COSTS OF URBAN INFRASTRUCTURE: EVIDENCE FROM INDIAN CITIES

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Abstract

Urbanization in India has increased significantly, consistent with the world-wide phenomenon. Undesirable outcomes that have reached alarming proportions as a result of the urbanization are denial of access to safe drinking water, sanitation, and adequate waste management for a substantial portion of the country's urban households. We examine the provision of infrastructure in India's urban areas by examining the costs of providing these services, an issue ignored until now. Time-series data over 1991/92 upto 2003/04 and cross-sectional data on the actual capital and operating expenditures incurred by six of India's major cities, are gathered on the basis of field visits, discussions, budgets, and other documents. We estimate the marginal cost of providing water supply. When the low-spending cities are excluded, we find that the supply of every additional kilo litre of water imposes extra burden on the cities ranging from $0.06 to $0.11, as marginal operating costs. This, while being lower than the evidence from the literature, of course excludes the capacity costs of creating assets such as civil works and plant/equipment needed to supply water. Even based on these short-run marginal cost estimates, we find some Indian cities such as Jaipur and Pune are under-charging their water. As far as the other services are concerned, cities' per capita expenditures on basic services such as toilets (let alone street lights) appear to be abysmally low, let alone adequate in any sense to meet the demands of an increasing population. Further, spending alone is not sufficient, since operations and maintenance expenditures might just mean increased salaries without improving service levels. So we find weak municipal finances might still be the core of the issue.

JEL Classification: H72, R48, R51
Key words: India, Urban services, Marginal cost, Expenditure, Water supply

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Costs of Urban Infrastructure: Evidence from Indian Cities

Introduction

The world population is expected to become two-third urban by 2025. While the urbanization phenomenon is widely accepted as being an inevitable by-product of development, there are many undesirable outcomes that have resulted from urbanization. With increasing population and increasing demand for urban infrastructure services, the capacities of local governments in many developing and newly industrialized countries are over-burdened. The government of Republic of Korea estimates that infrastructure shortages result in a GDP loss of as much as 16 percent of its potential in the mid-1990s (see Singh and Ta'i (2000)). It is estimated that losses from traffic jams in Bangkok range from US $272 million to US $1 billion a year. Moreover, with respect to infrastructure such as water, Cole (2004) points out that there is a systematic relationship between water use and income, ascertaining that an inverted U-shaped relationship exists. Cole (2004) suggests that the levels of water use in developing regions will continue to increase for many years to come. Adequate infrastructure is not only necessary for increasing productivity, but also for raising the general quality of living.

The urbanization pattern in India also has been undergoing significant change, consistent with the world-wide phenomenon. The share of urban population in the total population of the country grew from 11% in 1901 to 26% in 1991. In 2001, the urban share of population has increased to 29%. The urban population in the country is expected to increase to about 500 million by 2021. The role of migration in the urbanization process cannot be underestimated. According to the 2001 Census of India, out of the total population that migrated within the country between 1995 and 2000, 36 percent were migrants into urban areas (from rural as well as from other urban areas). More than 58 percent of those that migrated to urban areas over this period were from rural areas. Rural-urban migration is explained by the lack of suitable non-farm employment opportunity for youth in rural areas.

The by-products of urbanization have not been always positive. According to India's Union Urban Development ministry, 20 percent of the country's urban households are denied access to safe drinking water, 58 percent do not have safe sanitation, and more than 40 percent of garbage generated is left uncollected for want of proper waste management.[1] In fact, Delhi's Economic Survey 2003-04 showed that Delhi's demographic profile has changed significantly due to migration. This survey reported that there had been a 50% increase in migration into Delhi from other states since 2001. Further, this survey highlighted that the phenomenal increase in migration had exerted huge pressure on housing, water, power and other infrastructural demands in the city. In fact, that year, the Delhi government asked for extra funds from the Planning Commission because of this, which was not granted due to resource constraints.

This study examines the provision of urban infrastructure services in India's urban areas, quite crucial for the sustainability of the urbanization that has been continually occurring.

[1] These data are for urban areas in the country. It is possible that analogous, if not worse, problems exist in the rural areas regarding which reliable data are not available. However, if urbanization is an inevitable occurrence of growth, it is important to address these infrastructure problems in the urban areas. If such problems cannot be addressed in the urban areas, it would be much more difficult to address them in the rural areas!

Objectives

With increasing urbanization, rural-urban migration and their problems have received a lot of attention in the literature and policy circles. However, the question that remains unaddressed in a developing country like India, is whether there are too many city immigrants (see Williamson 1988). That is, is India over-urbanized in relation to the level of its development. If so, how can we identify this phenomenon more systematically.

It is important to answer these questions because they have implications for whether the problem is one of closing the cities to in-migration or correcting user prices being charged for urban infrastructure, as Williamson (1988) points out.

While the problems highlighted by India's Urban Development Ministry imply that there are probably too many immigrants, the problems could well be due to the fact that migrants do not compensate for the social costs they create. One outcome with too many city immigrants could be that the change in the total cost of providing infrastructure services resulting from migration (the marginal cost), would be *higher* than the user prices actually charged. As Williamson (1988) points out, there has been no attempt to assess the quantitative relevance of this question. As other studies have also pointed out, there are no estimates of marginal costs for urban infrastructure services in India. However, this is crucial for efficient allocation of resources and for answering the urbanization question.

The Expert Group on Commercialization of Infrastructure Projects (also called as the India Infrastructure Report (IIR) (1996)) appointed by the Government of India estimated, in respect of water supply, a requirement of US $17,418 billion to address the backlog till 1995. Besides, it estimated an additional investment of US $2,153 million during 1996-97 and investments of US $1,934 million during the period 2001-06. In the case of water supply, Suresh (1998) pointed out that the ratio between the water charges collected and expenditure incurred on operation and maintenance in some Indian states varies between 30 and 46 percent. Similar requirements are estimated for sanitation (see Suresh 1998).

While a number of factors underlie the levy of user charges for water, gaps between the actual expenditure and what is collected, may well be due to the costs created by migrants.

Of course, pricing is only one aspect of the problem, albeit an important one. The solution for financing such expenditure might be to correct user charges for these services. In this study, we propose to answer the questions:

a. What are the marginal costs of providing urban infrastructure services such as water in Indian cities?
b. With respect to urban services such as solid waste, sanitation, sewerage, street lights, what is the total expenditure required for ensuring a certain benchmark level of services? How do they compare with actual expenditures by cities for these services?

To answer the first question, we estimate the marginal cost (the change in the total cost resulting from unit change in service) of providing water. Then we are in a position to compare the costs with actual tariffs being charged for water supply.

There is a reason why marginal, not average costs, should be the basis of pricing for water supply. A city usually develops its least expensive water sources first, but it normally becomes increasingly expensive to produce an additional unit of water as demand grows with increasing migration into the urban area. In such an instance, using the average cost of today would lead to an underestimation of the cost of water production in the future.

While in theory, costs should be the basis of pricing, in India, after independence, the public sector was assigned the primary responsibility for the provision of these goods, that were substantially subsidized because of their essential nature. However, with a decade of economic liberalization in India, it is appropriate that private sector should participate in the provision of these services. If yes, these projects should be made viable for the private sector, which calls for market-based mechanisms in the provision of these services. This research facilitates private sector participation in this important sector by providing information on marginal costs of water supply, which was obscure until now (see also *World Development Report* 2004). Thus, while the pricing itself is based on considerations of economic efficiency, the question is important for public policy because of their implications for providing sustainable levels of essential infrastructure services such as water supply.

In this study, we estimate marginal costs of water supply, and compare these marginal costs with the user prices actually charged in various Indian cities. We find the marginal costs are in some cases higher, and in other cases, lower than user prices charged. To answer the second question we pose, for services other than water supply, namely sanitation, sewerage, solid waste, roads, and street lights, we compare actual spending by cities against some benchmarks and study service levels, against benchmarks developed by us in some cases.

Table 1 summarizes the access to water supply for all south Asian countries. While none of the south Asian countries have universal access to a basic service like water supply even as of 2002, the access to this service is better in Iran, Maldives and Sri Lanka than it is in India.

Survey of Past Literature

While there is a vast body of literature relating to costs and pricing of infrastructure, studies dealing with water supply (with its marginal costs) and other urban services, are quite limited. Noll, Shirley and Cowan (2000) analyze reforms of urban water systems in six developing countries that represent World Bank case studies of reforms. Their main finding is that, though conceptually rather simple to reform, water is quite different from other infrastructure so that 'appropriate' reform varies substantially across countries and quite difficult. Dinar (2000) discusses the political economy of water pricing reforms. That work addresses possible shortcomings of implementing normative economic approaches that may produce first-best pricing outcomes.

Llorente and Zerah (2002) examine in India's context, formal and informal water suppliers in the water sector. The informal water suppliers such as bottled water and tanker companies have become important in India in the post-1990 reform period. But these authors argue that in the actual regulatory context, the solutions these private operators provide are only peripheral ones. They conclude that the reform of the public monopoly in water is therefore inevitable.

Shah, Scott and Buechler (2004) analyze a decade of water sector reforms in Mexico with the specific purpose of drawing lessons for Indian water policy. They find that Mexico's experience may not be a model for India, but it does suggest that changing the way in which a nation manages its water resources frequently necessitates substantial changes in institutional structures, law, incentives and commitment to reform the sector. A case study by the Water and Sanitation Program, South Asia (2000) speaks of the cancellation of the $185 million Pune water supply and sewerage project. There are several reasons the case study cites were responsible for cancellation of the project, after great initial interest and enthusiasm. First, institutional structures were partly responsible, for when the Commissioner was transferred, the project was left without a local champion. Further, the estimated costs of the project were perceived by the local administration to be high, and were designed to ensure a high rate of return to the private operator at the expense of the consumer. Further, local contractors were averse to the idea of international firms being awarded the contract. The cancellation of this project thus highlighted how the lack of a well-informed public debate resulted in the cancellation of what may have been a model for other projects in the country.

Paul et al (2004) assesses the state of public services in India from a user perspective and offers a set of benchmarks for future comparisons. They covered five services in their study – drinking water, health care, PDS, public transport and primary education. They assessed each of the services along four dimensions – access, use, reliability, and user satisfaction, using state-level data to compare the performance of different states with respect to these dimensions. They found that drinking water is accessible only to 55 percent of Indian households within a distance of 100 metres from home. They also reported absence of pucca roads by 60 percent of the households in their villages, and the availability of public health facilities only to over 40 percent of households within a distance of 1 kilometre from their home. Thus they found that while the levels of all public services was considered to be generally low by the surveyed households, drinking water fared better than the other services, with primary education being the lowest.

Link (2003) points out that the marginal cost of operating and maintaining infrastructure represents a component of optimal prices. That paper presents results for marginal infrastructure costs for different modes of transport (road, rail, airport and seaports), employing different methodologies for estimating marginal costs, ranging from econometric approaches to engineering based methods. They summarize the marginal cost of roads to be between €0.42 to €0.50 per vehicle kilometre in Switzerland, for passenger cars. In fact, quite similar to the approach we take in this study, Tiina Idstrom (2004) estimates marginal rail infrastructure costs in Finland to be €0.13 per gross ton kilometre, taking into account operations and maintenance costs.

Warford (1997) describes the general rationale for marginal opportunity cost pricing, illustrating it with reference to municipal water supply, and provides numerical examples. This paper then reviews the key issues involved in the implementation of marginal opportunity cost pricing.

Davis (2004) presents empirical evidence regarding the types and magnitude of corrupt behavior in water supply and sanitation service provision in South Asian countries. The study examines the strengths and weaknesses of current strategies to reduce corruption among several public water and sanitation agencies. The study finds, based on interviews, focus group discussions, with key informants, consumers and staff, that where corruption is reduced, there is a shift in the accountability networks of service providers, and a change in the work environment.

Turvey (1976) is one of the earliest studies to explain the concept of the marginal costs of supplying water, which is a concept relevant only for pricing of metered supplies. That study presents a numerical example of how capital recovery factors may be computed for different components of capital expenditure because of the lumpy nature of the investments. In a similar spirit, Hanke and Wentworth (1981) analyze the marginal cost of municipal waste water services. They define and interpret marginal cost and then apply this to a hypothetical wastewater system.

Roy et al (2004) develops empirical measures of willingness to pay (WTP) by households for better water quality in Kolkata. This study estimates the average WTP as the investment made by households in purifying water, which it finds to be $3.65 (Indian Rupees (INR) 169) per month per household, based on a field survey of representative households in the city. This has implications for designing an appropriate and equitable water charge, since, as the study finds, monthly family expenditure (adjusted for family size) and educational attainment are also significant determinants of the WTP, at the household level.

While the mid-term review of the Tenth plan highlights the actual expenditure on various urban infrastructure schemes and their requirements, Bagchi (2001) examines various alternative and unconventional modes of financing basic urban infrastructure services in the country and their feasibility.

In this work, we attempt to estimate the marginal cost of water, controlling for many characteristics that determine the costs and expenditure of water supply. This is something that has not been attempted in the literature, especially so for India, as is clear from the literature review presented above. Further, we make an attempt to compare for other services such as sanitation, sewerage, solid waste, street lights and roads, their actual expenditures with benchmark service levels and required expenditures.

Scope of Study

A primary objective of the study is to estimate marginal costs for water supply. That is, to estimate the additional burden of population on the supply and costs of this service. We examine short-run costs of supplying water to residents. This means that we study costs of operation and maintenance for purposes of estimating short-run marginal cost. We do not attempt to perform estimation of long-run marginal costs, despite the availability and collection of data on capital expenditures by cities. This is because of two reasons:

i. Capital costs are generally lumpy in nature, which means that they may or may not occur every year. It would be rarely appropriate to apply an econometric approach to such expenditures (see Turvey 1976). However, operations and maintenance (O&M) costs are continually occurring, and an econometric approach would be appropriate. Other literature on estimation of marginal costs for various modes of transport (Link (2003) for roads and Tiina Idstrom (2004) for rail infrastructure) use operations and maintenance (O&M) costs as the basis for estimating short run marginal costs.

ii. For essential civic services, it may not also be desirable to recover the capital costs.

Given the data-intensive nature of marginal cost estimation, we confine the marginal cost estimation to water. For the other core urban services -- sewerage, sanitation, roads, streetlights, and solid waste management, we attempt to capture the cities' actual expenditures on these services and compare them with benchmarks of the total expenditures required to attaining a desired level of service. This desired level could be, in the case of solid waste management, for instance, what it would cost the city to get rid of all garbage on the roads.

In the case of less obvious examples such as streetlights, the actual expenditures are computed and compared in relation to benchmark service levels, which we define and measure. In the case of roads, we examine actual expenditures by cities and compare them with benchmark investments required. We attempt to examine if there were to be a discrepancy between the period for which the roads were *ideally* built, and the period for which they *actually* last. The underlying assumption is that among many factors, migrants could be responsible for the damage caused to roads, if they do not last for the entire period for which they were built. We proposed to explore from the cities, reasons for any discrepancy between the actual and ideal life of municipal roads.[2] We did not examine physical norms for roads, but studied only financial norms or investment requirements and compared them with actual expenditures.

In the case of sewerage, we study various systems such as underground drainage (considered the best), open (covered and uncovered), soak pits, flush/septic tanks and institutional systems such as those used by universities or self-contained campuses. Note a caveat here – systems such as soak pits are usually privately provided for, and we do not account for the costs of privately provided services. We examine the costs of only publicly provided services. As with other services, we compare cities' actual expenditures on sewerage systems, examine their existing state of services, and compare these with benchmark levels of incremental investment required for acceptable level of services.

In the case of solid waste management, the appropriate cost question would be what it would cost the city to get rid of all garbage on the roads. Here we compare service levels and actual expenditures by cities and examine discrepancy between what is needed ideally and what is actually being spent.

In the case of sanitation, we would have liked to define the cost question as being what it would cost the city to get rid of open defecation completely. This has been motivated by the Maharashtra model for rural sanitation (Economic Times, 2005) which is a cash incentive scheme for creation of rural sanitation infrastructure. It is estimated that by announcing prize money worth \$1,429,190 (INR 66,000,000) per year, the Maharashtra government was able to create toilets worth \$ 43,308,792 (INR 2,000,000,000) every year. With this, Maharashtra has been able to declare about 350 villages in the state, free of open defecation. However, we are unable to measure this adequately since our data allow us to measure access to public sanitation only, whereas open defecation is determined by the existence of private as well as public sanitation to a significant degree. So we confine ourselves to measures of public sanitation, actual expenditure by cities on this and benchmark expenditures needed for 100 percent sanitation coverage.

[2] Cities consist of different kinds of roads -- access roads to houses, shopping streets, arterial roads, state and/or national highways, some for which the concerned state's public works department could be responsible. We confine ourselves only to those managed by the city.

Sampling

For purposes of this study, we chose six cities in India:

1. Bangalore
2. Lucknow
3. Pune
4. Surat
5. Chandigarh
6. Jaipur

The sample of cities was selected, taking into account several considerations of population size, variety in fiscal arrangements, institutional arrangements for provision of public services, income, geography, data availability, and benchmark criteria. While Bangalore, Pune, Jaipur, Lucknow and Surat are million-plus cities, Chandigarh is a class I city, with 2001 population of 500,000.[3] The six cities cover the north (Chandigarh), east (Lucknow), south (Bangalore), and the western (Surat, Jaipur, and Pune) parts of the country.

The sample chosen represents a variety of fiscal arrangements. Pune and Surat continue to have the octroi, whereas Bangalore, Chandigarh, Jaipur and Lucknow do not. Further, the sample we choose represents a variety of institutional arrangements for the delivery of public services, most importantly water supply. In Bangalore, the municipal corporation does not provide water, the city's utility, a parastatal agency, the Bangalore Water Supply and Sewerage Board (BWSSB) is responsible for water and sewerage services, whereas in Pune, the urban local body (ULB) is responsible for providing water

[3] The Census of India's definition for various class size cities is as follows:
Class I: Population >100,000
Class II: Population of 50,000-99,999
Class III: Population of 20,000-49,999
Class IV: Population of 10,000-19,999
Class V: Population of 5,000-9,999
Class VI: Population <5,000.

supply. In Jaipur, water supply is not provided by the municipal corporation. Unlike in Bangalore, it is the responsibility of the Public Health and Engineering Department (PHED), which is a state government department. In Chandigarh, water supply and sewerage are the responsibility of the Municipal Corporation (since 1996, since the municipal corporation in Chandigarh came into being only in 1994).

Table 2 summarizes the source of drinking water for the six cities in the study, from the Census of India's 1991 town directory. As summarized in the table, most of the cities (except Lucknow) are dependent on tap water, in addition to tube wells and hand pumps in cities such as Surat and Jaipur.

Further, Bangalore, Surat and Pune are located respectively in the relatively high-income states, Karnataka, Gujarat and Maharashtra.[4] Pune's population grew at a whopping rate of 51 per cent over 1991-2001, compared to its growth of 45 per cent over 1981-91. Chandigarh is in a high-income Union Territory, whereas Jaipur and Lucknow are respectively in Rajasthan and Uttar Pradesh (U.P.), states of the country that are generally known to be BIMARU (acronym for the states Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh), laggard and slow-growing. Besides, we had to ensure data availability for the data-intensive processes of marginal cost estimation (for water supply).

Last, but not the least, Chandigarh and Surat in our sample serve as benchmarks for city planning in general and the provision of services such as sanitation/solid waste management in particular. Chandigarh is a planned city, having been built from scratch. Having been designed by Le Corbusier, Chandigarh has been adjudged the best city in

[4] For instance, Maharashtra, Karnataka, and Gujarat recorded more than 100 per cent growth of their per capita net state domestic product (at current prices) during 1993-4 to 2002-3.

the country for the provision of services. The city has a well planned underground network of pipes for the disposal of sewerage generated in the city. Further, the city has well laid out under ground storm water drainage system. The road network of the city of Chandigarh is based on a grid pattern, commonly found in cities in the west.

The city of Surat in India has also been rated quite highly since its transformation from the plague to one of the country's 'cleanest' cities that it has now become. The emergence of the powerloom industry in Surat has turned it into a million city, as Lahiri-Dutt and Samanta (2001) point out. In fact, if we examine the rate of growth of all million-plus cities during 1991-2001, Surat grew at the highest rate, with Nasik, Patna, Rajkot, Jaipur, Delhi, and Pune, occupying successive places. Broadly then, the costs in these cities for providing urban services should serve as benchmarks for those observed in other cities.

Thus the sample presents enough variety for local governmental responsibility and expenditure needs. These categories chosen are useful for we use them to report actual expenditures and service levels for all services we examine in the study.

Methodology and Data

The report is divided into two parts. We estimate the marginal cost of providing water supply in the first part. We compare these costs with user prices actually charged. In the second part, we study other services. There we do not estimate marginal costs. We merely summarize the cost of providing a certain benchmark level of services and compare these with actual expenditures by the cities on various services.

To enable the first phase of the study, we collected data on municipalities' capital and operating and maintenance expenditure on water supply. Further, we collected data on the actual volume of water supplied, along with data on other aspects such as leakages, revenues, and water tariffs. Next, we collected a variety of data pertaining to other factors that determine the costs of supplying water such as topography, rainfall, and price indices, along with the cities' octroi status and a description of institutional arrangements -- whether/not municipality provides the services. Data on all these indicators which were used as explanatory variables are explained below.

For estimating the marginal costs of supplying water, we performed estimation of the total costs of operation and maintenance (O&M) as dependent on the volume of service (water supply), which is endogenous (being determined by population or in-migrants), controlling for several other factors that determine costs. The estimation tells us the incremental O&M costs of supplying water for every extra kilo litre of water supplied.

The detailed reader should note that it is important to separate out capital from O&M expenditures. There would be a set of O&M expenditures associated with every set of capital equipment. For instance, better quality capital expenditures (better equipment) would have lower O&M costs associated with them. While it may have been important, it was difficult to separate out capital projects from their corresponding O&M expenditures. This is because we did not have disaggregated data on projects in the various cities where we visited, to enable us to determine which O&M were applicable to which capital projects. We estimate the O&M expenditures understanding that we could possibly be looking at short-run cost with changing capital.

Once we estimate the cities' marginal costs of providing an extra kilo litre of water supply, we compare them with the user prices charged in the cities we study. Water tariffs, in the event household connections are not metered, are charged by cities based on the size of the piped connection. We obtained relevant data in the case of such cities. In the case of cities with metered connections, we obtained data on the slabs of tariffs for various levels of consumption. We get this heterogeneous data from cities/utilities/parastatal bodies on actual tariffs and compare them across cities.

The time period we chose for the study is 1991/92-2004/05.[5] This time period covers the post-liberalization (1991) period for the country, when major economic and political reforms started taking place. The timeframe we have chosen also includes the landmark year for local governments in India, the 74th Constitutional Amendment Act of 1992, which recognized urban local bodies as the third tier of government. We collect time-series data on primarily water supply, and cross-sectional data, and where available, time-series data for the other services discussed for the six cities of the study.

The research team visited each of the six cities with detailed questionnaires regarding each of the services for time-series data. The questionnaires used to obtain data on all the services are with the authors and are available upon request.

Expenditure and Costs

From the beginning we were aware that what would be observed in the field was actual *expenditure* on all the services, whereas what we are actually interested in, is the

[5] While ideally the time period would have been historical, dating to the 1970s, such historical data has not been collected or systematically maintained by cities. Hence we had to satisfy ourselves to a relatively more recent time period.

cost of providing them, as pointed out by Chernick and Reschovsky (2004). Expenditure needs vary across local government jurisdictions in India, as in the other countries (Reschovsky, (2006), surveys the various ways different countries have attempted to measure expenditure needs), for several reasons:

1. Expenditure responsibilities are not the same for all local governments. As discussed earlier, in India, local governments in cities such as Bangalore, Delhi, and Chennai, do not provide water supply and sewerage. In these cities, the Metro City Water Boards are responsible for development of the system including capital works, bulk supply, and operation/maintenance for water supply and related services. In the case of other cities (such as Pune and Chandigarh), the respective urban local bodies are responsible for these services. Such differences in responsibilities do cause a huge amount of variation in expenditure needs of local governments even within a single country.
2. Further, expenditure needs could differ across local governments due to exogenous factors such as topography. The cost of providing water in elevated lands (such as Bangalore, which is 930 metres above sea level) would be higher than that they would be in low-lying areas. Further, the relative dryness or wetness of an area (rainfall) is a determinant of expenditure on various urban services (especially water supply). Finally, the vector of input prices a city is faced with, also determines the cost of providing services such as water supply (for instance, the costs of electricity).

Quite understandably, there are distinctions between the *costs* and *spending* on a public service, as the literature emphasizes. Actual spending (or expenditure) on a public service could be due to a number of different reasons, of which cost is just one. The costs of providing public services are determined by the price of inputs, and exogenous factors such as topography which aggravate or reduce the costs of providing services, as highlighted above.

Actual *spending* on public services is determined by other factors, in addition to costs. Spending on local public goods is determined by their *desired* level, likely to be different for different income groups. See de Bartolome and Ross (2003), for an analytical framework that describes why this would be true. In general, this is also well-known from Tiebout (1956). Specifically, we expect willingness to pay for local public goods such as water to increase with income and/or education.

Further, some local governments that are more efficient spend less for every unit of the public service delivered, when compared to less efficient ones. The size of the local economy could be a factor in determining scale economies for certain services. Other factors determining efficiency of service provision in India are the degree of privatization in service delivery. Typically, private provision of services is known to have cut costs in many Indian cities. This is because public recruitment of personnel is expensive, and there is no explicit performance appraisal, making public provision of services inefficient.

Naturally, a big methodological challenge is to separate out that part of *expenditure* attributable to *preferences*, and that because of *costs* (this includes input prices, topography and inefficiencies).

So, in reduced form, expenditure equations have to be estimated as a function of factors representing the various components – local preferences (measured by income or education), factors that determine efficiencies (scale economies, public-private partnerships), and those that influence costs (physical characteristics such as topography, temperate weather). This may be represented in the following equation for city i and time period t, as a proposed study by the National Institute of Public Finance and Policy (2005) points out:

$$E_{it} = f\,(P_{it}, Z_{it}, F_{it}) \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

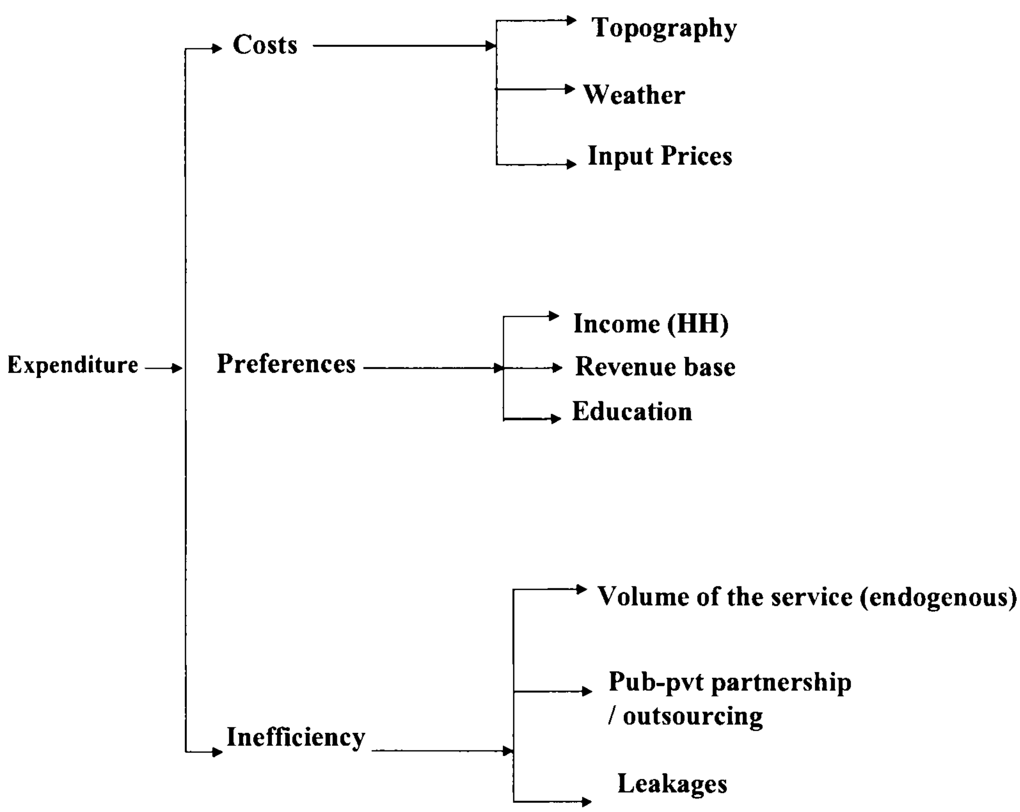
E_{it} in equation (1) refers to expenditure on water supply by the ith city at time period t. P_{it} refers to factors that denote *preferences* for local public services, such as income or education, again at time t. In the empirical work, we are unable to control for local preferences due to the unavailability of reliable data on income and lack of adequate data on education. Efficiencies (F_{it}) are determined by factors such as the level of the service, scale economies, expenditure responsibility and revenue base of the local economy. The revenue base of the local economy could be considered endogenous, but in India's context, local governments' revenue bases determine their expenditure, but not vice-versa. While it is difficult to separate out cost and efficiency issues, factors that influence costs (Z_{it}) refer to physical characteristics such as topography, temperate weather, and input prices. So, in reduced form, expenditure equations will be estimated as a function of factors representing the various components – preferences (where data were available), costs and inefficiencies, over time.

Figure 1 shows these relationships and the econometric determination of expenditure and attempts to separate out factors that determine costs, inefficiencies and preferences.

Thus, in the light of this discussion represented by Figure 1, we estimate the total O&M expenditure function for water supply for city i and time period t, as shown in equation (2), which is a reduced form of (1):

$$Y_{it} = a_0 + a_{1it}\text{volume of water supply} + a_{2it}\text{ rainfall} + a_{3it}\text{ altitude} + a_{4it}\text{ price index} + a_{5it}\text{ leakages} + a_{6it}\text{ octroi} + a_{7it}\text{ non-municipal body} + e_{it} \text{ --------------------(2)}$$

Figure 1: Econometric Determination of Expenditure on Water Supply



Expectations regarding relationships

The volume of water supply is the key variable we examine. The volume of water supply is clearly endogenous, so population is used as an instrument for this. All else remaining constant, higher volume of water supply (necessitated by increasing population or migration) should increase expenditures. The coefficient on this variable will indicate how much we may expect the expenditures to increase as and when there is an increase of one kilo litre of water supplied.

Rainfall should have a positive effect on expenditure. All else remaining the same, the higher the extent of rainfall, the higher would be the quantity of water that is pumped out of the water source into the pumping station for treatment and distribution into the pipelines. Because of this, the higher would be the expenditure.

Altitude has a positive impact on expenditure. The higher the altitude at which a city is located, the higher would be the costs of having to 'pump up' water from a low-lying water source. The vector of price indices has a positive impact on expenditure, for obvious reasons. If the prices of inputs were to increase, there is no way in which the expenditure on the service would be contained, assuming the same level of service as before.

Leakages are a sign of inefficiency in the system. While leakages in the previous year should have a positive impact on expenditure in the current year, leakages in the current year would be endogenous since the level of expenditure also has some impact on leakages. For this reason, we included distance from the water source to the pumping station as an exogenous instrument for leakages. This way, we were able to control for the leakage's endogeneity. When controlled for its endogeneity, the current year's leakage should have a positive impact on expenditure. However, note that, if the volume of water supply used is net of leakages (which is what is used here), leakages could have no impact on expenditure, since the municipality does not incur extra expenditure to supply the leaked water to households or to the end consumer. They are most likely stolen or wasted.

Finally, octroi should have a positive impact on expenditure. Note that while the amount of octroi revenue could be endogenous with expenditure, we have created an exogenous dummy (of 1) if the city has access to octroi, 0 otherwise. To distinguish the impact on expenditure of municipal bodies from those in cities in which non-municipal bodies (such as parastatal agencies and other state-level agencies) provide the service, we create a dummy (of 1) for non-municipal bodies, zero otherwise. The way in which this is set up, we expected this to have an ambiguous impact on expenditure. This is because non-municipal bodies are known to be more efficient in delivering the service, cutting on unit costs, but this does not in any way ensure that their total expenditure levels also would be lower or higher.

Based on the estimation in equation (2), it is possible to construct a cost index for each local government i, assuming actual values of other factors. We construct a cost index for water supply by city.

Marginal costs

Having defined costs, and distinguishing them from expenditure, ideally, we would have liked to do an estimation of operation and maintenance expenditures on water supply for every city so we can arrive at short-run marginal cost estimates. If done for every city, the marginal cost estimates would have implications for revision of water tariffs in each of the cities we study. However, recall that the time-frame for which the data are available does not permit enough degrees of freedom to enable estimation for every city. If we were to do a pooled estimation of marginal costs for all cities, the sample size would not be a problem. Hence we were able to perform estimations of total expenditures for all cities, and for sub-samples of cities, as relevant.

Note that our study also has implications only for the *average* tariff level in the cities. While *actual* water tariffs are somewhat different for various categories of users, the study is unable to throw light on what the *ideal tariff* levels should be for each of the categories of users – domestic, industrial and commercial -- of the system. This is because all cities' expenditures are reported only for total water consumption, not for consumption by use or category.

In the case of cities that have metering of water to record the volume of consumption, there is no problem in comparing marginal costs to water tariffs. Mathur and Thakur (2003) survey pricing mechanisms for water in various Indian cities. In the case of cities, however, that do not have metering, but some other pricing mechanisms, we get some additional and different data, to enable us to compare the marginal costs thus obtained to the average tariff level.[6]

Data, Sources and Variable Definitions

Tables 3-14 report descriptive statistics of the volume of expenditure and the level of service of water supply for various categories of cities, based on the primary data we obtained from our field work in the cities. The descriptive tables on (capital, O&M, and total) expenditures for water supply, (as with solid waste, sanitation, sewerage, roads, and street lights) are in per capita terms. Data on population for the six cities for the census years (1991 and 2001) were readily available from the Census of India. For the intervening years, we estimated population, using a method recommended by the Mumbai-based International Institute of Population Sciences (IIPS).

Population estimation

Data on population were fairly crucial to what we proposed (Figure 1) in the empirical work and estimation. First, note that while estimations for water supply expenditures were made of total (O&M) expenditure (in deflated terms), expenditure data were converted to per capita terms, for purposes of enabling descriptive comparisons across cities.

For 1981, 1991 and 2001, census data were available on population. For the intervening years (1992-2000 and 2002-04), we used an exponential growth rate assumption recommended by the IIPS.

The exponential growth rate is represented by the equation:

$$P_t = P_0 e^{rt} \text{ ------------------------------(3)}$$

P_t refers to population of the year t we are interested in estimating, P_0 is the base year (census year) population, t is the number of years from the base year for which we need to estimate P_t, and r is the growth rate of population from the base year to year 10.

[6] A question that one might like to answer is whether in cities that have metered connections and where tariffs reflect costs, the level and quality of services would be higher, or at least different from the others.

We used the r obtained from equation (3) to estimate population for the intervening years. Based on equation (3),

$$\frac{P_t}{P_0} = e^{rt} \text{----------------------------(4)}$$

It follows that

$$rt = \ln\left(\frac{P_t}{P_0}\right)$$

Solving for r gives us

$$r = \frac{1}{t}\ln\left(\frac{P_t}{P_0}\right) \text{---------------------(5)}$$

Calculating the growth rate, r, as given by equation (5), we estimated the population for the intervening years for all six cities, assuming the same growth rate within every decade.[7] Estimating population for the intervening years this way, we ensured that the final year's population (2001 population) we estimated was the same as what was reported in the Census for that year for all the cities. This way, we ensured confidence in our population estimation for the intervening years.

[7] This meant that for cities such as Surat and Bangalore for which we had data from the 1980s, we used the growth rate of population over 1981-91 to project data for the 1980s and used the growth rate of population over 1991-2001 to project population for the 1990s.

Construction of price index

Recall from our earlier discussion (see Figure 1) that the vector of input prices that a city or region is faced with determines the costs of providing water supply, along with other factors. Further, we needed data on price indices to convert the nominal expenditure into real terms. We used data on gross state domestic product at current and constant prices published and recommended by the Central Statistical Organization (CSO) to deflate the nominal expenditure data to that in real terms. City-specific price indices are not available nor are published by the CSO. So used price indices for states in which the selected cities were located.

We needed the price index data from 1991 (in fact, from 1985 for a few cities – Bangalore and Surat, for which expenditure and other data were available and had been collected all the way since the mid-1980s) upto 2004. The CSO has published data on components of GSDP by sector, in two series, at current and constant prices. The 'old series' covers the period 1980-81 to 1993-94 (for which 1980-81 is the base year); and 'new series' is for the period 1993-94 to 2003-04 (for which 1993-94 is the base year) (http://www.mospi.nic.in/mospi_cso_rept_pubn.htm).

We used data on GSDP in current and constant prices for three sectors: electricity, gas, and water supply, construction, and other services. We used the new series data from CSO from 1994-95 onwards for these three sectors in their original form, since they had the desired 1993-94=100 as the base year. For the data from 1980-81 to 1993-94 (since they had 1980-81=100 as the base year), we used a scaling factor, according to the methodology recommended by the CSO, to convert all price indices comparable against the same base year (1993-94=100). The following procedure was followed in order to accomplish this objective:

1. First, for the six states in which each of our cities are located, the ratios of the respective state's gross state domestic product at current to constant prices were calculated. These were computed for the three sectors of interest (electricity, gas & water supply, construction, and other services) for all years (both old as well as new series).
2. A scaling factor was computed, for all three sectors, based on ratio of the GSDP for 1993-94 that had 1993-94=100 as the base, to the GSDP for the same year, 1993-94, which had 1980-81=100 as the base. These scaling factors were computed both for GSDP at current and constant prices for the three sectors and six states in which the selected cities are located.
3. Then, the GSDP for the years from 1980-81 to 1993-94 (that had 1980-81=100 as the base), were multiplied by the scaling factor computed in step (3), making their base 1993-94=100.
4. This way we converted all years' data (1980-81 all the way to 2003-04) to the same base year, 1993-94=100. With this, we had the entire range of state GSDP at current as well as constant prices for six states and three sectors, with the same base, 1993-94.
5. We took the ratio of current to constant GSDP for all years (for the three sectors and six states). This way, as we would expect, we obtained a price index of 1 for 1993-94 for the three sectors and six states.

We used the deflator obtained in step (5) to deflate the nominal capital and O&M expenditures on all services to real terms. We used the deflators based on electricity, gas, and water supply, for deflating expenditures on water supply and street lights. We used deflators we obtained for construction to convert expenditures on roads and sewerage, to real terms. Finally, we used deflators based on "other services" to convert expenditure on sanitation, and solid waste to real terms.

Rainfall and altitude

As Figure 1 shows, in addition to the price index, we used data on rainfall and topography (measured by altitude) to represent a city's natural cost disabilities in providing water supply. We obtained secondary data on rainfall from the Pune-based Indian Meteorological Institute and data on altitude (extent (in metres) to which city is above mean sea level) from the individual cities. The data on rainfall for the cities required over the period 1991-2003 were in monthly terms. Based on the monthly rainfall (for 12 months) of a particular year for a particular city, we computed the annual average rainfall (expressed in millimetres) by year for every city.

Dependent and other variable definitions

The water supply data we used in the estimation are in net terms (net of leakages). The city incurs the cost of supplying a certain volume of water, and from an expenditure point of view, it does matter how much of this volume is lost. A caveat of course is that while the volume of water supply used is in *net* terms, the expenditure measure that we use, refers to what the city incurs on the *gross* volume of water supply, including what eventually leaks out of the system.

We expressed the daily net volume of water supply (for all cities and years) in 1,000 litres. Then we converted this quantity into annual terms (since the expenditure data are annual). We, of course, did have data on leakages in the supply of water in all cities, over time. We used this as a measure of inefficiency in the system.

As discussed earlier, the octroi is used as a measure of the revenue potential of the city (which could imply local *government* preferences), and should be a significant determinant of expenditures. All cities with octroi (Surat and Pune in our sample) received a dummy of 1 and others with octroi having been abolished received a value of 0.

Since we expected cities in which non-municipal (or parastatal) bodies offer the service to be more efficient, we included a dummy for whether it is a city in which a non-municipal body provided the service.

Description of data on water supply expenditure and service

For the entire period covering our study, combining all the 6 cities, the average deflated per capita capital expenditure is lower mostly than per capita O&M expenditure over the period (Tables 3 and 4). This does mean that cities spend less on creating assets than in operating and maintaining them, a trend that has been conventionally observed through the developing world.

The volume of water supply per capita per day in the six cities varies between 196 and 260 litres during the time period of the study. The maximum capital expenditure is

$9.68 (INR 447.24) per capita in 2001-02 while that for per capita O&M expenditure is $10.25 (INR 473.52) (2002-03). The minimum per capita capital expenditure incurred is $0.004 (INR 0.19) (1999) while the minimum per capita O&M expenditure is $0.03 (INR 1.24) (1995). Thus, after the 74th Constitutional Amendment Act (CAA), while the spending continues to be low, cities have been continually increasing their spending on water supply services.

Since our sample consists of cities based on several criteria, we make use of those classifications to study expenditures. As explained earlier, Chandigarh and Surat are our benchmark cities to demonstrate how much we can expect such cities to spend to offer a certain level of service.

Across the years, on average, we find that both per capita capital and O&M expenditures incurred by the benchmark cities are higher than that of non-benchmark cities, as we expect (Tables 5 and 6). Further, over time, benchmark cities supply greater quantity of water (265.18 litres per day per person) than the non-benchmark cities (which supply only 228 litres per capita per day). This finding emphasises that better access of water supply in terms of volume supplied per capita per day should be associated with substantially higher O&M and capital expenditures.

Next, we studied expenditure patterns on water supply by cities in which the municipal corporations supply water to residents vis-à-vis those in which non-municipal bodies such as parastatal (for instance, the Bangalore Water Supply and Sewerage Board (BWSSB) in Bangalore) and other state-level bodies offer the service. While non-municipal bodies (including state-level and parastatal bodies) are also governmental agencies, they may have incentives to be commercially viable, similar to a private company.

Our findings are interesting. We find that on average, both per capita capital and O&M expenditures for the cities in which non-municipal bodies offer the service are, in fact, lower than they are in municipality service provider cities (Tables 7 and 8). This could be either a reflection of the fact that non-municipal bodies are more efficient in the delivery of their services or that they spend too little per capita. There appears to be greater support for the latter since the average per capita per day volume of water supply is also higher in the municipality service provider cities than in the non-municipal counterparts. But, water supply is also more volatile in municipality provider cities than that in non-municipal service provider cities.

We slice the cities in another way to distinguish the impact of octroi-levying cities from those that do not. Historically, it is well-known that the octroi, while being a distortionary tax, is a buoyant source of revenue for cities. Hence cities that have access to this revenue, no matter what, should be spending more than the cities that do not have access to this revenue source (because their states have abolished it). In our sample of cities, as described earlier, Surat and Pune continue to have the octroi whereas Bangalore, Lucknow, Jaipur and Chandigarh do not.

Aggregating the O&M and capital expenditure across all the years, we find that the octroi levying cities indeed spend higher per capita on water supply than their non-octroi counterparts (Tables 9 and 10). The per capita per day supply of water in the octroi cities is also, on average, higher than that in the non-octroi cities, a finding that again reinforces the relationship between spending and level of service in the case of water supply. While spending may or may not translate into higher levels of service, it is possible that where cities are efficient (for instance, those that ensure minimal leakages) in their provision of the service, higher spending does result in higher volume of the service.

Further, we made a distinction between cities whose populations rapidly grew in the 1990s and those that grew more slowly during this period (Tables 11 and 12).[8] Surprisingly, the slow-growth cities spent more (capital as well as O&M) per capita on water and were able to supply higher volume of water per capita. We noted that Bangalore, which is the highest spender on water in absolute terms, was a slow-growing city during the 1990s. So it is possible that the findings in Tables 11 and 12, of the slow-growing cities spending more per capita than the fast-growing ones, are influenced by Bangalore.

Finally, we distinguished between cities that are located in the BIMARU (Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh) states with those in the non-BIMARU states (Tables 13 and 14). We find, as we would expect, on average, that the O&M and capital expenditure across the years for the non-BIMARU cities are higher than that of BIMARU cities. Noticeably, the per capita per day average of water supplied for non-BIMARU cities is also much higher than that for BIMARU cities, as we would expect, again demonstrating a strong relationship between spending and service levels with respect to water supply in the cities.

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[8] We used the average growth rate of population during 1991-2001 for the six cities to distinguish between fast-growth and slow-growth cities. Based on this, cities that grew relatively rapidly during the 1990s were Surat, Jaipur and Pune. Bangalore, Chandigarh and Lucknow were classified as being the slow-growth cities.

Results from Estimation

The literature (World Bank, 1994; McNeill and Tate, 1991) widely acknowledges that marginal cost pricing of water is efficient. Technically we know the marginal cost is determined by taking the first derivative of the total cost (understanding the distinction between cost and expenditure) curve with respect to the volume of water supplied. As McNeill and Tate (1991) , Link (2003) and Tiina Idstrom (2004) point out, the marginal cost is equal to the marginal operating cost, which includes variable costs. As Turvey (1971) points out, the capital costs required to meet incremental demand for water tend to be lumpy, and cannot be determined statistically. Others (e.g., Warford, 1997) also generally accept that for capital expenditures, a statistically determined function would be rarely appropriate. So we do not attempt to calculate or estimate marginal cost for capacity expansions, based on capital expenditures.

The first step in our analysis develops a cost (expenditure) function based on the city's/utility's budgets for O&M expenditures. As we know, more generally, the cost function shows the relationship between the water supplied and costs incurred.[9]

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[9] What determines this volume of water supply (or of any other service considered here) is of course subject to debate—migration, increasing population or simply demand. We do not have data to determine the demand schedule for water for which micro, household-level data on water tariffs paid and quantity of water consumed would be necessary. Education is a normative characteristic, which could affect the preference for water. But that may not necessarily affect the actual expenditure/cost incurred, at least not so in India's context. If education affects the demand for water, then it must be the case that the highest water spending municipalities should also be the ones with educated population since that indicates water demand. We did attempt to get data on the proportion of population with bachelors and masters' degrees in the six cities of our study over the entire time period. This was available only for a few years, which substantially reduced the size of our already small sample.

In alternative specifications, we were exploring the possibility of using average household income in the city as an exogenous determinant of the level of expenditure on water supply, which is a different variant of the education characteristic. But that may not be necessary or desirable. That will be mixing positive and normative issues. Further, income data at the city level in India are rarely collected; for a single year we could use data published by the National Council of Applied Economic Research (NCAER). But in no case are they available in a time-series fashion, required for the study. So, effectively, we were unable to adequately control for local preferences for public services in determining expenditures.

Further, other factors such as topography, input prices, expenditure responsibilities of local government determine expenditure/cost levels.

Tables 15-1 to 15-9 show the results of various regressions we estimated for purposes of obtaining the marginal cost of supplying 1000 litres of water. We estimate equation (2) by ordinary least squares (OLS) and two-stage least squares (2SLS) because of the endogeneity of the volume of the service.[10]

When all cities are taken into account (Table 15-1), the amount of water supply (net of leakages) does not have a significant impact on expenditures. This implies that when the low-spending cities are also included, the volume of water supply does not impose any extra costs on the system. But if the expenditures are themselves very low (which they were in the case of two BIMARU cities, Lucknow and Jaipur, see later discussion for estimates of how low their expenditures were, compared to the other four cities of study), this finding does not mean much (for instance, see Table 17 that compares the costs and expenditures by city).

As Table 15-1 summarizes, the altitude of the city and the price index it is faced with for water, gas and electricity, make a big difference to its cost of providing water supply. Specifically, for every one metre that the city is located above mean sea level, there is an increase in expenditure on water supply to the extent of $29,360 (INR 1,355,690).[11] This is reasonable to expect given the average expenditure of the cities on

[10] The instruments we used in the 2SLS estimations were population and average of the temperature difference between the maximum and minimum for various cities, along with the endogenous variables. Population determines the volume of water supplied and is exogenously determined. Further, temperature differences in any given city (between the summer and winter months) are exogenous and could affect the expenditure through its impact on rainfall. Finally, we use the distance from the water source to the pumping station as an instrument for leakages, as discussed earlier.

[11] The regressions were performed on data in deflated Indian Rupees (INR), hence the coefficients are to be interpreted in terms of INR.

water supply (INR 346, 469,375 or $7,502,585, see Table 17). This result is also reasonable because of the costs of having to pump up the water from a low-lying water source. In fact, this is the reason why Bangalore's O&M costs of providing water are quite high. Further, Table 15-1 shows that if the price index faced by the city is high, the cost of providing water supply is also high, reasonable to expect. Leakages in the system have a negative impact on expenditure. Note that, since the volume of water supply used is net of leakages, leakages could have a negative impact on expenditure, since the municipality does not incur extra expenditure to supply them to households or to the end consumer. Here the magnitude of the estimate implies that for every one percentage point leakage (water not supplied to the end-consumer), there is a reduction in expenditure to the extent of $213,230 (INR 9,846,940).

With a view to adjusting for the time availability of the water supply (e.g., whether random supply in some part of the day, or uninterrupted), we obtained time-series data from each of the individual cities on the duration of the water supply in terms of annual average of the daily number of hours of water supply. As one can imagine, this is a very rough measure of the time availability of water supply since it irons out seasonal variations (across summer, winter and rainy months) and across the year (drought, normal monsoon or flooding years) variations. Nevertheless, this was the only quantitative measure we could come up with, and we included this as another exogenous regressor to examine its impact on costs. Table 15-2 presents these estimates. This table shows that a city's altitude and the price index continue to be the factors that most significantly affect the costs (expenditures) of providing water to its residents. The volume of water supply or its duration do not have any impacts on the expenditures.

Table 15-3 presents estimates of the expenditure on water supply, assuming a double log form (log of expenditures (the dependent variable), and log of the net water supply). First, note that the double log form provides a much better fit than the estimates in Table 15-1. The adjusted R^2 is a distant 0.92 for the double-log model (compared with 0.79 for the linear model). It shows that for every 1 percent increase in net water supplied to residents, there is a more than 1 percent increase in expenditure incurred to supply the water, consistent with expectation. Altitude has the expected positive impact, and leakages continue to exhibit the negative impact as in the previous estimation. Non-municipal bodies spend less than municipal bodies on water bodies, because they are more efficient in delivering per unit of the service, or they spend less because of the fact that they operate like commercial entities.

Because of differences in the spending patterns for municipal and non-municipal entities providing the service, we performed estimations of expenditure on water supply by institutional arrangement. We performed separate estimations for cities in which the municipal body provides the service and those in which other entities such as parastatal agencies or other state-level agencies provide the service.

Tables 15-4 and 15-5 respectively summarize the results for non-municipal bodies and municipal entities respectively. The volume of net water supplied on expenditure is unanimously positive in both regressions. The magnitude of the estimate implies that municipal bodies incur greater expenditures (INR 3.39) per kilo litre of water supplied than the non-municipal entities (INR 2.53), probably because of their inefficiencies. Altitude has a positive impact on expenditure in the case of both institutional arrangements, as we would expect. Leakages have a positive impact on expenditure in the case of non-municipal entities, demonstrating that these problems are attended to, and are fixed. This could have a positive impact on expenditure (maintenance of a leaking pipe, for example). However, leakages do not have a discernible impact on expenditure of municipal bodies most likely because they are not fixed, at least not regularly. The only other difference is that in the case of municipal bodies, rainfall has a negative impact on expenditure. This most likely occurs because in the case of rainy years, the municipal bodies spend less, even after controlling for the water supplied, because it is likely that consumption of water for various purposes is obtained from rainwater. This is specially so if households are aware of and use rainwater harvesting effectively.

A few of the cities (the BIMARU cities, Lucknow and Jaipur) had unduly low expenditures (both capital as well as O&M). Lucknow's average (in constant 1993-94 terms) annual O&M expenditure on water supply during the period of study was INR 13,885,443 (or $300,680), and Jaipur's average (again in constant terms, with 1993-94=100) O&M expenditure on this service was only INR 2,823,760 (or $61,146), compared with an average annual O&M expenditure of INR 515,526,740 (or $11,163,420) for all cities excluding these two during the period of study. Hence we removed the two low-spenders and re-estimated the regressions. When we did this, we find several interesting results, as shown in Table 15-6. This table shows that the volume of water is statistically significant in determining expenditure. Specifically, the magnitude of the estimate shows that for every 1 kilolitre of water supplied by the city, it incurs an additional cost of $0.06 (INR 2.62). We discuss more regarding this in the section on policy insights.

When the low-spending cities are excluded, leakages have a positive impact on expenditures, implying the existence of inefficiencies. Specifically, for every one percentage point more of leakages in the distribution system, the city spends \$674,150 (INR 31,132,200) on O&M, reasonable to expect, because leaking pipes have to be fixed. Altitude has a negative and significant impact on expenditure in this specification, when, in fact, we expect a positive effect. This is due to the fact that when low-altitude and low-spending cities such as Lucknow and Jaipur are excluded, relatively low altitude cities such as Surat that spend more remain in the sample and dominate the results. A similar case holds good for octroi. Table 15-6 shows that octroi revenue has a negative impact on O&M expenditure, contrary to expectation. But note that the highest spender on water supply is Bangalore which does not have octroi. This dominates the results shown in Table 15-6. Finally, note that in cities in which non-municipal bodies supply water, the absolute O&M expenditures are higher. However, in *per capita* terms, note that such cities spend less on water supply than their municipal service provider counterparts, (see Table 8).

To control for the time availability of water supply when the low-spending cities are excluded, we re-estimated the regressions in Table 15-6 by including the duration of water supply in cities. These results are summarized in Table 15-7. As in Table 15-6, the price index for water, gas and electricity has the expected positive impact on the costs. Leakages and octroi continue to have the same impacts on costs as in the earlier regression. The duration of water supply has a negative impact on the costs. This implies that the longer the duration of supply, the lower are the marginal costs. Foster (2006) in fact points to the hidden costs of intermittent water supply, and the fact that well-managed continuous water supply turns out to be far cheaper than intermittent supply. For example, intermittent (lower duration) water supply systems are vulnerable to absorption of contaminated water during periods of low pressure and actually suck in raw sewage during periods of negative pressure, and the costs of treating it are higher. Further, if cities are committed to delivering a certain quantity of water to their residents, the shorter the duration, the greater the extent to which water pipes have to be larger. The cost of maintaining pipes in a shorter duration regime is also higher because of frequent turning off and on. For all these reasons, it is possible that cities that supply water to its residents for a shorter duration incur higher costs/expenditures than their counterparts that are able to supply for a longer duration.

We did separate regressions for fast-growing and slow-growing cities. Table 15-8 shows fast-growing cities incur greater marginal costs of supplying water than their slow-growing counterparts. Specifically, the fast-growing cities incur $0.11 (INR 5.05) for every additional kilolitre of water they supply. This implies that these cities need to recover a greater extent from consumers than the other cities, consistent with expectation. This makes sense when we recall that our fast-growth and slow-growth cities are classified in terms of their population growth. So whether or not migration makes a difference to a city's expenditures for producing a certain service, its population does. The only other factor that has a significant impact on expenditures in this specification is altitude, and this has a negative impact. This result is again dominated by Surat since that is located in a relatively lower altitude and is a high spender and rapidly grew during the 1990s.

Table 15-9 shows the regression results for slow-growing cities. Here the volume of water supply is not a significant factor any more in explaining expenditure, consistent with our expectations and hypotheses. The other significant factor explaining expenditure is altitude, which has the right sign, and is largely driven by Bangalore, which is a high-altitude, high-spending city.

Overall, the model chosen to represent O&M expenditures is a fairly good one, since the adjusted R-squared ranges above 0.80 in all cases.

Policy insights

We are answering this question in the study: given that the cities have spent a certain amount on O&M expenditures for water over a period of time, what should be their tariffs.

We checked with the individual cities as to what criterion their actual current tariffs were based upon. For a basic service like water, the primary criterion the cities have used to charge water is nothing more formal than a vague concept of affordability. So cities such as Jaipur have always kept the price of their water low (see Table 16) and affordable for major sections on the population. Also, note a city's household income does not have any impact on the government's *cost* of providing water supply. Alternatively, income may have some impact on the *expenditures* on water supply. Since it is a measure for affordability, it indicates local preferences. Had income data been available at the city level, it would have been possible for us to say whether the presence of high income households encourages the city to spend more or less on water supply or vice-versa. This would have also enabled us to examine the impact of affordability of households on expenditure by the service provider, holding other things constant.

However, as explained earlier, income at the city level in India is available at best only for a single year, but certainly not for a time-series that the data set developed here, requires. A city's income, if available, may have been used as the basis of tariff fixation, not estimation of marginal costs.

Remember that the estimates obtained here represent only the O&M expenditures. Because of this, they appear to be lower than the international evidence regarding marginal costs of providing water. A World Bank (1994) study finds that in Lima, the *long-run* marginal costs of providing water supply was \$0.45 per cubic meter (that is, per kilo litre) whereas the actual tariffs were only around \$0.28 per cubic meter. We have arrived at *short-run* marginal cost estimates in this study. Recall that for purposes of computing *long-run marginal costs*, we have to get data on expenditures by projects, disaggregated by civil works, and plant & equipment, on which we did not get any information from the cities. If we had had access to such disaggregated data, then we could have attempted computation of long-run marginal cost, using the approach suggested by Turvey (1976). This hinges upon the use of discount rates and arriving at different capital recovery factors for plant & equipment vis-à-vis civil works.

For a moment, assume that the estimates in Table 15-8 (for the fast-growing cities) represent the upper range for *short-run marginal costs* (INR 5.05 or \$0.11 per kilo litre). Table 16 summarizes the actual water tariffs in the six cities. Note that all cities except Surat have metered connections. In the case of Chandigarh and Jaipur, we have computed weighted average tariff based on the quantities and rates for various categories. This weighted average tariff turns out to be \$0.11 (INR 5.05) in Chandigarh and \$0.07 (INR 3.39) per kilo litre in Jaipur. Based on the estimates in Table 15-8, Jaipur and Pune (both of which fast-growing) are clearly undercharging their water, especially so if capital costs were taken into account. Chandigarh might be just another case of under-charging if capital costs were taken into account. Currently, based on just marginal O&M costs, it is just about right. Bangalore is over-charging. The results do not have implications for Surat which has all unmetered connections. If the direct outcome of what we have highlighted here is that an additional kilo litre of water supply imposes some burden on the city (which is statistically significant in the case of fast-growing cities of which Surat is counted), only a volumetric consumption regime (that is, metering of existing household connections) will be able to fix the problem. Finally, Lucknow spends very little on water supply and for this reason an additional kilo litre of water might not impose much burden for the city. However, as we see below (see Table 17), Lucknow and Jaipur spend even less than what their cost factors require them to spend. So spending better and charging consumers for the additional burden might be the solution, for better service delivery.

Frequently, price hike policies are viewed as the logical outcome of deregulation and break-even cost. This need not be necessarily the case. Over and above the issue of pricing, it is important for the cities to be efficient in their management. For instance, reduction of leakages, thefts and unaccounted for water, in the distribution system will have the impact of reducing expenditures. As we have observed in the case of most of the cities, leakages account for nearly one-third of the total water supplied. Needless to say that greater efficiency in management of the distribution will result in better service to consumers while containing the costs and the tariffs.

Based on the estimates in Table 15-1 (estimation for all cities), we arrive at predicted expenditures, predicted costs (based on cost factors including topography (altitude), price index, and rainfall) and compare these with actual average expenditures incurred by these cities on water supply. Table 17 summarizes this. It shows that in the case of Lucknow and Jaipur, the actual expenditure as a proportion of costs predicted on the basis of various factors, are shockingly low, being less than 10 percent! Bangalore is the one that spends most appropriately in accordance with its cost conditions.

Other Services

In the case of other services, as discussed earlier, we did not attempt to estimate marginal costs, but examined expenditures and the level of the service with a view to determining the expenditure required to ensure a certain, benchmark level of service.

Solid waste

In the case of solid waste, we examined city-level (per capita) expenditures on solid waste and compared this with solid waste collection efficiency over time. Solid waste collection efficiency represents the solid waste that is collected and disposed, as a proportion of what is generated. Data on solid waste collection efficiency was not readily available from the cities. We gathered data during our field visits regarding the solid waste generated and collected, and their expenditures (both capital and O&M) over time. Based on these data, we computed solid waste efficiency estimates for all cities in our study and compared them with their expenditures on the service.

Various committees have laid down the minimum physical standard of services to be 100% collection and disposal of solid wastes. For purposes of estimating costs, we examined expenditures classified by different categories of cities so that we can determine what is needed for 100 percent solid waste collection efficiency in India's cities. This is, of course, assuming that only spending levels determine solid waste collection and disposal.

The solid waste efficiency in cities with million-plus population, as reported by the India Infrastructure Report (1996), is 83%. Tables 18-20 summarize the solid waste collection efficiency of various cities we study, classified by category. Clearly, the *benchmark* cities (Chandigarh and Surat) demonstrate higher solid waste collection efficiency than their *non-benchmark* counterparts in all the years of our study. The average efficiency for benchmark cities is 96 percent, whereas for the other cities, it is only 72 percent. In general, we find most cities spend more on O&M than on creating capital assets. Clearly, the benchmark cities spend (average total (capital and O&M) per capita expenditures) more on solid waste than the other cities. Given this, the differences in solid waste collection efficiency might well be explained by finances.

Next, we examine differences in solid waste efficiency and per capita expenditures between *fast-growing* and *slow-growing* cities (Table 19). We find the fast growing cities to be more efficient in their collection of solid waste (98 percent vis-à-vis 73 percent for the slow-growing cities, over time). The surprising finding is that the slow-growing cities, on average, spend more per capita ($1.64) on solid waste than the fast-growing ones (that spend only $0.53 on average per capita). We noted that the slow-growing cities (primarily Chandigarh) spend more on O&M than on capital expenditures, and exhibited a higher level of collection efficiency. A slow-growing city, Bangalore, by contrast, spent more on capital expenditure, but was less efficient than Chandigarh. This implies that even higher capital expenditure does not necessarily translate into increased service levels. Increased expenditures might just mean buying new trucks that are used to transport garbage, include the cost of their fuel, and salaries of the drivers. This explains why the seemingly higher expenditures of the slow-growing cities have not meant improved solid waste collection efficiency in those cities.

In contrast, the fast-growing cities (with higher solid waste efficiency) such as Pune also spend more on O&M expenditure, but they seemed to have *managed* their solid waste in a much better way. For evidence regarding this, refer to the Surat case study in solid waste and civic management later in this section.

When we examine solid waste in the octroi and non-octroi cities (Table 20), a finding of interest is that the non-octroi cities spend more on average per capita ($1.12) than octroi cities, but their solid waste efficiency is only around 73 percent. The octroi cities on the other hand, spent much lower per capita than the non-octroi cities ($0.80), but are able to ensure higher levels of solid waste efficiency (at 98%). This is partly due to the fact that an octroi-levying city (Surat) has also been adjudged the 'cleanest city' in the country, and dominates the finding regarding solid waste collection efficiency in octroi cities. There, as we document later, overall, solid waste management, rather than its finances alone, is the secret behind its success.

Overall, we find that cities spend quite little on capital expenditures as they pertain to solid waste, in absolute terms. Further, even with sketchy data, we make an attempt to determine how much more expenditure is required in the cities that would ensure 100 percent solid waste collection efficiency.

As far as a desired level of service is concerned with respect to solid waste, various committees have recommended 100% collection of the generated waste, with its proper disposal. For instance, see the Report of the Third Working Group on Norms and Standards for Provision of Basic Infrastructure and Services, prepared for State Finance Commissions, 1995. To implement this 100 percent norm, India's urban local bodies are guided by the directives in the Municipal Solid Waste (Management and Handling) Rules 2000, issued by the Ministry of Environment and Forest, government of India. These directives are as follows (see Asnani, 2006):

a. Prohibit littering on the streets by ensuring storage of waste at source in two bins (one for biodegradable waste and another for recyclable material);
b. Primary collection of biodegradabale and non-biodegradable waste from the doorstep at pre-informed timings on a day-to-day basis.
c. Street sweeping covering all residential and commercial areas on all days.
d. Replacement of open waste storage containers with closed ones.
e. Transportation of waste in covered vehicles on a day to day basis.
f. Treatment of biodegradable waste.
g. Minimize the waste going to the landfill.

In addition to the above, some existing studies also indicate the amount of financial resources required for effective solid waste management in cities of various sizes, to attain the status of a 'clean city.' The costs estimated by Asnani (2006) for vehicles, tools, equipment and composting for cities of various sizes are summarized in Table 21.

All cities chosen in this study (except Chandigarh) are in the greater than 2 million population category. So, based on the above estimates, the total cost of solid waste management (SWM) in a million-plus city (including for cities chosen for this study) should be $4,218,276 (INR 194,800,000). At their respective populations we projected for 2005 for these five cities, the per capita total cost of SWM in Bangalore, Jaipur, Pune, and Surat, turn out to be $4.15, $1.51, $1.37 and $1.43 respectively. Compared with these cities' actual spending of $0.55, $0.36, $1.18 and $0.27, respectively on SWM, spending in all cities (except Pune) is highly inadequate.

Based on the estimates in table 21, for Chandigarh (which is in the population category 0.5-1 million) the total cost of SWM should be approximately $2,189,259 (INR 101,100,000). This translates to a per capita cost of $2.25 for 2005, using the population projection we arrive at for Chandigarh (971,724). We find Chandigarh's annual average spending during 1993-94 to 2003-04, like other cities, has been less than the required $2.25, at $1.85.

A report by the All India Institute of Local Self Government estimates the capital costs of collection and transportation for Pune. Assuming that these estimates are for the most recent year, the minimum total cost (of collection, transportation and processing) for Pune appears to be around $4,565,593 (INR 210,839,115) (73,100,000 (lowest cost model, Table 22) +137,739,115 (Table 23)). In per capita terms, this turns out to be $1.48 (INR 68.48). Note the similarity of this estimate with what is arrived at, based on the India Infrastructure Report (2006) above (which is $1.37). Comparison of this required expenditure with Pune's average annual per capita expenditure on solid waste (which is $1.18) shows that the city needs to increase its spending by roughly $0.30 per capita (at its current population, this turns out to be a total of $923,706 or INR 42,656,756).

As in the case of the country, in the case of Surat, it was a crisis in the form of the plague that acted as the catalyst of urban and civic management in the city. A case study of the Urban Management Program of the UN Habitat by Swamy, Vyas and Narang (2000) summarizes Surat's experience and management of the city, transforming it from the plague to one of the cleanest cities of the country. Soon after the outbreak of the plague in 1994, a massive cleanup operation was launched by the Surat Municipal Corporation in early 1995, followed by administrative reforms. These reforms consisted of sub-dividing the pre-existing 6 zones in the city into 52 sub-zones making sanitary inspectors responsible for each of them. Further, a system of strict enforcement and monitoring ensured that the checks were in place. For instance, a system of fines for littering public places was instituted. Finally, contracting was introduced to improve the waste collection efficiency and street cleaning.

On average, based on the data we obtained from the Surat Municipal Corporation, during the period 1997-2004, Surat spent a total (including both capital as well as revenue expenditures) of only about $0.27 (INR 12.61) on solid waste per capita (in constant terms, with 1993-94=100). On the other hand, other cities we studied (excluding Surat) spent an average of $0.98 on solid waste over 1993-94 to 2003-04 (total capital and O&M, in constant terms, with 1993-94=100). So we find that the size of the actual spending on solid waste (per capita terms) even in benchmark cities like Surat is several times less than what is actually required.

Based on this, we conclude that the estimates presented above are plausible in the context of the tasks required as part of solid waste management. However, in addition to the financial resources a city has to spend in order to get rid of all garbage on its roads, it is important to practise initiatives in financial innovation and urban reform, as much as spending adequately, to attain the status of 'clean cities'.

Sewerage

A sewerage system implies the network of mains and branches of underground pipes for carrying waste water (sewerage) to the point of disposal. Sewers that carry only household and industrial wastage are called separate sewers; those that carry storm water from roofs, streets and other surfaces are known as storm water drains, while those carrying both sewage and storm water are called combined sewers. To put this in perspective, Chandigarh has a system of underground covered, drains. Towns which are not provided with such underground sewerage systems normally have open surface drains, box drains, or drains of other patterns.

Table 24 summarizes data from the Census of India 2001 regarding the existence of drainage facility across rural and urban areas. Only one-third of India's urban areas have a closed drainage system (similar to that of Chandigarh), less than half have access to an open drainage, and nearly one-fourth of urban households do not have access to a drainage system at all. The situation is even worse in the rural areas of the country.

In the sample of our cities, according to the 1991 Census of India, in Bangalore, Lucknow and Jaipur, both underground sewers and open surface drains co-existed (see Table 25). Pune and Chandigarh had only underground sewer systems (all in their municipal corporation limits), no open surface drains, based on 1991 data. As of 1991, Surat was the only one using cess pools, apart from underground sewers.[12]

In Surat, as of 2005, out of the total city area of 112.27 square kilometres, 90.54 % area and 94.68 % of the present population had been covered with sewerage systems (http://www.suratmunicipal.org). Surat Municipal Corporation has prepared a master plan for comprehensive sewerage system (planning for more than 500 kilometres of sewers and 6 sewage treatment works) to serve not only the domestic and commercial but also the industrial developments for the year 2021.

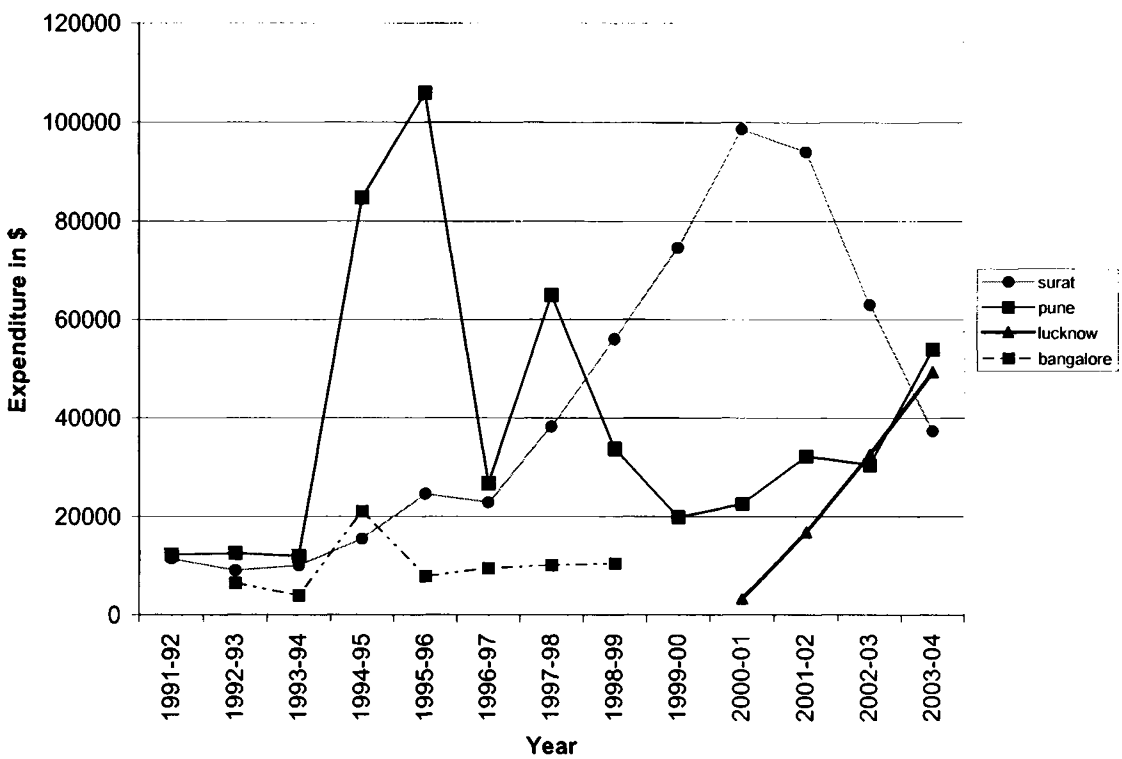
Tables 26-28 show, wherever they were available, expenditure on sewerage by category, collected and summarized from our primary data. Surprisingly, there are no significant differences in per capita expenditures on sewerage across benchmark and non-benchmark cities or BIMARU and non-BIMARU cities, over time. The only significant differences in terms of per capita spending on sewerage are across octroi and non-octroi cities (Table 28). We find, consistent with our expectation, that the octroi cities (Surat, Pune) spend significantly more per capita on sewerage than their non-octroi counterparts. With its spending, Surat has been able to cover most of the city with a sewerage network. Based on our computations, we find that with its expenditure on sewerage, Pune has also been able to cover roughly 72 percent of its land area with sewerage connections (as of 2003-04). Unfortunately, except for Chandigarh, we did not have information on other non-octroi cities' coverage of their sewerage networks. With its average spending of only $0.21 per capita during 2000-03, Chandigarh has been able to ensure a sewerage connection for every 8 people (Table 29). There is no question that its union territory status has contributed in no mean degree to its expenditure (Chandigarh became a municipal corporation only in 1994),[13] but this shows that finances of cities matter for provision of services.

Figure 2 shows the trend in total (capital and O&M) expenditures of the cities (for which the data were available) over time. Even in absolute terms, Surat and Pune are the highest spenders, both of which are octroi-levying cities. And, both these cities appear to have a fairly well-covered sewerage network as observed above. So it does seem that the solution to many problems India's cities are facing regarding sewerage, is lack of adequate spending on sewer networks. Even a high-water spender such as Bangalore has

[12] Comparable city-level data from the 2001 town directory are not yet available.
[13] All data we have presented for Chandigarh's public services are for the post-1996 period, after it became after it became a municipal corporation.

not invested much in the city's sewer networks. In the interests of comparing the actual expenditure of cities in the study with some requirements and benchmarks, we drew upon a few studies in the India Infrastructure Report (2006).

Figure 2: Capital and O&M Expenditures on Sewerage by City



Zerah (2006) summarizes the requirements of incremental investment in sewerage as being between INR 91.2 billion (about $1.97 billion) corresponding to a low urban population projection, and INR 165 billion (roughly $3.57 billion) for a high urban population projection scenario, over 2001-11, at 1995 prices. This assumes for large cities, full coverage by sewage with treatment, and for medium towns, public sewers with partial coverage by septic tanks and for small towns, low cost sanitation methods. These estimates have been summarized by Zerah (2006), based on a 1997 study by the National Institute of Urban Affairs. Using the urban population projection of 404.17 million for

2011 for urban India (National Institute of Urban Affairs, 2000, http://www.niua.org/newniuaorg/handbookindex.htm), this incremental investment need (for the low urban population projection) translates to a per capita requirement of nearly $4.89 ($8.83 per capita for the high urban population projection) for the urban population's sewerage needs during the entire period 2001-2011. Actual spending on sewerage infrastructure by the four cities that had information (Surat, Pune, Bangalore, Lucknow) are quite low. On average, annually during the period 1991-2004, these cities spent about $1.16 per capita (as annual average) on sewerage in constant 1995 terms. Surat was the highest spender with spending of $1.95 per capita on sewerage, trailed by Pune at $1.89 per capita. The high water spender Bangalore is a distant fourth in terms of spending on sewerage at only $0.31 per capita (or INR 14.29). However, the physical coverage of the sewerage to the city's residents is much inadequate in all the cities, based on visual inspection during field visits, since quantitative estimates are not available. So we find the estimates in Zerah (2006) are conservative, and there is no question that as far as sewerage is concerned, municipal finances are the core of the problem.

Street Lights

The Census of India's 1991 town directory contains information regarding the number of road lighting points by city. Table 30 summarizes this for the six cities of study. Table 30 shows that Jaipur, Chandigarh and Lucknow provided the best coverage in terms of coverage of households with their road lighting points, whereas Pune and Surat trailed the others in 1991. Note that the 1991 town directory summarizes data on the road lighting points, that is, number of electric connections existing for street lights, not street lights per se.

While even the India Infrastructure Report 2006 is characterized by the conspicuous absence of any discussion on street lights, we made an attempt in this study to examine the efficacy of expenditures on street lights in the chosen cities.

In order to develop a measure for street lights based on the primary data we collect, we attempted to capture the number of households (or housing units) covered by *new* street lights installed every year or the *total* number of street lights existing in a city in a given year.[14] For purposes of developing this measure of the service, we obtained data on population and households. Population and household data were readily available from the Census of India for 1991 and 2001. Since household data, as with population data, were unavailable for the non-census, intervening years, to get this for all years, we took the ratio of households to population for 1991 and 2001, using the respective year's census data. This provided information on the approximate number of persons per household for 1991 and 2001. We assumed that a similar trend regarding household size continued during 1992-2000. Making this assumption, we adjusted the projected population (described in an earlier section) for all intervening years, by the 1991 household-population ratio. This way, we arrived at estimates of the number of households for every non-census year. For post-2001 years, we made a similar

[14] In the case of Chandigarh, Surat, Lucknow and Jaipur, we had data on the *total* number of streetlights in the city by year, whereas in the case of Pune and Bangalore, we had data only on the *incremental* number of new streetlights installed in the city by year. Since we are interested in the total number of street lights, we leave out Pune and Bangalore for purposes of analyzing this service.

assumption about household size remaining constant since 2001, and estimated the number of households for all years during 2001-05.

Next, for purposes of understanding how many households are covered by a street light, we divided the number of households per year by the total number of street lights every year for cities in the study. So we study the total number of households covered by *total number of* street lights existing in the city (with the exception of Pune and Bangalore, where only data on the number of *new* street lights constructed every year were available).

Tables 31-33 summarize the per capita expenditures (capital and O&M) and service levels as defined above for cities classified by various types, based on the data we obtained from the cities. As with the other services, Table 31 shows that while average per capita expenditures on street lights are higher in the benchmark cities ($0.47) than in the non-benchmark ones ($0.28), the household coverage of street lights is remarkably better in the non-benchmark cities than in the benchmark cities. For instance, in the benchmark cities (Chandigarh and Surat), there is a street light for every 12 households, but in the other cities, there is one street light for every 4 households. Table 31 is quite revealing because it shows that higher per capita expenditures do not always translate into better service levels. To corroborate this further, we find that in one of our benchmark cities, Surat, over half of its expenditure over the years, is on operations and maintenance expenditures, hence household coverage by street lights is smaller compared with the other cities. Further, in both the benchmark cities, despite their higher expenditures (higher capital expenditures in the case of Chandigarh), installation of street lights has not kept pace with the growth in the number of households, whereas our non-benchmark cities such as Lucknow and Jaipur have done a much better job there. Since street lights are considered a proxy for safety, expenditures on this service throw light on the extent of crime in these cities as well.

When we study expenditure on street lights by other categories of cities, the octroi and fast-growing cities are the highest spenders (although still very low in per capita terms) on street lights (Tables 32-33). On average, octroi cities spend about $0.63 and the fast-growing cities spend about $0.53, compared with $0.29 in the non-octroi cities and $0.14 in the slow-growing cities respectively! These are per capita expenditures, so it is clear how much the cities are spending on this service. In terms of coverage, the non-octroi cities are better since they are able to ensure a street light for every 5 households whereas the octroi cities (only data on Surat were comparable with that of other non-octroi cities) provide one only for every 14 households. Surprisingly again, the slow-growing cities, with their lower average spending, provide a street light for every 5 households whereas the high spending fast-growing ones are able to afford a light only for every 13 households (Table 33).

Thus in the case of street lights, we fail to find an one-to-one relationship between spending and level of the service. It does appear that better spending cities are unable to ensure greater coverage of households with lights, and end up spending only on operations and maintenance of existing ones. Even when they spend on capital projects, they are unable to keep pace with population growth.

A study by PricewaterhouseCoopers (2001) updates the expenditure norms of the Zakaria committee report for Chhattisgarh for various urban services. It estimates the per capita norm for street lights in towns with greater than 2,000,000 population to be INR

59.26 ($1.28) per annum (at 2000-01 prices). While that study is only for cities in the state of Chhattisgarh, and we do not have any from that state chosen in this study, we use this study's estimates in the absence of better benchmarks. In contrast to this benchmark estimate of $1.28 as the per capita annual required spending on street lights, we find cities in our study, on average, spent an average of only $0.36 per capita (annual average) during 1994-2003, in constant 1993-94 prices. This is three and a half times lower than even the conservative estimates summarized by the PricewaterhouseCoopers study.

The India Infrastructure Report (1996) points out the standard (physical) norm for street lights in terms of distance between two lamp posts as being 30 metres. In our study, we were able to get information on physical norms only for Chandigarh. Here international norms are used for street lighting. The average distance between poles used for different types of roads is 27.67 metres, exceeding the standard norms summarized by the India Infrastructure Report (1996). The per capita total (annual) expenditure to exceed the standard norms has been only $0.17 in Chandigarh Municipal Corporation during 1999-2004, much lower than the average of all cities. While the physical norm based on distances between lamp posts has been exceeded in Chandigarh, the city's performance is unsatisfactory based on the measure we have developed – household coverage with streetlights. With its expenditure, Chandigarh has been able to cover every 11 households with a street light, but has been unable to keep pace with a growing population. As summarized above, other cities such as Lucknow and Jaipur have ensured much better coverage of households with streetlights with their per capita expenditure of $0.12 and $0.48 respectively.

This is a source of concern since the cities that cannot afford to spend cannot provide safety to its public. Hence they also cannot compete to attract residents or firms.

Sanitation

Table 34 summarizes sanitation data for all South Asian countries, including India, based on data reported by Water and Sanitation Program (South Asia). It shows that sanitation coverage in India leaves much to be desired when compared with countries such as Sri Lanka, Pakistan, Maldives, and even Bangladesh.

Table 35 summarizes data from the Census of India 2001 on the type of sanitation facility rural and urban households have access to. While majority (70 percent) of urban households have access to a bathroom facility within the house, less than half of the urban households have water closets. One-fourth of urban households do not have access to latrine within the house.

Motivated by the census data, we examined the level of service of sanitation facilities in cities and compared that with the expenditure in the cities we study. With a view to studying how to make cities open-defecation free, as stated at the beginning, we study construction of new sanitation facilities by year for every city. We measure sanitation by the number of new public toilets constructed every year. As in the case of street lights, data on the existing number of public toilets were not available, but only data on the *new toilets constructed each year* was available.[15] So we were able to compare only the incremental number of public toilets to population, to determine the extent of coverage.

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[15] We had data on the total number of public toilets by year in only two cities – Bangalore and Chandigarh. For the other cities – Jaipur, Pune and Surat, we had data only on the *incremental* number of new public toilets built by the city by year. In the interests of consistency, we converted the *total* information for Bangalore and Chandigarh into incremental terms. The sanitation

Tables 36-38 summarize the per capita expenditures on new public toilets constructed by year and by type of city, and the population covered by each new toilet. When we compare the benchmark with the non-benchmark cities (Table 36), the average per capita expenditure on new public toilets is much higher ($2.46) in the benchmark cities when compared to our non-benchmark cities ($0.34). Interestingly, however, the population coverage by the non-benchmark cities (131,710 for every new public toilet) is much better than in the benchmark cities (where there is one new toilet for every 357,005 persons!). This implies the benchmark cities have not constructed enough new public toilets to meet demands of an increasing population.

As Table 37 summarizes, the non-BIMARU cities spend higher ($1.98 per capita) than their BIMARU counterparts ($0.02) on sanitation, consistent with our expectation. But, with their lower spending on new public toilets, the BIMARU cities are able to cover the population with *new public toilets* in a much better way (constructing a toilet for every 46,835 persons) than the non-BIMARU cities (which provide a new public toilet only for every 258,534 persons!). The amount of spending on such a basic service is abysmally low.

The non-octroi cities spend higher in per capita terms ($2.39) than the octroi cities ($0.21) which is surprising (Table 38). The low level of spending in octroi cities also translates into a very poor level of service there as well (with one new public toilet for every 290,738 people), relative to the non-octroi cities (that constructed a new public toilet for every 226,718 population).

(number of public toilets) data for Lucknow was not available. The expenditure on sanitation for Lucknow was combined with that for sewerage.

Alternatively, it is possible that access to both *private and public* toilets is a much better measure of what we are trying to represent here. That is, what causes a city to be open-defecation free. However, apart from the Census, there is no micro-level data on sanitation facilities. The Census town directory of 1991 summarizes data on both public and private toilets for cities. Table 39 displays this for the selected cities of the study. Based on this, it does appear that sanitation access and coverage are much better in Pune, Surat and Bangalore (in that order) than in the BIMARU cities. Table 40 tabulates and summarizes from the Census of India (which may be derived from table 39 as well), the octroi, fast-growing, benchmark and non-BIMARU cities respectively have a toilet for every 10, 14, and 12 (each in the benchmark and non-BIMARU cities) persons, and perform better than their counterparts in terms of their coverage of population. We find that the total number of toilets (public and private) might be a good measure of what takes a city to be open-defecation free. Hence, based on data on the *total* (public and private) number of toilets and the cities' spending record, it does seem that lack of adequate spending might be the core of the issue even here.[16]

Zerah (2006) summarizes data on the per capita expenditure on sanitation from the Mumbai Metropolitan Regional Development Authority (MMRDA). These data show that the Mumbai Municipal Corporation spends Rs.54 per capita or ($1.17) on sanitation, higher than the average of all cities and time periods taken into account here in this study (roughly $0.80). As this study by Zerah (2006) summarizes, the average spending on sanitation by all municipal corporations and councils in the Mumbai urban agglomeration was much less than that incurred by cities of this study, at $0.24 (INR 11.05) as of 1999.

[16] Recall we do not venture into private provision of services here.

The III Working Group for the State Finance Commission on developing norms for various services summarizes past studies with regard to these services. For sanitation/sewerage, an ORG (1989) study calculates the cost of providing sanitation/sewerage at INR 587 per capita ($12.71) in metro centres (those with population of greater than a million).[17]

In cities with population between 100,000-million (Chandigarh's size), this study estimates this cost to be INR 604 ($13.08). Further, the IIR (1996) summarizes that to provide 100 percent sanitation coverage by the end of the Eighth plan (i.e., until 1997) itself required an investment of INR 202.60 billion at 1995 current prices. In per capita terms, using the NIUA's population projection of 255 million for 1996, this investment requirement translates to $17!

Comparing these investment requirements with the actual spending on sanitation by these cities ($0.80 per capita, summarized above), is only 6 percent of the recommended standard by the III Working Group (ORG study) and only 5 percent of the 1995 report's recommendation! Even the 1996 expert group report points out that the Eighth Plan provided for a meagre INR 57.57 billion for urban water supply and sanitation combined together. So we find lack of adequate spending is the problem.

Roads

The IIR 2006 makes an attempt to project travel demand for different categories of cities. Agarwal (2006) in the IIR 2006 summarizes travel demand projected by Rail India Technical and Economic Services (RITES). This study points out that although the population in class A cities (with population between 100,000 to 250,000) is estimated to

[17] Recall that all cities chosen for this study, with the exception of Chandigarh, are million-plus cities.

grow 2.5 times during 1991-2021, the corresponding intra-city travel demand would grow by 3.5 times during this period. Savage and Dasgupta (2006) summarize that in Bangalore the current vehicular number is 2 million, but is projected to go upto 3.7 million in 2021.

If this phenomenal increase in vehicular traffic were to continue, one solution is to build adequate length of good quality roads.[18] Wherever data on expenditures on municipal roads were available, we summarize them by relevant categories of cities used earlier. Tables 41 and 42 summarize the data we collect and compute, on per capita expenditures on municipal roads for benchmark/non-benchmark cities and octroi/non-octroi cities respectively. While census data (Table 44 on road density for cities) show that Chandigarh had the most dense network of roads (with 2.77 kilometres of roads for every 1,000 population there) as of 1991, Table 41 (on expenditure by our benchmark and non-benchmark cities) based on our primary data, shows that these cities (that includes Chandigarh) have spent less per capita on municipal roads than cities such as Pune and Bangalore, since 1991. According to 1991 census data, Pune was the city that had the highest proportion (93 percent) of surfaced roads to the total (Table 43). While in per capita terms the octroi cities in our study spent slightly more on municipal roads per capita than the non-octroi cities (Bangalore and Chandigarh) since 1991, the difference is not significant.

Figure 3 shows the total (capital and O&M) actual expenditure incurred by cities over time, based on the data available. The figure shows that in absolute terms, Bangalore

[18] Another solution is of course to restrict the rising number of private vehicles and encourage mass transportation options such as the metro, or bus systems. But the scope of the study does not permit us to get into such issues here.

is the highest spender with peak in 2001-02. Pune exhibits a secular trend of increasing expenditures on roads.

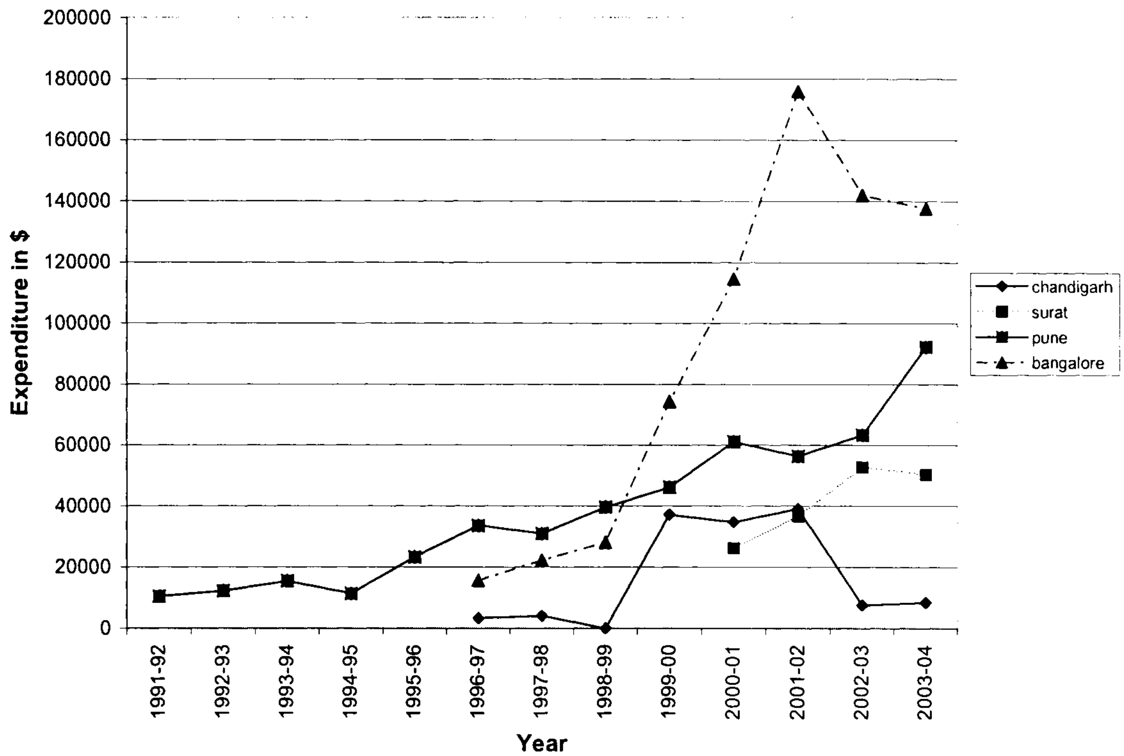
We also made an attempt to assess the extent of damage imposed by an increasing population, and what is needed to offset the costs. In the cities we visited, we attempted to find if there was a discrepancy between the life of municipal roads that they were ideally constructed for, and the actual period for which they lasted. We did this in order to examine if there were demands imposed by an increasing population and traffic density on the city's road infrastructure. We did find in the case of many cities there was discrepancy between the optimal and the actual life of municipal roads, as for example, in Lucknow. The discrepancy was attributed by officials to corruption. The use of sub-standard material by contractors ensured that the roads would get washed away, or become speckled with potholes and muddles, in the event of a downpour, much earlier than anticipated.

In the case of Bangalore, where the migration is of a highly-skilled nature, it is possible to believe that the city's high-technology firms have contributed significantly to the state of the roads (for instance, only 89 percent of surfaced roads to total as of 1991, Table 43). There are several high-technology giants such as Infosys, and WIPRO that have several thousands of employees that commute to work daily, and these migrants are the biggest cause of the problem.[19] Savage and Dasgupta (2006) in fact report that Bangalore's travel time (one way work trip) increased from 24 minutes in 1991 to 40 minutes in 2001-02. In relation to the size of the problem, it does seem that the spending

[19] This was confirmed in some discussions we had in Bangalore. We refrain from reporting the names of individuals or organizations for reasons of confidentiality.

by Bangalore, while being high in absolute terms, has not kept pace with its population growth.

Figure 3: Total (Capital and O&M) Municipal Road Expenditures by City



We computed per capita investment requirements for municipal roads based on the India Infrastructure Report (1996) for the states in which our sample cities are located, and compared them with the actual expenditure on roads by these cities. Table 45 summarizes the various estimates of (per capita) investment requirements for municipal roads. The results are startling. While the per capita investment requirements range from a low of $0.85 (Zakaria committee's estimate for Karnataka) to $1.77 (Government of India Planning Commission's high end estimate for Uttar Pradesh), cities in these states according to the data available to us are spending about $1.53 per capita in 1994-95 prices, with Bangalore spending in fact \$2.07 per capita during 1996-2003 in per capita terms, on municipal roads, much higher than these required estimates. But the traffic woes of Bangalore do show that the investment requirements in urban roads made by the IIR (1996) are highly conservative.

Concluding remarks

We started this study by answering questions regarding the marginal costs of water supply and expenditures on other services. We find that a few cities spend abysmally low on all services including water supply. When these low-spending cities are excluded, we find that the supply of every additional kilo litre of water imposes extra burden on the cities ranging from \$0.06 to \$0.11, as marginal operating costs. This, while being lower than the evidence from the literature, of course excludes the capacity costs of creating assets such as civil works and plant/equipment needed to supply water. Even based on these short-run marginal cost estimates, some Indian cities such as Jaipur and Pune are under-charging their water.

As far as the other services are concerned, cities' per capita expenditures on basic services such as sanitation and sewerage (let alone street lights) appear to be abysmally low, let alone adequate in any sense to meet the demands of an increasing population. Further, spending alone is not sufficient, since O&M expenditures might just mean increased salaries without improving service levels. So we find weak municipal finances might still be the core of the issue.

Table 1: Access to Water Supply in South Asian Countries

		Population		Water coverage (%)	
Country	**Year**	**Total**	**% Urban**	**Total**	**Urban**
Afghanistan	1990	13799000	18	NA	NA
	2002	22930000	23	13	19
Bangladesh	1990	109402000	20	71	83
	2002	143809000	24	75	82
Bhutan	1990	1696000	5	NA	NA
	2002	2190000	8	62	86
India	1990	846418000	26	68	88
	2002	1049549000	28	86	96
Iran (Islamic Republic of)	1990	56703000	56	91	98
	2002	68070000	66	93	98
Maldives	1990	216000	26	99	100
	2002	309000	28	84	99
Nepal	1990	18625000	9	69	94
	2002	24609000	15	84	93
Pakistan	1990	110901000	31	83	95
	2002	149911000	34	90	95
Sri Lanka	1990	16830000	21	68	91
	2002	18910000	21	78	99

Source: WHO-UNICEF, JOINT MONITORING PROGRAMME (Retrieved from the Water and Sanitation Program's website: http://www.wsp.org/ Retrieved May 18, 2006.)

Table 2: Important Sources of Drinking Water in the Selected Cities

Name of Town	**Tap water**	**Well water**	**Tank water**	**Tube well/ hand-pump**
Bangalore	√	-	-	-
Chandigarh	√	-	-	-
Jaipur	√	-	-	√
Lucknow	-	-	√	√
Pune	√	-	-	-
Surat	√	-	-	√

Source: Census of India 1991 Town Directory.

Table 3: Capital Expenditure on Water Supply: All Cities

	Per capita expenditure (in constant 1993-94 prices, US$**)				Water supply per capita per day* (Litres)	
Year	**Average**	**Stdev**	**Max**	**Min**	**Average**	**Stdev**
1991	1.09	1.12	2.32	0.01	206.13	99.65
1992	0.57	0.69	1.58	0.01	195.59	98.51
1993	0.47	0.40	0.95	0.01	239.98	148.26
1994	1.08	1.17	2.44	0.01	243.06	135.64
1995	0.97	0.65	1.84	0.01	257.54	147.88
1996	1.42	1.28	3.76	0.01	250.46	136.99
1997	1.05	0.82	2.22	0.00	246.11	130.14
1998	1.76	1.41	3.49	0.01	248.09	116.49
1999	2.40	2.65	6.96	0.00	248.13	103.73
2000	2.82	3.32	8.61	0.00	246.36	96.55
2001	2.22	3.70	9.68	0.00	244.56	96.48
2002	2.26	3.51	9.36	0.00	254.96	92.17
2003	1.20	0.95	2.62	0.01	248.48	84.61
Average	$1.49				**240.73**	

*The water supply data are net of leakages.
**The data in Indian rupees (INR) were converted into US$ by using the exchange rate $1=INR 46.18, as reported by the Reserve Bank of India on December 6, 2005.

Table 4: Operations and Maintenance Expenditure on Water Supply: All Cities

	Per capita expenditure (in constant 1993-94 prices, US$)				Water supply per capita per day (Litres)	
Year	**Average**	**Stdev**	**Max**	**Min**	**Average**	**Stdev**
1991	2.09	2.25	4.69	0.04	206.13	99.65
1992	2.16	2.38	5.40	0.03	195.59	98.51
1993	2.11	2.50	6.01	0.03	239.98	148.26
1994	2.59	3.44	8.27	0.03	243.06	135.64
1995	2.52	3.10	7.06	0.03	257.54	147.88
1996	3.23	3.41	8.56	0.03	250.46	136.99
1997	3.37	3.28	6.94	0.03	246.11	130.14
1998	3.60	3.48	7.60	0.03	248.09	116.49
1999	4.28	3.47	7.61	0.03	248.13	103.73
2000	4.66	3.95	9.21	0.03	246.36	96.55
2001	4.19	3.81	8.82	0.03	244.56	96.48
2002	4.40	4.24	10.25	0.03	254.96	92.17
2003	3.28	3.54	8.55	0.03	248.48	84.61
Average	**3.27**				**240.73**	

Table 5: Capital Expenditures on Water Supply and Service for Benchmark and Other Cities

	Benchmark Cities				Non-Benchmark Cities			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	**Average**	**Stdev**	**Average**	**Stdev**	**Average**	**Stdev**	**Average**	**Stdev**
1996	2.24	2.14	267.71	216.78	1.01	0.72	241.84	123.76
1997	1.62	0.86	266.99	210.17	0.67	0.66	235.67	114.30
1998	2.26	1.74	268.72	181.32	1.50	1.43	237.77	105.99
1999	4.17	3.95	284.14	134.29	1.51	1.85	230.13	103.08
2000	2.87	2.83	285.43	108.38	2.80	3.96	226.82	100.47
2001	1.20	0.76	294.10	108.90	2.73	4.65	219.79	95.43
2002	1.10	0.30	289.83	98.96	2.85	4.38	231.72	100.34
2003	2.00	0.87	280.70	89.00	0.67	0.61	227.01	92.88
Average	**2.18**		**279.70**		**1.72**		**231.34**	

Table 6: O&M Expenditures on Water Supply and Service for Benchmark and Other Cities

	Benchmark Cities				Non-Benchmark Cities			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	**Average**	**Stdev**	**Average**	**Stdev**	**Average**	**Stdev**	**Average**	**Stdev**
1996	2.66	2.21	267.71	216.78	3.51	4.18	241.84	123.76
1997	3.86	3.82	266.99	210.17	3.12	3.58	235.67	114.30
1998	4.50	4.38	268.72	181.32	3.15	3.60	237.77	105.99
1999	5.82	2.10	284.14	134.29	3.51	4.03	230.13	103.08
2000	6.24	2.93	285.43	108.38	3.87	4.55	226.82	100.47
2001	5.79	4.29	294.10	108.90	3.38	3.94	219.79	95.43
2002	5.42	3.97	289.83	98.96	3.89	4.87	231.72	100.34
2003	5.71	4.02	280.70	89.00	1.65	2.66	227.01	92.88
Average	**5.00**		**265.18**		**3.26**		**231.34**	

Table 7: Capital Expenditures on Water Supply and Service for Non-Municipal Provider Cities and Municipal Provider Cities

	Non-municipal Provider Cities				Municipal Provider Cities			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	Average	Std.Dev	Average	Std.Dev	Average	Std.Dev	Average	Std.Dev
1991	1.36	1.20	149.69	34.30	0.27	0.00*	262.56	118.72
1992	0.64	0.83	149.00	41.48	0.37	0.00*	242.18	126.60
1993	0.43	0.48	168.00	42.95	0.59	0.00*	311.97	193.82
1994	0.88	1.35	184.39	42.37	1.66	0.00*	301.72	184.04
1995	0.68	0.58	184.15	37.90	1.40	0.63	330.92	192.55
1996	0.85	0.79	181.62	34.91	2.00	1.57	319.30	177.43
1997	0.67	0.66	180.03	32.03	1.62	0.86	312.19	167.97
1998	1.18	1.56	189.15	51.68	2.34	1.23	307.02	144.35
1999	1.52	2.26	183.56	54.08	3.28	3.19	312.71	107.07
2000	3.07	4.81	181.46	52.91	2.58	2.06	311.25	88.73
2001	3.38	5.46	177.80	55.48	1.05	0.60	311.33	82.58
2002	3.56	5.07	182.83	76.12	0.97	0.31	303.05	73.63
2003	0.40	0.56	183.53	76.88	1.74	0.76	291.79	65.80
Average	**1.43**		**176.55**		**1.53**		**301.38**	

Table 8: O&M Expenditures on Water Supply and Service for Non-Municipal Provider Cities and Municipal Provider Cities

	Non-municipal Provider Cities				Municipal Provider Cities			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	Average	Stdev	Average	Stdev	Average	Stdev	Average	Stdev
1991	1.53	2.42	149.69	34.30	2.94	2.47	262.56	118.72
1992	1.86	3.07	149.00	41.48	2.61	1.78	242.18	126.60
1993	2.07	3.42	168.00	42.95	2.18	1.25	311.97	193.82
1994	2.80	4.73	184.39	42.37	2.27	1.51	301.72	184.04
1995	2.40	4.03	184.15	37.90	2.69	2.44	330.92	192.55
1996	2.91	4.90	181.62	34.91	3.55	2.20	319.30	177.43
1997	2.36	3.96	180.03	32.03	4.38	2.85	312.19	167.97
1998	2.40	4.01	189.15	51.68	4.80	3.14	307.02	144.35
1999	2.57	4.36	183.56	54.08	5.99	1.51	312.71	107.07
2000	3.13	5.26	181.46	52.91	6.20	2.07	311.25	88.73
2001	2.82	4.62	177.80	55.48	5.55	3.06	311.33	82.58
2002	3.47	5.87	182.83	76.12	5.33	2.81	303.05	73.63
2003	0.12	0.13	183.53	76.88	5.38	2.90	291.79	65.80
Average	**2.34**		**176.55**		**4.14**		**301.38**	

Table 9: Capital Expenditures on Water Supply and Service for Cities with and without Octroi

	Cities with Octroi				Cities without Octroi			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	Average	Stdev	Average	Stdev	Average	Stdev	Average	Stdev
1995	1.40	0.63	230.84	184.75	0.68	0.58	25.44	24.28
1996	2.63	1.59	226.18	170.55	0.82	0.65	34.24	36.33
1997	2.22		221.56	157.28	0.76	0.57	29.33	30.78
1998	2.99	0.71	220.89	140.92	1.14	1.27	64.93	67.98
1999	4.23	3.86	229.73	124.87	1.48	1.85	91.81	95.06
2000	3.43	2.04	234.12	118.15	2.52	4.07	195.27	198.72
2001	1.25	0.69	229.29	110.90	2.70	4.66	220.93	223.58
2002	0.80	0.13	226.12	100.39	3.00	4.29	210.18	216.30
2003	1.30	0.12	220.30	92.43	1.14	1.34	60.97	60.26
Average	**2.25**		**226.56**		**1.35**		**85.03**	

Table 10: O&M Expenditures on Water Supply and Service for Cities with and without Octroi

	Cities with octroi				Cities without octroi			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	Average	Stdev	Average	Stdev	Average	Stdev	Average	Stdev
1991	2.94	2.47	205.75	93.92	1.53	2.42	206.31	116.66
1992	2.61	1.78	183.62	107.16	1.86	3.07	201.57	110.47
1993	2.18	1.25	296.37	271.43	2.07	3.42	211.79	94.33
1994	2.27	1.51	283.87	256.58	2.80	4.73	222.65	83.98
1995	2.69	2.44	275.98	236.73	2.40	4.03	248.31	132.01
1996	3.21	2.99	268.45	217.83	3.24	4.05	241.47	123.04
1997	3.28	3.01	260.48	200.96	3.41	3.86	238.93	120.65
1998	3.40	2.83	262.06	171.90	3.70	4.18	241.10	112.13
1999	5.33	1.40	279.51	127.74	3.75	4.28	232.44	107.28
2000	5.14	1.36	285.84	108.96	4.43	5.02	226.62	100.10
2001	3.92	1.64	281.44	91.00	4.32	4.82	226.12	106.74
2002	3.88	1.80	274.67	77.53	4.66	5.35	241.82	115.48
2003	3.79	1.30	265.87	68.03	2.93	4.87	236.90	107.24
Average	**3.43**		**263.38**		**3.16**		**228.92**	

Table 11: Capital Expenditures on Water Supply and Service for Cities by Population Growth

	Fast-growing cities				Slow- growing cities			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	Average	Stdev	Average	Stdev	Average	Stdev	Average	Stdev
1991	0.14	0.18	199.80	67.20	2.04	0.40	212.45	142.09
1992	0.19	0.25	187.59	76.09	0.95	0.89	203.58	135.21
1993	0.30	0.41	242.15	213.68	0.64	0.43	237.82	96.35
1994	0.84	1.17	234.40	200.64	1.32	1.59	251.71	74.24
1995	0.93	0.92	230.84	184.75	1.02	0.06	284.23	135.64
1996	1.75	1.89	226.18	170.55	1.09	0.43	274.75	126.74
1997	1.11	1.57	221.56	157.28	1.01	0.33	270.66	125.67
1998	1.99	1.79	220.89	140.92	1.52	1.25	275.28	108.86
1999	2.82	3.66	229.73	124.87	1.97	1.91	266.53	101.45
2000	2.29	2.45	234.12	118.15	3.36	4.55	258.59	94.32
2001	0.83	0.87	229.29	110.90	3.60	5.27	259.83	101.35
2002	0.53	0.47	226.12	100.39	3.99	4.65	298.22	87.08
2003	0.87	0.75	220.30	92.43	1.71	1.29	290.76	74.78
Average	**1.12**		**223.31**		**1.86**		**260.34**	

Table 12: O&M Expenditures on Water Supply and Service for Cities by (Population) Growth during the 1990s

	Rapid growth cities				Slow-growth cities			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	Average	Stdev	Average	Stdev	Average	Stdev	Average	Stdev
1991	1.97	2.42	199.80	67.20	4.50	0.26	212.45	142.09
1992	1.75	1.95	187.59	76.09	4.63	1.08	203.58	135.21
1993	1.47	1.53	242.15	213.68	4.54	2.08	237.82	96.35
1994	1.53	1.68	234.40	200.64	5.81	3.48	251.71	74.24
1995	1.80	2.31	230.84	184.75	5.74	1.87	284.23	135.64
1996	2.15	2.80	226.18	170.55	6.04	2.26	274.75	126.74
1997	2.20	2.84	221.56	157.28	6.30	0.79	270.66	125.67
1998	2.28	2.79	220.89	140.92	6.67	1.14	275.28	108.86
1999	3.56	3.21	229.73	124.87	7.08	0.68	266.53	101.45
2000	3.44	3.10	234.12	118.15	7.88	1.60	258.59	94.32
2001	2.62	2.53	229.29	110.90	7.35	2.00	259.83	101.35
2002	2.60	2.56	226.12	100.39	7.88	2.57	298.22	87.08
2003	2.54	2.36	220.30	92.43	6.63	2.71	290.76	74.78
Average	**2.30**		**223.31**		**6.23**		**260.34**	

Table 13: Capital Expenditures on Water Supply and Service for Cities by State

	BIMARU cities				Non-BIMARU cities			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	Average	Stdev	Average	Stdev	Average	Stdev	Average	Stdev
1991	0.88	1.23	154.77	46.88	1.29	1.45	231.81	114.81
1992	0.16	0.22	155.71	56.32	0.97	0.86	215.53	116.31
1993	0.17	0.23	174.93	58.31	0.77	0.26	272.51	176.84
1994	0.10	0.13	172.63	52.54	2.05	0.55	278.27	157.42
1995	0.53	0.74	174.98	48.67	1.26	0.50	298.82	169.83
1996	0.49	0.68	173.82	45.53	1.89	1.30	288.78	157.21
1997	0.34	0.48	174.02	42.84	1.52	0.63	282.16	149.72
1998	0.29	0.41	190.20	73.05	2.49	1.05	277.03	132.25
1999	0.22	0.30	184.25	76.47	3.49	2.64	280.08	109.10
2000	0.30	0.42	183.48	74.66	4.09	3.45	277.79	98.62
2001	0.23	0.32	180.29	78.22	3.21	4.35	276.70	96.67
2002	0.66	0.92	182.83	76.12	3.07	4.20	303.05	73.63
2003	0.40	0.56	183.53	76.88	1.74	0.76	291.79	65.80
Average	**0.37**		**175.80**		**1.97**		**274.95**	

Table 14: O&M Expenditures on Water Supply and Service for Cities by State

	Cities in BIMARU states				Cities in non-BIMARU states			
	Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)		Per capita expenditure (in constant 1993-94 prices, US$)		Water supply per capita per day (Litres)	
Year	Average	Stdev	Average	Stdev	Average	Stdev	Average	Stdev
1991	0.14	0.14	205.75	93.92	3.40	1.92	206.31	116.66
1992	0.09	0.08	183.62	107.16	3.54	2.05	201.57	110.47
1993	0.09	0.09	296.37	271.43	3.46	2.38	211.79	94.33
1994	0.07	0.06	283.87	256.58	4.27	3.62	222.65	83.98
1995	0.08	0.07	275.98	236.73	4.15	3.05	248.31	132.01
1996	0.08	0.07	268.45	217.83	4.80	3.08	241.47	123.04
1997	0.07	0.06	260.48	200.96	5.02	2.66	238.93	120.65
1998	0.08	0.07	262.06	171.90	5.35	2.80	241.10	112.13
1999	0.05	0.03	279.51	127.74	6.39	1.48	232.44	107.28
2000	0.09	0.08	285.84	108.96	6.95	2.27	226.62	100.10
2001	0.15	0.17	281.44	91.00	6.20	2.82	226.12	106.74
2002	0.09	0.08	274.67	77.53	6.56	3.37	241.82	115.48
2003	0.12	0.13	265.87	68.03	5.38	2.90	236.90	107.24
Average	**0.09**		**263.38**		**5.04**		**228.92**	

***For 1991-94, the capital expenditures are just for Surat, hence the standard deviation is 0. Pune did not supply data on capital expenditures for those years and Chandigarh became a municipal corporation only in 1996.**

Table 15-1: Estimation of Expenditure on (Net) Water Supply

Dependent Variable: Operations & Maintenance Expenditure, all Cities (deflated in 1993-94 prices)

	OLS estimates			**2SLS estimates**			
Variable	**Coeff.**	**Std.Err.**	**t-ratio**	**Coeff.**	**Std.Err.**	**t-ratio**	**Variable Mean**
ONE	-409392000*	218210000	-1.8761	-409392000**	204117000	-2.0057	
RAINFALL	1090410	1023420	1.0655	1090410	957319	1.1390	66.61
ALTITUDE	1355690***	157051	8.6322	1355690***	146908	9.2282	350.88
P_INDEX	2360240***	880440	2.6808	2360240***	823576	2.8658	132.48
NWSLITANN	0.39	1.12	0.3456	0.3883	1.0512	0.3694	118,240,560
LEAKAGES	-9846940*	5299500	-1.8581	-9846940*	4957230	-1.9864	25.88
OCTROI	242468000	160781000	1.5081	242468000	150397000	1.6122	0.38
PARASTAT	66006300	143749000	0.4592	66006300	134465000	0.4909	0.58
Dependent Variable Mean	**371,780,893**						
Adjusted R^2	**0.79**						

Number of observations=64

***Statistically significant at the 1 percent level.
*Statistically significant at the 10 percent level.

Table 15-2: Estimation of Expenditure on (Net) Water Supply, Controlling for Water supply Duration

Dependent Variable: Operations & Maintenance Expenditure, all Cities (deflated in 1993-94 prices)

	OLS Estimates			2SLS Estimates			
	Coeff.	Std.Err.	t-ratio	Coeff.	Std.Err.	t-ratio	Variable Mean
ONE	-337056000	261870000	-1.29	-337056000	242444000	-1.39	
RAINFALL	1254560	1142480	1.10	1254560	1057730	1.19	66.69
ALTITUDE	1573830***	171535	9.17	1573830***	158811	9.91	362.76
P_INDEX	2820880***	941505	3.00	2820880***	871664	3.24	134.84
NWSANN	-1.06	0.83	-1.28	-1.06	0.77	-1.38	116136130
LEAKAGES	-8732970	6330150	-1.38	-8732970	5860580	-1.49	26.51
OCTROI	237953000	200904000	1.18	237953000	186001000	1.28	0.38
PARASTAT	74654800	173730000	0.43	74654800	160843000	0.46	0.57
WSHOURS	-15932000	15026100	-1.06	-15932000	13911500	-1.15	4.35
Dependent Variable Mean	**407,709,732.80**						
Adjusted R^2	**0.82**						

Number of observations=63

***Statistically significant at the 1 percent level.

Table 15-3: Estimation of Expenditure on Water Supply, Using Double Log Form

Dependent Variable: Log of Operations & Maintenance Expenditure, all Cities (deflated in 1993-94 prices)

	OLS estimates			2SLS estimates			
Variable	**Coeff.**	**Std.Err.**	**t-ratio**	**Coeff.**	**Std.Err.**	**t-ratio**	**Variable Mean**
ONE	-1.5000	5.1785	-0.2897	-4.7291	5.9797	-0.7909	
RAINFALL	0.0055*	0.0030	1.8225	0.0048*	0.0029	1.6496	66.61
ALTITUDE	0.0058***	0.0004	13.6956	0.0056***	0.0004	13.1020	350.88
P_INDEX	0.0030	0.0026	1.1641	0.0025	0.0025	0.9862	132.48
Log of net annual water supply	1.1425***	0.3051	3.7453	1.3341***	0.3531	3.7782	18.49
LEAKAGES	-0.1113***	0.0153	-7.2900	-0.1136***	0.0145	-7.8113	25.88
OCTROI	0.6921	0.4542	1.5240	0.5939	0.4393	1.3520	0.38
PARASTAT	-2.7948***	0.4125	-6.7755	-2.8754***	0.3968	-7.2458	0.57
Dependent Variable Mean	**18.17**						
Adjusted R^2	**0.92**						

Number of observations=64

***Statistically significant at the 1 percent level.
*Statistically significant at the 10 percent level.

Table 15-4: Estimation of Expenditure on (Net) Water Supply, for Non-Municipal Bodies

Dependent Variable: Operations & Maintenance Expenditure (deflated in 1993-94 prices)

	OLS Estimates			**2SLS Estimates**			
Variable	**Coeff.**	**Std.Err.**	**t-ratio**	**Coeff.**	**Std.Err.**	**t-ratio**	**Variable Mean**
ONE	-1049370000***	107787000	-9.7356	-1049370000***	98661200	-10.6361	
RAINFALL	44125	789464	0.0559	44125	722624	0.0611	67.78
ALTITUDE	1079310***	99483	10.8491	1079310***	91061	11.8526	395.09 metres
P_INDEX	17985	653323	0.0275	17985	598009	0.0301	134.86
NWSANN	2.5273***	0.8100	3.1202	2.5273***	0.7414	3.4088	116,902,220
LEAKAGES	30721700***	4498710	6.8290	30721700***	4117820	7.4607	23.46%
Dependent Variable Mean	398,800,236.80						
Adjusted R^2	**0.96**						

Number of observations=37

Table 15-5: Estimation of Expenditure on (Net) Water Supply, for Municipal Bodies

Dependent Variable: Operations & Maintenance Expenditure (deflated in 1993-94 prices)

	OLS Estimates			**2SLS Estimates**			
Variable	**Coeff.**	**Std.Err.**	**t-ratio**	**Coeff.**	**Std.Err.**	**t-ratio**	**Variable Mean**
ONE	213755000	251400000	0.8503	213755000	221714000	0.9641	
RAINFALL	-1370080*	788454	-1.7377	-1370080*	695351	-1.9704	65.01
ALTITUDE	580232*	326998	1.7744	580232*	288385	2.0120	290.28
P_INDEX	991955	768470	1.2908	991955	677727	1.4637	129.21
NWSANN	3.3912***	0.9923	3.4176	3.39***	0.88	3.8752	120,074,570
LEAKAGES	-16916800	11465200	-1.4755	-16916800	10111300	-1.6731	29.19%
Dependent Variable Mean	**334,754,384**						
Adjusted R^2	**0.68**						

Number of observations=27

Table 15-6: Estimation of Water Supply Expenditures, low-spending cities excluded

Dependent Variable: Operations & Maintenance Expenditure (deflated in 1993-94 prices)

	OLS estimates			2SLS estimates			
	Coeff.	**Std.Err.**	**t-ratio**	**Coeff.**	**Std.Err.**	**t-ratio**	**Variable Mean**
ONE	-398399000***	146249000	-2.7241	-398399000	130389000	-3.0555	
RAINFALL	-1160020	804080	-1.4427	-1160020	716882	-1.6182	71.96
ALTITUDE	-1033960***	257338	-4.0179	-1033960***	229431	-4.5066	487.12
P_INDEX	1634950**	796399	2.0529	1634950**	710034	2.3026	128.64
Net water supply	2.6200**	0.9782	2.6785	2.6200**	0.8721	3.0043	135,764,470
LEAKAGES	31132200***	6012290	5.1781	31132200***	5360300	5.8079	28.42
OCTROI	-366465000***	119914000	-3.0561	-366465000***	106910000	-3.4278	0.62
PARASTAT	1187610000***	138763000	8.5586	1187610000***	123715000	9.5996	0.31
Dependent Variable Mean	**605,248,321.90**						
Adjusted R^2	**0.93**						

Number of observations=39

***Statistically significant at the 1 percent level.
**Statistically significant at the 5 percent level.

Table 15-7: Estimation of Water Supply Expenditures (Controlling for Water supply Duration), low-spending cities excluded

Dependent Variable: Operations & Maintenance Expenditure (deflated in 1993-94 prices)

	OLS estimates			2SLS estimates			
	Coeff.	**Std.Err.**	**t-ratio**	**Coeff.**	**Std.Err.**	**t-ratio**	**Variable Mean**
ONE	403246000**	188088000	2.14	403246000**	167691000	2.40	
RAINFALL	-725718	1031570	-0.70	-725718	919701	-0.79	72.15
ALTITUDE	-48787	265291	-0.18	-48787	236522	-0.21	501.23
P_INDEX	2755060***	992242	2.78	2755060***	884639	3.11	132.45
Net water supply	-0.62	0.60	-1.03	-0.62	0.53	-1.15	131001910
LEAKAGES	39387600***	8109960	4.86	39387600***	7230480	5.45	29.41
OCTROI	-909550000***	170240000	-5.34	-909550000***	151779000	-5.99	0.62
Number of hours of water supply	-136936000***	17592000	-7.78	-136936000***	15684300	-8.73	4.06
Dependent Variable Mean	**653,821,675.3**						
Adjusted R^2	**0.92**						

Number of observations=39

***Statistically significant at the 1 percent level.
**Statistically significant at the 5 percent level.

Table 15-8: Expenditure Regressions for Fast-Growing Cities

	OLS estimates			**2SLS estimates**			
	Coeff.	**Std.Err.**	**t-ratio**	**Coeff.**	**Std.Err.**	**t-ratio**	**Variable Mean**
ONE	-352761000*	203387000	-1.73	-352761000*	186168000	-1.89	
RAINFALL	-1048110	725246	-1.45	-1048110	663843	-1.58	56.24
ALTITUDE	-715109*	398242	-1.80	-715109*	364525	-1.96	246.75
P_INDEX	-541579	569928	-0.95	-541579	521675	-1.04	129.86
Net water supply	5.05***	0.76	6.65	5.05***	0.69	7.27	158,519,210
LEAKAGES	12265800	10236500	1.20	12265800	9369780	1.31	28.10
Dependent variable mean	**218,216,083**						
Adjusted R^2	**0.77**						

Number of observations=37

***Statistically significant at the 1 percent level.
*Statistically significant at the 10 percent level.

Table 15-9: Expenditure Regressions for Slow-Growing Cities

	OLS estimates			**2SLS estimates**			
	Coeff.	**Std.Err.**	**t-ratio**	**Coeff.**	**Std.Err.**	**t-ratio**	**Variable Mean**
ONE	-1052430000***	124751000	-8.4363	-1052430000***	110020000	-9.5658	
RAINFALL	213324	837460	0.2547	213324	738570	0.2888	81.21
ALTITUDE	1125800***	85795	13.1219	1125800***	75664	14.8788	505.17
P_INDEX	294778	673557	0.4376	294778	594021	0.4962	136.16
Net water supply	0.32	0.88	0.3619	0.32	0.78	0.4103	136,525,070
LEAKAGES	41460500***	5494390	7.5460	41460500***	4845600	8.5563	23.28
Dependent variable mean	**582,221,557**						
Adjusted R^2	**0.97**						

Number of observations=27

***Statistically significant at the 1 percent level.

Table 16: Current Water Tariff Structure for Metered Water Connections

<table>
<tr><th>City</th><th colspan="5">Rate of Water Tariffs (rate per kiloliter)</th></tr>
<tr><th></th><th>Duration</th><th>Domestic</th><th colspan="3">Non-domestic</th></tr>
<tr><td>Chandigarh</td><td>From 31.3.2002 till now</td><td>1-15 kilo litres @ $ 0.04 (INR 1.75)
15-30 kilo litres @ $ 0.08 (INR 3.50)
30-60 kilo litres @ $0.11 (INR 5.00)
above 60 kilo litres @ $0.13 (INR 6.00)
Weighted average: $0.11 (INR 5.01) per KL</td><td colspan="3">Institutional: $0.19 (INR 9)
For government & semi-government offices $0.26 (INR 12).
For industrial, semi-industrial, commercial establishments $0.24 (INR 11).</td></tr>
<tr><td>Surat</td><td></td><td>All unmetered Monthly $5.20 (INR 240) (not consumption-based)</td><td colspan="3"></td></tr>
<tr><td rowspan="2">Pune</td><td>1.4.2000 to 31.3.2005</td><td>$ 0.06 (INR.3.00) per kilo liter</td><td colspan="3">$0.35 (INR16.00)</td></tr>
<tr><td>from 1.4.2005 till now</td><td>$ 0.06 (INR.3.00) per kilo liter</td><td colspan="3">$0.45 (INR21.00)</td></tr>
<tr><td>Bangalore</td><td>current</td><td>$0.42 (INR 19.44) per kilo liter</td><td colspan="3">$0.13 to $1.30 (INR 6 to INR 60.00)</td></tr>
<tr><td rowspan="4">Jaipur</td><td rowspan="4">From 1.6.98 till now</td><td rowspan="4">upto 15 kilo litres @ $0.03 (INR 1.56)
15-40 kilo litres @ $0.06 (INR 3.00)
above 40 kilo litres @ $0.09 (INR 4.00)
Weighted average: $0.07 per KL (INR 3.39)</td><td>Limit</td><td>Non-domestic</td><td>Industrial</td></tr>
<tr><td>upto 15 kilo litres</td><td>$0.10 (INR 4.68)</td><td>$0.24 (INR 11.00)</td></tr>
<tr><td>15-40 kilo litres</td><td>$0.18 (INR 8.25)</td><td>$0.30 (INR 13.75)</td></tr>
<tr><td>Above 40 kilo litres</td><td>$0.24 (INR 11.00)</td><td>$0.36 (INR 16.50)</td></tr>
<tr><td>Lucknow</td><td>Current</td><td>$0.05 (INR 2.45) per kilo liter</td><td colspan="3">Non-domestic: $0.27 (INR 12.25)
Commercial: $0.30 (INR 7.35)
Government: $0.36 (INR 4.90)</td></tr>
</table>

Source: Individual cities, Service providers, and authors' computations.

Table 17: Predicted Expenditures, Costs, and Actual Expenditures

	Predicted expenditure (in US$)	**Predicted costs (in US$)**	**Actual expenditure (in US$)**	**Expenditure as % of costs**
Bangalore	24,090,300	26,705,178	25,140,503	94.14%
Chandigarh	5,313,831	10,338,228	5,745,929	55.58%
Lucknow	1,714,474	3,528,495	300,681	8.52%
Jaipur	721,793	3,792,433	61,147	1.61%
Pune	13,728,940	15,337,757	10,489,382	68.39%
Surat	9,143,165	7,474,064	3,277,866	43.86%
Average	**9,118,750**	**11,196,026**	**7,502,585**	**45.35%**

Table 18: Solid Waste Collection Efficiency and Expenditures in Benchmark and Non-benchmark Cities

	Benchmark cities		**Non-Benchmark Cities**	
Year	**Average capital and O&M per capita expenditure (in US$, 1993-94=100) (Chandigarh, Surat)**	**Solid waste collection efficiency**	**Average capital and O&M per capita expenditure (in US$, 1993-94=100) (Pune, Bangalore, Jaipur)**	**Solid waste collection efficiency**
1993	$2.36	NA	NA	0.60
1994	$1.99	NA	$0.08	0.60
1995	$1.96	0.98	$0.08	0.65
1996	$2.14	0.98	$0.72	0.65
1997	$1.00	0.98	$0.64	0.70
1998	$1.01	0.98	$0.50	0.70
1999	$0.99	0.98	$0.54	0.70
2000	$1.00	0.93	$0.60	0.70
2001	$1.00	0.95	$1.13	0.70
2002	$0.99	0.93	$0.66	0.93
2003	$0.92	0.97	$1.01	0.93
2004	NA	0.97	NA	0.91
Average	**$1.40**	**0.96**	**$0.60**	**0.72**

Table 19: Solid Waste Collection Efficiency and Expenditures in Cities by Population Growth During 1990s

	Fast-growing cities		**Slow-growing cities**	
Year	**Average capital and O&M per capita expenditure (in US$, 1993-94=100) (Surat, Jaipur, Pune)**	**Solid waste collection efficiency**	**Average capital and O&M per capita expenditure (in US$, 1993-94=100) (Chandigarh, Bangalore)**	**Solid waste collection efficiency**
1992	NA	NA	NA	0.60
1993	NA	NA	$2.36	0.60
1994	$0.08	NA	$1.99	0.60
1995	$0.08	0.98	$1.96	0.65
1996	$0.72	0.98	$2.14	0.65
1997	$0.50	0.98	$1.80	0.70
1998	$0.38	0.98	$1.89	0.70
1999	$0.43	0.98	$1.78	0.70
2000	$0.50	0.98	$1.69	0.79
2001	$0.97	0.98	$1.24	0.81
2002	$0.64	0.99	$1.02	0.87
2003	$1.02	0.99	$0.92	0.90
2004	NA	0.95	NA	0.90
Average	**$0.53**	**0.98**	**$1.64**	**0.73**

Table 20: Solid Waste Collection Efficiency and Expenditures in Octroi and Non-Octroi Cities

	Octroi cities		Non-Octroi cities	
Year	Average capital and O&M per capita expenditure (in US$, 1993-94=100) (Surat, Pune)	Solid waste collection efficiency	Average capital and O&M per capita expenditure (in US$, 1993-94=100) (Chandigarh, Bangalore, Jaipur)	Solid waste collection efficiency
1992	NA	NA	NA	0.60
1993	NA	NA	$2.36	0.60
1994	NA	NA	$1.04	0.60
1995	NA	0.98	$1.02	0.65
1996	$1.41	0.98	$1.09	0.65
1997	$0.74	0.98	$0.90	0.70
1998	$0.56	0.98	$0.95	0.70
1999	$0.63	0.98	$0.90	0.70
2000	$0.75	0.98	$0.85	0.79
2001	$0.69	0.98	$1.33	0.81
2002	$0.80	0.99	$0.79	0.87
2003	$0.78	0.99	$1.11	0.90
2004	NA	0.99	NA	0.89
Average	**$0.80**	**0.98**	**$1.12**	**0.73**

Table 21:Estimates of the Cost of Solid Waste Management by City Size

City population (in million)	Cost of vehicles, tools & equipment (in Rs.lakh)	Cost of composting (in Rs.lakh)	Total (in Rs. Lakh)	Total (in $ at $1= Rs. 46.18)
<0.1	50.97	20	70.97	$153,681.25
0.1- < 0.5	295	150	445	$963,620.61
0.5 - <1.0	511	500	1011	$2,189,259.42
>2.0	948	1000	1948	$4,218,276.31

Source: Asnani (2006)

Table 22: Total Cost of Collection and Transportation for Pune

Model assumption	Capital cost (in INR)	Per tonne cost (in INR)
Model 1- combination of tricycle and tractor trailer	146,405,000	599.43
Model 2 - combination of tricycle and tractor container carrier	131,238,333	584.58
Model 3 – auto rickshaw	157,500,000	960.87
Model 4 – combination of auto rickshaw and refuse compactor	187,477,650	411.53
Model 5 – tricycle	73,100,000	721.46
Model 6 – combination of auto rickshaw and tractor container carrier	88,959,533	325.77

Source: 'Action Plan for Implementation of MSW Rules 2000 in Maharashtra', 2004, All India Institute of Local Self-Government

Table 23: Consolidated cost (in INR) of processing and sanitary landfilling activity for Pune

Waste	Capital cost	Annualized capital cost	Operation & maintenance	Manpower cost	Total annual cost	Per tonne cost waste processing cost
1000	137,739,115	27,426,247	36,564,793	9,269,249	73,760,289	171.39

Source: 'Action Plan for Implementation of MSW Rules 2000 in Maharashtra', 2004, All India Institute of Local Self-Government

Table 24: Type of Drainage Connectivity for Waste Water Outlet in India's Urban and Rural Areas

	Total households	%	Rural households	%	Urban households	%
Closed drainage	23,925,761	12.5	5,402,679	3.9	18,523,082	34.5
Open drainage	65,142,354	33.9	41,857,772	30.3	23,284,582	43.4
No drainage	102,895,820	53.6	91,011,108	65.8	11,884,712	22.1
Total	191,963,935	100	138,271,559	100	53,692,376	100

Source: Census of India, 2001

Table 25: Sewerage Systems in Cities, 1991

	Two most prevalent systems of sewerage						
Name of Town	**Sewer**	**Open surface drains**	**Box surface drains**	**Sylk drains**	**Cess pool method**	**Pit system**	**Others**
Bangalore			-	-	-	-	-
Chandigarh		-	-	-	-	-	-
Jaipur			-	-	-	-	-
Lucknow			-	-	-	-	-
Pune		-	-	-	-	-	-
Surat		-	-	-		-	-

Source: Census of India Town Directory 1991.

Table 26: Per Capita Expenditure on Sewerage across Benchmark and Non-benchmark Cities

Year	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in benchmark cities (Chandigarh, Surat)	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in non-benchmark cities (Pune, Lucknow, Bangalore)
1991	$0.76	$0.78
1992	$0.57	$0.51
1993	$0.61	$0.42
1994	$0.89	$2.69
1995	$1.35	$2.91
1996	$1.20	$0.81
1997	$1.04	$1.69
1998	$1.55	$0.91
1999	$1.91	$0.86
2000	$2.19	$0.54
2001	$2.00	$1.02
2002	$1.42	$1.29
2003	$0.84	$2.03
Average	**$1.26**	**$1.27**

Table 27: Per Capita Expenditure on Sewerage across BIMARU and Non-BIMARU Cities

Year	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in BIMARU cities (Lucknow)	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in non-bimaru cities (Surat, Chandigarh, Pune, Bangalore)
1991	NA	$0.77
1992	NA	$0.53
1993	NA	$0.49
1994	NA	$2.09
1995	NA	$2.39
1996	NA	$0.94
1997	NA	$1.37
1998	NA	$1.23
1999	NA	$1.56
2000	$0.43	$1.77
2001	$1.04	$1.76
2002	$1.69	$1.33
2003	$2.36	$1.20
Average	**$1.38**	**$1.34**

Table 28: Per Capita Expenditure on Sewerage across Octroi and Non-octroi Cities

Year	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in octroi cities (Surat, Pune)	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in non-octroi cities (Lucknow, Chandigarh, Bangalore)
1991	$0.77	NA
1992	$0.67	$0.25
1993	$0.65	$0.15
1994	$2.78	$0.70
1995	$3.46	$0.24
1996	$1.27	$0.27
1997	$2.50	$0.23
1998	$2.10	$0.35
1999	$2.12	$0.44
2000	$2.59	$0.28
2001	$2.57	$0.58
2002	$1.81	$1.04
2003	$1.66	$1.32
Average	**$1.92**	**$0.49**

Table 29: Population Coverage of Sewerage Network, Chandigarh

Year	Per capita expenditure	Population (number) covered by each connection
2000-01	$0.13	7.64
2001-02	$0.13	7.94
2002-03	$0.38	8.25
Average	**$0.21**	**7.94**

Table 30: Road Lighting Points by City

Name of Town	Road lighting (points)	Households, 1991	Households/road light point
Bangalore	39487	515138	13
Chandigarh	23184	128306	6
Jaipur	107000	262560	2
Lucknow	50513	283188	6
Pune	18125	316347	17
Surat	10389	279907	27
Average	**41,450**	**297,574**	**12**

Source: Census of India 1991 Town Directory.

Table 31: Per Capita Expenditure on Street Lights and Service Levels Across Benchmark and Non-benchmark Cities

	Benchmark cities (C,S)		Non-benchmark cities (L,J)	
Year	Average capital and O&M per capita expenditure (in US$, 1993-94=100)	Households /street light	Average capital and O&M per capita expenditure (in US$, 1993-94=100)	Households/ street light
1996	0.66	15.21	0.24	NA
1997	0.58	14.51	0.27	NA
1998	0.56	14.18	0.28	NA
1999	0.65	12.38	0.30	NA
2000	0.58	11.84	0.14	5.00
2001	0.36	12.77	0.25	5.02
2002	0.35	11.58	0.66	4.93
2003	0.45	10.76	0.36	4.50
2004	0.00	11.19	0.40	4.53
Average	**0.47**	**12.71**	**0.28**	**4.80**

Table 32: Per Capita Expenditure on Street Lights and Service Levels Across Octroi and Non-octroi Cities

	Octroi cities (Surat)		**Non-octroi cities (C,L,J)**	
Year	**Average capital and O&M per capita expenditure (in US$, 1993-94=100)**	**Households /street light**	**Average capital and O&M per capita expenditure (in US$, 1993-94=100)**	**Households /street light**
1991	NA	18.18	NA	NA
1992	NA	17.56	NA	NA
1993	NA	17.43	NA	NA
1994	NA	17.71	NA	NA
1995	NA	17.34	0.39	NA
1996	0.66	15.21	0.24	NA
1997	0.58	14.51	0.27	NA
1998	0.56	14.18	0.28	NA
1999	1.10	12.38	0.30	NA
2000	1.02	11.84	0.16	5.00
2001	0.54	12.77	0.21	5.02
2002	0.57	11.58	0.50	4.93
2003	0.67	10.76	0.28	4.50
2004	0.00	10.66	0.31	6.93
Average	**0.63**	**14.44**	**0.29**	**5.28**

Table 33: Per Capita Expenditure on Street Lights and Service Levels Across Cities by Population Growth

	Fast-growing cities (Surat, Jaipur)		**Slow-growing cities (C,L)**	
Year	**Average capital and O&M per capita expenditure (in US$, 1993-94=100)**	**Households per street light**	**Average capital and O&M per capita expenditure (in US$, 1993-94=100)**	**Households per street light**
1991	NA	18.18	NA	NA
1992	NA	17.56	NA	NA
1993	NA	17.43	NA	NA
1994	0.44	17.71	NA	NA
1995	0.22	17.34	NA	NA
1996	0.24	15.21	0.08	NA
1997	0.56	14.51	0.09	NA
1998	0.52	14.18	0.08	NA
1999	0.47	12.38	0.23	NA
2000	0.63	11.84	0.16	5.00
2001	0.71	8.79	0.12	5.22
2002	0.87	8.09	0.14	5.25
2003	0.57	7.72	0.14	4.33
2004	0.54	7.77	0.22	7.95
Average	**0.53**	**13.48**	**0.14**	**5.55**

Table 34: Access to Sanitation in South Asian Countries

Country	Year	Population Total	Population % Urban	Sanitation coverage (%) Total	Sanitation coverage (%) Urban
Afghanistan	1990	13799000	18	NA	NA
	2002	22930000	23	8	16
Bangladesh	1990	109402000	20	23	71
	2002	143809000	24	48	75
Bhutan	1990	1696000	5	NA	NA
	2002	2190000	8	70	65
India	1990	846418000	26	12	43
	2002	1049549000	28	30	58
Iran (Islamic Republic of)	1990	56703000	56	83	86
	2002	68070000	66	84	86
Maldives	1990	216000	26	NA	100
	2002	309000	28	58	100
Nepal	1990	18625000	9	12	62
	2002	24609000	15	27	68
Pakistan	1990	110901000	31	38	81
	2002	149911000	34	54	92
Sri Lanka	1990	16830000	21	70	89
	2002	18910000	21	91	98

Source: WHO-UNICEF, JOINT MONITORING PROGRAMME (Retrieved from the Water and Sanitation Program's website: http://www.wsp.org/ Retrieved May 22, 2006.)

Table 35: Sanitation and Type in Rural and Urban India

Sanitation access and type	Total households	%	Rural households	%	Urban households	%
Number of households having bathroom facility within the house	69,371,158	36.1	31,569,044	22.8	37,802,114	70.4
Type of latrine within house						
Pit latrine	22,076,486	11.5	14,236,297	10.3	7,840,189	14.6
Water closet	34,598,446	18	9,837,054	7.1	24,761,392	46.1
Other latrine	13,210,867	6.9	6,231,008	4.5	6,979,859	13
No latrine	122,078,136	63.6	107,967,200	78.1	14,110,936	26.3
Total	191,963,935	100	138,271,559	100	53,692,376	100

Source: Census of India, 2001

Table 36: Per Capita Expenditure on Public Toilets and Service Levels Across Benchmark and Non-benchmark Cities

	Benchmark cities		Non-benchmark cities	
Year	**Average per capita capital and O&M expenditure (in US$, 1993-94=100)**	**Population covered by each new toilet**	**Average per capita capital and O&M expenditure (in US$, 1993-94=100)**	**Population covered by each new toilet**
1994	2.21	434789	NA	NA
1995	2.42	152058	NA	NA
1996	1.53	76577	NA	NA
1997	1.44	60866	NA	NA
1998	3.02	146584	NA	NA
1999	2.86	184251	NA	NA
2000	2.84	598687	0.43	10995
2001	2.74	1377831	0.32	436543
2002	2.79	181400	0.67	116372
2003	2.72	NA	0.56	52252
2004	0.00	NA	0.00	42389
Average	**2.46**	**357005**	**0.34**	**131710**

Table 37: Per Capita Expenditure on Public Toilets and Service Levels Across BIMARU and Non-BIMARU Cities

	BIMARU cities		**Non-BIMARU cities**	
Year	**Average per capita capital and O&M expenditure (in US$, 1993-94=100)**	**Population covered by each new toilet**	**Average per capita capital and O&M expenditure (in US$, 1993-94=100)**	**Population covered by each new toilet**
1994	**0.06**	NA	2.21	434789
1995	0.02	NA	2.42	152058
1996	0.03	NA	1.53	76577
1997	0.01	NA	1.44	60866
1998	0.01	NA	3.02	146584
1999	0.01	NA	2.86	184251
2000	0.01	NA	1.73	402789
2001	0.02	NA	1.18	907187
2002	0.01	51770	1.47	165036
2003	0.01	46347	1.31	55204
2004	NA	42389	NA	NA
Average	**0.02**	**46835**	**1.98**	**258534**

Table 38: Per Capita Expenditure on Public Toilets and Service Levels Across Octroi and Non-octroi Cities

	Octroi cities		Non-octroi cities	
Year	**Average per capita capital and O&M expenditure (in US$, 1993-94=100)**	**Population covered by each new toilet**	**Average per capita capital and O&M expenditure (in US$, 1993-94=100)**	**Population covered by each new toilet**
1994	NA	434789	2.25	NA
1995	NA	152058	2.38	NA
1996	0.12	76577	2.86	NA
1997	0.15	60866	2.58	NA
1998	0.08	117076	2.98	176091
1999	0.04	184251	2.85	NA
2000	0.62	411137	2.80	386095
2001	0.48	1283177	1.41	531197
2002	0.28	159496	1.94	130974
2003	0.17	27957	1.81	42933
2004	NA	NA	NA	42389
Average	**0.21**	**290738**	**2.39**	**226718**

Table 39: Summary of Sanitation Facilities for Selected Cities

Name of Town	Pop, 1991	Water borne	Service	Others	All latrines	Pop/latrine
Bangalore	3302296	223227	-	-	223227	15
Chandigarh	510565	N.A.	N.A.	N.A.	N.A.	NA
Jaipur	1458483	60000	9000	275	69275	21
Lucknow	1619115	25502	32300	-	57802	28
Pune	1566651	200000	2500	4000	206500	8
Surat	1505872	122832	-	-	122832	12
Average	**1660497**	**126312**	**14600**	**2138**	**113273**	**17**

Source: Census of India 1991 Town Directory.

Table 40: Public and Private Toilets per Person by Type of City

Type of city	Average persons/toilet
Benchmark cities	12
Non benchmark cities	18
Cities with octroi	10
Non octroi cities	21
Fast-growing cities	14
Slow-growing cities	21
BIMARU cities	25
Non-BIMARU cities	12

Source: Tabulated from the Census of India, 1991

Table 41: Per Capita Expenditure on Municipal Roads Across Benchmark and Non-benchmark Cities

Year	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in benchmark cities (Surat, Chandigarh)	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in non-benchmark cities (Pune, Bangalore)
1991	NA	$0.66
1992	NA	$0.74
1993	NA	$0.90
1994	NA	$0.62
1995	NA	$1.22
1996	NA	$1.05
1997	NA	$1.03
1998	NA	$1.26
1999	$1.70	$1.91
2000	$1.17	$2.63
2001	$1.29	$3.15
2002	$1.48	$2.80
2003	$1.42	$3.17
Average	**$1.41**	**$2.73**

Table 42: Per Capita Expenditure on Municipal Roads across Octroi and Non-octroi Cities

Year	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in octroi cities (Pune, Surat)	Average capital and O&M per capita expenditure (in US$, 1993-94=100) in non-octroi cities (Bangalore, Chandigarh)
1991	$0.66	NA
1992	$0.74	NA
1993	$0.90	NA
1994	$0.62	NA
1995	$1.22	NA
1996	$1.68	$0.41
1997	$1.48	$0.57
1998	$1.80	$0.71
1999	$2.00	$1.76
2000	$1.83	$1.98
2001	$1.86	$2.58
2002	$2.22	$2.05
2003	$2.59	$2.00
Average	**$2.10**	**$2.07**

Table 43: Proportion of Surfaced Roads in Selected Cities

City	% of Surfaced Roads to total
Pune	92.86
Jaipur	90.26
Bangalore	88.94
Surat	79.63

Source: Census of India, 1991

Table 44: Road Density for Cities

Name of Town	**Total road length (in Kms)**	**Population, 1991**	**Road length/1,000 population**
Bangalore	1925.00	3302296	0.58
Chandigarh	1412.00	510565	2.77
Jaipur	975.00	1458483	0.67
Lucknow	3131.64	1619115	1.93
Pune	826.40	1566651	0.53
Surat	777.52	1505872	0.52
Average	**1508**	**1660497**	**1.17**

Source: Census of India, 1991 Town Directory.

Table 45: Requirements of Per Capita Investment in Urban Roads, 1994-95 prices

	Planning Commission		**Zakaria Committee's estimate**
State	**Low**	**High**	
Gujarat	$1.05	$1.57	$0.87
Karnataka	$1.02	$1.51	$0.85
Maharashtra	$1.10	$1.65	$0.92
Rajasthan	$1.13	$1.71	$0.95
Uttar Pradesh	$1.18	$1.77	$0.99

Source: India Infrastructure Report (1995) and Authors' computations.

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