.79 (1.91)
fiscal decentralization ²	-0.23 (-1.31)**	0.05 (3.03)	-0.01 (-1.01)	-0.59 (-2.04)
fiscal decentralization ³	0.001 (0.89)	-0.0004 (-2.95)	0.0001 (1.01)	0.005 (1.92)
Constant	-0.59 (-2.73)	-2343.94 (-1.95)	-2180.05 (-1.60)*	-62393.27 (-2.96)
rho	0.69 (5.70)	-0.42 (-2.28)	0.32 (1.56)*	0.53 (3.32)
R-square	0.75	0.97	0.76	0.81
Observations	24	24	24	24

Fiscal decentralization measured separately as the percentage local government contribution to construction, maintenance, administration, and road provision in general in the first, second and third order respectively.

Shaded portions significant at 90% level of confidence.

* significant at 85% level of confidence.

** significant at the 80% level of confidence.

When we measure the impact of various types of decentralization on preference costs (table 11), we find decentralization of administration has the strongest effect. The second-order effect for decentralized administrative costs is positive and significant at an 85 percent level of confidence, while the third order effect is negative but significant only at a 70 percent level of confidence. These results indicate a mildly convex relationship between preference costs and decentralization of administration, and that the optimal level is less than 100 percent but more than 50 percent decentralization (see figure 13). The theoretical assumption on decreasing returns to decentralization gain empirical proof from case of Korea. These results provide further evidence from the perspective of road users, that there is a need to keep some control in the hands of the central government, with respect to administering road provision, as well as setting standards for road conditions in maintenance and construction.

Table 11: Impact of Decentralization on Preference Costs--Case of Korea

Variable	Construction	Maintenance	Administration	Total Effect
year	-4.22 (-5.88)	-3.66 (-6.83)	-4.22 (-5.27)	-4.31 (-5.94)
per capita GNP	-0.15 (-1.18)	-0.20 (-1.44)**	-0.23 (-1.32)**	-0.13 (-1.03)
fiscal decentralization ¹	-0.02 (-0.21)	0.10 (0.48)	-0.18 (-1.68)	-0.05 (-0.46)
fiscal decentralization ²	0.0006 (0.22)	-0.002 (-0.30)	0.004 (1.48)*	0.002 (0.48)
fiscal decentralization ³	-8.76e-06 (-0.37)	8.23e-06 (0.17)	-0.00002 (-1.08)	-0.00002 (-0.62)
Constant	8446.1 (5.91)	7326.39 (6.90)	8453.7 (5.31)	8623.33 (5.97)
rho	0.92 (56.59)	0.87 (22.15)	0.92 (63.18)	0.92 (60.28)
R-square	0.75	0.79	0.75	0.76
Observations	24	24	24	24

Fiscal decentralization measured separately as the percentage local government contribution to construction, maintenance, administration, and road provision in general in the first, second and third order respectively.

Shaded portions significant at 90% level of confidence.

* significant at 85% level of confidence.

** significant at the 80% level of confidence.

We also looked at the simultaneous impact (model 3) of decentralization on both resource and preference costs (the results are displayed in table 12). All types of decentralization had no impact on preference costs, with the exception of decentralized administration. Road conditions improve with increasing degrees of decentralization; note that the first order coefficient for decentralized administration is negative and

significant. More importantly, the second order effects is positive, smaller than the first order effect, and not as significant, indicating that with increasing levels of decentralization, increased preference cost savings can be achieved even though there are diminishing returns. In contrast to our previous findings, we find that in Korea the joint impact of decentralization is only captured through preference costs, and that it is the decentralization of administration which leads to service quality gains from the point of view of the user.

**Table 12: Impact of Decentralization on Resource and Preference Costs
When They are Jointly Determined**

Variable	Construction		Maintenance		Administration	
	Resource	Preference	Resource	Preference	Resource	Preference
year	65.46 (5.64)	-	6.71 (5.44)	-	2.30 (10.06)	-
per capita GNP	-	-2.89 (-6.00)	-	-2.56 (-6.19)	-	-2.81 (-16.36)
fiscal decentralization ¹	5.47 (0.33)	-0.51 (-0.50)	-1.29 (-1.08)	0.84 (1.12)	-0.15 (-0.35)	-1.38 (-3.79)
fiscal decentralization ²	-0.29 (-0.60)	0.02 (0.66)	0.009 (0.22)	-0.03 (-1.36)**	-0.01 (-0.95)	0.013 (1.17)
fiscal decentralization ³	0.002 (0.43)	-0.0002 (-0.95)	-6.94e-06 (-0.02)	0.0002 (1.11)	0.0001 (1.50)*	0.00005 (0.58)
Constant	-129102 (-5.64)	157 (12.11)	-13223 (-5.44)	148 (13.74)	-4523 (-10.02)	157 (27.18)
R-square	0.67	0.75	0.78	0.86	0.85	0.93
Observations	25	25	25	25	25	25

Fiscal decentralization measured separately as the percentage local government contribution to construction, maintenance, administration, and road provision in general in the first, second and third order respectively.

Shaded portions significant at 90% level of confidence.

* significant at 85% level of confidence.

** significant at the 80% level of confidence.

Comparison of Estimated Results from Korea and the Cross-Country Panel

Table 13 gives a summary view of the impact of decentralization on performance for Korea. Overall, our results for Korea are consistent with our cross-country panel estimations. Despite some sign switches for individual coefficients, the estimated models predict the same point for the optimal level of decentralization.

The results for decentralization of administrative functions (figure 9) have the same pattern as those obtained using the cross-country panel. The only difference is that the results of the cross-country panel seem to overestimate the possible gains from

complete decentralization. The optimal level of decentralization of administration using both the cross-country panel and the case of Korea is between 50 and 90 percent.

In the case of maintenance, the cross-country panel seems to miss an initial gain in efficiency between 10 and 20 percent decentralization as can be seen in figure 10. The estimated optimal level of decentralization is the same for both models at 100 percent. Similar to the case of administration we find that the cross-country panel overestimates the efficiency gains from total decentralization and underestimates those from partial decentralization.

Table 13: Summary Results for Korea

Model	Estimated Results	Decentralization of Construction	Decentralization of Maintenance	Decentralization of Administration	Total Effect of Decentralization
Model 1	Resource Costs (1st order, independent effect)	positive*	decrease*	neutral	increase*
	Resource Costs (2nd order, independent effect)	neutral	increase*	neutral	decrease*
	Resource Costs (3rd order, independent effect)	neutral	decrease*	neutral	increase*
Model 2	Preference Cost (1st order, independent effect)	neutral	neutral	decrease*	neutral
	Preference Cost (2nd order, independent effect)	neutral	neutral	increase**	neutral
	Preference Costs(3rd order, independent effect)	neutral	neutral	neutral	neutral
Model 3	Resource Costs (1st Order, joint effect)	neutral	neutral	neutral	not studied
	Resource Costs (2nd order, joint effect)	neutral	neutral	neutral	not studied
	Resource Costs (3rd order, joint effect)	neutral	neutral	increase**	not studied
	Preference Cost (1st order, joint effect)	neutral	neutral	decrease*	not studied
	Preference Cost (2nd order, joint effect)	neutral	decrease**	neutral	not studied
	Preference Costs (3rd order, joint effect)	neutral	neutral	neutral	not studied

(*) significant at 90% level of confidence

(**) significant at 85% level of confidence

Recognizing the limitations in the data from the cross-country panel, we use a confidence interval test to check whether the findings for the case of Korea are consistent with those found in the cross-country data set; i.e., whether they fall in the same range of

estimates with 95% confidence. The main difference in estimated results is with respect to decentralization of construction (see figure 11). The 95 percent confidence interval around the estimates from the cross-country panel shows losses of economies of scale are as possible as efficiency gains from increased decentralization of construction activities. The estimates using the Korea data set, which are completely included within the confidence band of the cross-country panel estimates, shows that there are benefits to be gained after a level of decentralization of 30 percent, with the optimal being at 100 percent. It was mentioned earlier that the country conditions are especially strong for the case of construction, as there are effects such as geography and network configuration as well as the efficiency of contracting out procedures that affect the unit costs of construction. Once you remove country-specific effects (as in the Korea case) we see that one can see efficiency gains even with decentralized construction.

The total effect of decentralization as shown in figure 12, is non-linear as predicted by Oates for both the cross-country and Korea data sets. The Korea data set demonstrates the increasing costs of decentralization after a level of about 80 percent. Oates has suggested that decentralization may result in losses of economies of scale; these losses may indeed outweigh the gains, as empirically shown for the case of Korea. However, this particular effect may be country specific.

It is important to see the position of Korea in the global scale of decentralized road provision to understand these results. In table 1, we see that the level of decentralization of administration functions for roads in Korea is on average 29 percent, a point in figure 9, just before the efficiency gains with respect to increasing degrees of decentralization start to show up. With respect to maintenance Korea has an average level of decentralization (taken across a period of 10 years) of 56 percent, a point in figure 10 where there are high gains from decentralized provision of maintenance. On the construction side, Korea's average is 64 percent, a point in figure 11, where the increase in unit costs of construction just begins to escalate as a function of degree of decentralization as predicted by the estimates from the cross-country panel.

To verify the robustness of the findings from the Korea data set, after controlling for country-specific fixed effects, we use another case study from Germany, as presented in the next section.

5. Decentralization of Road Functions in Germany

In this section we study the impact of decentralization on road performance for Germany. We use two measures of decentralization: (a) fiscal decentralization as was defined and used in sections 3 and 4 as the percent local government financing of road works; and (b) spatial decentralization, which serves as a measure of depth of decentralization, and defined as the number of local governments per state GDP. Due to data availability, we also expand the concept of performance. On the input side, the size of the road network under the jurisdiction of state and local governments is used as a

measure of total coverage as well as unit costs of construction and maintenance which serve as measures of resource cost efficiency. On the demand side, preference costs are captured through the frequency of road accidents (accidents per km per year) and the size of state road user charges, both of which serve as indirect measures of expression of preferences²³.

In the case of Germany, the nature of transfers between the state and local governments is an important determinant of the level of effort expended by each level of government. We estimate models (11) and (12) in section 2, assuming we do not observe the actual transfers for one major reason: some state governments in Germany in addition to giving transfers to the local governments for financing local roads, have also delegated the provision of state roads to these local governments. A companion paper investigates the impact of the nature of transfers on the unit costs of road provision using a number of case studies including Germany (see Humplick and Moini-Araghi, 1995).

Does the Level of Government Play a Role in the Outcomes with Respect to Fiscal Decentralization?

There are significant differences between the gains and losses as a result of decentralization at the state and district levels. In Table 14, we see that the coefficients have the same sign for both state and district level impacts of decentralization on construction and maintenance costs; however, the size of the coefficients is much larger at the district level than at the state level. These results can be seen more clearly in figures 13 and 14.

With respect to maintenance, we see that, unlike the case of the cross-country and Korea data sets, unit costs of maintenance increase with increasing degrees of decentralization for both state and district governments (see figure 14). There are two possible explanations for this result. First, the effect of uniformization may be dominating any efficiency gains from decentralized provision of roads²⁴. Second, it may be that when road maintenance is decentralized, lower levels of government who are closer to the voting public spend more on maintenance (or use more expensive technologies for maintenance to reduce future rehabilitation costs) than when road maintenance is centralized²⁵.

²³ We recognize that the usefulness of the number of accidents per km per year and the size of state road user charges are not as useful indicators of preference costs as road quality. However, we were unable to obtain quality data for the level of analysis we were conducting. Since accidents and direct contributions by users to the maintenance and upgrading of roads are costs directly incurred by users, these indicators are noisy proxies for the "preference costs". The major limitation is with respect to accidents which are also dependent on driver behavior and may hence have a positive correlation with the quality of roads.

²⁴ In Germany, because of equity concerns, road conditions are centrally regulated to be uniform in all states and districts depending on the functional classification.

²⁵ Note that in Germany, local governments have less fiscal responsibility for maintenance (49 percent) on average compared to Korea (56 percent). Looking at figure 8, Germany is at the point just before the efficiency gains from decentralized maintenance begin to take off, while Korea is after this point, thus receiving more of the efficiency gains from decentralized maintenance.

District governments do seem to benefit from increased decentralization of construction after a level of about 40 percent, when the unit costs of construction decrease with increasing degrees of fiscal decentralization. This finding is consistent with the case of Korea, where there was an observed reduction in construction costs as a function of increasing degrees of decentralization²⁶. The gains in lower construction costs are not available for state governments, as unit costs of construction continue to increase with increasing degrees of decentralization (see figure 15). The rate of increase in construction costs at the state level, however, decreases with increasing degrees of decentralization, suggesting that there are indeed some benefits at higher levels of decentralization. We do not see any evidence of a transfer in costs across levels of government from these results.

Table 14: Impact of Decentralization on Resource Costs for the Case of Germany

Variable	State-level Unit Costs (\$/km)		District-level Unit Costs (\$/km)	
	Maintenance	Construction	Maintenance	Construction
year	-0.0001 (-0.66)	-0.002 (-4.63)	0.0007 (2.41)	-0.004 (-3.64)
per capita GDP	0.33 (2.92)	0.98 (3.71)	-0.09 (-0.53)	1.53 (2.37)
fiscal decentralization ¹	0.004 (1.49)	0.04 (2.76)	0.03 (6.61)	0.125 (3.73)
fiscal decentralization ²	-6.97e-05 (-1.76)	-0.0005 (-2.36)	-0.0004 (-7.21)	-0.002 (-3.82)
fiscal decentralization ³	3.63e-07 (1.91)	2.30e-06 (2.87)	2.25e-06 (7.96)	7.74e-06 (3.93)
Schleswig-holstein	-0.002 (-1.50)	-0.006 (-3.20)	0.001 (0.65)	-0.009 (-1.85)
Niedersachsen	0.002 (2.21)	-0.002 (-1.11)	0.002 (1.33)	-0.015 (-3.16)
Nordrhein-westfalen	-0.002 (-1.29)	0.007 (4.99)	-0.004 (-2.08)	0.039 (10.82)
Hessen	-0.002 (1.77)	-0.012 (-6.50)	0.007 (4.47)	-0.013 (-2.79)
Rheinlandpfalz	-0.002 (-1.87)	-0.009 (-3.39)	0.016 (11.24)	0.033 (4.95)
Saarland	0.009 (9.61)	0.016 (5.10)	0.015 (10.92)	0.018 (2.31)
Baden-württemberg	0.00005 (0.07)	-0.004 (-2.31)	0.006 (5.62)	0.004 (1.12)
R-squared	0.87	0.95	0.95	0.87

²⁶ Note that Germany (66 percent) and Korea (64 percent) have about the same degree of fiscal decentralization of construction on average as shown in Table 1).

Observations	103	103	103	103
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Fiscal decentralization measured separately as the percentage local government contribution to construction, maintenance, administration, and road provision in general in the first, second and third order respectively.

Shaded portions significant at 90% level of confidence.

* significant at 85% level of confidence.

** significant at the 80% level of confidence.

A study comparing the unit costs of construction across provinces in Argentina found a similar result (see Humplick, 1995). The difference between provinces was explained by the degree to which they contracted out construction activities. Provinces with higher levels of contracting out had lower unit costs of construction than those with more force account work. The reason for such observed gains over and above those of decentralized provision is the added efficiency from competitive bidding for road provision.

Does the Depth of Decentralization Have an Impact on Resource Costs?

When we look at the impact of the depth decentralization on resource costs, where depth is measured by the number of local governments in a state divided by state GDP, we see that the results with respect to fiscal decentralization are verified (see table 15). The effects are slightly reversed, however, with the rate of increase in maintenance costs as a function of the depth of decentralization being higher at the state level than at the district level.

Due to the robustness of the results in table 14 and 15, we estimate the impact of depth of decentralization on preference costs. We focus on the following measures of preference costs: (a) size of the road network in km per square km at the state and district level which is used as a measure of coverage and access to roads; (b) number of road accidents per km per year used as a proxy for safety; and (c) the total amount of revenue collected from user charges in million of DM, which is a measure of the degree to which users pay for road expenditures. The results are shown in table 16.

The size of the state road network, a measure of coverage, decreases with increasing depth of decentralization, similarly with the case of coverage at the local level, though with somewhat less significance. This is expected, as the finer the depth of decentralization, the smaller the size of the road network per unit of government.

A possible negative implication of decentralization is with respect to the number of road accidents per km per year, which increases with increasing depth of decentralization. In fact, road accidents have been increasing over time at a rate of 0.2 accidents per 1,000 km per year. Since the size of the road networks at the state level has been decreasing over time and has not been increasing at the local level, the result we find indicates that it is the level of safety that has been decreasing over time. This interpretation is consistent with arguments that equity concerns (in terms of provided

level of safety) are not as well addressed by decentralized units of government, as they are when the decisions with respect to safety are centralized.

Direct user charges (independent of federal taxes on fuel) have been increasing over time at a rate of about DM 47 million per year. After controlling for time and state-fixed effects, we see that the more local governments per GDP in a state, the higher the share of direct user charges. This result is consistent with the assumption that when the provision of public services is decentralized (fiscally and functionally as in the case of Germany) the local units of government raise more revenues from direct user charges than from general taxes.

Table 15: Impact of Number of Local Governments in Resource Costs in Germany

Variable	State Level Unit Costs (\$/km)		District Level Unit Costs (\$/km)	
	Maintenance	Construction	Maintenance	Construction
year	0.0002 (3.66)	-0.001 (-5.21)	0.001 (4.90)	-0.0016 (-3.54)
# local governments per GDP	0.0002 (1.24)**	-0.0009 (-2.40)	0.0006 (1.41)*	-0.001 (-1.29)**
Schleswig-Holstein	-0.002 (-1.30)*	0.005 (1.19)	-0.014 (-3.03)	-0.012 (-1.06)
Niedersachsen	0.002 (2.37)	-0.008 (-3.92)	-0.005 (-2.34)	-0.02 (-4.22)
Nordrhein-Westfalen	-0.0007 (-0.64)	0.0008 (0.29)	0.027 (9.35)	0.03 (4.74)
Hessen	0.006 (5.76)	-0.008 (-3.43)	-0.002 (-0.66)	-0.014 (-2.29)
Rheinland-Pfalz	-0.004 (-1.45)*	0.024 (3.53)	-0.002 (-0.34)	0.04 (2.37)
Saarland	0.011 (9.85)	0.036 (14.22)	0.011 (4.50)	-0.007 (-1.19)
Baden-Württemberg	0.002 (1.69)	-0.003 (-1.33)*	0.005 (2.36)	0.002 (0.43)
constant	-0.58 (-3.58)	2.04 (5.27)	-1.91 (-4.84)	3.35 (3.60)
R-square	0.78	0.91	0.82	0.75
Observations	103	103	103	103

Shaded coefficients significant at the 90% level of confidence.

* significant at the 85% level of confidence.

** significant at the 80% level of confidence.

The GDP per capita variable was dropped as the measure of depth of decentralization is a ratio of the number of local governments per state GDP.

Table 16: Impact of Decentralization on Preference Costs for the Case of Germany

Variable	State Coverage	District Coverage	Road Accidents	User Charges
year	-0.002 (-2.34)	0.0005 (0.62)	0.0002 (5.35)	47.35 (9.52)
# local governments per GDP	-0.003 (-2.02)	-0.002 (-1.08)	0.0002 (2.15)	28.33 (2.84)
Schleswig-holstein	0.05 (3.11)	0.03 (1.59)*	-0.0008 (-0.80)	-1481 (-12.60)
Niedersachsen	-0.01 (-1.60)*	0.010 (1.19)	-0.0004 (-1.07)	-559 (-11.06)
Nordrhein-westfalen	0.15 (13.71)	0.20 (16.65)	0.013 (21.59)	806 (10.97)
Hessen	0.13 (13.74)	0.12 (11.79)	0.005 (8.91)	-652 (-10.28)
Rheinlandpfalz	0.21 (8.16)	-0.06 (-2.12)	0.004 (2.71)	-1476 (-8.46)
Saarland	0.10 (9.90)	0.15 (14.56)	0.011 (22.10)	-1253 (-19.15)
Baden-württemberg	0.11 (13.36)	0.16 (17.74)	0.002 (4.73)	-159 (-2.78)
constant	3.69 (2.47)	-0.53 (-0.33)	-0.43 (-5.22)	-92699 (-9.34)
R-square	0.94	0.96	0.96	0.97
Observations	103	103	103	103

Shaded coefficients significant at the 90% level of confidence.

* significant at the 85% level of confidence.

** significant at the 80% level of confidence.

The GDP per capita variable was dropped as the measure of depth of decentralization is a ratio of the number of local governments per state GDP.

6. Conclusions and Policy Implications

We have conducted an empirical investigation of the impact of decentralization on the efficiency of road provision from the point of view of the local public goods provider (resource costs) and the road user (preference costs). The theoretical model used is a double-cost hidden level of effort specification derived from Buchanan and Tullock (1962) and Laffont and Tirole (1993). We find that it is important to include both user and provider concerns in determining the optimal level of decentralization, otherwise the impacts of decentralization are mis-estimated.

Using four different model specifications and three data sets, we find that decentralization of maintenance functions (when there is no central regulation on quality standards) results in efficiency gains, as quality roads are provided at lower unit costs. The optimal level of decentralized maintenance is 100 percent, indicating that there is little justification for a central government role in road maintenance. In fact, uniformization of standards in the presence of decentralized provision of maintenance, as in the case of Germany, removes the incentive to lower costs and erodes most of the efficiency gains from decentralized maintenance.

There is strong evidence for the need for a central government role (for coordination and central administration purposes) as the optimal level of decentralized administration was found to be less than 90 percent local government finance of administrative functions. This result is corroborated when looking at safety under decentralized provision where there is evidence that increasing decentralization contributes to decreased levels of safety. Central governments can regulate safety and other network externalities by having a stake in the financing of road administration functions such as planning, policy setting, and regulation of safety and other network externalities.

The case for construction is more country specific, with countries like Korea and Germany achieving benefits from decentralization. Country-specific effects, such as the quality of procurement procedures and other factors seem to dominate the unit costs of construction. In terms of policy, this finding suggests that it may be better to first ensure that the contracting procedures within a country are efficient before suggesting decentralized provision of roads.

Preference costs, from the point of view of the user, were found to be mostly neutral with respect to decentralization. They are, however, sensitive to decentralization of maintenance, showing an improvement in road quality as maintenance is decentralized. The exception is the case of Korea where there is evidence that decentralized administration results in lowering preference costs. These findings both point to the importance of including road users in decision-making about road expenditures. Maintenance by definition is a local activity and addresses local concerns, thereby requiring the diversity of user preferences to be included in decisions about maintenance.

Under decentralized provision, it is easier for local governments to incorporate user preferences in their decisions on spending. Similarly, administration of roads in terms of where to make investments, how to procure the works, and monitoring the quality of construction and maintenance is many times more efficiently done at the local level. The exception being when the capacity to carry out road works is very limited requiring some degree of centralization.

It is interesting to note that all the results (with the exception of construction in the cross-country panel and maintenance in the case of Germany where road standards are regulated) point to the benefits of decentralized provision of roads, or the neutrality of the performance of roads with respect to decentralization.

More work needs to be done on the shape of the preference costs function and the additional effects of privatization of construction, maintenance and administration activities. Presently, many countries are contracting out maintenance and construction. In such cases it may not matter whether local competitive bidding is carried out by a central or local agency. We expect the effects of decentralization of expenditures and private provision through competitive bidding to be additive due to the differential impact of information asymmetries at local and central levels. Ongoing research is investigating the impacts of information, economies of scale and other effects on the additional impact of competitive private provision of decentralized public services.

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