PLANNING FOR PUBLIC INFRASTRUCTURE INVESTMENT

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Chapter 4

PLANNING FOR PUBLIC INFRASTRUCTURE INVESTMENT

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1 INTRODUCTION

The purpose of this paper is two-fold. First, three principal alternative approaches (developmental, economic stabilization, and maintenance) that can be used to plan at the macro level for public-infrastructure investment are outlined, with an emphasis on the contrast in their use for industrialized versus developing countries.[1)] Second, five major factors that need to be considered when planning for infrastructure investment are discussed. These include physical, economic, institutional, political, and sociocultural factors.

When Choate (1982) stated that $2.5 to $3.0 trillion (not billion, but trillion dollars) would be required between 1982 and the year 2000 just to reconstruct and maintain the rapidly deteriorating infrastructure in the United States, shock waves poured across the nation. Many analysts and politicians expressed disbelief in the figure. Others did not know how the money could be found to undertake such a massive scale of investment. Over the next two years, more than eleven studies were undertaken, partly to prove or disprove the $3 trillion figure. One of the latest of those studies provided estimates that were in the $1.1 trillion range, which was considered to be a more "manageable," albeit still gigantic, number than $3 trillion (U.S. Joint Economic Committee, 1984). Anyone who has tried to drive in some of the major East Coast cities, such as Boston and New York, recognizes that the problem in the United States in regard to its public infrastructure is serious. Given that there is a major problem and regardless of whether the figure is $1 trillion, $3 trillion, or some other significantly large number, the required construction and maintenance should be carefully planned. The need for planning is equally great in developing countries, even though the problems in regard to infrastructure may take different forms in those countries.

In the literature on infrastructure, very little attention has been devoted to the alternative approaches when planning for infrastructure investment. This paper is an initial attempt to help fill this gap in the literature. By understanding the alternative approaches, analysts should be able to plan and evaluate infrastructure investments more effectively than at present, recognizing that each approach emphasizes different economic, political, and institutional arrangements. Some basic definitions are provided before discussing this in more detail.

For this paper, the discussion is limited in several ways. First, the focus is on macroplanning, rather than microplanning, issues. Second, consideration is restricted to infrastructure investment in capitalist countries. Third, the discussion is primarily limited to planning for three broad categories of infrastructure: transportation, water (supply, treatment, and distribution), and wastewater (collection and treatment). Development theorists often refer to these as social overhead capital to distinguish them from what are called directly productive activities. In some studies, the three categories

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1) For the remainder of this paper, the term infrastructure will be used to refer to public infrastructure only.

mentioned above are called "economic infrastructure" to separate them from so-called "social infrastructure," such as public buildings and facilities (schools, hospitals, jails, public offices, parks, swimming pools, parking lots, and so on). The rationale for including or excluding certain types of infrastructure will depend upon the purpose of the study.

In the present paper, the authors have adopted the definition of infrastructure used by the European Economic Community (EEC) analysts in a recent report, EEC (1982). They specify six basic characteristics of infrastructure: immobility, indivisibility, nonsubstitutability, nonexcludability, polyvalence, and system effect (EEC, 1982, pp. 41-42, 69). The first four do not require explanation, but the last two do. Polyvalence refers to the degree to which infrastructure can be used in a large number of alternative production and consumption processes. If a particular infrastructure system can be used with only limited restructuring to produce and consume additional goods and services, that system is said to have a high degree of polyvalence (EEC, 1982, p. 42). This characteristic, therefore, is highly related to the sixth, and final, characteristic, the system effect, which is also referred to as the spill-over effect. This effect differentiates those infrastructure facilities that improve "the access to other types of infrastructure" from those that do not (EEC, 1982, p. 69).

2 ALTERNATIVE APPROACHES FOR PLANNING INFRASTRUCTURE INVESTMENT

The alternative approaches to planning infrastructure investment can be classified according to three objectives: developmental, economic stabilization, and maintenance. The first approach dominates at present in developing countries, while the second and third are used mainly in industrialized countries. For each approach, specific planning goals and evaluation criteria can be identified. Each approach, consequently, requires substantially different types of data. Different information will be required, for example, to plan and evaluate a project in terms, say, of its ability to fulfill the basic needs of the population versus its contribution to stabilization of the economy by bolstering employment during recessions. Part of the confusion in discussions of infrastructure planning stems from attempts to define policy goals in terms that are either too general (such as total public services) or too narrow (such as highways). Admittedly, different types of infrastructure demand specialized engineering/planning techniques in order to translate policy guidelines into programmatic directives. At either extreme, a planner is likely to ignore the function of specific types of public works within the larger infrastructure system. A brief discussion of each approach is presented here to highlight how decision-makers can improve the planning and evaluation process by correctly specifying the type of approach used.

2.1 Developmental approach

Within the developmental approach, four different subdivisions exist: stimulation of economic growth, fulfillment of basic needs, restoration of destroyed facilities, and accommodation of demands.

2.1.1 Stimulation of economic growth

Infrastructure investment has been proposed as a necessary expenditure required to help stimulate and maintain economic growth. In the 1940s

Rosenstein-Rodan (1943) introduced the concept of social overhead capital (SOC), indicating that SOC was of crucial importance for a private economy to develop. Hirschman (1958) agreed with Rosenstein-Rodan that SOC is a prime requirement for private investment in directly productive activities (DPA) to occur. Like other unbalanced-growth theorists, Hirschman, however, emphasized the need to concentrate investment in a few key sectors, specifically, those that induce the largest backward and forward linkages. Without the basic or supporting services provided by the SOC, investment in primary, secondary, and tertiary industries (DPAs) would not occur. He therefore saw a major link between public and private investment; public investment in SOC increases the productive attractiveness of developing regions. It lays the groundwork for the formation of external economies that arise from investments no individual investor would profitably undertake. Because the SOC is lumpy and because capital, managerial skills, and entrepreneurial capacity are scarce, Hirschman advocated an unbalanced-growth strategy, with infrastructure investment playing a dominant role.

In contrast to Hirschman, the balanced-growth theorists, such as Rosenstein-Rodan (1943) and Nurkse (1953), argued for investing in a number of sectors simultaneously as a means of creating employment, which generates income and creates markets for the goods and services produced. They agreed with Hirschman that SOC is indivisible, and not only in physical terms. The life-cycle of the infrastructure project may be indivisible, given the long and phased construction and utilization periods. There is usually a need for a mimimum set (or range) of complementary investments. This notion of indivisibility is related to Rosenstein-Rodan's theory of the "big push," whereby a large volume of investment has to occur simultaneously to reap external economies; individual projects would fail, but investor uncertainty in any one project is reduced considerably when the project is part of an ensemble of projects. These aspects of indivisibility are used by both the balanced and unbalanced-growth analysts to examine how bottlenecks and excess capacities in infrastructure inhibit or induce private investment in DPA (EEC, 1982, pp. 31-32). However, as Hansen (1965a, 1965b) notes, the debate over the impact of SOC bottlenecks and excess capacity is confused by the lack of common SOC definitions. In his work, Hansen tries to distinquish between SOC and what he calls economic overhead capital (EOC). He says that EOC enters directly into the production process, while SOC exerts an indirect influence, through education or health improvements, on the productivity of workers. The distinction between the two is very difficult, however, to apply in an actual analysis.

There is a trend in policy-oriented work to de-emphasize the controversies between EOC and SOC as well as that concerning the role of infrastructure in balanced and unbalanced growth models. For example, analysts such as Lee (1982) and Mera (1984) have adopted Hansen's notion of EOC in modelling production and its spatial distributions; a public-goods or stock-of-infrastructure variable is introduced directly into the production function of a city or firm. In his bid-rent analysis, Lee (1982) uses the quality of local public goods (as measured by the frequency of electricity interruptions) to model the intra-urban location decision of particular types of firms. Mera (1984) uses a city-wide production function and includes the stock of infrastructure as a third factor of production that determines the allocation of capital and labor interregionally. The popularity of the production-function approach, no doubt, stems from a need to make quantitative estimates of the costs and benefits of infrastructure investments. Even the EEC analysts, who state their preference for Hirschman's unbalanced growth theory sidestep the issue of the exact role of infrastructure in initiating or supporting economic growth. Instead, they stress the "complementarity between regional economic growth and infrastructure"

(EEC, 1982, p. 32). The balanced/unbalanced growth controversy is unlikely to regain its former importance in discussions of development. Instead, emphasis will increasingly be given to modelling the role (and therefore quantifying the costs and benefits) of specific types of infrastructure in the production process.

A question arises as to whether any of the more recent alternative theories of development emphasize the role of infrastructure. From a review of the literature, it appears that varying degrees of attention have been paid to it in the product life-cycle theories, the international division of labor theories, and the dependency theories. The theorists tend to assume more implicitly than explicitly that the public sector will provide the necessary infrastructure, either in response to or in an effort to attract private investment.

The product life-cycle theory, as proposed by Vernon (1966) and extended by Wells (1972), focuses on income elasticity, economies of scale, freight costs, and other components of private production costs in examining the relationship between innovation and international trade. The comparative advantage of regions depends upon the stage of the life cycle of the product. In the innovation stage, the still unstandardized product requires a wide range of both public and private goods and services. Vernon, for example, describes the U.S. advantages in this early stage as including communication and external economies that provide the new producer access to price-insensitive customers, varied suppliers, and potential competitors. Like the arguments of Hirschman and Hansen, Vernon's implication is that in developing countries the lack of these advantages reflects a lack of SOC, both economic and social, to support the key external economies.

Increasing emphasis is being placed in the literature on the international division of labor (IDL) and the role it plays in expanding investment opportunities in industrialized and developing countries. The IDL concept has theoretical underpinnings closely related to, but conceptually distinct from, the product life-cycle theory. According to the IDL analysts, investment is undertaken in response to a need to expand markets at a rate commensurate with the technological capability to produce larger volumes of output at lower unit costs. While the product life-cycle analysts focus on the role of innovation, the IDL analysts emphasize the role of labor in the production process. It is labor - its differential cost (including the cost of reproducing labor power), availability, and receptivity to the demands of business - that is the prime determinant of business investment. The primacy of labor is a consequence of the international mobility of capital. Froebel et al (1978, 1980) describe how international agencies (including multinational corporations) have facilitated this mobility by coordinating monetary and commercial policies, and what is more relevant to this discussion, by financing improvements in infrastructure throughout the nonindustrialized world. Infrastructure, then, can be considered as part of the technical conditions of production that are becoming equalized throughout the world. The more widespread these technical conditions, the weaker their influence in determining the international division of labor. Once again, like Hirschman and Hansen, Froebel et al recognize the importance of infrastructure as a precondition for private investment in DPA.

Dependency theorists, while very concerned about investment in general, do not analyze explicitly the potential role that infrastructure might play in promoting or hindering a dependent relationship. They focus instead on the underlying social relations of production, looking both at international dependencies and internal dependencies that arise between the core of dominant and dependent nations. Writers in this area include dos Santos

(1970), Chilchote (1974), Frank (1977), Evans (1979), and Palma (1981), just a few of the many authors who are sometimes referred to as dependistas. Dependent social relations are reflected in a variety of investment decisions, including those related to infrastructure. An example of their implicit concern for infrastructure is the dependista argument that the outward orientation of transport and communication networks in developing countries provides for the integration between core and peripheral economies and also assures the disintegration within the peripheral economies.

From the literature, it appears that the balanced-growth, unbalanced growth, and international division of labor theorists are the primary ones who have paid explicit attention to infrastructure and its role in stimulating economic growth. The next three developmental approaches to be discussed in relation to planning for infrastructure investment are less thoroughly based than the stimulation-of-economic-growth approach upon theories of economic growth.

2.1.2 Fulfillment of basic needs

In the 1970s, attention shifted from the employment-generation strategies of development implicit in the above discussion to alternative strategies. One alternative was the basic-needs strategy, discussed by Stewart and Streeten (1976), Ghai (1977), the staff at the International Labour Office (1976), and others. Streeten describes the basic-needs strategy as an approach used by those whose central concern is to eliminate the mass deprivation of the poor by improving (1) their income-earning opportunities, (2) their access to public services, (3) the flow of private goods and services to them, and (4) their participation in efforts to meet their own needs (Streeten, 1979, p. 29). In terms of infrastructure, basic-needs advocates call for a redirection of public expenditures away from the building of large-scale sophisticated infrastructure, such as long-distance motorways and international ports and airports, towards the construction of a network of rural roads and communication facilities, and away from the building of large hydroelectric and irrigation projects towards local small-scale energy and water systems. In some cases, not building infrastructure may be the preferred alternative. As an example, rather than using limited funds for new water and sewerage systems serving relatively few people, funds may be more effectively spent training all the population to boil water and to learn other health-related practices.

Data from the World Bank (1980, p. 34) indicate a significant shift between 1970 and 1980 by the Bank away from lending for large-scale infrastructure projects towards smaller-scale, basic-needs activities that often include housing (mostly sites and services), nutrition, health, and education programs. In 1970, 58 percent of their total lending was directed toward infrastructure expenditures, whereas by 1980, this percentage had been reduced to 37 percent. This reduction was partially offset by an increase in lending to "basic-needs programs," which increased from 5 percent in 1970 to 12 percent in 1980. Overall, the lending to sectors targetting the poor rose from 8 percent in 1970 to 31 percent in 1980.

Earlier, Hansen's distinction between economic and social overhead capital was noted. Social overhead capital, under which many basic-needs activities are included, may be more appropriate than economic overhead capital for developing regions. Recently, Looney and Frederiksen (1982) adopted Hansen's argument in formulating guidelines for planning public investment in Mexico. They argued that without basic social overhead capital, economic overhead capital would have little impact in generating employment and income. However, a lagging region that possessed absolute comparative

advantages, such as natural resources or a large employable labor force, might be able to fully utilize investment in fixed economic infrastructure. The decision as to whether the major share of investment should be directed to basic-needs infrastructure or to other types of infrastructure must be made within the context of the overall economic position of the country or region.

2.1.3 Restoration of destroyed facilities

The restoration-of-destroyed facilities approach to infrastructure investment has a long history, part of which is related to wars and part to natural disasters. The Marshall Plan aid, for example, was probably one of the best-known disaster relief plans that resulted in large-scale reconstruction of port facilities, transport networks, and the like throughout Europe and Japan. During the four years after the Marshall Plan was initiated in April 1948, over $12.5 billion of aid was given to Europe and Japan by the United States. This represented five percent of the gross national product (GNP) of the receiving countries and two percent of the GNP of the United States (Anell and Nygren (1980), pp. 44-45). Some analysts speculate that if developing countries were to go to war with the United States and lose, they too, like Germany and Japan, might benefit from aid.

In the United States, damages resulting from natural disasters, such as droughts, earthquakes, fires, floods, and hurricanes, are now dealt with by officials in cities and/or states declaring a state of emergency and applying for aid from the Federal Emergency Management Agency. Disaster public assistance consists of emergency work to save lives and property, to remove debris, and to restore damaged public facilities (U.S. House of Representatives, 1982). Aid is also given in the form of low-interest loans, direct grants, and aid in kind (food, clothing, and other supplies). As the damage is repaired, infrastructure is often, of necessity, one of the first components of the local economy to receive attention. Aid cannot be delivered if the transportation and communication network is not functioning. Concern for health and sanitation likewise means that water and sewer systems are often among the first to be repaired. At the international level, agencies such as the United Nations Disaster Relief Organization, the International Bank for Reconstruction and Development, and the International Monetary Fund, as well as the governments of various countries, respond with aid, or even, as in the case of the 1985 famine in Africa, individuals send money and supplies directly or through private groups.

Given the frequency of disasters throughout the world, the planning for the rehabilitation of destroyed infrastructure appears to occur on a very ad hoc basis. The question arises as to whether or not a more systematic approach to the removal, repair, and/or replacement of the destroyed facilities can be devised.

2.1.4 Accommodation of demands

The accommodation-of-demands approach is perhaps the hardest one to discuss in a substantive way. Yet, it seems essential for planners to understand why at times an infrastructure investment not justified by any economic or social critera is undertaken. An astute political leader will often realize that a new highway, a new irrigation system, or some other visible type of infrastructure will help win votes or will elicit the goodwill of citizens. In the United States, for example, the large and uncoordinated system of federal grants for infrastructure has been called the "public works pork barrel" (Choate and Walter, 1981).

More specifically, the political factors that are central to this approach can help explain why the Economic Development Administration (EDA) is still in existence, even though key politicians, such as President Reagan, wish to abolish it. Since its inception in 1966, many members of the House of Representatives have secured public-works funds to help their local constituencies. Originally, EDA expenditures were to be allocated according to growth centers, based upon the belief that infrastructure costs could be minimized if client populations were spatially concentrated. In 1966-1967, however, one-half of the public-works investment, or almost 40 percent of EDA total investment, was allocated to communities with fewer than 5000 inhabitants (Cameron, 1970).

The accommodation-of-demands approach is also important at the micro or local level. In the United States as well as other industrialized and developing countries, municipal governments are responsible for local infrastructure, such as secondary or intrametropolitan roads, local water and power distribution systems, etc. Much of this infrastructure is designed to alleviate the problems of successful development in these areas (CONSAD, 1980). Economic growth generates congestion, pollution, and other negative externalities that only governments can address. In this case, then, the inverse of the developmental approach occurs - private investment induces public investment in infrastructure. Rather than socialize the risks of private investment, the public sector, in this instance, socializes the costs resulting from its concentration. It is in this sense that social overhead capital becomes more important relative to economic overhead capital as development progresses (Hansen, 1965b). But, even when infrastructure projects are economically and socially justifiable, the political factor remains important in determining the mix of infrastructure types and their distribution across jurisdictions.

Although an exact percentage cannot be determined, almost all of the infrastructure investments in developing countries can be categorized according to one or more of the four developmental approaches just reviewed. Economic stabilization and maintenance of existing facilities play a much smaller, in some cases negligible, role in those countries. In industrialized countries, on the other hand, all three of the major approaches are used at one time or another.

2.2 Economic-stabilization approach

The economic-stabilization approach could also be termed the employment-generation or countercyclical approach. It is used to help alleviate large swings in employment. In developing countries, this approach has been considered less appropriate to use than in industrialized countries, because government officials have had limited access to the full complement of fiscal and monetary tools, particularly with respect to revenue-raising for deficit spending (Howenstein, 1968). Because this approach is one frequently employed in industrialized countries, its use in the United States is especially relevant to review here. A more extensive survey of the literature cited is provided in a paper by Fournier (1983) and a book by Garraty (1978).

With unemployment at 24 percent in 1932 and private construction dropping from $8.7 billion in 1929 to $1.4 billion in 1932, President Franklin D Roosevelt launched a series of work programs, many of which centered on investment in infrastructure (or what were then called public works). The Emergency Relief Construction Act, passed in 1932, employed about 3 million people; the Civil Works Administration about 4 million; the Emergency Work Relief Program 2.5 million; the Public Works Administration, over a 10-month period, employed from 100,000 to 650,000 per month;

and the Works Projects Administration about 16 million total (Jerrett and Barocci, 1979, pp. 1-13; Palmer, 1978, p. 158). Despite these efforts, unemployment in the late 1930s was still estimated to be about 17 percent of the labor force. Thus, it seems to have been World War II, not the countercyclical works programs, that finally put most of the population back to work.

After the end of World War II, it was not until 1961, with the passage of the Area Redevelopment Act (ARA), that the federal government again sought to generate jobs through public works. During the 1960s, however, expenditures on public works were designed to stimulate development, rather than to act as countercyclical measures. Part of the rationale for the ARA, for example, was to provide loans for use in the construction of public facilities to encourage the location of new businesses in depressed regions (Jerrett and Barocci, 1979, p. 17). In 1965, the Public Works and Economic Development Act was passed, which led to the creation of the Economic Development Administration (EDA) with one of the principal tasks being to generate employment. Public works played an important role in this task; during the first 10 years, 73 percent of the obligations by the EDA went to public-works expenditures.

In the 1970s, EDA initiated two programs - the Public Works Impact Program and the Local Public Works Program - to create jobs in areas of high unemployment. These efforts signalled a shift in the focus of countercyclical public-works programs. During the 1930s, all of the work-relief programs had the goal of providing jobs during a crisis period - the depression. Later programs were targeted to specific regions - those chronically depressed or those especially hurt by national economic downturns. The ARA was targeted to the former. The Local Public Works (LPW) I and II programs were used in 1976 and again in 1977 to inject about $6 billion into selected local economies particularly affected by the economic downswing. In these years, "priming the pump" obtained a temporary decrease in unemployment in construction and related industries. In effect, however, the LPW programs were not countercyclical; they did not absorb a large number of the unemployed, and the countercyclical impact was delayed by administrative bottlenecks (U.S. Department of Commerce, 1980). Vaughan (1983) estimates that the LPW funds merely displaced by as much as 80 to 100 percent the infrastructure spending by state and local governments. The studies by Vaughan (1976, 1983) and by Vernez and Vaughan (1978) are especially directed to a discussion and assessment of these countercyclical programs.

2.3 Maintenance approach

In the older regions of the United States, an increasing share of expenditures on infrastructure must be directed to maintenance rather than to new construction. Most of the highway, water, and air transportation network is in place, and some of the rail network has even been abandoned. The wide range in the age of the U.S. infrastructure is especially evident in the 23 state reports to the U.S. Joint Economic Committee (1984). In Massachusetts, for example, the five-member research team found that some water mains were over 150 years old, some highway bridges were between 50-80 years old, and the list of old infrastructure goes on and on (Polenske and others, 1984, pp. 53-54, 104). The age of the infrastructure in Massachusetts and other older states in the East constrasts sharply with the considerably younger facilities in some of the states in the West, such as Colorado, Montana, and Washington.

As the infrastructure in regions and nations ages, the maintenance approach becomes more dominant than in early development stages. Without

maintenance, the useful life of many facilities will be reduced drastically. The Secretary of the U.S. Department of Transportation, for example, estimated that if no new capital investment were to be made to the existing (1981) highway system, between 70 and 90 percent of the highways and roads in the nation would need to be completely replaced within 15 years (U.S. House of Representatives, 1981). It is becoming evident that maintenance of infrastructure should be considered more carefully than it is now during the initial planning stages when deciding upon the particular technology to employ, financing to use, etc. Part of the problem stems from the distorting effects of infrastructure aid and grants. These financing mechanisms are biased against maintenance and rehabilitation and favor early replacement of capital stock (Congressional Budget Office, 1983; CONSAD, 1980).

The maintenance of infrastructure is becoming a crucial problem in developing countries. Many international agencies, such as the World Bank, have financed infrastructure construction in these countries and are now alarmed by its rapid deterioration and are therefore beginning to focus on the maintenance issue. It would be hoped that in later years if this paper were to be rewritten, maintenance would not have to be identified as a separate approach, but would have been completely incorporated into the planning for the construction of the infrastructure.

3 MAJOR FACTORS IN PLANNING FOR INFRASTRUCTURE INVESTMENT

Regardless of which of the three major approaches is used, the planning of infrastructure will entail certain tasks. Steiss (1975), for one, describes three: (1) those tasks relating to needs assessment, that is, an inventory of the present system, estimation of the gap between what is available and what is "needed," and projection of additions "needed" in the future; (2) those tasks of staging or phasing of discrete, but often complementary, projects across time and place; (3) the task of structuring a realistic and detailed financial plan so that "needed" projects are constructed when and where appropriate. While separate, these generalized sets of tasks are undertaken in iterative fashion. "Needs," for example, may be reduced as standards are lowered to fit financial constraints.

The range of variables affecting these tasks may be categorized as physical, economic, institutional, political, and sociocultural. In practice, these categories are often difficult to separate one from the other. As in the example above, needs, standards, and constraints are defined by planners in the context of particular economic, institutional, political, and sociocultural arrangements. A discussion of these variables seems warranted to explore the complexity of the planning process and, in so doing, hopefully to improve this process. The sociocultural factors will not be discussed in depth. There is little reference to these factors in the literature on infrastructure planning.

3.1 Physical factors

Making an inventory of the infrastructure system can present a number of problems related to the different types of infrastructure and their different units of measurement. Experience in conducting analyses for the planning of infrastructure highlights two major difficulties. First, there is the organization of data to guide its collection, classification, and presentation. Second, there is the particular problems of older regions where

the infrastructure system is in place, but records on its location and other characteristics are unavailable. Of course, the specific information (and its level of detail) that is relevant to include in the inventory will vary from one approach to another.

Table 1 portrays some of the typical information included in an inventory. Along the left-hand side of the table, infrastructure is divided into three main types: water, sewers, and transportation. Each type is subdivided into principal components. The transportation infrastructure, for example, covers highway, air and water, rail, mass transit, and bus. Each component is then subdivided into its principal subcomponents related both to the network and the facilities. Mass transit, for example, is divided into stations, vehicles, garages, track miles, route miles, and bridge track miles.

Table 1 Public infrastructure: existing stock, current-year additions to stock, and planned investment.

Infrastructure Type	Existing Stock: Physical			Existing Stock: Cost		Current-Year Additions to Stock: Physical		Current-Year Additions to Stock: Cost		Planned Investment: Physical		Planned Investment: Cost	
	Quantity	Age	Quality	Construction	Maintenance	Quantity	Quality	Construction	Maintenance	Quantity	Quality	Construction	Maintenance
WATER													
Supply													
Distribution													
SEWERS													
Supply													
Distribution													
TRANSPORTATION													
Highway													
State													
Local													
Turnpike													
Bridges													
Tunnels													
Air and Water													
Airports													
Ports													
Rail													
Crossings													
Bridges													
Tunnels													
Mass Transit													
Stations													
Vehicles													
Garages													
Track Miles													
Route Miles													
Bridge Track Miles													
Bus													
Vehicles													
Garages													
Route Miles													

Along the top of the table, some of the chief physical characteristics, such as quantity, age, and quality, are listed. Quantity measures will vary from track miles to square feet of floor space to number of vehicles to pipeline miles, depending upon the particular infrastructure category being measured. Even a greater variation will occur in the case of quality measures, which may be determined partially by national standards, but will also reflect the value system of individual communities in terms of preferences for different types of infrastructure and levels of service. The existing stock of infrastructure is separated from the current-year additions to the stock and from those investments planned for future years. Planned investment includes any that has been "approved" for years later than the current. In the United States, for example, some state and local governments construct annual capital budgets and five-year to ten-year capital-improvements programs. Infrastructure needs for future years will sometimes differ markedly from the planned investment, especially in locations where there are severe financial constraints, resulting in unfulfilled needs; consequently, it may be necessary to make a separate tabulation of needs versus planned investment in order to document the shortfall. For both plans and needs, separate information is required for construction of new

facilities and for maintenance of existing infrastructure. The cost components of the table are dealt with later.

Planners in older regions and nations will generally find it considerably more difficult to obtain complete information than those in newer regions and nations. The staff who tried to collect inventory information for the state of Massachusetts, for example, found that almost no information was readily available for infrastructure at the local, compared with the state, level (Polenske and others, 1984). A questionnaire was prepared and mailed to each of the 13 regional planning agencies (RPAs) in the Commonwealth. In most cases, the information could not be collected by RPAs with the limited time and budget available. A large share of the information concerning their water and sewer lines was usually not obtainable from the local towns, because these networks were very old and records had not been kept as the initial systems were constructed. Information was therefore only available if a breakdown occurred in the system; when a line broke, it was obvious, and it was repaired. The cost of a statewide survey to provide local information probably could not be rationalized in terms of need. It would therefore appear that a complete inventory of the existing network and facilities cannot be prepared for older states in the United States. It would be possible, however, to establish a systematic way to collect information on the current investment in new infrastructure. If data were kept on a year-by-year basis, a fairly complete inventory of the entire stock of infrastructure would be available five to ten years from now.

3.2 Economic factors

The economic factors that must be considered when planning for infrastructure investment can be separated into three key issues: cost, budget, and finance.

3.2.1 Cost issues

The physical characteristics of the inventory just described will need to be complemented with cost figures that put a value on these physical assets. For each of the subcomponents of infrastructure identified for inclusion in the inventory, the construction and maintenance costs should be obtained. Both are crucial for an accurate estimate of the lump-sum as well as ongoing expenditures needed (currently and in the future) to keep facilities in proper working condition. This additional information is included in Table 1, along with the physical characteristics. The estimation of the value of the current stock of capital is complicated by the question as to whether the planner needs to know the historical cost or the replacement cost. Ideally, both types of estimates should be available, to supply information on depreciation as well as the level and rate of growth in the value of the capital stock. All values should be translated into constant dollars to allow comparisons from which to base projections. These projections of the future needs for capital must take into account inflation rates, particularly in developing countries, where the rate of inflation may be as high as 200 percent or more per annum, and may fluctuate by large amounts from year to year. Problems of estimation based upon such large and highly volatile rates of inflation are complicated further by fluctuations in the rate of exchange, especially for countries in which a major portion of the materials and services (including labor and capital) used in the construction of an infrastructure project may have to be imported.

3.2.2 Budget issues

In the United States, capital budgets have not been systematically used either at the federal or state or local levels. Capital budgets are more widely used in other industrialized countries as well as in developing countries, where they are generally referred to as development budgets. A fairly extensive literature exists on capital budgets and budgeting both here and abroad, as illustrated by the literature surveys conducted by Azad and Clarke (1983) and Hylton (1984). More work, however, is needed in order to make capital budgets a useful tool for planners at all levels of government. The U.S. literature is relatively old, as shown by the seminal works by Comiez (1966) and Howard (1973).

A few of the many potential improvements include: (1) A set of guidelines for the preparation of capital budgets, documenting past experience with alternative, but consistent, budget formats. More uniform information would allow comparisons of capital-budget items to be made from one jurisdiction to another. (2) An analysis of the ways in which a capital budget may improve or distort development investment decisionmaking. Some analysts maintain that a capital budget biases development efforts towards large-scale, capital-intensive projects and away from small-scale, labor-intensive ones. If this is the case, must it, or could the budget itself (the form in which information is presented), or the budget process be designed to overcome these biases?

3.2.3 Finance issues

Given the substantial amounts involved, infrastructure projects depend upon long-term sources of finance. Whereas most general-operating expenditures can be covered out of tax revenues, infrastructure projects generally depend upon a number of financial sources including: taxes, user fees, betterment levies, general obligation bonds (usually financed through taxes), and special revenue bonds (usually financed through user fees).

There is a large literature on financing issues. Some of the key issues surrounding the finance of infrastructure are:

> What is the fiscal capacity of the government unit, and how can it be measured? How useful is this concept as applied to an isolated expenditure, such as infrastructure, for which the financing usually comes from many sources and may not be directly tied to the expenditure? (Advisory Commission on Intergovernmental Relations, 1982).
>
> What sources of revenues are available? Why are betterment levies generally restricted to use in Latin America? What are the tradeoffs (equity versus efficiency) between use of bonds, taxes, and user fees for the raising of the required amount? In the U.S. case particularly, what are the pros and cons of the new "creative financing" mechanisms (tax-increment financing, leasebacks to the private sector, etc.)?
>
> What financial institutions exist or should be established to assure that infrastructure financing continues to be available in a systematic and low-cost way?
>
> At what level of government should the financing be done? How should the financing relate to the expenditures in terms of the level at which each is carried out? Given the financing constraints, how appropriate is the privatization alternative, which is becoming popular in developed countries?

The issue of financing is growing in importance as governments both here and abroad face ever-increasing public debts and revenue-raising limitations (Vaughan, 1983). The size of the international debt will also create new pressures on the financing of infrastructure. Past reliance on existing financing mechanisms and institutions will certainly be altered. The latter are discussed in the next section of this paper.

3.4 Institutional factors

In the extensive literature on infrastructure, little emphasis is given to the types of institutions that exist or are needed in order to construct, maintain, finance, and regulate the use of the public capital stock. There appears to be a tremendous variation in these within any one country, such as the United States, and even a greater variation across the countries of the world. The U.S. public-works agencies referred to in the first section of this paper are only a few of the most important ones that came into existence during the Great Depression at the national level. These, however, were only the agencies concerned with the creation of employment; other agencies scattered throughout the federal, state, and local governments had responsibility for different aspects of the construction, maintenance, financing, and regulation of the infrastructure. To this day, the fragmentation of responsibility for infrastructure, within and between the different levels of government, continues to complicate the planning process.

Many institutions directly or indirectly working on infrastructure issues also exist in developing countries. Although these countries tend to have centralized governmental structures, fragmentation of responsibility across ministries and subnational government units can also be a problem. In Cairo, Egypt, for example, 37 different agencies deal just with transport. Despite efforts at coordination, or steps toward comprehensive planning, it is seldom easy for planners to identify the specific agencies who have direct and indirect responsibilities for each of the different aspects of infrastructure.

As noted in the first section, the institutions involved in infrastructure planning tend to vary under the alternative approaches described. Specifically, while higher levels of government usually take primary responsibility for most developmental and economic stabilization objectives, lower levels are more instrumental in accommodating the demands resulting from economic growth. Under the accommodation-of-demands approach, lower-level government units are more likely to perform the entire set of planning tasks, from needs assessment to actual construction and implementation of planned projects. This seems appropriate, given the localized nature of these demands. Nevertheless, these tendencies deserve more systematic research. What is the division of responsibility among infrastructure institutions, under each of the alternative approaches? How and why do these vary across countries?

Still another research question involves exploring the most effective internal organization of these institutions and their place within the larger government bureaucracy (Vaughan and Pollard, 1984). Which combination of characteristics - legislative mandate; public-private status; management structures; labor, financial, and political resources - is conducive to managing infrastructure construction and maintenance effectively? Echoing other analysts, the authors of the Massachusetts study, for example, concluded that "most maintenance expenditures are being deferred, forcing a crisis response rather than planned maintenance" (Polenske and others, 1984, p. 2). This fact was especially evident in the information they obtained from the Massachusetts Bay Transportation Authority (MBTA). An

indepth study of the MBTA and other public-transit authorities in the United States would help identify the key elements within the relevant institutions that could be changed to tranform the maintenance approach from one of crisis response to one of planned response.

3.5 Political factors

This political category contains a vast array of disparate variables that influence infrastructure planning, ranging from the political compromises and tradeoffs that enter into the decision to build a particular piece of infrastructure, to the establishment of standards and regulations. Only a few comments will be made here on the latter two points. Although knowledge of the level of service "desired" is critical for an accurate specification of needs, there appears to be little agreement in the United States concerning "desired service levels" (U.S. Joint Economic Committee, 1984, p. 16). Needs vary across individuals and political jurisdictions, yet the U.S. federal government sets many of the standards by which infrastructure needs are defined. Design and procurement standards, for example, are specified by federal programs and monies are conditional upon their fulfillment. These federal standards have been used in recent attempts to assess the level of need nationwide (Choate and Walter, 1981; U.S. Joint Economic Committee, 1984).

Design standards are generally set by engineers rather than by a combined group of specialists concerned with the economic, social, and political, as well as engineering requirements for such a standard. Tradeoffs between alternative designs in terms of economic and social ramifications are seldom considered. The increasing popularity of assessing the impacts of large-scale projects, particularly those related to infrastructure, has emphasized these non-technical considerations. According to Dajani (1977), this trend can be explained by the fact that traditionally, design standards have been producer-oriented, rather than consumer-oriented. In some cases, this has produced a mismatch between infrastructure plans, financial means, and social needs. An oft-cited remedy for this mismatch is to increase citizen participation in the planning process. How citizen participation is incorporated into the process is decidedly a political consideration. There is little doubt, however, that this participation can be enhanced by planners' efforts to clarify choices regarding the level, extent, and quality of infrastructure, given technologically feasible options. As in U.S. land-use planning practice, the emphasis could shift from design to performance standards, reflecting a more even balance than occurs at present between "technical" criteria on the one hand and judgemental policy-oriented values on the other (Dajani, 1977, p. 7).

There is an often-ignored link between the design standards and regulations for use, and both can affect the type of construction and the level of maintenance that will be required. For example, a highway engineer may suggest a particular standard in terms of the inches of bitumen to be laid, assuming that vehicles exceeding certain weight limits will not use the highway. If the regulation for use of the highway is not clearly specified, vehicles exceeding the expected weight limits may cause the road surface to deteriorate far more rapidly than anticipated. Overall coordination is therefore required among the people responsible for setting the standards and those responsible for establishing and enforcing the regulations for use of the infrastructure. Here again, there is considerable research to be done.

3.6 Sociocultural factors

This is a very difficult set of factors to discuss, mainly because sociocultural variables greatly influence the understanding of what is meant by economic, political, and institutional considerations. They underlie the definition of infrastructure needs and determine the balance between economic, political, and technical criteria. Furthermore, there is little reference to this set of factors in the literature on infrastructure planning. Only some implicit links can be made with the principles of basic needs and more self-reliant forms of development. The sociocultural factor is included here as a separate factor to emphasize its importance in the planning, financing, construction, and maintenance of infrastructure. This is indeed an area where research is needed.

4 CONCLUSION

In this paper, three major approaches to planning public infrastructure have been discussed. These approaches were categorized according to their differing policy objectives, which, in turn, call for different programmatic agendas and evaluation criteria. The authors believe this framework is a preliminary step in designing infrastructure planning processes that will match given objectives.

In the second section of the paper, consideration was given to the physical, economic, institutional, and sociocultural factors affecting the planning and evaluation of infrastructure investments. Information is frequently lacking even for some of the most basic components of infrastructure relating to the inventory of existing stock, assessment of future "needs", and details of financial aspects. This often means a lack of informed discussion from which to make the necessary trade-offs and compromises inherent in any planning process. Some of the potential areas for future work concerning these factors have therefore been specified. As additional research is conducted, it will be useful to investigate how each of the factors varies under each of the alternative objectives discussed in the first part of this paper.

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