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A Review of Experience
and Policy Implications

Christine Kessides

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Christine Kessides

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ABSTRACT

This paper reviews the linkages between infrastructure and economic development on the basis of both formal empirical research and informal case studies. The main thesis is that economic benefits result from investments in infrastructure only to the extent that they generate a sustainable flow of services valued by users. Thus, an analysis of infrastructure's contributions to growth must look at the impacts of services as actually perceived, not at indirect indicators that measure only aggregate provision of infrastructure capital.

The paper notes that macro- and industry-level research, although having limitations both in methodology and data, suggest a positive and statistically significant relationship between infrastructure and economic output. However, the conclusions derivable from this research (most of which has been conducted on developed countries) provide little specific guidance for policy. To gain more practical insights about how infrastructure contributes to economic growth and to improved quality of life, and to understand the welfare costs of inadequate or unreliable infrastructure, it is necessary to look at microeconomic evidence. Developing countries provide particularly interesting illustrations of these relationships because they demonstrate a wide variance in the availability and quality of infrastructure. Some research on firms and households, as well as individual country experiences, are discussed which portray the ways in which distortions and inefficiencies in infrastructure affect the economy through: the costs of production and prospects for international competitiveness; the potential for economic restructuring and technological change; macroeconomic stability (especially through the impact on fiscal balance); and the implications for poverty and the environment. Some lessons are then drawn for public policy, strategy, and investment planning in the infrastructure sector.

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FOREWORD

Infrastructure has been a major focus of World Bank lending since its founding, and currently accounts for about forty percent of our portfolio. A key concern of the Bank is to ensure that countries obtain the full benefits from their substantial investments in infrastructure. It is therefore essential to understand how infrastructure contributes to economic development. Whether each country's priorities are defined as enhancing international trade, stimulating private investment, diversifying the industrial base, or achieving greater consistency with environmental or equity concerns, the ability to meet these objectives depends on the performance of an interrelated set of infrastructure services. It is increasingly evident that infrastructure is central to countries' efforts to resume growth after past adjustment efforts.

The present study was undertaken as part of an ongoing effort in the Transport, Water and Urban Development Department to look at the key cross-sectoral issues in infrastructure. This analysis supports the Bank's internal review of its own policy and operational activities in infrastructure, as well as the Bank's dialogue with borrowers and other agencies on infrastructure issues. The paper draws upon much recent analytical work, done within and outside the Bank, as well as on numerous economic and sector studies by Bank staff which evaluate the performance and impact of infrastructure in the context of the overall development strategy and priorities for specific countries. The intended audience for this paper includes students of economic development as well as officials, in both developed and developing countries, who are concerned with infrastructure policy.

L. Pauliquen

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EXECUTIVE SUMMARY

Infrastructure—defined here to include the sectors of transport, water and sanitation, power, telecommunications, and irrigation—represents a large portfolio of expenditure in all countries, ranging from a third to one-half of public investment (equivalent to roughly three to six percent of GDP). Since the mid-1980s, there has been evidence of increasing concern and debate about the performance of infrastructure—among economic policy-makers, politicians, and the public in both developed and developing countries—and a resurgence of research on the impact of infrastructure on economic development.

Much of the formal research on the linkages between infrastructure and economic growth has looked at macroeconomic or industry-wide variables (e.g. aggregate public capital investment). These studies, most of which have been done with respect to developed countries, generally find that infrastructure capital has a significant, positive effect on economic output and growth. Where infrastructure appears to “lead” economic growth, the effect seems to be indirect and relatively long-term, and the research provides only limited insights regarding the necessary conditions for this effect to occur. A problem with this highly aggregated analysis (which is attempting to capture all of the possible externalities, or spillover effects, of investment in infrastructure) is that it does not provide specific guidance for policy. Nor does it explain much about the mechanisms by which infrastructure affects growth.

The main focus of this paper is to examine a wider range of evidence on the impacts of infrastructure on economic development. In most of this discussion, attention is given to the impact on economic growth; however, development ultimately must be measured by improvements in the quality of life. Infrastructure’s contribution to the latter objective is also considered here through its consumption or “amenity” value, mainly in connection with the impacts on personal welfare and the environment. The analysis provides evidence that the flow of infrastructure services is the main measure of economic benefits from these sectors, and that an efficient allocation of resources in this area should be in response to effective demand for services.

What are the Nature and Channels of Impact on Economic Development?

First, infrastructure contributes to *economic growth* (acting through both supply and demand). In an aggregate sense, the character and availability of infrastructure influence the marginal productivity of private capital; public investment thus complements private investment. At the microeconomic level, this effect of infrastructure is seen specifically through:

Reduced costs of production. Infrastructure thereby affects profitability, levels of output, income, and employment, particularly for small-medium scale enterprises. Infrastructure also has an impact on the costs and service quality in international trade (trade logistics), which determines competitiveness in export/import markets. Finally, it has an impact on domestic transaction costs and access to market information—thus permitting the economy to enjoy efficiency gains from policies of market liberalization.

Structural impacts on demand and supply. Infrastructure contributes to diversification of the economy—in rural areas, for example, by facilitating growth of alternative employment and consumption possibilities. Infrastructure (especially telecommunications) provides access to applications of modern technology in many sectors. It is also key to the economy’s ability to adjust the structure of

demand and production in response to changing price signals (a particular issue in the former socialist economies, for example).

When infrastructure “works” in these ways to promote economic growth, the effects are seen through increases in the productivity of other factors (capital and labor), as illustrated by three examples:

- Infrastructure is essential to create the productivity gains from urbanization. When infrastructure problems result in congestion and negative net impacts on the environment, the potential growth from urbanization is sacrificed.

- Infrastructure developments, such as improved transport, which reduce workers’ time spent on nonproductive activities, or which improve health status (e.g. through better access to clean water and sanitation), raise the economic returns to labor. By the same token, the lack of affordable access to adequate infrastructure is a key factor determining the nature and persistence of poverty.

- Efficient production and financing of infrastructure services can reduce wasteful consumption of water, fuels, or land and contribute to the protection of natural resources.

Second, infrastructure contributes to raising the *quality of life* by:

- **Creating amenities in the physical environment**—such as cleaner water, land and air; and by providing spatial order to human settlements and public works of architectural appeal and civic pride. Improvements in infrastructure are central to the quality of life and enjoyment gained from both the natural and man-made (built) environment, especially in urban areas.

- **Providing outputs which are valued in their own right**--such as transportation and communication services as consumption goods; and by contributing to improved personal health and national integration.

- **The financing of infrastructure has important implications for macroeconomic stability.** As a countercyclical tool, infrastructure investment can generate employment and consumer demand in the short term, as well as in the longer term (when the investment is well chosen). However, the modes of financing infrastructure investment, operations and maintenance can also contribute to internal and external imbalances. In many countries, the persistent deficits of railways, airlines, and power utilities have contributed measurably to fiscal and financial instability.

How Can the Potentially Favorable Outcomes of Infrastructure Activities be Achieved?

The positive impacts from infrastructure indicated above derive not primarily from the investment in the physical facilities, but from the services generated. Four conditions are necessary to realize these impacts on economic development:

- The basic macroeconomic climate should be conducive to an efficient allocation of resources; this reduces the potential for investment in infrastructure to take resources away from (“crowd-out”) other more productive investment.

● **Infrastructure projects can only raise the returns to other resources when there is a sufficient complement (and productive capacity) of other resources; infrastructure investments cannot create economic potential, only develop it.**

● **Infrastructure activities which have the most significant and durable benefits in terms of both production and consumption are those providing the degree of reliability and quality of services desired by users.**

● **Infrastructure is more likely to be economically efficient, and to have favorable impacts on the environment, when it is subject to user charges. User charges are necessary to elicit effective demand and discourage wasteful consumption. The absence of user charges has usually not promoted access to services by the poor, but rather reduced availability and worsened inequalities. User charges should be based on economic prices reflecting both costs of supply and demand considerations (willingness to pay), as well as externalities to the extent possible.**

Introduction

This paper looks at the economic benefits from infrastructure, and the necessary conditions for these benefits to be realized. Infrastructure's linkages to the economy are multiple and complex, because it affects production and consumption directly, creates many positive and negative spillover effects (externalities), and involves large flows of expenditure. The analysis provides evidence that the flow of infrastructure services is the main measure of economic benefits from these sectors, and that an efficient allocation of resources in this area should be in response to effective demand for services.

In most of this discussion, attention is given to the impact of infrastructure on economic growth. However, development ultimately must be measured by improvements in the quality of life; infrastructure's contribution to the latter objective is also considered here through its consumption or "amenity" value, mainly in connection with the discussion of linkages with personal welfare and the environment. The impact of infrastructure on the economy is the main focus, but the influence of macroeconomic developments on infrastructure is also examined, since causality runs in both directions.

The first section summarizes very briefly the theoretical arguments regarding infrastructure and economic growth. Section II reviews evidence from formal empirical research, much of it based on macroeconomic aggregates with data taken mainly from developed countries. Section III examines the linkages through illustrations at a more microeconomic level and in some cases through less formal methods of case study—these aspects in particular concerning costs of production, structural effects, impacts on personal welfare, and impacts on the environment. Section IV looks at the linkages between infrastructure and fiscal/financial aggregates and the labor market, emphasizing the implications of sectoral policy for macroeconomic stabilization. Section V provides conclusions for policy and investment planning.

I. Infrastructure's Impact on Economic Development—An Overview

Infrastructure contributes to economic development both by increasing productivity and by providing amenities which enhance the quality of life. The services generated by infrastructure investment lead to growth in the production of firms in two ways:

(i) infrastructure services, such as transport, water, and electricity, are intermediate inputs to production, and any reduction in these input costs raises the profitability of production, thus permitting higher levels of output, income, and/or employment;

(ii) infrastructure services raise the productivity of other factors (labor and other capital)—for example, by permitting the transition from manual to electrical machinery, reducing workers' commuting time, and improving information flows through electronic data exchange. Infrastructure is thereby often described as an "unpaid factor of production", since its availability leads to higher returns obtainable for other capital and labor. The existence of infrastructure in a given location may attract flows of additional resources ("crowding-in" private investment); this can lead to reduced factor costs and transaction costs at that site. The resulting "economies of agglomeration" are the great advantage of urbanization. However, when the available infrastructure becomes congested or begins to create a predominantly negative impact on the environment, the quality of services declines and their contribution to productivity suffers.

Both effects contribute to economic growth by stimulating aggregate supply as well as demand.

The consumption of infrastructure services by households contributes to economic welfare because many of these services, notably clean water and sanitation, are essential for health and create environmental amenities; others (e.g., recreational transport, residential telecommunications) are valued items of consumption in their own right. These services also provide access to jobs, education, and opportunities for consumption of other goods. Thus, reductions in the cost and improvements in infrastructure services to households can have the beneficial effects of increasing their real income and consumption, raising the productivity of their labor, and freeing time of individuals for higher-value activities—analogously to the benefits realized by firms.

It is worth emphasizing that all of the above contributions of infrastructure to economic growth and the quality of life, which are long recognized in economic theory, derive not from the mere existence or creation of the physical facilities but from their operation and the value of the services generated. Yet very little of the empirical research which has attempted to establish the linkages between infrastructure and economic growth examines the infrastructure variable directly in terms of characteristics of a flow of services (such as the actual availability,¹ diversity, quality, reliability, and price of services obtained by users). The findings from macro-level (including industry-level) quantitative research are briefly summarized in the next section. Microeconomic studies which have looked at the impact of infrastructure on the firm or household are discussed in section III.

¹ What is relevant here is effective availability or access of users to the services, as opposed to the mere physical existence of a facility. For example, the presence of a road in an area may not represent effective availability or access of road services if the road is severely congested or severely deteriorated.

There is also a set of important economic effects which do occur specifically from the flows of expenditure on investment in infrastructure, as opposed to the operation or generation of services. The *first* is the multiplier effect of the expenditure on wages and inputs used in the construction of physical infrastructure facilities, and the derived demand thus generated for the output of other sectors. Under certain conditions (such as where markets are rigid and factors not mobile), the pressures generated by infrastructure investment may "crowd out" private investment by bidding up the cost of labor and inputs. The *second* linkage concerns the way in which the infrastructure is financed. Expenditure on infrastructure investment affects the availability of financial capital for other uses; it may also affect fiscal balance and external creditworthiness, and therefore macroeconomic stability. The potential of infrastructure investment to raise the cost of capital is described as financial "crowding-out". It should be noted that both the multiplier effect and crowding-out may apply to government expenditure on any sector, and not only infrastructure; moreover, crowding-out is not limited to expenditure on investment, and could also occur to the extent that operation and maintenance (O&M) are financed by taxation (budgetary subsidies) or borrowing rather than by revenues from the services generated. These effects of infrastructure expenditure are briefly illustrated in section IV below.

II. Empirical Evidence from Formal (mainly Macroeconomic and Industry-Level) Research

Most of the empirical research on this topic has examined the infrastructure variable in terms of public gross capital expenditure, as a proxy for net increments to the stock of infrastructure facilities. This orientation of the empirical work may in part be responding to the policy-makers' preoccupation with infrastructure as a problem of public investment in physical capital stocks. However, the direction of research also has followed the availability of data, which is weak enough on expenditure but worse on real service flows.²

As noted in section I, infrastructure can be viewed conceptually as an unpaid factor of production, which works through the production function by making labor and other capital more efficient. Much of the existing empirical literature on the linkage between infrastructure and economic growth seeks to capture this effect through observation of the relationship between increases in the stock of infrastructure (measured indirectly through public capital expenditure) and some measure of growth in aggregate output or productivity. Much of this literature has been generated since the mid-1980s with respect to developed country (mainly U.S.) data,³ and has been reviewed elsewhere (e.g., Hulten 1991a, Fox 1990, World Bank 1991a). A review paper by Munnell (1992) shows that there has been some interesting consistency among several of these studies in the estimated output elasticity of public capital. The coefficients are larger for the studies at the national level than at the regional level, and lowest at the metropolitan level of impact; this is explained by the ability of more aggregated studies to capture the indirect effects ("externalities") of infrastructure investments on various aspects of the economy.

Many of the findings from these studies have demonstrated positive and statistically significant relationships between public capital and output, but the conclusions have been heavily debated. The main methodological criticisms of much of this research are that:

- (i) simultaneity of effects is not accounted for (economic growth can lead to public capital expenditure as well as result from it), and therefore causality cannot be inferred from time series correlations;
- (ii) some studies suffer from other econometric flaws such as omitted variables, potentially spurious correlation of time series data, and poor model specification—for example, the effect of private investment in infrastructure is not accounted for.⁴

² It is significant in this context that in the U.S., which has been the focus of most of the empirical literature in this area, data on public capital expenditure only include infrastructure which is publicly financed, and therefore does not measure the important component of infrastructure which is provided through private investment (especially electricity, telecommunications, and some roads).

³ Work frequently quoted from this body of empirical research includes that by Aschauer (1989), Deno (1988), Duffy-Deno and Eberts (forthcoming), Eberts (1986), Garcia—Mila and McGuire (forthcoming), Holtz—Eakin (1988), Mera (1973), and Munnell (1990, 1991).

⁴ For example, Hulten (1991) demonstrates that the results in some studies have been changed dramatically when the analysis is made of the relationship between changes in the variables, rather than between their levels.

It is also difficult to interpret the findings in terms of implications for policy, for the following additional reasons:

(iii) the variables used (e.g., public capital expenditure) are often not decomposed by sector or purpose. Many of the studies do not differentiate among types, location and composition of infrastructure, or levels of the stock (e.g., expenditure to expand a sparse network versus improvement of quality or decongestion of a mature network); by the same token, they do not differentiate among types of economic activity;

(iv) most importantly, the research does not consider the efficiency of utilization of the infrastructure, that is, the flow of services actually generated from the investment expenditure,⁵ nor the extent of use of the infrastructure (e.g. degree of congestion).

The remainder of this section reviews only a few of the research studies in this area to illustrate the sorts of findings and some of their limitations.

Studies of Aggregate Public Capital Expenditure and Aggregate Output

A recent paper by Easterly and Rebelo (1993) assembled historical time series and cross-country data on 28 developed countries to study the relationships between investment by the consolidated public sector (including both government and public enterprises) and GDP growth. After controlling for other variables that could affect growth, the authors find that transport and communication investment is consistently positively correlated with growth with a very high coefficient. Infrastructure investment is uncorrelated with private investment, suggesting that infrastructure raises growth by increasing the social returns to private investment, not by promoting private investment itself. The study does not exclude the possibility of reverse causation; however, not all categories of public investment were positively associated with growth.

In a similar vein, Baffes and Shah (1992) use a flexible production structure to estimate the contributions to national output (per capita GDP) of public capital (disaggregated into infrastructure, human resource development and military capital), labor and private capital, for both a time series and cross section of 25 developed and developing countries. They concluded that infrastructure capital has a low but positive output elasticity (following in importance human resource development capital, private capital, and labor appearing as the major determinants of GDP), while for the majority of countries military capital showed a negative elasticity. There were no evident differences in the infrastructure capital elasticity when the sample was broken down into four groups by average income level.⁶

⁵ Some of the studies use an estimated "capital utilization factor" to represent services, though this is a contentious variable. Taking account of services does not fit neatly into quantitative analyses relating public capital expenditure to economic growth. A recent proposal for a research grant makes the oversimplifying assumption, for ease of estimation, that "the services of public capital are proportional to public capital, and can be measured satisfactorily by the public capital stock variable." In addition, the proposed model assumes that "government provides these services directly to producers without employing user fees and subsequently finances expenditure through taxes," an assumption which could affect greatly the efficiency of service supply as well as demand.

⁶ The infrastructure variable in this study was represented by government (mainly central) capital expenditure on "economic infrastructure," from the International Monetary Fund's Government Finance Statistics.

In striking contrast to these and a number of other studies (e.g. Barro, 1991) on the composition of public expenditure, Devarajan, Swaroop, and Zou (1993) found a negative, but statistically significant, relationship between the share of central government investment on transport and communications and per capita GDP growth for a 20-year time-series on 69 developing countries. The authors tested for fixed effects due to country-specific variations, other variables explaining growth (e.g., policy distortions, external shocks, initial level of development), and a nonlinear specification of the model. The negative relationship between transport and communications continued to appear negative, although statistically insignificant when fixed effects were included. Given these surprising results, the authors conclude that data on public expenditures in these sectors do not necessarily lead to increases in the stock of physical capital, nor necessarily to an allocation of physical capital that is productivity-enhancing, possibly because of political factors in decision-making.

Studies of Physical Capital Stocks and Aggregate Output

Canning and Fay (1993a) use physical measures of infrastructure networks (kilometers of paved roads and railways, and number of telephones) in the beginning of a period to explain growth over the period in a panel of 104 countries (developed and developing) at five year intervals between 1960 and 1980.⁷ Country-specific intercepts are used to account for fixed effects. The study finds that both transportation and telephone systems have large effects on growth rates, with rates of return estimated to be around 40 percent for the U.S. and even higher for countries with lower ratios of infrastructure to output. In time series analysis, the short run effects of changes in infrastructure on output appear very small; it is in the cross-section analysis that the high rates of return are seen. The authors conclude that the returns to infrastructure occur slowly, but are ultimately very large.

In a later paper (1993b), Canning and Fay extend this analysis of the same data set for transportation (road and rail) infrastructure by groups of countries at different income levels, and estimate rates of return to the infrastructure stocks by including an estimate of construction costs. They conclude that the developed, high income countries show "normal" rates of return for transport infrastructure, while very high rates are found for the high-growth, newly industrializing countries such as South Korea and Chile. In the less developed, mainly agricultural countries such as in South Asia, rates of return are closer to those for the high income countries. The authors find strong cross-sectional evidence that output levels are positively related to the amount of transport infrastructure, but little evidence from the time series analysis that increases in infrastructure lead to immediate increases in output. They conclude that infrastructure is therefore not to be considered like a factor of production, but rather as a condition for high rates of economic growth; and they postulate that its effect is mainly through promoting total factor productivity growth (by facilitating technological progress in an economy).

The two Canning and Fay studies are among the most carefully designed (including in terms of the quality of data used) efforts in this line of empirical research. Other studies have attempted to show correlations between stocks of particular types of infrastructure and level of income or other indicators of economic development. For telecommunications, Hardy and Hudson (1981) conducted time-series regression analysis of a large number of both developed and developing countries which indicated telephone coverage per capita as a significant variable explaining differences in GDP per capita with a one-year lag. Since the effect was not found for business telephones separately, the authors concluded

⁷ In an attempt to measure road services rather than roads, the variable for the road stock is deflated by L , the labor force. This is at best a crude proxy for road use, but a more direct indicator (e.g., congestion) was unavailable.

that the development impact was not primarily in the transfer of information within particular economic activities (production, marketing), but rather in facilitating the information flows which support more efficient economic organization. For road infrastructure, Queiros and Gautam (1992) have found strong correlations between the extent of paved road networks and GDP per capita for a large sample of developing countries, which closely match similar correlations estimated for the United States. Moreover, their data demonstrate that both deterioration and improvement in the quality of paved road networks are correlated with the trends in per capita GDP over time for a sample of African countries.

Studies Linking Infrastructure and Sectoral Output

Among the best designed research are the studies by Binswanger et al. of cross-country time series data (1987) and cross-district data in India (1989), which control for observed agro-climatic characteristics and infrastructural differences in explaining agricultural output. Once these climatic effects are accounted for, roads are found to have a strong positive effect on aggregate agricultural output, and growth of electricity supply similarly appears to be significant in explaining farm investment. Irrigation investments prove to have little effect on output in the India study, apparently because of high initial levels of irrigation and the omission of private pumps from the irrigation variable. In the 1989 study, Binswanger et al. concluded that the major effect of roads in rural India is not "via their impact on private investment but rather on marketing opportunities and reduced transaction costs of all sorts." The multivariate analysis in this study indicates that determinants of agricultural output growth are complex and include road and irrigation infrastructure, but in combination with prices, markets, and credit availability.

Antle (1983) estimated a production function for agriculture in developed and developing countries and found that a normalized indicator of spending on transport and communications services in each economy was a significant determinant of differences in aggregate agricultural productivity across countries, when account was taken for variations in resource endowment, human capital, and use of modern technology in agriculture.

Chhibber (1988) examined the supply elasticity of agriculture with respect to prices in contrast to non-price factors (public goods and services, including infrastructure), and concluded that it is higher with respect to the non-price factors, particularly where the level of public goods and services is low. He argues that in the poorer countries of Asia or especially, Africa, which have binding constraints of poor roads and transport facilities, capital, and research and extension facilities, the supply response of agriculture to these non-price factors will be greater than to price factors, whereas in more developed economies which have better basic infrastructure, price is more of a determinant of agricultural output.

Infrastructure and Regional Growth Differentials

One line of research argues that regional differences in productivity growth are related to regional differences in public infrastructure, where the latter creates externalities which lead to increasing returns to scale and endogenous regional growth (Romer, 1986; Lucas, 1988). Another school of thought holds that the key variable explaining regional growth differentials is industrial location, which follows shifts in the flow of capital and labor among regions (Krugman, 1991). Tests of these models on regional differences in the growth of manufacturing output for the U.S. give more weight to the latter explanation (interregional flows of capital and labor) (Hulten and Schwab, 1991). These findings suggest that public capital is not a key determinant of total factor productivity growth in manufacturing, at least in this context, but leave open the possibility that public capital influences the demand and supply of inputs,

which in turn account for differences in output. In this connection, several studies of the U.S. (reviewed by Fox and Murray, 1990) have looked at the importance of infrastructure as an attraction to private capital, demonstrated by the regional location of business investment. These studies indicate that transportation, more than other infrastructure factors, is important in locational decisions.

Hansen (1965) provided a conceptual argument for distinguishing among regions which are lagging (those with few intermediate inputs or human resources), intermediate (those with adequate input availability), and congested (those suffering from diseconomies of scale); he theorized that infrastructure would show the greatest returns in intermediate regions. There is little formal empirical testing of this hypothesis, except for one study in Mexico by Looney and Frederiksen (1981), which found that infrastructure variables were less significant in explaining income among lagging regions than were social investments, while the reverse was true for intermediate regions. In other studies which have looked at regional variations in economic performance (Mera, 1973 for Japan; Eberts, 1986 for the U.S.), the effect of public capital appears stronger in the more developed or rapidly growing regions, compared to those that are declining.⁸

Evans (1990) notes that there has been an evolution in the literature on the role of infrastructure in urban development. The earlier theories that infrastructure could induce growth to follow planned development was reflected in efforts to create "new towns" and "growth poles"; such investments proved to have low returns where the underlying conditions for potential economic growth were unfavorable. He argues that infrastructure, supported by ancillary services, is most effective where it can strengthen and spur exchanges among settlements, such as between rural and urban markets, and facilitate interactions.

Links between Composition of Public Investment and Private Investment

Another body of research has examined the linkages between public capital investment and private investment to determine the existence of "crowding-in" or "crowding-out" effects. Several studies of developing country data (reviewed in Chhibber and Dailami, 1990; Serven and Solimano, 1992) tend to confirm the hypothesis that public investment in infrastructure has a positive effect on private investment, whereas non-infrastructure public investment has a negative impact. Moreover, there is some evidence in this research that the extent of "crowding-out" of private investment depends on how the public investment is financed. The suggestion is that public investment financed by bank borrowing could crowd out private investment.

Comment on Research Findings

The empirical research mentioned here supports the intuitive observation that public capital expenditure has a significant, positive effect on economic output and growth. However, the available studies are not very illuminating regarding the workings of this relationship and therefore the policy implications are not clear. For example, the empirical research has not been conclusive regarding the potentially important debate as to whether infrastructure investment can be a "leading" factor in stimulating growth of underdeveloped regions (by crowding-in private investment and labor inflows), or

⁸ This conclusion, although based on very different data, appears consistent with that of Canning and Fay (1993b), noted above, regarding the higher average returns to transport infrastructure in rapidly growing countries as compared to slower growing countries.

a “lagging” factor (following from, and responding to, output growth which is already present). Even where the “leading” effect appears dominant, it seems to be indirect and relatively long-term. A number of the studies reviewed here suggest that infrastructure promotes growth most effectively in situations where there is already a high level of economic activity. The research provides only limited insight as to what exactly are the prior or accompanying conditions which make infrastructure an effective catalyst for growth.

The highly aggregated variables measured in much of the formal research attempt to capture the externalities of infrastructure, that is, the spillover effects of infrastructure investment at location A at time (t) on economic events elsewhere and at later periods.⁹ These externalities arise in part because most infrastructure consists of networks of interlocking facilities (roads and highways, telephone cables, electricity, water, and sewage distribution systems). The productivity of any one piece of the network depends on the extent and configuration of the entire network, and the returns to one link will be greater or lesser as other links are added. However, once a network of a given size is built, congestion becomes a key determinant of the need for further investment and its returns. Adding capacity to a congested link of a network can have a higher payoff than expanding the network.

The empirical studies linking infrastructure investment and economic performance fail to capture the complexity of this relationship, which is that “the economic impact of additional investment depends on the size and configuration of the existing network and on the degree of congestion at each point in the network”.¹⁰ These factors may imply that two equal amounts of investment expenditure on infrastructure can yield different amounts of productive services, and alternatively, the same services may be generated by different amounts of infrastructure investment. The productive value of a given increment to the stock of infrastructure depends critically on the efficiency with which the overall facility or network is operated, and the patterns of demand by all users (households and industry). These factors are essentially microeconomic, and cannot be captured by research based on macroeconomic variables.¹¹ Some of the work that has attempted to examine the impacts of different characteristics of infrastructure services on firms and households, and the various means by which infrastructure services contribute to economic development, is discussed in the next section.

⁹ Following Hulten and Schwab (January 1991).

¹⁰ *Op. cit.*, p. 20.

¹¹ It must be acknowledged that microeconomic studies (at the level of firms or households) cannot reveal all of the externality effects of infrastructure. The macroeconomic research has attempted to capture these effects by focusing on an overall sector or economy, but this level of aggregation misses many of the insights necessary for policy recommendations.

III. The Nature of Infrastructure's Effects on Economic Development— Further Evidence from Experience and Microeconomic Research

This section illustrates and analyzes some of the various mechanisms by which infrastructure affects economic growth and quality of life, through reference to both formal and informal microeconomic research and country studies. None of the individual evidence discussed here is generalizable to all circumstances, but taken as a whole it portrays a fairly clear picture of the factors determining the economic impact of infrastructure. Most of the studies below concern developing countries, in which characteristics of infrastructure services such as effective availability, quality, diversity, reliability, and price often demonstrate a much greater range or variability than in developed countries. Thus, there is more stark evidence in developing countries of the impact of inadequate services on economic growth and welfare. The same kinds of impacts would be assumed to exist in developed countries, although of lesser degree if the infrastructure problems are not as severe.

Contributions to Growth through Reductions in Costs

Effects on Production, Investment and Employment

Most directly productive activities in industry, agriculture, and services use electricity, telecommunications, water, and transport services as intermediate inputs. Manufacturing establishments surveyed in Nigeria report that infrastructure averages 9 percent of their variable costs, with electric power accounting for half of this share (Lee and Anas, 1992). Elhance and Lakshamanan (1988) estimate the effects of changes in the stock of economic infrastructure on cost reductions in manufacturing in India. Even in the informal sector, infrastructure can be a major share of business expenses (e.g., in Zimbabwe, transport accounted for 26 percent, the largest single item) (Kranton, 1991). A measurable benefit of investment in infrastructure is the reduced cost to users of each service unit consumed. This benefit is greater, the more the service is characterized by economies of scale (i.e., declining unit costs as volume of output increases).

If enterprises are unable to realize the benefit of efficient generation of infrastructure services, either because the services are absolutely unavailable or provided so unreliably as to be virtually unavailable, the firm is forced to seek higher cost alternatives which may have unfavorable impacts on profits and level of production achieved. The economic costs of infrastructure unreliability (e.g., power outages, call interruptions, erratic water pressure, poor road passability) are multiple. They include, first of all, the direct costs of production delays, loss of perishable raw materials or outputs, and damage to sensitive electronic equipment. In their totality, these costs lead to underutilization of existing productive capacity, and constrain short-run productive efficiency and output growth. Secondly, unreliability or lack of access to infrastructure services requires users to invest in alternative sources, thus raising their capital costs. Third, the resulting higher costs and disruptions of output have ripple effects on other sectors, creating bottlenecks and slack capacity utilization elsewhere in the economy (Box 1 illustrates an attempt to measure the multiple effects on the economy of reductions in costs of infrastructure).

A 1987 study of primarily the first of these multiple effects of power outages in Pakistan estimated that the direct costs of load shedding to industry during a year, coupled with the indirect multiplier effects on other sectors, implied an 1.8 percent reduction in GDP and a 4.2 percent reduction in the volume of manufactured exports. In India, a 1985 study concluded that power shortages were a major factor in low capacity utilization in industry, and estimated the total production losses in 1983-84 at 1.5 percent of GDP. Neither of these studies estimated the value of foregone infrastructure services

Box 1 Modelling the Impacts of Transport Costs

One particularly ambitious attempt at estimating the impact of transportation investments various sectors of the economy is the Multiregional Variable Input-Output (MRVIO) model developed by the U.S. Army Corps of Engineers (Liew and Liew, 1985). Unlike traditionally static input-output analysis, the MRVIO is a general equilibrium model which simulates the effect of savings in transportation costs, travel time, and relative prices which result from a specific transportation project, on the input and output prices, production levels, trading relationships, and employment in as many as 35 industrial sectors and across 10 regions. The model, in short, attempts to capture the "substitution effects" of infrastructure-induced reductions in input costs, based on neoclassical assumptions about profit-maximizing behavior of producers. As applied to waterway investments in the U.S., for example, the model has calculated the indirect effect of a given transportation cost savings for chemicals on the production costs of cotton, and the reduced costs of grain shipment on livestock production, as well as specific changes in interregional trading patterns due to the investment.

Interestingly, this model was developed in part to address the concerns of local communities with the impact of potential infrastructure investments by the Army Corps of Engineers on their local economy. These concerns were incited by the cost-sharing provisions of the 1986 Water Resources Development Act, which entitled non-Federal and local sponsors to participate in planning, funding, and executing Corps projects (U.S. Army Engineer Institute for Water Resources, "Economic Development Impacts, Water Resource Projects, and the Multiregional Variable Input-Output Modeling System," mimeo, 1991).

to commercial or residential users, nor the dynamic long-term costs, for example of delays in application of new technology which depends on reliable power (USAID, 1988). Similarly, power rationing in Colombia is expected to reduce overall economic output by almost one percent of GDP in 1992.

Problems with undermaintenance of facilities and poor service quality shift the burden of infrastructure provision, and often increase the overall costs, to produce outcomes which are not the most economically efficient. Studies in several Latin American countries (including Chile and Cost Rica) have concluded that each dollar not spent on needed road maintenance can increase vehicle operating costs by three dollars, and lead to an additional \$2-3 dollars for premature reconstruction. These incremental (preventable) capital expenditures amount to 1-4 percent of GDP. Moreover, two-thirds of the additional vehicle operating costs are in foreign exchange and represent a substantial drain on this scarce resource. In the water sector, various studies have documented the considerable private investment incurred to compensate for an unreliable public supply. In Lima, Peru, households have been investing in pumping and water storage facilities at costs 40-80 times higher than those of the public utility. And in Tegucigalpa, Honduras, the amount invested by households in such systems is comparable to what it would have cost the city to double the city water supply from deep wells (Gyamfi, 1992). This is truly "demand-driven" infrastructure development with an admirable degree of private resource mobilization, but it may not represent efficient use of capital resources for the sector overall and is particularly burdensome to the poor (see later illustration in Box 5).

To the extent that small firms face relatively high infrastructure cost burdens (see Box 2), the growth of such enterprises and the generation of employment will be affected. Other research has shown that new small firms tend to start up near urban centers with easy access to good utilities and relocate to peripheral areas as they expand production. Small new firms generate between 60 to 80 percent of the new jobs created in large cities in Asia and Latin America (Lee, 1985, 1989), and much of the supply response to structural adjustment in many countries and systemic reform in former socialist countries is expected to come from the small-medium enterprise sector. In Nigeria, however, the cities with poor infrastructure are unable to offer this "incubator" function to new small firms, which are less able to

Box 2 Impacts of Infrastructure Deficiencies on Firms in Nigeria

A 1988 study of 179 manufacturing establishments in Nigeria documented in detail the costs of unreliable infrastructure for firms of different sizes, as well as the costs of their investments in alternative sources. The study found that because of the pervasive failures of publicly-provided infrastructure, 92 percent of the firms surveyed owned electricity generators. The impact of infrastructure deficiencies of all types was consistently higher for the small firms. Private infrastructure provision (for generators, boreholes, vehicles for personnel and freight transport, and radio communications equipment) constituted 15 percent of total machinery and equipment costs for large firms (over 50 employees), but 25 percent for small firms. Small firms were found to generate a larger percentage of their power needs privately than did larger firms, and to pay a higher premium for doing so, as measured by the excess costs of privately-generated power over that publicly provided. In part because of economies of scale in generating electricity, the average costs of private generation declined sharply with firm size, and the reliability premium (the excess of private unit cost over the public power tariff) declined rapidly to zero as firm size increased. However, both the large and small firms in Nigeria underutilized their private generating capacity (average utilization was only 25 percent), and with the regulatory regime prevalent at the time of the study, they were not permitted to sell their private excess capacity to other firms or to the public network. Similar scale economies of private water provision were also found to favor the large firms (K.S. Lee and A. Anas, "Impacts of Infrastructure Deficiencies on Nigerian Manufacturing: Private Alternatives and Policy Options," World Bank DP/INU 98, 1992).

afford their own infrastructure.

Other enterprise-level surveys conducted in several other countries have found infrastructure costs and problems of unreliability to rank high among issues in the business environment. A 1991 survey of small enterprises in Ghana cited power outages, transportation costs, and other infrastructure problems among the top four problems of operation (behind taxes), with this response strongest among "micro" and small firms. Electricity outages were also ranked by very small firms as among their top four constraints to expansion (Steel and Webster, 1991). A 1991 survey of industrial enterprises in Sri Lanka found that over a quarter of the firms cited poor infrastructure (along with lack of raw materials) among their top three constraints to business, and half of these respondents exported more than half of their production. Moreover, the firms citing infrastructure and raw materials as their main constraints tended to be relatively small (fewer than 50 employees) (World Bank, 1992g). A survey by the Bangladesh Chamber of Commerce of 1200 private establishments in all sectors in 1991 found that the shortage of electricity and fuel was ranked third among constraints cited, following problems with credit and raw materials. Large firms were indicated to be at a relative advantage in access to power supplies because of their regional concentration in major urban areas (World Bank, 1992f).

Wheeler and Mody (1991) examine panel data on 42 developed and developing countries to explain patterns of foreign direct investment in manufacturing and electronics through variables representing "classical" features of comparative advantage (labor cost, corporate taxation, market size), agglomeration benefits (infrastructure quality, degree of industrialization, and level of past foreign direct investment), socio-political risk, and openness of economic policy. Among the developing countries, infrastructure quality is found to be the dominant explanatory factor in both manufacturing and electronics investment, with labor costs also ranking highly for electronics. Among the industrial economies, however, the two agglomeration measures other than infrastructure quality are dominant, presumably because these countries already have fairly adequate infrastructure.

Impact on International Competitiveness

Inadequate and unreliable infrastructure cripples the ability of countries to engage in international trade, even of traditional export commodities. In Brazil, for example, the potential growth of exports from the development of new industrial and agricultural centers in the interior is being hampered by increasing costs of domestic transport; none of the large surplus of maize produced in 1992 could be exported, in part because of the high transport costs involved.¹² But the fight for new export markets is even more dependent on infrastructure.

In the last two decades, the increased globalization and intensified competition in world trade has resulted not only from the liberalization of trade policies in many countries, but also from major advances in communication, transport, and storage technologies. These developments have transformed the traditional organization of production and marketing to focus on the management of logistics¹³ to achieve cost savings in inventory and working capital and permit rapid response to changing consumer demands. During the 1980s, order cycle times in the OECD countries have been reduced by up to 80 percent; more than 60 percent of production and sales in these markets are now processed directly to order, and "just in time" (JIT) delivery to customers is projected to increase continuously. About one-quarter of logistics costs in industry are due to transport. Virtually all the improved practices reducing logistics costs have been based in some way on information technologies using telecommunications infrastructure; the growth of electronic data exchange is considered by many to be the most pervasive change to affect international business practice in recent history. Trade and industry managers in OECD countries report that a one percent reduction in logistics costs are equivalent for them to a ten percent increase in annual sales (Peters, 1992).

The exigencies of modern logistics management in developed industrial countries pose similar requirements on developing countries wishing to compete in these markets. Global sourcing has created interwoven networks of international trading and industrial relations, in which businesses in several countries produce different goods and services components of the same final product. The ability of developing countries to provide the transport and communications services essential for modern logistics management will increasingly determine their ability to compete for export markets and direct foreign investment. Mexico's maquiladora operations, Chile's export of fruits, Columbia's of cut flowers, and Kenya's of horticultural products are examples where countries have been able to meet the logistical requirements of their overseas customers. There are also many illustrations of countries which are losing a competitive edge because of shortcomings both in key infrastructure as well as institutional and procedural delays, especially related to customs processing and the management of infrastructure services. In India, the freight rates of container traffic and transit times through ports exceed those of Asian competitors by large margins, which seriously constrains the country's export promotion goals (Peters, 1990). The main reasons for this poor performance lie in excessive regulation of trade and transport, administrative practices, and inefficient management by public transport entities. The evidence of trade performance and logistics in many countries indicates that dysfunctional regulatory and administrative practices which reduce the quality and reliability of trade and transport services can be a serious impediment to the growth of international trade, even if physical infrastructure is otherwise good. At the

¹² "Brazil: Infrastructure Plans", Oxford Analytica, October 22, 1992.

¹³ Logistics is defined as the "orchestration of purchasing, production, and marketing functions in order to obtain the least cost combination of all activities involved in these processes, while maintaining a high level of customer service," (Peters, 1992)

same time, however, structural reforms of the policy and institutional environment for trade and transport cannot substitute for the minimal transport and communications infrastructure needed to compete in export markets (e.g., multimodal facilities to handle container traffic; trade-related telecommunications networks based on satellites or dedicated interchange systems which bypass the congested public network).

A recent review of the experiences of export processing zones (EPZ) in developing countries (World Bank, 1992a) provides further insight into the relative importance of infrastructure in successful trade development. EPZs consist of two components: an industrial estate with links to international transport and communications infrastructure and utilities, and policy instruments providing a suitable trade and regulatory regime. The evaluation of experience of EPZs concludes that a key factor for success (together with a favorable macroeconomic policy regime, and managerial and marketing know-how) is appropriate location, generally in a major urban area already having good access to physical trade infrastructure (international sea, air, and road transport systems and communications). Zones located in backward regions with the intention of accelerating their development have yielded poor returns, as have zones in small cities far from major centers of activity; the infrastructure investment costs required by such sites have been exorbitant and have not been compensated by the activity generated.

Impact on Domestic Market Development

Various research in developing countries has concluded that rural (farm to market) roads have a major effect in improving marketing opportunities and reducing transaction costs. The marketing of agricultural commodities, excluding the stages of processing, can account for 25–60 percent of final prices for foodstuffs in developing countries, with about half of the marketing costs attributable to transport (Beenhakker, 1987). In Nigeria, for example, 30–40 percent of the market price of agricultural produce, particularly food crops, consists mainly of transport costs and other incidental services, and it is estimated that farm to market costs on the rural road network are three times as high as what they could be with satisfactory road rehabilitation and subsequent maintenance. Analyses of the impacts of transport systems on agricultural marketing (Beenhakker, 1987 and for Africa, Gersovitz, 1991) argue that the benefits of investments in improved transport depend greatly on the policy regimes governing crop pricing, regulation of marketing, and conditions of competition in transport. In rural Java, Alexander (1986) observed that the highest profits in the marketing chain for chillis are captured by depot operators who command superior access to price information. This kind of evidence supports the conclusion that market transparency and widespread access to market information through transport and communication channels are essential to create a competitive marketing system.

Contributions to Growth Through Structural Change

Economic Diversification

Infrastructure has direct effects on production costs and profitability of agriculture which are similar to those for industry discussed earlier, and also create profound structural changes on the rural economy. These latter changes have been found in various studies to affect income levels, the availability of alternative sources of income, the composition of consumption, and the health of the population. A recent study conducted by IFPRI in Bangladesh (see Box 3) illustrates some of these effects.

A study of the impact of improved rural roads in Colombia (Van Raalte, 1979 cited in Evans, 1990) documented not only increases in agricultural production, but also greater use of credit and alternative nonfarm employment, resulting in higher overall earnings. In Thailand, reduced transport costs

Box 3 The Impact of Infrastructure on the Rural Economy in Bangladesh

A household and village-level survey conducted by IFPRI in Bangladesh provides some evidence of the impact of transport infrastructure on various facets of the rural economy. The sampling method used controlled for differences in observed natural endowments to focus on the effects of infrastructure development (of roads in particular) on several components of the rural economy. Villages were grouped according to an "infrastructure index" which measured the degree of physical access to various markets and services. Villages which were classified as "most developed" infrastructurally showed a significantly improved situation compared to the underdeveloped villages, in terms of agriculture production, income and labor demand, and health, as summarized below.

Indicators of Impact: 5. Higher in Developed vs. Underdeveloped Villages

Agricultural indicators:

| | |
|---|-----|
| Farmgate price of rice | 6 |
| Farmgate price of fertilizer-14 (lower) | |
| Share of land under irrigation | 105 |
| Area under high-yielding varieties | 71 |
| Use of fertilizer | 92 |

Labor market indicators:

| | |
|---|-----------|
| Demand for agricultural labor | 12 |
| Demand for nonagricultural labor | 30 |
| Total household income | 8 |
| Total household income from wages | 101 |
| Per capita wage income of: | |
| Landless workers | 36 |
| Small/medium/large landowners | 95/165/30 |
| Livestock and fisheries income per capita of: | |
| Landless workers | 109 |
| Small/medium/large landowners | 19/26/39 |

Social indicators:

| | |
|--|----|
| Share of total population in good health | 16 |
| Share of women in good health | 19 |
| Educational attainment, total population | -1 |
| Educational attainment, women | -4 |
| Share of female workers in labor force | 9 |

Infrastructure was found to affect agricultural production through improved prices, diffusion of technology, and use of inputs. It was also found to increase incomes both from crop production, and by providing alternative employment; the income benefits were significant even for landless laborers. The study also looked at impacts on savings and investment behavior in the two groups of villages, and concluded that infrastructure may encourage private saving and investment indirectly through its positive effect on income. The finding that infrastructure development was not positively related to educational attainment is believed to reflect the higher opportunity cost of school attendance in villages with alternative employment opportunities.

As qualifications of the above results, it should be noted that there may be factors affecting the productivity of the villages which were not controlled for, such as unobserved differences in their natural endowments. The composite infrastructure index constructed to compare the villages does not permit separate examination of the effects of particular types of infrastructure on development outcomes. The index does not measure actual access to services, the extent to which the services are used, or their quality.

(Source: Ahmed, Raisuddin and Mahabub Hossain, *Developmental Impact of Rural Infrastructure in Bangladesh*, Research Report No. 83, International Food Policy Research Institute (IFPRI), Washington, D.C., 1990)

from improved roads were found to shift local demand away from some cheap locally-produced goods as costs of competing manufactured consumer goods were reduced; however, the improved roads were found to contribute more nonfarm jobs than were lost (Bhushanger, 1983).

Impact on Technological Innovation

In a fundamental sense, and today more than ever before, infrastructure provides the key to modern technology in practically all sectors. The changes in markets and production brought about by the railroad and electric power in the past are significant enough, but are dwarfed by the "information revolution" of recent decades which is based on telecommunications. Electronic information systems (informatics) using the technology and services of telecommunications underlie a very large share of production and distribution activities in secondary and tertiary sectors of the modern economy, including banking, government, and culture.

Information is today considered itself a factor of production, and activities involved with the processing and generation of information account for one-third to half of GDP and employment in OECD countries, and a growing share of GDP in the modern sectors of LDCs (Wellenius et al, 1993).¹⁴ Technological change in telecommunications, which has drastically reduced the cost of communications and expanded the range of services available, has also reduced the costs of transportation and many other activities using telecommunications (Hufbauer, 1991). The result has been a dramatic change in cost structures and increased information intensity of many activities, an increased globalization of trade, manufacturing, and capital flows, as well as increased contact and cultural exchange across populations.

Impacts on Structure of Production and Consumption

Infrastructure is central to the basic patterns of demand and supply, and to the economy's ability to respond to changes in prices or endowments of other resources. In the United States, for example, it is observed that the expansion of service, high technology, and financial sectors relative to manufacturing and goods-producing industries increases the demand for telecommunications, but decreases the relative requirements for transportation of manufacturing inputs and outputs, and infrastructure for industrial waste disposal. Similarly, the development of computer-integrated flexible manufacturing systems, which are expected to be adopted throughout the manufacturing industries over the next 20 years, involve placement of production much closer to final consumers in the domestic market, thereby increasing the requirement for short-haul transportation relative to long-haul¹⁵ within the country. In the countries of East/Central Europe and Central Asia which are shifting from socialist to market principles, infrastructure will have to undergo fundamental changes to serve the economy-wide restructuring of demand and supply (see Box 4).

¹⁴ The information sector comprises all activities that involve the production, processing, and distribution of information and knowledge, as distinct from capital goods; it thus includes the sectors of banking and government, as well as the information components of primary and secondary production (e.g., accounting and managerial services used in manufacturing).

¹⁵ More detailed analysis of these illustrations is provided in US Department of Commerce, 1987, *Effects of Structural Change in the U.S. Economy on the Use of Public Works Services*, A Report to the National Council on Public Works Improvement.

Box 4: Structural Reform in the Formerly Socialist Economies (FSE) of Central/Eastern Europe and the Former USSR: Implications for Infrastructure

Certain characteristic features of these economies under socialism had implications for infrastructure: (i) the dominance of large state enterprises; (ii) the emphasis on heavy industry and self-sufficiency in production. The services sectors were constrained to meet the needs of industry, and distribution (domestic trade) was less than half its relative size in FSE compared to market economies; (iii) international trade was heavily intra-regional, and access to Western technology (particularly relevant to telecommunications) was proscribed by NATO restrictions; (iv) consumers were unable to express demand through purchasing power, or to influence the provision of goods and services through local governments, interest groups, or other channels.

These and other elements of the traditional socialist economies led to a characteristic structure and performance of infrastructure: (i) organization—practically all infrastructure subsectors were organized as government departments or state enterprises (both equally lacking in managerial and financial autonomy); (ii) transport intensity—transport ton-km per \$GNP is several times greater in most FSE than in market economies with similar geographic distances and length of haul. This is explained by the heavy share of industrial commodities, uneconomic plant location, high consumption of raw materials, and lack of influence of pricing on transport demand. The modal composition of transport was also peculiar in socialist countries, with railways carrying 50–90 percent of freight traffic; (iii) energy intensity—extremely low tariffs for electricity, both relative to other energy sources and to economic costs of generation, contributed to the region's very high energy demand and low energy efficiency; they also added to the demand for transport of fuels; (iv) tariff policy—infrastructure tariffs for industry were fixed at low levels for long periods in the pre-reform era, and tariffs to households were heavily subsidized (e.g., consumer subsidies for electricity/heating, public transport, and water/sewerage amounted to about 3 percent of GDP in some countries); (v) investment planning—investments were planned within an input/output framework, with evaluation based on payback period rather than a least-cost assessment at economic prices. This led to a deterministic, quantitative approach to assessing demand—for example, to meet forecast increases in traffic, planners would typically aim at new capacity in one main transport mode with little consideration to possible alternative modes, or to the scope for demand management through pricing or other traffic management policies; (vi) financing—financial surpluses of infrastructure enterprises were absorbed by the state; investments were financed by grants or loans from the government budget or investment bank, with little reflection of the cost of capital.

Summary of main infrastructure issues in the region. The countries of Central/Eastern Europe and the former USSR present a stark legacy of infrastructure planning and provision oriented to the creation of physical capacities rather than efficient delivery of services. Projects tended to be over-large and of standard design, and the needs of users (in particular households) were given little consideration. As a result of the distorted demand structure and poor incentives for capacity utilization, the subsectors of railways, electricity generation, and irrigation have become relatively overdeveloped in terms of availability of physical facilities, while roads and telecommunications are relatively underdeveloped for these countries' income levels. In view of the large scale of overall investment needs and scarcity of funds (especially foreign exchange) in the region, even expenditures to restore the productive capacity of existing facilities should be subject to serious economic evaluation, since some of these investments may no longer correspond to actual or future demand in a market economy.

The economic reforms underway in the region will entail shifts in production from heavy industry to light industry and services; a greater share of output and employment in small-medium scale enterprises; increased trade with developed market economies (which have higher demands for quality than the former CMEA zone); and increased economic and political influence of the population compared to the past era. All of these developments will create inexorable pressure for higher quality and a changed composition of infrastructure services.

Impacts of Infrastructure on Personal Welfare

Infrastructure relates to welfare (and to the absence of welfare, poverty) in three broad respects: first, infrastructure has a basic consumption value, and as such affects the utility that persons realize from their existing income; second, infrastructure affects labor productivity and access to employment, and thus the capacity to earn future income; and third, it affects real wealth.

In many, if not most, countries, low income groups generally have less access to infrastructure services, or face lower quality of such services when they are available, than higher income groups within any given population or country.¹⁶ This observation in itself is neutral with respect to causality—that is, whether having higher incomes enables a population group to acquire better infrastructure, or having better infrastructure leads to higher incomes. There are exceptions across populations (e.g., the relative poor in developed countries are better served than the income elites in many LDCs; the poor in central, older urban areas can have better availability of certain infrastructure because of their location than the rich in newer settlements not yet serviced). The main focus here is on the implications of inadequate or low quality infrastructure services for the reduction of welfare and persistence of poverty.

One important policy issue concerns not only the distribution of access or quality of infrastructure services among income groups, but also the incidence of net public expenditure on these services.¹⁷ For example, in Bangladesh, public current expenditures on transportation, energy, communications and housing combined amount to twice as large a percentage of incomes of the “nonpoor” as of the “poor”. The “nonpoor” receive over 80 percent of the public expenditure on these services, and over five times the value in local currency per household, relative to the “poor”. Net public expenditures on irrigation were found to accrue predominantly to well-to-do farmers, while flood control infrastructure was assumed to benefit the population more evenly (internal World Bank study). In Egypt, the highest subsidy rates in rail transportation are for the first and second classes of travel used mainly by upper income groups. In Poland and Hungary in the late 1980s, the absolute amount of local public transport subsidies were found to be fairly evenly distributed among income groups, while subsidies for rail passenger transportation and (in Hungary) for water supply and sewerage in state housing were strongly skewed in favor of the rich (internal World Bank studies and Hungary Central Statistical Office et al., 1989). The overall impression conveyed by these studies is that apart from whatever effects

¹⁶ Two formal empirical studies include those by Selowsky (1979) for Colombia and Meerman (1979) for Malaysia, which find that service connections for electricity, water and sewerage services favor the rich. In the former research, this outcome was due to greater coverage in urban areas, which had higher average incomes. The incremental investment in infrastructure in the later years examined was found to be more progressively distributed. The Colombia study also found that among urban households not using the services, half were constrained by demand factors (high cost of tariffs) rather than supply factors (inaccessibility).

The 1985 Living Standards Measurement Study (LSMS) in Cote d'Ivoire documents the different sources of drinking water, lighting, and type of toilet by income level and urban/rural region. Access to indoor or outdoor faucets and use of water vendors is largely limited to the top 40 percent of the income distribution and to urban areas, with the remaining population dependent on wells and surface water. Electric lighting (as opposed to candles/oil lamps) is overwhelmingly an urban phenomenon. Use of flush toilets is highly correlated with income and urbanization, and the absence of any system is negatively correlated with both, as expected; pit toilets are more dispersed among various groupings. Within rural and urban areas, the relationships between these forms of infrastructure and income levels were less strong and consistent (Glewwe, 1987).

¹⁷ The following studies are based on allocations of household expenditure or profiles of users of particular infrastructure services, and so estimate the direct beneficiaries of subsidies; they do not attempt to take account of the distribution of indirect benefits or externalities from infrastructure.

infrastructure provision may have on poverty, the actual patterns of public spending on infrastructure frequently tend to worsen inequalities.

Infrastructure's Value in Consumption

Infrastructure services such as clean water, transport, and communications are important consumption benefits, and their availability is a measure of the basic welfare of the population. In this sense, individuals are poor because (insofar as) they do not have access to infrastructure services of the necessary quality. In India, over 1981–91, the population living in slums grew even while poverty fell, as measured by indicators of income and food consumption. Thus, the dimensions of poverty and likewise, the policies needed to address poverty, are changing in developing countries and infrastructure is becoming a central poverty issue.

Besides their direct value as an item in the “consumption basket” of households, infrastructure services are a means to acquiring other goods and services. The direct and indirect consumption benefits from electric power, for example, includes the extra hours of study time due to electric lighting, the availability of new forms of entertainment (e.g., cinema, television), and the access to labor-saving appliances. In addition, the price of infrastructure services relative to other items affects the level of overall consumption which households can achieve within a given budget constraint. Two budget constraints are relevant here—both cash income and time.

The value to households of any infrastructure can be inferred quantitatively, at least in part, from the analysis of three types of behavior: willingness to pay, allocation of expenditure, and allocation of time. As an example of the first, a study of informal sector water vending in Onitsha, Nigeria reveals that the vast majority of households were not service by the municipal piped water distribution system, and instead were purchasing water from private vendors at prices that were 20 times those of the public utility. The authors note that whereas it is often assumed that households will only spend 3–5 percent of their income on water, the poor especially often spend much larger shares of income for water—up to 20 percent according to one study in Haiti (Whittington et al., 1989). This is a reflection of water's value as a basic necessity.

Recent research on households' responses to the unreliability of public water supply in Istanbul (Turkey), Faisalabad (Pakistan), and Jamshedpur (India) reveals the range of alternatives used to meet the need for water (see Box 5). This research shows that households incur high costs of coping with unreliability. Lower income households (and households headed by women) have fewer options to deal with unreliability, and pay higher portions of their income to cope, than higher income groups.

A comparison of villages in rural Sindh, Pakistan found that women who had access to improved water supply spent 70–80 percent less time collecting water than those without. Skilled women spent the greatest amount of their time savings on income-generating activities, and to a lesser extent on leisure; unskilled women spend their extra available time mainly on domestic activities (Read and Kudat, 1992).

The benefits of transport include personal mobility and the access it provides to other goods and services. The share of income reported to be spent on transport varies considerably among different research studies (reviewed in Kranton, 1991). However, many studies on the distribution of household expenditures indicate that the lowest income groups often spend virtually nothing on transport, and instead take the option of walking for local trips, which entails cost in terms of time rather than money. Recent

Box 5 Households' Responses to Unreliability of Water Supply

In 1991, micro level research on households' responses to deficient water supply was undertaken in Faisalabad (Pakistan), Istanbul (Turkey) and Jamshedpur (India). The studies identified in each of the three cities the self-provision measures for water supply adopted by households, the costs of such self-provision to households and to society at large, and the distribution of the cost burden by income categories when the publicly supplied water was either unavailable, inadequate relative to demand, and/or of a quality which was unsatisfactory for the desired uses.

The household level surveys revealed that nearly all households in the three cities are dependent on multiple sources of water—these sources include water from taps, wells, tubewells, public taps, rivers and street vendors. Not all alternatives are available to all households. The access to a source increases with income so that poorer households bear a disproportionate burden of deficient infrastructure. In Istanbul, the ratio of household's expenditure on water to income increases as income levels drop—for households earning more than \$50,000 per annum, the cost to income ratio is .01, for incomes between \$16,000 and \$50,000, the ratio increases to .02 and for the lowest income category, households with less than \$15,000, the cost to income ratio is .05. These costs are in addition to the user charges for water which amount to 3-4 percent of annual income.

The private costs of water generation indicate the willingness to pay for water by consumers. The connection charges for piped water vary between \$1.66 and \$16.66 in Jamshedpur. The residents of the peri-urban areas, served by the local municipal authorities, incur capital costs of \$50 to \$65 on installing tubewells and \$150 to \$300 on digging wells to avoid dependence on the unreliable public water supply. Despite the existence of a piped water system, at least 17 percent of the population needs 90 percent of its water needs from wells and handpumps. All households connected to the public water system have invested in storage facilities such as overhead tanks, drums, tin containers, buckets and pots. Those households with income levels of \$800 per annum or more have water filters. Over and above the monetary costs that consumers bear, households in Jamshedpur spend on average two hours per day in fetching and storing water. The burden of these activities falls in nearly all cases on women.

The pattern of private augmentation of the public water supply at substantial private costs to consumers is observed also in Faisalabad, Pakistan. Less than 20 percent of the households which have piped water use this source exclusively—70 percent have motor pumps and 14 percent have hand pumps. 75 percent of these households have invested in water storage devices versus 46 percent in areas where there is no piped water system.

Estimation results using a binomial choice model for the case of Istanbul showed that the most important variable influencing the household's decision to relocate in order to gain improved water supply is income level. Income is also the single most important determinant of the decision to invest in fixed storage devices, while income and education both influence the decision to invest in water filters.

Sources: World Bank, "Households' Responses to Unreliable Water Supply in Jamshedpur, India," INUVS draft working paper, April 1992; F. Humplick and S. Madani, "Household Responses to Reliability of Water Supply: The Case of Istanbul, Turkey and Faisalabad, Pakistan," World Bank, INURD, May 17, 1992.

research in Sub-Saharan Africa documents the extensive practice of "headloading" of firewood, water, and crops due to the absence of road infrastructure for motor vehicles and of intermediate means of transport (e.g. bicycles) (Riverson and Carpeis, 1991). Thus, where the poor have little access to modes of transport other than walking, they have to forego time which could be spent on activities with higher utility to them. The research cited by Kranton, and the LSMS for Peru,¹⁸ indicate that the share of the

¹⁸ "Living Standards Measurement Study" see Glewwe and de Tray, 1989. This study also shows that the shares of household budgets spent by the rural poor on water services, electricity, and telephones are each less than one percent, and the share for public transportation is below 2 percent. The poor in urban areas, however, have a higher propensity to spend on each of these

family budget spent on travel increases with income. This suggests that at higher expenditure levels, households are less willing to forego time and have more money to spend on leisure and social activities that involve travel—in other words, the value of transport as a means to other consumption increases with income.

The available evidence from sectoral research and household expenditure studies indicates that the demand for public transport is more evenly distributed among income levels than automobile or rail transport, and is fairly inelastic with respect to price (Oum et al, 1990). This implies that when public transport fares are raised the poor would tend to increase their expenditure, at least for essential trips to work or school, and reduce their consumption of other goods and services within their fixed income. Over the longer term, when the cost of transport rises and no cheaper modes are available, the poor would have to reduce their use of transport and forego the benefits they would have gained from it, which could imply sacrificing employment or the ability to take advantage of education, health, or other important services.¹⁹ Moreover, in most urban areas there is a trade-off between the level of housing rents and the transport costs required for commuting between a given settlement and the main business districts. When distortions in the housing market require the poor to be concentrated in the periphery of urban areas, as is the case in many developing countries, the costs and availability of public transportation become especially critical factors in determining their ability to obtain employment and maintain an adequate level of overall household consumption.

Being disadvantaged in access to infrastructure also entails losing out on the positive externalities of infrastructure as discussed in the previous sections. A minimum level of transport and communications services is necessary for markets to function efficiently; the lack of such services has highly unfavorable impacts on prices faced by the poor either as producers or as consumers.

Infrastructure and Labor Productivity

Infrastructure also has impacts on labor productivity and availability of employment—these connections imply that the lack of basic infrastructure services can be a factor determining whether individuals and households remain poor.

As noted above, inadequate access to infrastructure services affects the time allocations of the poor and thus their ability to engage in income-earning activities or activities which would have a greater impact on the household's welfare (such as child care or food preparation). Since women's responsibilities include work in the home, their ability to take employment elsewhere depends greatly on the time required for commuting (Kranton, 1991).

Inadequate infrastructure can also have multiple effects on health, and thereby on individuals' labor productivity as well as quality of life. A large body of research has documented that improvements in water supply and sanitation have a large measured impact in reducing morbidity from major

services, particularly public transportation (4.5 percent of the budget).

¹⁹ Surveys of urban women indicate that the lack of secure and reliable transportation is an important factor discouraging girls from attending secondary school in Zambia, and reducing the participation of women in evening vocational training in Guayaquil, Ecuador (from 1993 communication with Caroline Moser, World Bank, on ongoing research project on urban poverty in Zambia and Ecuador).

water-borne diseases (ranging from 25–78 percent), reducing child mortality, and reducing the severity of disease when it occurs. It is interesting that the health benefits are not assured merely by access to the physical infrastructure for water supply. Adequate sanitation (excreta disposal) is critical to the reduction in incidence and severity of diseases and thus planning for both water supply and sanitation needs to be more better integrated. Moreover, the research has found that consistent and reliable operation of the facilities are necessary—for example, they must not fail during seasonal transmission periods of the diseases—and must be supported by appropriate behavior of users regarding personal and domestic hygiene (Esrey et al, 1990).

In addition to the obvious linkage between water and sanitation and health, the quality of transport and communication infrastructure can affect access to health care; pollution of air and safety hazards connected to motor transport (e.g., road accidents on congested routes) also affect morbidity and mortality, particularly in densely populated areas where the poor are often concentrated (see following section on environment).

Infrastructure also has an affect on the **availability of employment**. As discussed earlier, research in Nigeria has demonstrated that small-scale enterprises are particularly affected by inadequate infrastructure, which reduces the potential employment generation by these firms. The IFPRI study in Bangladesh revealed that the poorest groups experienced the greatest gains from some of the new income-generating opportunities which occurred in the villages with better infrastructure. In addition, levels of wage income and diversity of income—which is important to provide risk insurance for the poor—are considerably greater in villages well served by infrastructure. Transport and communications infrastructure are also important to reduce the transactions costs of looking for employment, and thus making labor markets more efficient. The time and money spent commuting are basic determinants of poor households' access to employment in urban areas. Research comparing two poor neighborhoods in Mexico City found that residents of an inner-city slum were better situated to maintain income in the context of an economic crisis than residents on the outskirts of the city (Eckstein, 1990).

Infrastructure and Wealth

Investments in infrastructure facilities are most often fixed in place, and thereby affect land values and consequently wealth. The irrigation and drainage sector is an obvious example of the implication for poverty. In many countries, the wealthier farmers benefit from irrigation investments most directly as poor farmers use mainly non-irrigated land. Since the direct economic returns of irrigation are private (obtained by individuals), the investments are heavily subsidized by the government, and the beneficiaries pay little if any water charges, the publicly-supported irrigation programs not only maintain the existing unequal distribution of wealth and income but skew it further.

In urban areas, water and sanitation infrastructure, access to roads and public transit routes, and connection to power and telephone lines can have a major impact on real estate values. In Karachi, Pakistan, Dowall (1991) developed a regression model to determine the effects of infrastructure development on prices of land plots in 1987 and 1988. The estimation results, which were highly significant statistically, found that the provision of infrastructure doubles land values after controlling for the distance of plots from the city center.

The main point from the above discussion of infrastructure's linkages to poverty is not that the provision of infrastructure is often highly unequal, as is so often the case with other resources as well. Rather, the way in which infrastructure is provided and especially, the way in which it is financed, have

important implications for the potential to mitigate poverty and reduce inequalities in the longer term. The impact on individuals of low access to infrastructure depends on the options available, and the poor as a group have fewer or less attractive options than the rich. Alternative sources of service (e.g., by investing in their own well or water pump, private transport, kerosene stoves or lighting, or by moving to a better-served neighborhood) may be unavailable or unaffordable to the poor. Their real income and consumption are thus reduced, with a consequent loss of welfare.

Policies to improve access of the poor should not be focused mainly on reducing the costs of the formal supply systems, e.g. through subsidies on public utilities, since these are often poorly targeted as well as financially unsustainable. The main supply system may not even be the most appropriate for low income users. At the same time, equity and efficiency are both served when private beneficiaries of public infrastructure investments are required to pay for them to the greatest possible extent. Public policies should aim at increasing the range of affordable options for service of the type and quality required by the poor. Often, this will call for directing policies to facilitate alternative forms of provision by the private sector, within a framework of regulation which provides minimal protection of safety and fairness (e.g., initiating hire-purchase schemes to promote intermediate forms of transport, freeing the importation of vehicles and equipment for use by small-scale private operators, etc.).

Impacts of Infrastructure on the Environment

Infrastructure's linkages to the environment, as to poverty, are felt both through its effects on the quality of life and on economic productivity. These effects may be positive as well as negative, depending on the nature of each infrastructural development and what the alternatives are. While there may be trade-offs between the economic benefits and the environmental impacts involved in particular cases, there is a wide scope for "win-win" strategies through which both the infrastructure services and environmental quality can be enhanced. More discussion of infrastructure and environment is provided in the World Bank's 1992 World Development Report (particularly regarding power, water supply and sanitation). Some of the environmental impacts of urban infrastructure are treated in Faiz et al (1990), in Shin et al (1991), and UNDP/World Bank/UNCHS (Habitat), 1992.

Negative environmental impacts often result, or become more serious, from a failure to take account of interdependencies among infrastructure sectors. For example, underinvestment in sewerage relative to water supply in many places has led to harmful contamination of water reserves, exacerbated flooding, and reduced the health benefits from water investments alone. Poor management of solid waste and inappropriate disposal further complicates wastewater disposal and urban street drainage. The lack of safe water requires users to boil contaminated supplies, with a considerable cost in energy—in Jakarta, energy consumption for this purpose is estimated to amount to one percent of the city's GDP (World Bank, 1992e). The prolonged dependence in many countries on biomass fuels rather than commercial energy such as electric power leads to increased erosion and loss of soil fertility as plant and animal wastes are removed from forest and fields. In many countries as noted above, overuse of water for irrigation has severely constrained its use for urban areas, where it would have higher economic returns and more positive environmental benefits. Finally, the severe shortage of telephone connections in many cities requires businesses and individuals to increase their use of transport facilities—with the consequent traffic-related air and noise pollution—for necessary communications.

There are also many positive opportunities for synergism among activities in infrastructure and other sectors to increase both environmental and economic benefits in urban areas (see Box 7). For example, reclaimed landfill sites and wetlands used for sewage treatment can be developed into

Box 6 Infrastructure and the Spatial Environment

The fact that infrastructure services derive from physical facilities which tend to be large and fixed in place has clear implications for both the built and natural environment. The "spatial context" of human activity occurs in a built environment imposed on a natural setting; the design skill with which this occurs is a direct result of the infrastructure planning. Transport facilities, power and telecommunications lines, water and sanitation pipelines, and irrigation and drainage channels function in the physical environment both natural and man-made, influencing the circulation patterns, form and density of human settlements. Infrastructure configurations and policies—for example, concerning development of public transport versus private transport—affect motorization, land use patterns, and the economic productivity of urban agglomerations. Because of their potential to facilitate interactions among spatially dispersed population groups, infrastructure linkages (especially transport and telecommunications) are often viewed by governments as having a role in promoting national integration.

The strategic and timely location of urban infrastructure can play a key role in guiding the future form of the urban area. Curitiba, Brazil, is an example where the planning of a public transport network in the 1960s has guided the physical growth and layout of the city to the present with very positive results for the urban environment. Planning of infrastructure should be integrated with overall land use planning in urban areas. A good example of the approach which the Bank is now adopting can be found in the strategic infrastructure planning and environmental management project in Singrauli, India.

Physical infrastructure has a strong visual impact through the appearance, size and scale of installations such as power stations, highways, rail systems and transmissions lines. Infrastructure facilities and the quality of services generated can increase aesthetic enjoyment of both the built and natural environment (e.g., from removal of solid waste and sewage) or decrease it (due to infrastructure related noise, physical congestion, and poorly designed and located facilities). Although much of infrastructure planning in developing countries has focused on the economic costs and benefits, the design and amenity aspects of infrastructure should be an integral part of the investment. The aim is a well-designed project which is aesthetically pleasing as well as functional and cost-effective. A notable example is the way in which the early reinforced concrete bridges spanning the gorges in Switzerland fit into a sensitive and beautiful natural physical setting. The joint land use development of urban highways and metro rail systems can help integrate them more effectively into the urban fabric (e.g., Singapore's Newtowns, La Defense in Paris). The Trevi Fountain in Rome, widely considered a work of art, is the endpoint of an aqueduct. Many of the major infrastructure investments in presently developed countries, such as bridges, railway stations, and water towers, have been viewed from their inception as objects of architectural interest and monuments to civic pride.

recreational parks. Duckweed ponds can serve both as wastewater treatment and a source of high quality protein feedstocks for animals. Methane can be extracted from sewage treatment plants and from the decomposition of organic matter in landfills and used as a fuel source. Compost from organic solid waste can restore soils, and properly treated municipal sewage and wastewater can be used for irrigation. Recycling of municipal solid waste can reduce the requirements for virgin raw materials, such as trees for pulp. The technical and economic requirements for these options will not make them attractive or feasible in all places, but examples do exist of their current application even in some of the least developed countries (Kalbermatten and Middleton, 1992).

Box 7 Recovery of Solid Waste in Jakarta

Solid waste in developing countries is very often dumped in waterways, burned in the open air or left to rot on unused plots of land. There is, however, increasing awareness that garbage can be a valuable resource. Resource recovery from municipal solid waste contributes both to environmental improvement and improvement of infrastructure services in urban areas by reducing the negative impacts of inefficiently managed solid waste operations. These detrimental effects include but are not restricted to garbage clogging storm drainage, impeding traffic flows, polluting air and contaminating water sources.

Jakarta generates upwards of 5000 metric tons a day of solid waste; small bands of scavengers earn a steady income extracting recyclable materials such as rubber, cardboard, glass, paper, metals, wood and textiles from the city's rubbish heaps. What they leave behind is mainly the organic portion of the waste which can be converted into compost-compost is an organic soil amendment that is both a pesticide substitute and an organic fertilizer.

The technical and economic viability of small scale, privately run operations for the composting of municipal solid waste in Jakarta has been studied since 1989 by a research team from the Center for Policy and Implementation Studies, Indonesia, and Harvard Institute for International Development, USA. In late 1990, the results of the study led to the establishment of pilot projects in four locations. These projects, called the Enterprises for Recycling and Compost Production (ERCs), are operated by private entrepreneurs (lapaks) and assisted by CPIS via the provision of partial start up grants, technical assistance, worker training and two year guaranteed purchase arrangements for the compost produced. The two main functions of the ERCs are (i) the production and sale of compost made from the organic component of municipal solid waste and (ii) the recycling and sale of economically valuable waste materials.

Each project processes roughly 3 tons of raw waste per day which yields .75 to 1.25 tons of compost. The city government contributes to the project by arranging the daily delivery of fresh garbage and the removal of non-compostable residues and hazardous materials as they accumulate. The composting process—developed specifically to suit the city's climate, local waste stream, and labor surplus economy—uses only indigenous and relatively inexpensive materials in combination with "informal sector" labor and produces saleable compost in 50 days. The end product is sold commercially to a variety of users such as farmers, landscapers, nurseries, shrimp and fish farmers, and home gardeners. The available data suggests that ERCs can be privately profitable given factor prices. The system is flexible regarding who delivers the waste and where the facility is located and is therefore easily replicable in other municipalities and cities. It is estimated that if each of Jakarta's 260 local units had an average of two ERCs, they could handle 20 percent of the city's solid waste.

Converting waste into compost yields several benefits: i) value is captured from materials that are otherwise considered waste, ii) employment opportunities are increased through the use of a labor intensive technology, iii) environmental pollution decreases as the quantity of waste that is burned or disposed in landfills is reduced, iv) the use of compost conserves natural resources such as water, topsoil and humus, v) due to ERCs being privately managed, the municipal government is saved space at the final disposal site, waste transportation and incineration costs.

(SOURCE: Tellus Institute, *Enterprises for the Recycling and Composting of Municipal Solid Waste in Jakarta, Indonesia*. Discussion Paper, September, 1992.)

Much has been learned about assessing the potential harmful environmental effects of infrastructure activities such as power generation and road construction, and about ways of mitigating such effects as ozone depletion, soil erosion, deforestation, and other issues of the so-called "green agenda". The environmental problems within urban areas (often termed the "brown agenda") have even more immediate and serious implications for health and productivity, particularly for the poor. These issues include the lack of safe water supply, sanitation and drainage; inadequate solid and hazardous waste management; uncontrolled emissions from cars and low-grade domestic fuels; accidents linked to transport congestion and crowding; and the occupation and degradation of environmentally-fragile or hazard-prone land. Addressing issues of the urban environmental agenda requires, in part, improved infrastructure and better infrastructure services such as through substitution of "dirty" fuels for cleaner-burning power generation, safe water supplies and sanitation systems, and support for public transport and traffic management. In most countries, better maintenance of facilities is also a strategy with

clear environmental benefits: in the power sector, for example, inadequate maintenance leads to inefficient thermal generation which accounts for a substantial share of energy-related pollution; likewise, inadequate upkeep of water and sewerage lines results in contamination of water supplies. Environmentally-sound practices can also be introduced in the management of existing infrastructure, for example, by appropriate disposal of wastes from port dredging and railway maintenance workshops.

Providing users, especially the poor, with options for acquiring their desired level and quality of service will frequently promote more efficient use and less waste—and thus a more favorable net impact on the environment—than under traditional supply systems. Users in many countries have indicated their willingness to contribute to the financing, organization and operation of environmentally sound techniques of small-scale irrigation, low-cost sewerage, private solid-waste collection, communal (e.g., cooperative) power generation, reliable water supplies with house connections, and nonmotorized transport. The role of the government in connection with these options will be important in public education, facilitating the availability of credit and in regulation, particularly to promote appropriate technologies and participation of the groups affected by environmental externalities. The potential for harm to the environment from mainstream, large-scale infrastructural developments can be reduced or eliminated by appropriate policy and institutional responses. By far the most important of these is economic pricing of vehicle fuels and power, irrigation, and water supplies to encourage conservation. It is also necessary to provide for broad participation of users and other stakeholders in the process of planning, operating, and regulating infrastructure so that environmental impacts can be properly identified and evaluated.

IV. Infrastructure and Macroeconomic Stabilization

Whether public expenditure in this sector “crowds out” private investment is only a concern if the infrastructure involved has lower benefits to the economy than alternative uses of the same resources. The previous section has argued that the benefits of infrastructure depend on how well it meets effective demand by various user groups in the economy, as well as on externalities such as environmental impacts. Following this reasoning, it is not possible to determine *a priori* what effects a given level of public infrastructure spending will have on economic growth in a given country without considering the efficiency of its allocation and its valuation by users. The incentives for efficient allocation of resources to infrastructure depend in large measure on the way in which the expenditures are financed—for example, whether users pay a price (user charge) for the services. Appropriate financing policies are necessary to ensure that the infrastructure expenditures required for development do not threaten macroeconomic stability through fiscal or financial imbalances, or distortions to the labor market. This section looks at the linkages between infrastructure expenditures and the markets for capital and labor in developing countries.

Infrastructure and Financial/Fiscal Aggregates in Developing Countries

Public expenditure on infrastructure has contributed to, and been deeply affected by, macroeconomic destabilization arising from deficits in public budgets. This linkage has been demonstrated especially where infrastructure is provided by public enterprises (PEs) with inadequate cost recovery, whose financial losses have added to the consolidated public sector deficits and public sector borrowing requirement. The present section concentrates on documenting the magnitude and nature of these macro-financial linkages.

Fiscal Linkages

The existence of net transfers from government to infrastructure entities often reflects inappropriate policies on internal cost recovery and expenditure, and poor management by the entities or the government. Policy and institutional reforms aimed at making the entities more commercial and financially autonomous, including by shifting financial responsibility to the private sector, would reduce or eliminate many of these transfers. However, some of the transfers are desirable (e.g., targeted subsidies from the budget to entities which perform certain nonremunerative social services; and payments by infrastructure entities of taxes and dividends to the state for its share of ownership). For these kinds of transfers, the aim of reform would be to increase their amount or improve their structure in the interest of greater efficiency.

Net financial transfers have been calculated for a number of countries for the transport sector. An analysis for transport in fourteen countries in Latin America, Asia, Africa, and EMENA between 1982 and 1987 indicated that none of the railways delivered positive fiscal flows to the government. In only six of the countries did the aggregate results of the public transport sector show a profit (Heggie and Quick, 1990). A consistent pattern in many other countries is that of net subsidies to railways and often to the airline. The roads sector is usually an exception, however (see below). In Zambia, the total cash shortfall in the transport sector in FY91 (mainly due to the airline and railway) absorbed 12 percent of the government’s total current revenue. Financing of transport was thus one of the country’s main macroeconomic problems. Similar situations are seen in the power sector in many countries (World Bank, 1993a).

The heavy burden of subsidies often reflects the dominance of socio-political rather than commercial objectives in infrastructure. A comparative study of utility companies in Sub-Saharan Africa reveals that their operating losses in 1987-89 were proportional to the expressed importance of social objectives. The water/sewerage, urban transport and (to a lesser extent) electricity sectors, for which universal service is an important social value, together registered a net operating loss of 7 percent, in contrast to a net operating profit of 4 percent for telecommunications (France, Ministry of Cooperation and Development, 1991). Some subsidies can indeed be justified for certain kinds of infrastructure services, but they must be financed without creating serious fiscal imbalances and be properly targeted. Analysis of budgetary subsidies to consumers for transportation, power and heating, water and sanitation in several countries indicate that they can be unsustainably high (up to 5 percent of the government budgets in Central European countries in the late 1980s) (Holzmann, 1991). As already noted, these subsidies provide greater direct benefits to higher income users than to the poor in many cases. Large consumer subsidies to infrastructure divert public funds which could be used more effectively on other programs to alleviate poverty, and can discourage other suppliers from competing in the market for the same services.

The potential for some infrastructure activities, in particular telecommunications and power, to provide fiscal revenues to government is often abused when the entities lack financial and managerial autonomy from government budgets. The roads sector provides a relatively inexpensive source of revenues from vehicle-related charges, and they represent a significant share of total government tax revenues in developing countries (up to 30 percent). However, the portion of road receipts which can be considered strictly as "user charges" is much lower, typically around 10-25 percent. For roads, a recent review found that user charges were adequate to cover maintenance in all but 4 of 40 countries, and total expenditures in about half of them (Heggie, 1991). However, because road user charges are not linked to maintenance expenditures, the latter remain too low in many countries. Mobilizing the potential of road taxation through commercialized management of roads is an important issue for improving the performance of the sector.

The trend of fiscal and administrative decentralization to subnational levels of government is now apparent throughout the former socialist countries of Central/Eastern Europe and the former Soviet Union, and in a large number of countries in Latin America, Africa, and Asia. This development underlines the importance of governments at all levels limiting their involvement in infrastructure to those activities which require a public role, and leaving the remainder to the private sector; as well as the importance of appropriate financial policies to recover the costs of public infrastructure provision.

Linkages with Credit Markets

In developed countries, municipalities and private sector suppliers of infrastructure obtain much of their needs for finance from private capital markets, while in developing countries, infrastructure providers (mainly public or parapublic entities) are more likely to receive credit and equity from banks and government budgets. An important step in creating financial autonomy for public enterprises in many countries has been to curtail their access to budgetary financing and require them to obtain private capital.

The major obstacles to debt financing of infrastructure in developing countries are the lack of creditworthiness of many public suppliers (especially at the local level), and the immature domestic financial markets for long-term capital. In many developing countries, expanding private involvement in infrastructure will require greater availability of even medium-term domestic credit, particularly for

the small firms that could provide much of the new entry in ancillary services and subsectors such as trucking.

Borrowing by local governments is especially underdeveloped in many countries, and appropriate policies in this area should be put in place in the context of the decentralization process noted above. In a number of countries, specialized financial institutions ("municipal credit institutions" or "infrastructure development funds") have existed for some years to channel funds raised through bond issues, government transfers, and external donor support to municipalities for housing and infrastructure investment. In an unfortunate number of cases, especially in Latin America, such funds have engaged heavily in government-guaranteed lending at below-market interest rates, which has contributed to undermining the soundness of the financial system and to macroeconomic destabilization. Quite often the institutions have not made worthwhile investments or maintained financial viability, because criteria for project selection have been too political, the entity has not had to compete for funds, nor been concerned with recovering its costs (Davey, 1988).

Many infrastructure enterprises have made less use of debt financing than would be efficient for them, in some cases (e.g., TELEBRAS in Brazil in the 1980s) because of a general credit shortage in the country. An alternative illustration is that of the Philippines in the late 1970s-early 1980s, where heavy foreign borrowing by public infrastructure enterprises was a factor which contributed to the external debt crisis in 1983-85. In other cases, the performance of infrastructure entities has made them no longer creditworthy. In a survey of electricity enterprises in 60 developing countries, for more than half of the respondents net revenues were inadequate to cover debt service by a factor of 1.5 times; one-fifth of the countries did not even show a coverage of 1.0 times, and were thus insolvent and unable to cover their costs of borrowing without government support or loan guarantees. Among the total group of 60 developing countries, the average level of cash generation of the power utilities was only 12 percent of their investment requirements. This compares to the average levels of cash generation achieved by these utilities in earlier decades (30-40 percent). Due to this internal lack of creditworthiness and compounded by the external debt crisis, during FY79-88, supplier credits and private commercial financing together accounted for only 12 percent of total financing under Bank-financed power projects (World Bank, 1993a). This type of situation represents highly inefficient mobilization and allocation of financial resources in infrastructure, and results ultimately in poor performance of services and high levels of unmet demand. An analysis of the declared purpose of public external debt recorded by the Bank's Debt Reporting Service reveals that at the end of 1990, 27 percent (\$43 billion) of the outstanding debt of all 114 developing countries in the system was attributed to the five infrastructure sectors (including all energy) (see Table 4.1).

Financing infrastructure through instruments such as revenue bonds and equity issues can provide a good "feedstock" for emerging capital markets and attract funds from institutional investors (both foreign and domestic). There is especially strong potential for these instruments in power, telecommunications, and railways, once the sectors demonstrate financial discipline. An appropriate legal and regulatory framework is essential to foster capital market activity in infrastructure.

Labor Market Issues and Infrastructure

Infrastructure is an essential enabling condition for a well-functioning labor market, as discussed earlier. There are two specific linkages between employment and infrastructure which are of analytical interest here. First, the fact that investment in infrastructure creates employment both in the construction stage and through later operation of the assets has made infrastructure a traditional focus of

counter-cyclical, employment-generation policy in many countries, through labor-intensive public works projects. Second, the widespread tendency towards overemployment in public enterprises is particularly apparent in infrastructure, and is a major problem to be addressed in improving sectoral productivity. The dimensions of these two issues are briefly discussed below.

Infrastructure Investment as a Countercyclical Tool: Labor-intensive Public Works

Investment in infrastructure creates employment in construction and generates purchasing power. This "multiplier" aspect of infrastructure is well understood by macroeconomic managers and politicians, for whom it can be a valuable counter-cyclical instrument in periods of slack demand and a magnet for political support.²⁰ As a stimulus to growth during a recession, infrastructure investment requires a sustained source of financing. Many developing countries cannot use public deficit spending (which was available in the Depression-era U.S.), nor substantial access to foreign savings for this purpose. It is therefore the longer-term effects of infrastructure on growth which should guide investment policy in this sector.

"Public works" schemes are defined as labor-intensive projects financed by public revenues; they usually create or maintain public goods (of interest here is economic infrastructure, e.g., projects to build roads, irrigation works, drainage and sewerage, erosion control, well construction, etc.), but may also involve private goods. Public works programs usually involve a combination of objectives including poverty alleviation (transfer of income, stabilization of income, and/or redistribution of assets), employment generation, and asset creation. What is summarized here are the issues and evidence mainly concerning the latter two objectives (for more extensive reviews, see Burki et al, 1976; Ravallion, 1990).

Public works programs in theory have an impact on employment and incomes both in the short term (construction stage), and in the longer term (from the operation of the assets). In evaluating such programs, the effects in both stages need to be considered, and compared to the benefits the economy would have gained from the alternative uses of the resources (labor and capital) absorbed by the public works projects. Where such programs are financed by incremental and concessional foreign aid which does not substitute for other foreign funding or divert domestic savings for debt service, public works can be considered to create additional assets in the economy, although the quality (returns) to the investment still need to be demonstrated. Where they are financed by general tax revenues, or taxes which are regressive (hitting the poor harder than the rich), they can crowd-out more productive investments and can even have negative redistributive effects.

The "traditional" public works programs as have existed for decades in South Asia, Africa, and many presently developed countries (e.g. the Works Project Administration during the Great Depression in the U.S.) generally provide low wages (sometimes below-market) to unskilled workers, particularly in rural areas, often with the aim of supplementing or replacing normal sources of income during natural emergencies such as droughts, or to combat chronic seasonal underemployment. The programs which have been evaluated, such as the Maharashtra Employment Guarantee Scheme in India,

²⁰ Duffy-Deno and Eberts (1991) find for regional data of the U.S. that infrastructure appears to affect local incomes both through the demand side stimulus during construction and through supply-side productive effects. However, their study suggests that the multiplier effects dampen quickly and are completely realized in the year in which construction expenditures are made.

and the Food for Work scheme in Bangladesh are said to target the direct job creation reasonably well to lower income groups, and contribute to raising wages in the local labor market. Programs which aim at lower income workers also can have a multiplier effect on the local economy, since they tend to spend their wages on domestically-produced goods.

Table 4-1 External Public Debt Attributable to Infrastructure Purposes

| AS OF % OF TOTAL PUBLIC DOD* | | | | *(DOD) DEBT OUTSTANDING AND DISBURSED AS OF 12/90 | | | |
|-----------------------------------|-------------------|--------|--------------|---|------------|--------------------|------|
| SECTOR | | | | | | | |
| COUNTRY GROUP | TRANSPORT & COMM. | ENERGY | WATER SUPPLY | SANITATION | IRRIGATION | ALL INFRASTRUCTURE | |
| | % | % | % | % | % | % | \$Ba |
| A. SEVERELY INDEBTED LOW INCOME | 10.00 | 7.40 | 1.85 | 0.30 | 0.48 | 20.12 | 23.1 |
| B. SEVERELY INDEBTED MID-INCOME | 4.20 | 4.56 | 0.73 | 0.11 | 0.09 | 9.69 | 33.0 |
| C. MODERATELY INDEBTED LOW INCOME | 11.41 | 16.14 | 1.61 | 0.12 | 0.79 | 30.07 | 43.6 |
| D. MODERATELY INDEBTED LOW INCOME | 10.44 | 11.40 | 1.78 | 0.21 | 0.80 | 24.63 | 37.5 |
| E. ALL OTHER COUNTRIES | 13.36 | 10.75 | 1.25 | 0.37 | 1.31 | 27.04 | 42.6 |

*NOTE: Countries in A thru E add up to total developing countries in WDI data bank (114)

Source: World Bank "World Development" Tables 1991-92 database.

The quality of infrastructure created by the traditional public works programs—and thus the longer term economic benefits to be derived from it—is varied. Several studies of a large number of public works programs reviewed in Kessides (1992) indicated that many have quite respectable rates of return and compare favorably to projects in other sectors. However, as a rule there is a trade-off between an emphasis on short-term benefits (through quick creation of employment and assets) and longer term benefits (through more careful project selection, creation of higher-quality assets, and more emphasis on training of workers). Programs which require a high ratio of labor in total project costs tend to focus on works such as unpaved roads and often demonstrate low labor productivity and poor project implementation. By contrast, projects which entail higher proportions of skilled labor and materials (e.g., for irrigation, land reclamation, paved roads) may have higher economic returns (see Box 7).

In contrast to the traditional, rural-oriented public works, some of the programs set up in the late 1980s are of a different design, and focus on urban areas. In Latin America and Africa, "social action/investment" funds have been established to support small-scale infrastructure interventions, among

other compensatory measures, in the context of structural adjustment (the prototype was the "Emergency Social Fund" in Bolivia). As a similar model in a number of countries in Africa, a non-governmental agency (NGO; the prototype is called AGETIP in Senegal) has been set up to contract-out small-scale public works to private sector contractors. Significantly, both types of programs derive project proposals from local communities and NGOs in a "demand-driven" approach; both also depend on the private sector contractors to execute the works and hire the labor, and thus the nature of employment and wages provided are entirely market-determined. Although the experience of these new types of public works programs is still very limited, indications are that both models are relatively successful at developing local capacity in contracting and construction. In both project selection and implementation, the programs have been designed to maximize responsiveness to expressed needs of the community institutions and to the labor market.

Box 8 Short-term versus Longer Term Benefits of Labor-Intensive Public Works

An interesting illustration of this trade-off appears from a CARE study of the Food for Work Program in Bangladesh. This program has focused on expanding the rural road network. The assets are primarily earthworks constructed by manual labor and paid in foodgrains; they lack the minimal structures and physical characteristics (culverts, bridges, and drainage) required to make them fully usable by the rural economy and capable of surviving heavy rains. Although the study reported that local officials had expressed a clear preference for increased structures along existing roads rather than new roads, the study found that the program had not shifted its focus of project selection because of constraints of food aid policy, which prevented the government from monetizing the commodity aid. This case illustrates not only the above-mentioned trade-off between short and long term benefits of public works, but equally a case of an infrastructure program promoting a predetermined package of investments in new capacity, rather than what users really wanted—improved quality of service from existing assets.

Source: Study by Abt. Assoc. (1989), cited in World Bank, *Bangladesh: Transport Sector Review*, Report No. 9414-BD, June 1991.

The review of past experience with the variety of public works programs in developing countries suggests the following conclusions and lessons of interest for infrastructure policy. First, public works programs can be effective in generating significant amounts of short-term employment and income transfer where these are important policy objectives. However, the extent of their broader economic impact in terms of stimulating domestic demand in the surrounding economy, influencing structural unemployment, or increasing incomes and employment in the longer term are more questionable. Regarding the trade-off between short-term and longer-term benefits, the infrastructure is clearly of higher quality when projects are designed and selected to produce the highest economic returns, not to maximize employment during construction. The projects should be integrated into other development programs of the local area to generate the greatest benefit, and public works alone cannot be expected to create employment and income in the post-construction phase in regions which do not have development potential. To ensure that projects meet effective demand, beneficiary communities should identify and contribute to the costs of investment as much as possible, and should take responsibility for financing operation and maintenance. User charges, where feasible, are the most efficient and equitable means of financing O&M of public works (although rarely a feature of such programs in past experience).

Labor Redundancy in Infrastructure

Overstaffing is a common problem in infrastructure enterprises, including telecommunications, power, water, railways, ports, and urban transport. For example, the number of electric power consumers per employee is less than 50 in five South Asian countries and in Kenya, compared to over 300 in Korea (Faiz, 1991). The number of employees per 1000 water connections is about four in a well-run utility in developing countries (e.g. EMOS in Santiago), but averages 10–20 in most Latin American utilities (World Bank, 1992). Railways are among the most notorious overemployers in both developing and developed countries. Railway traffic units (in thousands) per employee range between about 200 to 500 in most developing countries and Western Europe (and in the thousands in North America), but in some African countries and Sri Lanka the rate is less than 100. It should be noted that such physical indicators of labor productivity are based on technical standards of performance, ignoring differences in factor costs among countries. Comparisons which take account of local prices are preferable in this respect as they suggest the economic and financial implications of overstaffing. For example, the railway wage bill in many of the African countries is relatively low, but it amounts to 90 percent of recurrent revenues in Nigeria, and 100–200 percent in Argentina, Columbia, Uruguay, Egypt, and Turkey (Galenson and Thompson, 1991). Estimates of actual redundancy in specific agencies or enterprises in the transport sector of a large number of developing countries are quoted in Galenson (1989); these estimates for various periods (noted here only for illustration) include two-thirds of railway staff in Tanzania and Zaire, one-fourth of road department staff in Brazil, and 80 percent of ports staff in Argentina.

The reasons for overstaffing include the standard lack of incentives for cost efficiency in the public sector, political influence in hiring, and legal restrictions (staffing norms and constraints against firings), all of which prevent enterprises from adjusting to declining demand (a factor especially in the case of railways), relative price changes, or increased competition. There are also economies of scale in some services (e.g. municipal water supply and sewerage) which are not captured by the level of effective demand in some developing country municipalities (Yepes, 1990). In many cases (particularly in telecommunications and ports operations), labor redundancy has been intensified by technological change (Galenson, 1989). Programs to implement labor reductions are often critical to restructuring of infrastructure operations in order to reduce the drain of budgetary subsidies, improve productive efficiency, and make the firm attractive to privatization.

The issues of labor redundancy in transport enterprises have been studied under a recent World Bank research project (Svejnar and Terrell, 1991), and some main points from this work are noted here which have general applicability to other areas of infrastructure. The research examined case studies in six countries (Brazil, Chile, Ghana, Mauritius, Sri Lanka, and Yugoslavia) which had dealt with labor redundancy in rail, port, or bus operations. Among measures to eliminate excess labor, the most politically acceptable include conducting a staffing audit to eliminate vacancies and “ghost” workers from the payroll; relying on attrition with a freeze on hiring; offering early retirement; and redeploying or retraining workers in other activities. However, often countries cannot achieve sufficient reduction of staff by these methods and must resort to dismissals, which is the most efficient approach for the enterprise as it can target the number and types of workers who are no longer needed. The research reveals that when dismissals are combined with severance pay, the reduction in force is more likely to be both politically accepted and sustainable. The economic costs and benefits of these schemes were evaluated both in terms of the economic rate of return and the payback period for the severance payments. The researchers found that the severance schemes had economic rates of return ranging from 48 to over 500 percent and payback periods between one and five years, even when compensation was set at fairly high levels. However, to ensure that the productivity gains from labor reduction are sustained, it is important

that restrictive work rules be removed at the same time, and that other necessary restructuring of the enterprise is undertaken to strengthen incentives for improved performance, for example by commercializing, corporatizing, or privatizing the enterprise.

Impact of Macroeconomic Policy on Infrastructure

While infrastructure policies can thus contribute to macroeconomic destabilization through negative impacts on financial and labor markets, the management of infrastructure also suffers as much as any productive sector from poor macroeconomic policy. In the telecommunications sector of Brazil, for example, in the face of successive macroeconomic crises during the 1970s and 80s, the government failed to prescribe adequate rate increases, diverted surplus revenues from an earmarked telecommunications investment fund to other sectors, restricted both domestic and foreign borrowing by the telecommunications entities in an effort to curb public debt, and forced them to depend on domestic equipment suppliers. These policies, which had the aim of promoting stabilization and import substitution, severely impeded the expansion and modernization of the sector (World Bank, 1992c).

As to more formal empirical evidence, a study undertaken in 1991 examined the impact of macroeconomic policy variables on the economic rates of return of a large sample of World Bank and IFC (International Finance Corporation) projects in various sectors in 58 countries over twenty years. The analysis revealed that the ex-post economic rates of return (ERR) of projects in "public non-tradable sectors" (a proxy for infrastructure) were indeed responsive to indicators of policy distortion, although generally less so than projects in tradable sectors. In particular, whether the trade policy was classified as "highly restrictive" or "nonrestrictive" represented almost 10 percentage points of difference in the average ERR of the infrastructure projects. At high levels of exchange rate overvaluation, average ERRs were almost 8 percentage points lower than for projects with low overvaluation. The size of the fiscal deficit showed a mildly inverse correlation with rates of return. The study concluded that for all groups of projects, policy indices have an independent and additive effect on the ERRs, and the economic and statistical significance is large (Kaufmann, 1991).

V. Lessons from Experience: Implications for Infrastructure Policy and Planning

The preceding discussion suggests that infrastructure policy involves high stakes for developing economies: there are multiple benefits to be gained, but likewise high potential costs (economic and financial) from mistakes in these sectors. A number of conditions appear necessary for infrastructure to have the favorable impacts on economic development described above.

As a first and basic condition, there should be a macroeconomic policy climate which is favorable to efficient allocation of resources. It is particularly important to avoid pricing rigidities in factor and goods markets so that infrastructure draws other resources to productive activities and does not crowd out more attractive investments. Macroeconomic policy issues such as inappropriate budgetary subsidies of infrastructure and distortions in financial and foreign exchange markets can seriously handicap the sectors' access to financing and undermine incentives for efficiency. This implies that major infrastructural investments should be accompanied or preceded by macroeconomic structural adjustment; and that where severe macroeconomic distortions persist, even "strictly hardware" projects may not be a productive use of resources.

Second, infrastructure projects can only raise the productivity of other resources when there is a sufficient complement and basic productive level of other resources. Infrastructure investments cannot create economic potential, only help develop it. This point has been illustrated by earlier references to the experience regarding "new towns" or "growth poles", and export processing zones in developing countries.

Third, infrastructure having the most significant and durable benefits to both productivity and consumption is that which provides the degree of reliability and quality of services needed by users. Reliability is found to be particularly essential to infrastructure's impact on international trade, production costs for small enterprises, and even for the health benefits from water supplies. Achieving such reliability will require institutional arrangements for infrastructure provision which are capable of assessing changes in demand quickly and accurately, and responding in flexible and innovative ways. The policy regime must also create incentives for efficient operation of infrastructure and accountability to users.

Finally, infrastructure is likely to be more economically efficient, and have favorable impacts on the environment, when it is subject to user charges based (as much as possible) on (i) the marginal costs of supply, and (ii) willingness to pay. In order to obtain the greatest benefits from infrastructure's ability to raise the returns to other factors of production, resources for infrastructure should be priced to reflect their scarcity value (e.g., the cost of capital used in financing projects should be realistic). User charges are necessary to elicit expressions of effective demand, and to discourage wasteful consumption of infrastructure services. The absence of user charges has often not promoted effective access to services by the poor, but rather reduced both quality and availability and worsened inequities.

Investment Planning and Project Evaluation

There are four main implications of the above analysis. **The first is that investments should be based on analysis of the nature of demand for specific services, not on quantitative projections of physical "need".** The latter approach involves calculations of investment requirements based on assumed coefficients of the capacity utilization of facilities, and estimates of future consumption of

Table 5-1 World Bank: Ex Post Rates of Return of Infrastructure Investments

| Unweighted-Average Re-estimated Economic Rates of Return | | | | | | | | |
|--|------|------|------|------|------|------|------|------|
| Sector | 1980 | 1982 | 1984 | 1986 | 1988 | 1989 | 1990 | 1991 |
| Irrigation | 30 | 22 | 20 | 14 | 11 | 11 | 13 | 11 |
| Electric Power | 8 | 13 | 11 | 11 | 11 | 12 | 13 | 12 |
| Telecommunications | 21 | 18 | 24 | 13 | 20 | 18 | 21 | 18 |
| Transport | | | | 23 | 29 | 26 | 23 | 32 |
| Highways | 23 | 17 | 22 | | | | | |
| Railways | 20 | 13 | 22 | | | | | |
| Ports | 16 | 24 | 17 | | | | | |
| Water Supply and Sanitation | 7 | 7 | 11 | 8 | 12 | - | 8 | 11 |
| Average of All Bank Operations | 17 | 14 | 12 | 16 | 17 | 16 | 14 | 17 |

* Urban Loans Not Included

Source: World Bank, OED Annual Review of Project Results

services without reference to prices. The design of a demand-based strategy for infrastructure policy imposes additional information requirements. It must entail analysis of the underlying determinants of demand, such as the composition of user groups and their demand for specific kinds of services (which depend, for example, on price elasticities), and the patterns of congestion (see Box 9 on some experiences with assessing demand).

The second implication, which is complimentary to the demand assessment, is that the planning of supply should take account of all possible alternatives to generate the flow of services demanded—including measures (with or without investment) to increase the efficiency of existing facilities and relieve specific congestion points; to promote conservation options (reducing demand); as well as projects to create additional capacity. This investigation should involve a survey of how potential users of a new investment are currently being serviced, even by informal or illegal channels which may be exploited in designing future supplies. Such an approach in many cases would have prevented countries from making new investments which could have been avoided or delayed by efforts to manage better the existing facilities and/or the demand itself. The principle of “least cost investment planning” is consistent with this approach, although it is not often practiced. An example of a creative approach to supply planning in contrast to a more mechanistic approach is described in Box 10.

Thirdly, choosing between potential investments within infrastructure, or between infrastructure and other sectors, is best done with the traditional tools of benefit-cost (rate of return) analysis. The trends in economic rates of return (ERRs) for World Bank infrastructure projects are summarized in Table 5-1. These annual average ERRs range from averages of 7-10 percent in water supply and sanitation to over 20 percent in transport and telecommunications. The table shows ERRs

Box 9 Using a Contingent Valuation Survey to Measure Willingness to Pay for Urban Sanitation and Water Services

In the fall of 1989 a survey of over 1200 households was conducted in Kumasi, Ghana to determine how much people were willing to pay for two types of improved sanitation systems. A stratified random sample of households was selected from all parts of the city. Enumerators described the different sanitation options to respondents by reading from a prepared text and by showing them pictures and diagrams. The respondent was then asked whether he or she would choose to pay a stated monthly fee for one of the specified technologies. Depending on the respondent's answer, the enumerator would then raise or lower the fee and ask whether the respondent would be willing to pay the new monthly fee. Finally each respondent was asked his or her maximum willingness to pay for the service described.

The results of the survey indicate that conventional sewerage is not affordable to the vast majority of households in Kumasi unless very large subsidies are provided. There was, however, a widespread acceptance of improved pit latrines, as opposed to water closets connected to a piped sewerage system. For a relatively modest aggregate subsidy of a few million US\$ (for a city of 600,000 population), most of the population of Kumasi could be equipped with the former in their housing compounds.

The study also highlighted the fact that a narrow focus on technological options for improved sanitation and financing of government subsidies is likely to overlook important relationships between the demand for improved sanitation and the demand for housing and capital. Sanitation facilities are just one part of a package of services provided by an individual's housing. The information on household demand collected for this survey assumed that households' expenditures on other housing services will remain essentially unchanged. The housing market in Kumasi is currently highly distorted by rent control regulations; if policy reforms were introduced to eliminate some of the distortions in the housing market, this would be likely to have an impact on the demand for improved sanitation. Similarly, the subsidies required for improved latrines are greatly affected by assumptions about financial market conditions; policy reforms in the financial sector which permit the operation of more efficient capital markets could have a direct and important impact. A focus on demand-side issues in sanitation planning thus means much more than simply determining households' willingness to pay for a limited range of technological options.

Source: Infrastructure Note W&S No. SW-7, Dale Whittington, et. al., *Households' Willingness to Pay for Improved Sanitation in Kumasi, Ghana: Results of a Contingent Valuation Study*. January 1992.

* * *

In the city of Onitsha, Nigeria, the vast majority of residents obtain their water from an elaborate water vending system, created and operated by the private sector. A survey of users of this system in 1987 revealed some surprising results. Not only did households report that they were prepared to pay substantial amounts for water from a piped distribution system, but the data also make it clear that households were already paying a lot for water. They showed that during the dry season, the private sector vendors were supplying twice as much water as the public system, but were collecting 24 times as much revenue. In the rainy season, the sales of private vendors were still ten times the amount collected by the water utility. On an annual basis, households in Onitsha were paying water vendors over twice the operation and maintenance costs of a piped distribution system. A majority of households can afford to pay for a connection to a piped water system, even one which requires them to pay full economic costs.

The Onitsha study illustrates that a rapid reconnaissance survey of water vending activities and of the willingness of households to pay for improved water services can yield valuable policy insights for water supply planning. Such studies are very inexpensive relative to the capital costs of urban water projects.

Source: Dale Whittington, et al., "A Study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria." *World Development* 19, no. 2/3, 1991.

reestimated at the time of project completion (ex post), which are very often lower than those at the time of appraisal, both for infrastructure as well as for other sectors. This gap reflects, among other factors, the tendency for project benefits to be overestimated at the time of appraisal.

It should be noted that in the power, telecommunications, and water supply sectors, cost-benefit analysis uses revenues or actual tariffs rather than economic prices, and this is not a true measure of economic returns. Moreover, the recalculated ERR is based on actual costs but still projections of benefits; when it is recalculated a number of years after project completion, the results are sometimes less encouraging, particularly where there are institutional problems affecting the project. For a more accurate evaluation of proposed investments, it is necessary for benefits to be determined on the basis of demand assessments which include some estimation of economic prices, such as willingness to pay, as discussed above. In addition, the indirect benefits and costs which infrastructure investments entail, such as impacts on adjoining land values and environmental quality, should also be included in the analysis; such externalities, by definition, are not captured in beneficiary valuation. More experimentation with ways of taking account of such externalities in rate of return analysis of infrastructure is needed.²¹

Finally, to practice a demand orientation in both the evaluation of investments as well as in their operation and regulation requires performance indicators which reflect quality of service and user satisfaction. Most of the performance indicators customarily used by planners and operators in the infrastructure sectors reflect physical parameters of the facilities and internal (including financial) efficiency. Adding to these indicators, service quality needs to be measured and monitored as an input to evaluating the effectiveness of alternative service providers, and helping planners and regulators to evaluate success in the achievement of operating standards or performance benchmarks.

²¹ It has been suggested, for example, that much of the residual value of infrastructure projects (producer and consumer surplus) that is not reflected in users' willingness to pay is capitalized in the value of land or other relatively fixed assets affected by the projects. Taking account of the rents on such fixed assets in the estimation of benefits could prevent the potential risk that more rigorous application of cost/benefit analysis would lead to underinvestment (Garn and Ledebur, 1986).

Box 10 Two Approaches to Planning for Road Investment in Hungary

Some of the highway development plans prepared by or for the Central/Eastern European countries consider needs in terms of bringing physical standards up to the comparable levels in Western Europe. They do not give sufficient consideration to the changing nature of domestic demand, nor to alternatives such as phased and incremental improvements to existing routes. For example, one consultant study in 1991 estimated transport infrastructure needs for thirteen major corridors that were considered critical to increased traffic between West and Central/East Europe. Developments in domestic traffic were not considered. The study estimated that these transport corridors would require needed investment for motorways and railway upgrading of some \$70-100 billion in 1991 international prices. Investment estimates such as these ignore dynamic demand changes (which are admittedly difficult to predict in the present reform context), and do not consider what alternatives and actual quality of services would be required by both domestic and international users.

A recent master plan developed by the Hungarian government for road and rail investments over a five-year period resulted in a similarly unrealistic claim for an increase in government investment expenditure on the sector (from 0.6 percent of GDP in 1990 to 3.8 percent by 1995), in addition to considerable mobilization of private foreign resources. Given patterns of infrastructure spending in other middle-income countries and the need to scale back the size of the Hungarian budget, an increase in the investment share to 1.0-1.5 percent of GDP would be a more approachable target. Within this target, many of the requirements for improved services could be addressed through a different approach to evaluating needs.

The suggested approach would be based on a detailed evaluation of each route (i.e., very location-specific), with study of traffic patterns and possible alternatives, the scope for improvements to existing roads (e.g., strengthening, resurfacing, minor realignments, widening, city by-passes), and development of a phased plan for introducing new routing where necessary. Other measures such as "value engineering analysis" (assessing the cost-effectiveness of technical standards and particular design features) and policies or physical designs to manage the flows of traffic and delays in border formalities can also reduce the needs for new capacity. In short, the alternative planning approach determines the differentiated service requirements, leads to greater discrimination among investment possibilities, and a more realistic assessment of priorities for expenditure in the near to medium term.

Sources: COWIconsult, 1991; Institutional Investor, *Infrastructure Finance Forum*, 1991; World Bank, *Issues in Central and East European Land Transport*, June 1991; "Hungary: Reform and Decentralization of the Public Sector", Report No. 10061-HU, 1992.

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