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Meeting the Challenges of Megacities in the Developing World

A Collection of Working Papers

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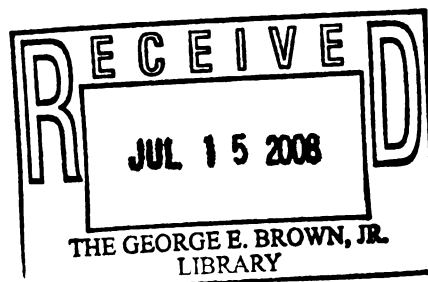
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Meeting the challenges
of megacities in
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PREFACE

In the next 30 years, the world's population is expected to increase by 2.5 billion persons. Most of this growth will occur in the cities of developing countries, which are adding about 55 million residents a year. These working papers are focused on the megacities--defined here as large, rapidly growing cities of 8 million or more residents. Megacities merit special attention because of the magnitude of their population increases and the enormity of the challenges involved in providing services to such rapidly growing populations. At the same time, many of the innovations and changes discussed in these papers are applicable to a broad range of cities. Early recognition of future growth can enable a city to address challenges before they become overly complex or expensive.

In the twenty-first century, the economic and social development of urban areas will be influenced by continued global economic integration and the need for a nation's commerce to be competitive in the global economy. City businesses will have to compete for investment and export markets in the global marketplace. A successful transition from industries relying on low-wage labor and cheap raw materials toward technology- and knowledge-based systems of production and services will require better-educated and more-skilled workers, effective infrastructure, and responsive public and private organizations.

In the two decades since the United Nations Conference on Human Settlements (Habitat) was held in Vancouver, there have been significant advances in both technologies and management strategies that can be applied to address megacity challenges. Nevertheless, rapid urbanization has outpaced the ability of governments to provide adequate shelter and basic services to the urban poor. Given the increasing importance of these challenges, the world's academies of science and engineering were asked by Dr. Wally N'Dow, Secretary General of the Second United Nations Conference on Human Settlements, to organize a scientific forum that would develop a joint statement for presentation to the United Nations delegates at the Conference on Human Settlements (Habitat II) in Istanbul in June 1996.

The U.S. National Academy of Sciences/National Research Council is also undertaking a study of the many challenges faced by megacities in the developing world. Results of the full study are scheduled for publication later this year by the National Research Council. The working papers presented here--on labor markets, water and sanitation services, and transportation--have been prepared for that study by three panels of the National Research Council.

Options for Improving Labor Markets for Megacities in the Developing World

A Working Paper

Commission on Behavioral and Social Sciences and Education

PANEL ON IMPROVING LABOR MARKETS

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EXECUTIVE SUMMARY

Development experts are concerned with fostering economic growth, alleviating poverty, protecting the environment, and improving the general standard of living of people in developing countries. Much of this work is directed toward either creating employment or raising labor earnings because at the bottom of the earnings scale, labor earnings comprise the most significant portion of total income, and hardship and poverty are often the direct results of insufficient access to adequate employment opportunities.

Developing countries span a wide range of income and development levels, and their megacities reflect these differences. Yet most of the megacities share some key labor market characteristics: a formal manufacturing sector that is usually dwarfed (in employment terms) by the service sector; a large government sector, often riddled with inefficiencies; and an informal sector whose size depends on the level of economic development, business cycle influences, and the degree of government tolerance and support. Moreover, almost all megacities have been impacted substantially by globalization and the opening up of world markets; these trends have accelerated the need for increasingly flexible labor markets.

This paper addresses the problem of the need to expand productive capacity in developing-country megacities in order to create a billion new jobs over the next 35 years. Labor markets in developing-country megacities are vulnerable to several problems that may be amenable to policy intervention. These include the following:

- Unemployment and low-productivity employment
- Poverty and income inequality
- Job mobility constraints
- Lack of protection for workers
- Big firm bias

What policy prescriptions are available to alleviate some of these conditions? Depending on the extent of market failure and the importance assigned to distributional issues, governments are probably most effective in improving urban labor markets when they assume a modest role (World Bank, 1995a). The most promising opportunities for alleviating megacity labor market problems through policy intervention are as follows.

1. The promotion of economic growth and economic (and political) stability. Economic growth offers the best guarantee of expanded employment opportunities, higher wages, and labor productivity growth. Appropriate macroeconomic policies (e.g., fiscal discipline, control of inflation, and financial reforms), combined with both tariff and nontariff trade liberalization, offer the most promising strategy for promoting employment growth and generating enough resources to pay for the infrastructure investments needed to achieve income equity.

2. For this strategy to work efficiently, the economy in general and the labor market in particular need to adjust quickly to changing market conditions. Many developing countries have labor policies in place (such as minimum wage laws, job security provisions, job-related housing provision, pension systems, and centralized--often government-controlled--labor unions) that, when enforced (often they are not), aggravate labor market distortions and impede adjustments. Deregulation of the labor market offers prospects for increasing its flexibility, especially by recognizing that policy interventions should work with rather than against market forces and should pay attention to the incentives driving the behavior of individuals and households. At the same time, improved access to credit markets for potential entrepreneurs, as well as to job information and to skills acquisition for potential employees, can help megacities' labor markets run more efficiently.

3. Whereas redistribution policies tampering with spatial (geographical) variations in labor supply and demand are unlikely to be effective, efficiency-oriented urban policies (e.g., low-cost improvements in transportation, broadly based educational investments, privatization of government services, access to credit for small-scale enterprises, and creation of a favorable entrepreneurial environment) can promote labor productivity growth and improve the competitive efficiency of megacities, directly impacting macroeconomic performance.

Finally, with respect to the role of science and technology, more rapid diffusion of known and already widely applied technologies (e.g., computer information systems, cellular telephones) may transform the structure and composition of employment in developing-country megacities, especially given the global competitive environment. These and similar measures will be critical to avoid widespread urban unemployment and underemployment in the megacities of the developing world.

INTRODUCTION

Development experts are concerned with fostering economic growth, alleviating poverty, protecting the environment, and improving the general standard of living of people in developing countries. Much of this work is directed toward either creating employment or raising labor earnings because at the bottom of the earnings scale, labor earnings comprise the most significant portion of total income, and hardship and poverty are often the direct results of insufficient access to adequate employment opportunities.

Megacities are frequently the centers of production for a country's goods and services and the location of the vast majority of a country's paid-employment opportunities. Every year, megacities attract considerable numbers of rural migrants, who, together with the rapidly growing native population, quickly expand the labor force and generate an enormous policy challenge: to create sufficient employment opportunities to absorb the large number of new workers. With public-sector wage bills being forced to contract in many countries, much of the needed increase in employment is likely to occur within the small-scale "informal sector" or within self-employment.¹ Traditionally, nonagricultural self-employment has declined with modernization, and the urban labor force has become increasingly occupied in regular protected wage employment. However, the recent change in economic conditions, coupled with rapid population growth, may be inducing profound changes in the structure and nature of employment.

This paper addresses the problem of the need to expand productive capacity in developing-country megacities in order to create a billion new jobs over the next 35 years. The remainder of the paper is organized as follows. The next section addresses the question of whether labor markets in megacities have special characteristics. The next two sections describe the labor force and the labor market, respectively, in developing-country megacities.² This is followed by a review of problems in developing-country megacity labor markets that may be amenable to policy intervention. Next is an examination of the role of policy in addressing these problems. A discussion of the potential role of science and technology is then presented. The paper ends with a summary and conclusions.

WHAT IS SPECIAL ABOUT LABOR MARKETS IN MEGACITIES?

Just as megacities have characteristics that distinguish them from other urban areas, there are several distinguishing features of megacity labor markets. First, the urban scale involved means that the tradeoff between scale economies and congestion costs is different than for smaller urban areas. Agglomeration economies create opportunities for improved productivity and for less costly information dissemination per capita, but congestion costs are also likely to be greater. The latter may weaken, especially in higher-income megacities, as access to the World Wide Web and other computer sources improves, although the extent to which telecommunications can substitute for transportation is controversial (see the discussion later in this paper).

Second, the composition of economic activity in megacities is distinctive in a number of ways, permitting easier comparisons across megacities than among different locations (e.g., urban and rural areas) within countries. The most distinctive characteristic of economic activity in most megacities is a large quaternary (i.e., high-order financial and service) sector, often global in scope. In addition, the informal sector represents a large share of employment, though typically not as large a share as in smaller cities; the manufacturing sector may be more or less important than in other cities, usually depending on the type of development strategy (e.g., import substitution or export orientation) and when it was adopted; and the government sector is substantial in the majority of cases where the megacity is the national capital.

Third, megacities are more open to global influences than are many other urban areas (although some natural resource locations, such as mining towns, are even more influenced by global considerations). The increasing globalization of recent years has made the world's megacities much more interdependent than before, and international capital mobility and the ease of information connectivity have resulted in a set of megacities competing for internationally footloose economic activities. There will be winners and losers in this competition, and labor market efficiency can help determine the outcome.

Fourth, megacities have a mix of advantages and disadvantages that affect their competitiveness and the demand for labor:

- A better-educated, better-trained, and more diverse labor pool, but more expensive labor costs
- More access to sources of capital, with favorable influences on the labor market, given the complementarity of factors of production
- A concentration of educational and training facilities, increasing the potential for human resource investments
- Much higher urban absorption costs per capita (i.e., the capital costs of accommodating people in the megacity, including housing, infrastructure, and job creation) than in other urban areas and up to six times higher than in rural

areas (Richardson, 1987), implying that megacity concentration aggravates the investment constraints that cripple many developing countries

- Severe traffic congestion, with its adverse implications for job accessibility and labor market performance
- A complicated nexus (though not necessarily fully supported by evidence) from megacity living to higher incomes to lower fertility to higher female labor force participation
- Higher land costs that may favor locational choices in other areas (e.g., distant sites within the core region or other regions)
- Information barriers to both migration and labor market entry that may be more difficult as a result of the scale effect

Megacities contain a large share of both a country's industrial sector and the national population, but economic activities are much more heavily concentrated than population. In Seoul, for example, there is a heavy concentration of the nation's modern and internationally oriented economic activities: 61 percent of managerial personnel, 96 percent of the top 50 corporate headquarters, 64 percent of research scientists, all stock brokerage offices, and 66 foreign bank offices (Yeung, 1995). Istanbul accounts for only one-tenth of Turkey's population and is not the national capital, yet it accounts for 45 percent of manufacturing, 40 percent of commercial activity, 25 percent of all vehicles, 44 percent of the country's hotel rooms, and 50 percent of all university students (El-Shakhs and Shoshkes, 1995). Before the revolution in Iran, Tehran accounted for 83 percent of registered companies, 60 percent of wholesale employment, 55 percent of telephones, 53 percent of city bank branches, 47 percent of construction investment, 41 percent of insurance companies, and 40 percent of retail employment.

In the new global economy, function becomes more important than population size. For example, in Asia, Bangkok and Singapore are smaller but more interconnected than Beijing or Shanghai (Yeung, 1995). In these new world cities, the sectoral composition of the labor force may be quite different than in the traditional megacities (see the discussion in the next section).

On the other hand, developing-country megacities rank higher in terms of population (and employment) than production. Of the world's top 20 cities in gross urban product, only 2 are in developing countries: Seoul (a marginal candidate for developing-country city status) ranks twelfth with \$93 billion, and São Paulo ranks twentieth with \$70 billion, as compared with \$854 billion for Tokyo, \$448 billion for New York, and \$326 billion for Los Angeles. Among other developing-country megacities, Singapore accounts for 65 billion; Hong Kong for \$60 billion; Bangkok and Rio each for about \$40 billion; and Manila, Cairo, Jakarta, Shanghai, and Calcutta each for \$10-15 billion (Prud'homme, 1995).

THE MEGACITY LABOR FORCE

As suggested above, megacities have different economic structures from other urban areas because of their higher degree of connectedness to the international economy, the existence of high-order (i.e., quaternary) services, and the presence of a cosmopolitan elite. This differentiation has implications for the types and composition of the labor force found in megacities.

Types of Labor

While it is common to discuss the urban labor force in terms of a "formal" and an "informal" sector, recent analysis has suggested that this split is too simplistic and fails to capture the diversity in capital-widening activities, earnings, labor quality, and entry barriers (Kannappan, 1985; Cohen and House, 1996). Some analysts draw instead a distinction between "vulnerable" (Harriss, 1989) and "protected" sectors (Mazumdar, 1983). An alternative but related classification might distinguish five categories: (1) protected labor (contracts and restrictions on entry); (2) competitive but regular labor; (3) unprotected labor (e.g., casual labor, domestic service, wage labor in petty trades); (4) self-employment and family labor; and (5) marginal activities (e.g., hawking, semilegal, or illegal activities). Only numbers (3), (4), and (5) would be included in most definitions of the informal sector.

Thus while we refer to the informal sector in the discussion that follows, we are mindful of this underlying complexity, as well as of the need to recognize the informal sector itself as a heterogeneous entity. Indeed, much of the debate surrounding the functioning of urban labor markets is concerned with how to conceptualize the diversity of income opportunities and heterogeneity of the informal sector. Some experts have emphasized the diversity and dynamism of the informal sector (e.g., House, 1987) or the problems these characteristics imply for devising and implementing effective policy prescriptions (Tokman, 1989). On the other hand, despite the heterogeneity of the sector, many studies have found similar identifying characteristics, suggesting a sector of family-based enterprises ranging in size from one-person operations to medium-sized firms. These firms usually operate in relatively competitive markets and use labor-intensive technologies. Workers in these enterprises are often young and poorly educated. Many rural-urban migrants view the informal sector as a point of entry into the urban economy and as a means of lowering their costs of searching for a formal sector job. It is in this broad, inclusive sense that we use the term here.

Sectors of Employment

The Informal Sector

Because of its size in low-income megacities, the informal sector plays a critical role in their economies. It is sometimes described as a residual sector--implying not a small segment of the labor force or a subsistence component, but rather a large, unprotected sector

with considerable economic potential and dynamism, sometimes even contributing to export performance.

The informal sector employs more than 50 percent of the labor force in most developing-country megacities.³ In Indian cities, unregistered (i.e., informal sector) manufacturing firms employ more than do those officially registered by the government. The informal sector is generally larger in sub-Saharan Africa and Latin American than in Asia (World Bank, 1995a), influenced by two main policy considerations: pro-urban strategies that encourage faster rural-urban migration and labor market policies that dampen formal sector job growth by weakening the role of wage adjustments as market signals.

The informal sector is also very important for non-household-head workers (see Browder et al., 1995, on Bangkok, Jakarta, and Santiago). Its growth during national recessions is an important labor market adaptation strategy. It acts as a buffer for avoiding more negative effects elsewhere in the labor market, such as downward adjustments in wages and increased open unemployment. On the other hand, it may not be an avenue to formal sector jobs. In a labor survey in Bombay, 70 percent of "casual" workers had not changed jobs, whereas 57 percent of factory workers had (only 13.5 percent had started as casual workers). There is little evidence for the "graduation hypothesis" from the informal sector. Contacts (family, caste, neighborhood) are very important. "Regular work looks like an enclosure, to which a limited number hold the keys" (Holmstrom, 1984:203). On the other hand, especially in Asian countries, many capable informal sector workers "graduate" to more remunerative family enterprises (Blau, 1986; Foster and Rosenzweig, 1994; Soon, 1987).

One view about government interventions in the informal sector is that they should be minimal ("benign neglect"). An alternative view is that if governments are to develop informal sector strategies, these should be related to long-term development objectives. In Cairo, for example, "reconstructing, improvement and upgrading low-income, deteriorated urban areas have been temporary remedial procedures to face violence, terrorism, and inflamed social unrest....it is important that the government recognizes and deals with the informal sector. The informal sector should not be seen as either an economic or physical liability (as it is indeed still perceived as such by the government), but rather as an asset that could be directed, upgraded, and recruited to be an efficient, impelling force in systemic development" (Yousry, 1995:25).

Manufacturing

In many developing-country megacities, the role of the modern and/or large-scale manufacturing sector is relatively small, and the informal sector employs more people. For example, manufacturing accounts for only 15 percent of employment in Delhi and for less than 15 percent in Jakarta, while in the latter case one-fifth of the employed population is own-account workers, and about one-half of the labor force is in the informal sector. In

Manila, the manufacturing sector accounts for 20 percent of employment and the personal services sector for about 35 percent.⁴ Even in São Paulo, with its reputation as a megacity industrial dynamo, fewer than one-third of all jobs are in the manufacturing sector (more or less equally divided among the 500-plus firms, the 100-499 firms, and the less-than-100 firms).

Government Employment

There is a large segment of urban employment in the government sector in many developing countries (e.g., Egypt, Argentina). In 1988, 23 percent of urban employment (much higher in Cairo) was in the public sector, although the share may be falling slightly as privatization strategies are implemented. There is evidence of overmanning, and sinecures are common (PADCO, 1982). Efficiency has been impeded by low wages (especially for critical skills) and the problem of the principal agent (i.e., monitoring of work performance).

The growth of corruption is a by-product of low and declining public-sector salaries (see Kpundeh, 1994). For example, real public-sector wages fell by 36 percent in Egypt during 1981-86 and by 80 percent in Ghana during 1977-85. In a sample of African countries, the ratio of private- to public-sector salaries for engineers ranged from 1.6 to 8.6 and averaged 3.7 (World Bank, 1995c).

Urban Services

The housing, transportation, and water and sanitation sectors are also important for job creation. Examples are informal sector construction workers, transportation operatives (120,000 bicycle rickshaw drivers in Dhaka and "phut-phut wallas"--drivers of three-wheel scooters--in Delhi), home-based auto repair shops, and community participation in public works projects. Thus efficiency in these three sectors can have a major impact in terms of higher labor productivity, as well as improved quality of life.

The High-Order Financial and Service or "Quaternary" Sector

As noted above, most megacities have a high-order service sector specializing in banking, finance, information processing, and professional services. This sector may be small in size, but it is important as a source of employment for highly trained professionals and as a direct link with the global economic system. As international markets are liberalized, this sector can play a major role in the efficient functioning of international trade and finance.

Women and Children

Women and children are employed in many sectors, but their potential vulnerability in the work force and in society justifies specific attention.

Female Labor

As might be expected, women are paid less than men in developing-country megacities, although in many cases female employment has grown more rapidly, especially in the informal sector. In a survey of urban West Bengal, India (mainly Calcutta), one-fifth of male workers but two-fifths of women were in the two (out of six) lowest-income (expenditure) classes. Male workers earned about double what female workers earned. About one-fifth of adult females were in the labor force (Bardhan, 1989). In addition, the female labor force participation rate was lower in locations where the manufacturing sector was more important, where male job opportunities were better, and where skilled jobs were more plentiful (women, mostly unskilled, were more likely to work in the informal sector). The taboo against women working outside the home was weaker for nonmanual jobs requiring education and for lower castes. The female labor force participation rate was lower for large households (where women were looking after children and old women), better-off households (income effect), households with more adult male workers, and wage-employed households (women having more job opportunities in self-employed households). In Bombay, the adult female labor force participation was 35 percent among casual-labor households, but less than 10 percent among factory-worker households. Of course, women (and children) were extensively employed in family-based economic activities, such as tailoring and laundering.

The gender gap in share of informal sector employment in favor of women varies between 5 percent (Korea, Thailand) and 28 percent (Bolivia, Egypt) (World Bank, 1995a). In Jakarta and Santiago, household heads earn two to three times the combined income of other household members (Browder et al., 1995). In São Paulo, the income disparity between male and female workers is also 2:1, although female employment has grown spectacularly, probably because of the need to augment household income in an era of crisis (Arriagada, 1990). In Mexico City between 1960 and 1986, the female labor force participation rate increased from 28 to 35 percent, while the male labor force participation rate declined from 81 to 70 percent. A major factor was the relative growth of the tertiary sector. In Latin America, the economic recessions of the 1980s had a positive impact on women's participation in the labor force. In the longer run, rapid economic development was frequently associated with the growth of female employment, more education for girls, and lower fertility.

Studies of cities below the megacity size class confirm the above gender wage gaps. Telles' (1993) study of Brazil's nine metropolitan areas found a formal-sector female/male wage ratio of 0.73, which widened to 0.47-0.54 in the informal sector; Cohen and House

(1993) found a wage gap of 0.77 in formal-sector work in Khartoum, while Ashraf and Ashraf (1993) estimated a gap of 0.60 in Rawalpindi. There is also debate about explanatory factors behind the wage gap, emphasizing either education and skill differentials (Cohen and House) or discrimination (Ashraf and Ashraf). Reduction of the gender wage gap, implying rising female wages, is a key determinant of increasing female labor force participation because it widens the options available to women and increases the opportunity cost of staying at home. Other facilitating conditions include the development of community child care centers.

Child Labor

Children work to provide insurance against family poverty and fluctuating incomes. UNICEF has calculated that in 1991, 80 million children aged 10-14 were working, although many of them worked on farms (World Bank, 1995a). In Brazil, for example, about 18 percent of children aged 10-14 work, despite legal restrictions. On the other hand, in megacities child labor may be less of a social problem than street urchins and abandoned children.

THE MEGACITY LABOR MARKET

Labor Supply

It has been estimated that the economically active population in developing countries (largely in urban areas) will increase by about 1.2 billion between the mid-1980s and the year 2020 (International Labour Organization, 1986). The total developing-country urban labor force should expand from 598 million in 1990 to 1,521 million in 2020, although much of this growth will take place in smaller urban places. The distribution of the labor force varies considerably among different segments of the population: in the developing countries, 94 percent of males aged 20-59 are economically active, 53 percent of women aged 20-49, and at least 15 percent of children aged 10-14.

Growth in population and employment in the majority of megacities is slowing down (Beijing and Shanghai are striking exceptions; see United Nations, 1995), and this trend will continue. Moreover, in some cases the slowdown is dramatic. For example, the Rio de Janeiro Metropolitan Area grew in the 1980s at one-third the rate of the 1970s, while the share of the State (and Rio accounts for more than four-fifths of the State's economic activity) in Brazil's gross domestic product (GDP) fell from 13 percent in 1980 to 9 percent in 1994 (Tolosa, 1995). However, a few large cities (Dhaka and Lagos, for instance) will continue to grow rapidly (in the 4 percent per annum range), even after decelerating (United Nations, 1995). Undoubtedly, these changes will have important implications for the age structure of the labor market in developing-country megacities.

The slowdown in megacity growth will relieve labor supply pressure, but only to a modest degree. However, Williamson (1995:101-102) argues that labor supply is not a problem; on the contrary, he suggests that there has not been *enough* immigration into developing-country cities. Everybody (new migrants, skilled workers, capitalists) gains from additional migration except city-born unskilled workers. The problem, in Williamson's view, is "underinvestment in cities, not overmigration." This is an interesting opinion, but a little extreme. A more accurate statement might treat migration as a valve that regulates labor market supply in megacities, sometimes increasing and sometimes declining in response to changes in wages and in labor demand.

The Egyptian example gives an idea of the scale of the problem. In Egypt, job creation as a whole is slow, largely reflecting the low rate of private investment (7-8 percent of GDP), given that the working-age population growth rate has been and is expected to be more or less constant at 2.5 percent from 1960 through the year 2010. The urban labor force is growing somewhat more rapidly, at 3.3 percent per annum, because of migration and the rise in the labor force participation rate (Yousry, 1995).

Labor Demand

Because the demand for labor is derived from the demand for goods produced by labor, its strength in megacities depends on their ability to compete in the production and sale of tradable goods with other urban areas in the national economy and with other export-oriented cities in the international economy. Factors that impede the competitiveness of megacities, such as core city congestion and constraints on transportation and communications, will have adverse effects on the demand for labor. However, the negative impacts on the labor market are mitigated by the existence of adjustment mechanisms, such as variations in the interurban and rural-urban migration rate and the dynamism and flexibility of the informal sector. The extent of this mitigation varies from megacity to megacity. As a generalization, these cities can be divided into economically dynamic (e.g., Bangkok, Jakarta) or stagnant (e.g., Calcutta, Rio de Janeiro), with widely divergent demand for labor conditions. The labor absorption problem can be very severe in the latter cases (even in conditions of low immigration), resulting in poverty and the risk of serious social unrest.

Labor Market Equilibrium

There is an apparent inconsistency between high unemployment in megacities and rural-urban labor market equilibrium. However, complex forces are at work, such as the role of age-selective migration in stimulating future megacity rates of natural increase and in promoting increases in the domestic savings rate, the cost of public overhead capital and inelastic land supplies in choking off real wage and welfare gains, and competition between city-building investment and industrial capital accumulation (crowding out). The appearance

of disequilibrium can be deceptive because of equalizing differences and adjustments across various sectors, as well as problems involved in estimating unemployment and the size of the informal sector.

Megacity employment growth is affected by the extent of social development in rural areas and by the level of resources for industrial capital accumulation. Other factors, such as foreign capital inflows, global terms of trade, and the supply of mineral and energy resources, have played a role (Williamson, 1995). Technological progress can be important as well: "If urban sectors tend, as they do, to have relatively high rates of total factor productivity growth and if the demand for urban output is relatively price elastic, as it is at least for tradables, then final demand shifts toward the dynamic sectors, the derived demand for urban employment is augmented, urban job creation is accelerated, migration responds, and cities expand. The higher the price elasticities of demand for urban output, the greater the migration and city growth given some rate of unbalanced technological progress. The more open the economy to foreign trade, the more likely it is that these conditions will be satisfied" (Williamson, 1995:91). This explanation applies to much of developing-country city growth since the 1950s (Kelley and Williamson, 1984).

A somewhat different view is that urban economic growth is self-defeating because "increased in-migration might well undermine any gains from policies to reduce urban poverty directly" (Rodgers, 1989:2-3). However, even if this were true, aggregate welfare would still be improved because urban wages would remain higher than rural wages, and the urban/total labor force share would have increased. The formal sector urban-rural wage ratio ranges from 1.10 (Costa Rica) to 8+ (India, Ivory Coast) and is typically in the 1.50-2.00 range (World Bank, 1995a). But such data tell us nothing about what is happening in the urban informal sector, which is often characterized by rapid growth and substantial wage levels (certainly overlapping the wage distribution in the formal sector). Because of data limitations, the assertion that growth-induced migration significantly reduces welfare gains is untested.

Another option is to argue for stronger rural development interventions to increase the supply of domestically produced food and to ease the pressure on megacities from rural in-migration. However, strategies to increase rural incomes often involve labor-saving technology, thereby increasing the rural labor surplus. This may be one factor that explains the upswing in the growth rates of Beijing, Shanghai, and other large cities in China in the last decade.

Megacity Spatial (Geographical) Structure and Labor Markets

To what extent has the decentralization of large metropolitan areas in the developed countries been replicated in developing-country megacities, and how has the spatial reorganization that has occurred affected the operation of labor markets? The severity of core-city transport congestion in many megacities (e.g., Bangkok) suggests that job

decentralization could dramatically improve labor market efficiency and productivity. In Jakarta and the Hong Kong-Zhujiang Delta region in the 1980s, population growth was much more rapid in the periphery (Tangeram and Bekasi in the first case, Shenzhen and Zhuhai in the second) than in other areas, largely because of the decentralization of manufacturing (Yeung, 1995). In São Paulo during 1977-1987, tertiary employment grew 77-90 percent in peripheral locations (e.g., Ipiranga, Penha, Ibirapuera, São Miguel, Campo Limpo) as compared with 54 percent in the municipality as a whole (United Nations, 1993). Mexico City's manufacturing sector is declining, and both population and employment growth are more dynamic outside the Federal District in the municipalities of the State of Mexico (Rowland and Gordon, 1994). In addition, Mexico City will benefit much less than the northern border cities from the effects of the North American Free Trade Agreement (Richardson and Rowland, 1994). A related issue that merits more research is whether the spatial ambit of agglomeration economies is extending in developing-country cities as it is in developed countries (a major influence on this pattern is the telecommunications revolution, which has reduced the need for face-to-face contacts).

Research Needs and Information Constraints

There is a need for more information "on the operation of urban labour market mechanisms, the labour recruitment and job rationing process, the nature of labour market segmentation, the network of 'connections' and migration linkages, the working of intermediaries and contract systems, the formation and structure of trade unions, access to credit and marketing systems for the self-employed, the pattern of remittances and links with relatives in villages" (Bardhan, 1989:215). The fact is that we know relatively little about how labor markets work or about employment and wage levels, especially at the megacity level. The source of information on these issues is usually survey data, but surveys are sparse, and their results are not always in the public domain. Moreover, the private-sector component of labor market operations (e.g., recruitment agents, contract systems, information networks) is rarely integrated into existing databases.

The role of social structures and ascriptive networks, including ethnic ties, in constraining access to information about labor market conditions, skills, and credit is very important (Kannappan, 1988). Kinship networks reduce the risks for potential migrants and help overcome the limitations of employment exchanges and government sources of employment. At the same time, however, they restrict access to jobs and pose a challenge to equity-oriented policy interventions. On the other hand, as economies develop, the relative importance of informal networks declines, while that of more formal market networks increases. It would be wrong to draw inferences about the potential superiority of either type of network; both may be quite efficient at different phases in economic development. However, the natural transition from informal networks to market systems may be distorted by legal prohibitions. In many African countries, for example, governments retain a monopoly over employment agencies.

LABOR MARKET PROBLEMS

Labor markets in developing country megacities are vulnerable to several problems that may be amenable to policy intervention. These include unemployment, poverty and income inequality, job mobility constraints, a lack of protection, and big firm bias.

Unemployment

Unemployment in megacities is the product of many factors, such as rapid population growth, disequilibrium in the migration process, changes in megacity competitiveness, constraints on efficient job search, and skill deficiencies. In general, open unemployment rates in developing countries are misleadingly low because such a high proportion of the labor market is unstructured. However, low-productivity employment or "underemployment" is a serious problem (World Bank, 1995a). For example, Krooth and Moallem (1995) report that one-fifth of Egypt's urban labor force is unemployed, with another fifth working part-time. Unemployment may increase with city size. To illustrate, the labor force participation rate was much lower (53.6 vs. 63.8 percent in 1986) and unemployment higher (19.3 vs. 6.7 percent) in Metro Manila than in the Philippines as a whole (Alonzo, 1989); Mexico City offers a similar example.

Poverty and Income Inequality

It is difficult to generalize about whether poverty is more severe and the distribution of income more unequal in megacities than elsewhere. The reason for this is a dearth of information on the distributional pattern of wages and on the size and distribution of nonwage income, and the fact that wage and nonwage incomes are often pooled and difficult to separate. Alegria (1994) presents evidence on the distribution of earnings by the labor force showing that Mexico City has a pattern similar to that of Monterrey, but more unequal than that of Guadalajara and (especially) Tijuana. In Brazil, only 2.7 percent of urban families were found to be in the poorest category in São Paulo, compared with 10.4 percent in Brazil as a whole and 26.6 percent in the urban Northeast (Jatoba, 1989). São Paulo also had a much lower Gini coefficient--0.48 compared with 0.58 in the northeast. However, São Paulo may be in a special position (for example, relative to Rio de Janeiro) because real wages increased strongly, by 55 percent, over the 1984-94 decade. In Egypt, the super-rich are heavily concentrated in Cairo, with the top 5 percent receiving 50 percent of the income (Yousry, 1995). Poor public investment allocation decisions between urban and rural areas can have an important influence on spatial inequality (Becker et al., 1992).

Of course, it is difficult to expect improvements in the distribution of income in the present economic climate when real wages are stagnating. As a generalization, real wages have increased only modestly, if at all, over the past two decades in all regions with the notable exception of East Asia, where real wages (in the manufacturing sector at least) have increased more than two-and-a-half times (World Bank, 1995c).

Multiple job holding is an important strategy for alleviating poverty, but its prevalence varies from country to country. It is especially common in countries with short public sector hours (e.g., 7 a.m.-2 p.m. in Jakarta). On the other hand, in Bangkok, Jakarta, and Santiago (at least with respect to peripherally located households, the samples analyzed), multiple-earner households were found to be much more common than multiple-job-holding household heads (Browder et al., 1995). Also, household earnings often combine incomes generated in different sectors of the urban economy.

Job Mobility Constraints

Various labor policies and practices result in severe constraints on job mobility. These policies and practices include job security, severance pay requirements, minimum wage policies, and housing allowances and other fringe benefits.

The Lack of Protection

The existence of a very large unprotected sector, combined with a heavily protected (in terms of labor regulations) but small formal industrial and government sector, would appear to contradict the job mobility problem as stated above. But the basic problem is the lack of equity across the labor market. The excessively protected formal sector and its associated costs may provide a strong disincentive for employers in the unprotected sector to offer even the most minimal levels of protection to their workers.

Big Firm Bias

Industrial policy in developing countries is biased in favor of large firms (both public and private). These firms are often protected from overseas competition, and they frequently, and successfully, engage in rent-seeking activities (i.e., winning subsidies and concessions from government). Their activities and preferential treatment have damaging effects on employment growth because small firms are often more dynamic and much more labor-intensive--an important characteristic in capital-constrained developing economies.

THE ROLE OF POLICY

The social sciences offer a number of robust insights into how to improve the efficiency of labor markets. For example, mandates and labor regulations will be ineffective unless they take account of rational decision making by both individuals and households. Twenty or more years of economic research and close documentation of the recent economic history of both developing countries and the former centrally planned economies has taught

us that in general, incentive mechanisms are much more efficient as instruments to guide behavior in desired directions. This section reviews some of the key lessons learned with regard to effective (and ineffective) policy interventions in the labor market.

Goals of Policy

The key government policy goal in the labor market is to raise urban labor productivity and utilization by such means as improving the efficiency of the labor market (e.g., with respect to job mobility and the search process); promoting productivity in both the urban formal and informal sectors; building up human capital; restricting interventions in the labor market to those serving an overriding public purpose in order not to erode the competitive position of developing-country megacities; and reducing unemployment.

The Role for Government

Governments are most effective in improving urban labor markets when they assume a modest (though important) role, depending on the extent of market failure and the importance assigned to distributional issues (World Bank, 1995a). Principles for intervention include the following:

- Let markets work, but intervene where appropriate in key areas (e.g., provision of infrastructure, environmental externalities⁵).
- Make interventions subject to market discipline.
- Intervene openly (e.g., simple rules, not discretionary action).
- Invest and encourage investment in human development (education, health care, nutrition, family planning) where markets are likely to fail (because of externalities) and/or where favorable distributional effects can be expected.
- Create a favorable climate for entrepreneurs (e.g., eliminating restrictions, providing infrastructure support, creating a competitive regulatory framework, and reducing price distortions).
- Facilitate integration with the global economy (lower tariffs and fewer nontariff restrictions on trade and capital flows).
- Promote macroeconomic stability (reduce fiscal deficits, control inflation, reform the financial sector).
- Provide incentives to encourage firms to reinvest profits.
- In the labor market, increase access to information (although this may be inadequate if job access is controlled through informal networks).
- Reduce the complexities of labor legislation that discourage (especially) small entrepreneurs from establishing formal labor contracts.
- Revise labor policy mandates that are easily evaded, are enforceable only very selectively, and clash with household and worker incentives.

In many developing countries, the state is a major actor influencing wage determination: fixing public-sector pay, repressing or promoting worker organization, and prescribing minimum wages. Some of these interventions may be inefficient in the sense of adversely affecting productivity. In addition, there are several other (in some cases possibly convincing) rationales for action: uneven market power, discrimination against women and minority groups, obstacles to information (e.g., about health and safety hazards), and insufficient insurance against risks (e.g., unemployment, sickness, and old age). Furthermore, some actions conducive to employment growth can be implemented locally. These include measures to improve the quality of the labor force, to provide and maintain sound infrastructure (particularly transportation investments), to hold local tax rates at a moderate level, and to promote environmental quality. "Cities with efficient labor markets, and with appropriate conditions for growth and innovation, will adjust more easily than others. What is done in each urban area--by urban policies--to promote the efficiency of labor markets and the business creation potential will facilitate adjustment and flexibility of the entire economy" (Prud'homme, 1995:735-6). The argument is that labor-augmenting policies may improve macroeconomic performance just as efficient macroeconomic policies can improve labor market performance. Thus, it is insufficient to take the obvious macroeconomic steps (e.g., trade liberalization, fiscal discipline, and deregulation of financial markets). These measures will not create jobs rapidly enough and may not garner long-term political support for market-oriented strategies. Complementary strategies are needed: faster provision of infrastructure in poor settlements and in metropolitan-wide transportation and telecommunications, and social policy reforms in taxation, education, housing, and social security to reduce resource misallocation and promote income equity (World Bank, 1995c). Similarly, policies to raise labor productivity may not be labor policies per se, but more general in nature. For example, "urban policies could be defined as measures to increase positive externalities and decrease negative externalities" (Prud'homme, 1995:732).

On the other hand, Rodgers (1989) has challenged the view that the labor market can be analyzed as if it were just another commodity market. Instead, he argues in favor of emphasizing social, institutional, and legal factors associated with unequal access to the labor market. However, this argument does not undermine the need for freeing up the market, but only emphasizes that such attempts will be more difficult to achieve and more prolonged. Freeing up the urban labor market will weaken the social and cultural constraints on its efficiency.

Others (e.g., Jatoba, 1989) recommend a more sweeping menu of policies, including measures to support small-scale production; stronger enforcement of minimum wage laws; wage subsidies for particular groups; interventions to prevent worker exploitation; better organization of the labor legislation concerning the right to strike, collective bargaining, entry into protected labor markets, and aid to the unemployed; and better labor market information. Such government activism would be unwise, because (among other problems) developing-country governments are not equipped to handle such a broad mandate. The narrower and more conservative principles outlined above provide a sounder basis for

intervention. We turn now to specific policy interventions that can address the problems outlined in the previous section.

Policies to Reduce Unemployment

Macroeconomic Policies

There are striking regional differences in macroeconomic policy. In East Asia, there has been generally successful export-oriented industrialization, combined with equitable income distribution policies (e.g., land reform, agricultural development policies) and an emphasis on labor-intensive measures. In Africa and Latin America (with notable exceptions, such as Botswana and Chile), on the other hand, government efforts to promote industrialization have been based on less open (to international markets) and more interventionist strategies, including trade regulation, creation of investment incentives, and direct public investment in manufacturing. These policies favor large firms and discriminate against the smaller firms that generate most jobs.

Structural adjustment policies have a mixed impact on employment. For example, a study of Costa Rica showed that structural adjustment policies helped to stimulate export promotion and private investment, and that unemployment *eventually* dropped (Fields, 1988). Of course to date, the forced and delayed adjustment in Mexico has had the opposite effect, although the current situation may be no worse than what would have happened in the absence of any adjustment. Structural adjustment strategies are often associated with short-term formal-sector job losses, but the key issue is whether the adjustment costs are short-run, offset in the longer run by the creation of new jobs. The benefits of export promotion tend to be concentrated in labor-intensive industries, and more emphasis on the private sector can fuel the growth of new labor-intensive businesses. Fields (1989) also points out that in the urban modern sector, the employment of unskilled workers has been limited by labor demand constraints; this implies that promotion of economic growth, especially export growth in labor-intensive industries, is critical.

Countries faced with serious debt problems, in particular, must be very careful with respect to policy choices. Wrong-headed policies can result in severe capital flight that almost always inflicts high adjustment costs on workers. For example, in the 1980s real wages fell 15-40 percent in Latin American countries, with a few exceptions, such as Argentina.

International Trade Policies

This is a controversial issue. Krugman (1991) has argued that protectionism and autarky reinforce primacy (i.e., the dominance of the largest city in a country's urban size distribution). Open markets create a more level playing field between core and periphery

manufacturing and between urban and rural economic activities. However, at least in the short run, a dampening of labor demand has ambiguous impacts on the labor market because of doubts about the indirect effects on labor supply (via induced rural-urban migration).

An interesting feature of global interactions since 1970 is the rise in trade and capital flows and the decline in labor flows (World Bank, 1995a). The deceleration in international migration may work to dampen wage convergence, but this effect can be offset by international trade and capital flows that substitute for international labor movements. Also, international trade benefits workers because of lower consumer prices and stimuli to higher labor productivity.

Ades and Glaeser (1994) found that the share of trade in gross national product (GNP) was negatively related to the size of the largest city; in a large cross-section, a 10 percent increase in the trade share was associated with a 6 percent decline in the size of the primate city. High tariffs (measured by the ratio of import duties to total imports) were associated with increasing primacy (a 1 percent increase in the tariff variable increased primate city size by 3 percent). In an earlier study, Krugman (1991) found that a 1 percent increase in the share of GDP spent on government transport and communications investments was associated with a 10 percent reduction in primate city size, indicating that barriers to internal trade reinforce primacy. Tests of these hypotheses on Pacific Rim countries by Richardson (1995) produced ambiguous results.

Nevertheless, outward-oriented countries do grow more rapidly than inward-oriented countries. In the Pacific Rim, manufacturing accounts for three-quarters of exports, and manufacturing is overwhelmingly urban. Measures to increase urban productivity (e.g., human resource investments, infrastructure provision, and alleviation of negative externalities such as traffic congestion and air and water pollution) have direct and favorable effects on growth and export competitiveness (Richardson, 1995).

Human Resource Policies

Although there is a serious problem of the educated unemployed in some megacities, provision of better education is generally associated with rising labor productivity and higher wages; examples are offered by many East Asian countries, such as Singapore and South Korea (see Park, 1988). However, there is no clear evidence that there are public benefits to education beyond the private benefits (Psacharopoulos, 1985).⁶ On the other hand, some recent studies (e.g., Behrman, 1995; Rosenzweig, 1995) have found that more education has externalities that include facilitating the spread of knowledge about new production techniques and new markets. Also, there is evidence of positive rates of return to education even in the informal sector (Cohen and House, 1995).

Government training programs have a poor record, but on-the-job training programs in the private sector can be very important. Of course, government stimulation of the private

sector can also be important. For example, in the mid-1970s, Chile changed from a centralized government training system to one where the government subsidized decentralized private training programs and supervised both government and private employment offices through a coordinating and supervising agency called SENCE (Servicio de Capacitacion y Empleo). Tax credits have induced the provision of training for about 5.5 percent of the labor force, or about 250,000 workers. Also, educational reforms in Chile since the 1980s have resulted in a 50 percent expansion in the provision of secondary education, especially by offering additional subsidies at different rates to technical, agricultural, industrial, and commercial schools and by attracting private providers into the system.

Policies to Reduce Poverty and Income Inequality

Minimum Wage Policies

It is difficult to draw a clear-cut conclusion about whether minimum wages have favorable consequences. The consequences depend on the employment impact, determined in turn by market structures, the threshold level, and the degree of enforcement. To the extent that minimum wages are effective in the formal sector, they tend to protect the labor elite employed in that sector at the cost of restricting access to formal sector jobs by others.

Minimum wages relative to average incomes tend to be higher in poor countries (World Bank, 1995a). For example, some sectoral minimum wages in Bangladesh are more than double GNP per capita. To the extent that this is true, minimum wage legislation reduces employment.

Minimum wage legislation has no impact on wage levels of the unprotected informal sector that dominates income-generating activities in the megacities of low-income countries. Conversely, the minimum wages are often irrelevant to privileged formal sector workers who earn much more.

In periods of crisis, real minimum wages fall drastically (as they lag behind inflation), e.g., by more than 40 percent in the 1980s in countries such as Mexico, Chile, and Kenya. Yet minimum wage legislation is often not enforced, with substantial proportions of the labor force being paid less than the minimum wage. In Mexico City, for instance, a 1985 study by the Mexican Labor Congress found that 56 percent of workers were earning less than the minimum wage (United Nations, 1991). However, Gregory's (1986) data did not support this conclusion, with average wages in all service sectors found to be well above the minimum. In expanding economies, minimum wages tend to be irrelevant as productivity growth fuels real wage increases.

The impact of the contribution of minimum wages is less in very big cities. Why? People are more productive in larger cities. The "natural wage" (i.e., the wage without legislative constraints) is higher, and fewer people are paid less than the minimum wage; the

minimum wage constraint is not binding (Prud'homme, 1995). Nevertheless, especially in Latin America, minimum wages can be an instrument for keeping wages down because they are used as a reference standard and are usually set far below the market wage.

Informal Sector Promotion

Measures to facilitate the expansion of informal sector activities and small-scale family businesses (discussed under "Policies to Reduce Big Firm Bias" below) can have an important role in relieving poverty. Not only do they create income-generating activities for low-income populations, but they also open up opportunities for upward mobility, given the significant overlap in the wage distributions of formal and informal sector work.

Policies to Eliminate Job Mobility Constraints

Labor Unions

Labor unions in developing countries vary widely in bargaining power and impact. Generally, they defend the interests of a relatively privileged group of regular workers, and the interests of this group may diverge widely from those of workers on the margins of the labor market. However, union membership tends to be low in developing countries, typically less than 20 percent of the urban labor force.

Labor unions are often not independent, but under indirect government control. For example, in Egypt the labor syndicates operate under the umbrella of the General Union of Labor (GUL); tensions persist between the workers and the syndicates, and between the syndicates and the GUL. In India, too, the major labor federations are affiliated with political parties, and their collective bargaining is subject to compulsory adjudication.

The influence of labor unions is mixed. On the positive side, they minimize labor turnover; improve productivity; and reduce wage dispersion and discrimination, e.g., against women workers. On the negative side, their monopolistic behavior boosts member wages (union wage premiums being in the 10-30 percent range) at the expense of nonunion labor, consumers, and stockholders, and they oppose necessary structural adjustments. Appropriate policy would attempt to create an environment that would promote the positive impacts of unions while mitigating the negative. Such policy would involve creating competitive product markets, facilitating workers' freedom of association, and promoting decentralized bargaining (as in Seoul since the late 1980s). In addition, in some developing countries (e.g., Bangladesh, Egypt), the repression of unions has often been coupled with actions (such as featherbedding in the public sector, job security provisions, and high minimum wages) that exacerbate labor market distortions. In general, wages and the terms of working conditions should be left to voluntary agreements between workers and employers.

Social Policies and Job Security Laws

Social policies covering housing, pricing of "essential" goods, public services, and social insurance may have an important impact on poverty and welfare. When they are job-attached, however, they can impede labor market efficiency. Similarly, job security legislation mandating severance pay and long notices (as in Mexico and Sri Lanka) can impede the growth of formal-sector employment by encouraging firms to rely on casual labor and/or subcontracting.

Transportation Strategies

Many megacities suffer from inadequate transportation that undermines labor productivity. Bangkok and Cairo are merely two of many examples. Bangkok's problem is insufficient allocation of land to road space in the central city. Dealing with the problem by investments in intersection flyovers has had a negligible impact. Decentralization of jobs and population would appear to be a more viable strategy. Cairo has also invested heavily in intersection flyovers, in elevated freeways at the 6th of October and 15th of May satellite cities, and in the Ring Road project. By 1993, more than 96 percent of the Greater Cairo Project Implementation Agency's investments were in transportation (Yousry, 1995). However, the experience of developed-country cities suggests that it is impossible to build enough roads to control congestion. There are lower-cost and more effective approaches to overcoming the inaccessibility obstacles to higher worker productivity, including spatial reorganization (i.e., the decentralization of both jobs and people); the promotion of small-scale, private paratransit operators in peripheral settlements; and a combination of transportation demand management and transportation supply management strategies.

Spatial (Geographical) Redistribution Policies

Explicit spatial redistribution policies have had a mixed record. Job growth has slowed down in Seoul, but there is a great deal of controversy about whether this was the result of direct policies or of many other considerations, including market forces. In many other countries, however, spatial redistribution policies have been ineffective and often costly.

Secondary city strategies have value in helping those individual cities, but they have a negligible effect in reducing labor market pressures on megacities. Rural development strategies have done little to relieve megacity labor force growth, although labor-intensive public works programs may have a modest but discernible effect. The slowdown in megacity growth, where it has occurred, has been largely a natural consequence of declining national population growth rates and has had little to do with spatial redistribution.

The most striking change in direction in spatial redistribution policies is post-Mao China's abandonment of its long-established anti-urban policy to discourage rural migrants from entering urban areas. This shift may reflect the view that reducing rural surplus labor is key to efforts to raise rural living standards, in part because of urban-rural remittances. As a result, the growth rates of China's two largest megacities have soared--1.8 times faster growth than in the 1970s and 1980s in Beijing and 2.62 times faster growth in Shanghai (United Nations, 1995). This rapid growth has aggravated the job creation problem in those cities, and there have been recent attempts to reimpose strict controls by sharply raising the cost of urban entry.

Policies to Protect Labor

Child Labor Laws

Legislative mandates against child labor are symbolic rather than effective unless incentives can be developed to shift children out of work and into school and/or to implement income security programs (e.g., food for work). Premature enforcement of labor laws is less desirable than "a comprehensive approach that takes into consideration the interaction between labor market conditions, school availability, child labor, and poverty" (World Bank, 1995b:72).

Nevertheless, child labor laws are a test of the effectiveness of government intervention in the face of market trends. Everyone agrees on the central objective--to improve child welfare; the potential disagreement is about the measures used to achieve this goal. Banning child labor outright, other than its public relations value, is ineffective if enforcement procedures are weak and if the ban conflicts with household goals. A preferred strategy is to create an environment in which child employment declines through expansion of primary and secondary education facilities, promotion of economic growth, and other non-labor market policies.

Health and Safety Legislation

The costs of occupational injuries comprise up to 4 percent of GNP in developed countries and are probably much higher in most developing countries. In general, the rural and informal sectors have received little protection from health and safety standards. Also, there are enforcement problems in the formal sector, especially with respect to small firms. In developed countries, the unions play a significant watchdog role; this could be an important contribution in low-income countries where enforcement capacity is so weak. Furthermore, developing effective liability measures may have more concrete results than relying on unenforced safety regulations.

Trying to link labor standards to international trade sanctions is ill advised because it panders to protectionist interests, unless the focus is limited to core standards (e.g., no forced labor, freedom of association, and prevention of extreme forms of discrimination). It should also be recognized that such provisions, if effective, may worsen rather than improve the income-generating opportunities and the welfare of the alleged beneficiaries.

Privatization

For the past 15 years there has been a strong trend toward privatization, including private-sector participation in shelter, infrastructure, and services. The more typical privatization strategy, however, involves the sale of the assets of inefficient public enterprises. For example, in Egypt privatization reforms were one element in the structural adjustment program adopted in 1987. A direct result was Business Sector Law 203 of 1991, which initiated cutbacks in the bloated public sector by the sale of shares and other assets of state-owned enterprises, most of them located in Cairo (Yousry, 1995).

Privatization of public-sector activities, including production establishments, can have beneficial effects on labor productivity through the incentives offered to both employers (managers) and workers. Nevertheless, it is frequently opposed by labor unions, which fear job losses, wage cuts, and the erosion of benefits. In many countries (e.g., Thailand), the strongest labor unions are found in the government sector (Rondinelli and Kasarda, 1993).

Policies to Reduce Big Firm Bias

Small-Scale Sector Policies

There is a case for intervention to overcome obstacles to entry, including limited access to credit, high start-up costs, a lack of technical assistance, marketing problems, an uneven playing field in competition with large firms, inadequate training, and a lack of managerial skills.

There is a clear policy choice between "removing regulatory restraints" (de Soto, 1989) and providing a "battery of costly supports" (International Labour Organization, 1986). Bromley (1993:133) argues that the former course is insufficient, while the latter is costly and difficult to implement. "The crucial issues are how to generate a macroeconomic and macropolitical climate favorable to the growth of small enterprises; how to ensure sustained and consistent application of government promotion policies; how to encourage simple, easily replicable pilot programs; and how to encourage the diffusion of successful innovations among small enterprises." Measures to facilitate on-the-job apprenticeships in the informal sector are cost-effective (Cohen and House, 1995). However, there remains "an inherent contradiction between the flexibility and adaptability of the IFS [informal sector] and the bureaucratic rigidities that so often accompany intervention in developing countries. The IFS

is the product of a competitive environment and, by and large, it flourishes best in an environment unhampered by government regulation. If the government regards its role as supportive and facilitating, this may be enough" (Richardson, 1984:30).

Stronger efforts should be made to convert paid workers to self-employment (e.g., bicycle rickshaw drivers in Dhaka). Family-based enterprises also offer substantial benefits (stimulating capital accumulation, a long-run planning horizon, and incentive-based labor productivity).

Industrial Incentive Policies

Relatively few governments offer incentives for firms to start businesses or expand in megacities, or if offered, the incentives are higher for establishing businesses at alternative, more peripheral locations. However, most of these programs are targeted at the larger firms that are capable of meeting subsidy application requirements.

Labor Policy and Key Megacity Issues

Another way of slicing the policy cake is to relate the policy reforms discussed above to four key megacity issues: productivity, poverty, the environment, and management.

Productivity would be improved, perhaps dramatically, by policy reforms in several areas, including macroeconomic stability, open international markets, informal sector promotion, and labor policy reforms.

The informal sector is also important from the point of view of poverty alleviation, as is eliminating barriers to female employment (e.g., offering more flexible working hours or providing community-based child care).

The relationship between improvements in the labor market and protection of the environment is an important issue that has not been addressed in detail in this paper. Policies for intrametropolitan location of industry to reduce stationary-source air pollution can contribute to the spatial dispersion of the labor market. Moreover, there is substantial scope for expanding labor-intensive informal sector work in recycling and the management of waste, especially if associated with some organizational and managerial improvements in transportation. Trade-offs between environmental protection and employment can be exaggerated: introducing cleaner technology is not necessarily associated with reducing labor inputs, and servicing pollution-abatement activities is labor-intensive.

The goal of improving megacity management has implications for the upper end of the labor market, especially from the point of view of training engineers, planners, and city managers. In addition, strategies are needed for making public sector management careers

more attractive to the high-quality educated people who currently, and overwhelmingly, look to the private sector for employment.

Finally, we note that the analysis in this paper is restricted to megacity labor markets because traditionally, the development literature has emphasized the importance of the urban economies in absorbing surplus rural labor into a modern industrial sector. Nevertheless, it is important that planners not neglect the direct needs of both rural areas and other, smaller cities. Hence all the above-mentioned policies need to be evaluated at the national, and not just the megacity, level.

THE ROLE OF SCIENCE AND TECHNOLOGY

How can megacity labor markets benefit from rapidly changing technology? In several developing-country megacities, there are pools of unused educated talent. The back-office telecommunications jobs (e.g., in credit card divisions of major banks) that have decentralized to places such as South Dakota and Ireland could equally go to developing-country megacities if it were possible to finance and undertake the massive capital investments required. The latter would involve further freeing up the privatized telephone companies and facilitating the development of joint, i.e., domestic-foreign ventures.

International transportation and communications costs (for commodities, capital, labor, and communications infrastructure) have fallen by 82-97 percent since 1920. Accordingly, national economies cannot be insulated from global pressures, except by self-defeating autarkic interventions. However, megacities are much better placed than other locations within developing countries to take advantage of these falling costs because intranational transportation and communications costs have fallen much more slowly than international costs.

The telecommunications lags in many developing-country megacities threaten to widen the disparities between these cities and their developed-country counterparts. However, privatization offers an opportunity to overcome some of these telecommunications infrastructure deficits (e.g., by expanding cellular telephone services). As an example of what is possible, a large-scale telecommunications infrastructure project (Teleport) is being implemented in the decaying downtown of Rio de Janeiro. It involves a 62,000 cubic meter building on a 250,000 cubic meter site, incorporating a satellite ground station; a fiber-optic vertical transmission system; a server for voice mail, e-mail, and fax; a telecenter for voice, data, and image terminals; a video conference facility; and hotels and restaurants (Tolosa, 1995). Similarly, Tehran recently inaugurated the largest telecommunications center in the Middle East (El-Shakhs and Shoshkes, 1995).

Telecommunications may also offer developing-country megacities an opportunity to exploit the benefits of being late starters. It is well known that many of these cities (e.g., Bangkok) have woefully inadequate levels of investment in transportation. Would it be

feasible to jump a stage of technology and, instead of building more highways and transit systems, invest heavily in telecommunications, building a quaternary sector (both national and global) dependent on decentralized, satellite office centers? (Of course, in low-income developing countries, home-based information processing would be more difficult until housing and infrastructure conditions had dramatically improved.) Some analysts (e.g., Schuler, 1992) have argued that telecommunications and transportation are more complements than substitutes, but this relationship--if true--is likely to hold only in the short run, not the long run.

The two major innovations already widely in use even in developing countries are the computer and the cellular telephone. For example, Brazil is one of the fastest-growing computer markets in the world. Although most developing countries are not yet competitive in producing state-of-the-art hardware, cities such as São Paulo and Bombay have generated significant numbers of highly skilled jobs in producing software. In the United States, computerization has had destabilizing impacts on the labor force, creating many jobs in some sectors and destroying jobs in others (e.g., bank tellers, telephone operators, and secretaries). In developing countries, on the other hand, in part because of the availability of cheap labor, the prospects for net job creation are excellent. Moreover, significant opportunities are being created in related activities, such as the expansion of electronic repair services in the informal sector and subcontracting for CD-ROM production and desktop publishing from developed-country corporations.

The cellular telephone has penetrated into surprising markets. For example, women participants in the Grameen Bank's microenterprise loan program in Bangladesh were provided with cellular telephones to increase intervillage communications. More generally, the cellular telephone has enabled developing-country megacity businesses to overcome the frequently severe lags in obtaining regular telephone service. Diffusion could increase rapidly as cellular transmission costs drop; the rate at which this might take place depends not only on privatization, but also on the creation of a competitive rather than a monopolistic environment.

SUMMARY AND CONCLUSIONS

Developing countries (especially when the so-called transitional economies are included) span a wide range of income and development levels, and their megacities reflect these differences. Yet most of the megacities share some key labor market characteristics: a formal manufacturing sector that is usually dwarfed (in employment terms) by the service sector; a large government sector, often riddled with inefficiencies; and an informal sector whose size depends on the level of economic development, business cycle influences, and the degree of government tolerance and support. Moreover, almost all megacities have been impacted substantially by globalization and the opening up of world markets; these trends have accelerated the need for increasingly flexible labor markets.

While acknowledging that there are always exceptions to any rule, several key conclusions can be drawn from the analysis presented here.

1. The promotion of economic growth and economic (and political) stability offers the best guarantee of expanded employment opportunities, higher wages, and labor productivity growth. Appropriate macroeconomic policies (e.g., fiscal discipline, the control of inflation, and financial reforms), combined with both tariff and nontariff trade liberalization, offer the most promising strategy for promoting employment growth and generating enough resources to pay for the infrastructure investments needed to achieve income equity.

2. For this strategy to work efficiently, the economy in general and the labor market in particular need to adjust quickly to changing market conditions. Many developing countries have labor policies in place (such as minimum wage laws, job security provisions, job-related housing provision, pension systems, and centralized--often government-controlled--labor unions) that, when enforced (often they are not), aggravate labor market distortions and impede adjustments. Deregulation of the labor market offers prospects for increasing its flexibility, especially by recognizing that policy interventions should work with rather than against market forces and should pay attention to the incentives driving the behavior of individuals and households. At the same time, improved access to credit markets for potential entrepreneurs, as well as to job information and to skills acquisition for potential employees, will help megacities' labor markets run more efficiently.

3. Whereas redistribution policies tampering with spatial variations in labor supply and demand are unlikely to be effective, efficiency-oriented urban policies (e.g., low-cost improvements in transportation, broadly based educational investments, privatization of government services, access to credit for small-scale enterprises, and creation of a favorable entrepreneurial environment) can promote labor productivity growth and improve the competitive efficiency of megacities, directly impacting macroeconomic performance.

4. With respect to the role of science and technology, more rapid diffusion of known and already widely applied technologies (e.g., computer information systems, cellular telephones) may transform the structure and composition of employment in developing-country megacities, especially given the global competitive environment.

ENDNOTES

1. Definitions of what actually comprises the formal and informal sectors are not always very consistent. Nevertheless, "the basic distinction [between the formal and the informal sectors]...turns on the idea that employment in the formal sector is in some sense or senses 'protected' so that wage levels and working conditions in the sector are not available, in general, to job seekers unless they manage somehow to cross the protective barrier. This kind of protection may arise from the action of trade unions, of governments, or of both acting together" (Mazumdar, 1981:85). However, this is not to imply that wages to employees in the formal sector are always superior to those in the informal sector with similar education and skills. Indeed, heads of more established enterprises frequently have considerable labor market experience and earn more than their formal sector counterparts.
2. The availability of hard data on labor characteristics and labor markets in megacities is very limited. Some of the information presented in this paper refers either to nationwide data or to urban data generally, rather than to megacities specifically. In many cases, extrapolation of the more general findings to the megacity case is appropriate. However, the limitations of the database are a major problem.
3. The share is even larger (70-90 percent) in secondary cities.
4. Characteristics of the informal sector in Manila include the following: 80 percent sold food and other items; 57 percent were unpaid family workers, while only 20 percent earned fixed wages; two-thirds of enterprise heads had not finished high school, compared with one-third of all workers; one-half of enterprise heads had worked at the same place for at least 4 years; and 56 percent were primary breadwinners (Alonzo, 1989).
5. An externality occurs whenever the actions of one person or firm affect another person or firm in ways that are not taken into account by the operation of the market (Varian, 1984).
6. Calculations of the private and social rates of return to education are often hindered by a paucity of appropriate data. Theoretically, the decision by an individual or a government to invest in education entails weighing all the costs against the expected benefits of such an

investment. The private rate of return to education equals the internal rate of return that equalizes the discounted present value of the private costs of attending school--including all private outlays for school fees, books, uniforms, and other school materials and the opportunity cost of lost earnings while attending school--and the discounted present value of the higher earnings that the individual enjoys in subsequent years upon completion of his/her education (Schultz, 1993). To calculate the social rate of return to education, one must add the public costs and benefits of education. The public cost of education includes public expenditure on buildings and teacher salaries. The public benefits of education include the higher taxes that better-educated workers pay, as well as the effects of raising education on improving the status of women, lowering fertility aspirations, improving maternal and child health, reducing infant and child mortality, and lowering crime, each of which may be significant. Rarely are these calculations even close to complete, although estimates of the private rate of return to education tend to be closer to its conceptual measure:

In practice, few studies even deduct from labor earnings or wage rates what the more educated worker is likely to pay in increased taxes (both income and indirect), although doing so is not conceptually difficult. This deduction is irrelevant if the number of hours worked is independent of education and if taxes are proportional to wages....The calculation of the social return to education also tends to be flawed. In most empirical studies, the only distinction between the private and social returns to schooling is that the latter adds public expenditure per student into the calculation of the internal social rate of return (Schultz, 1993:52).

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Water and Sanitation Services for Megacities in the Developing World

A Working Paper

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Commission on Geosciences, Environment, and Resources

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FOR MEGACITIES**

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EXECUTIVE SUMMARY

Water and sanitation services in the megacities of developing countries are inadequate for a large and rapidly growing number of urban residents. A history of nationally subsidized water services and lack of attention to cost recovery have limited the capacity of water and wastewater service providers to expand the network, treat water and wastewater, and fund repairs. In low-income communities, especially the squatter settlements that characterize many megacities, facilities for proper disposal of human wastes are seldom available; hygiene practices are generally poor; and water for household use is often inconvenient, insufficient, and contaminated. In many of the large cities, municipal and industrial wastewaters are rarely treated prior to disposal, and urban streams, rivers, and estuaries are severely polluted with human pathogens and toxic wastes. Diarrheal and respiratory infections that result from these conditions continue to be among the most frequent causes of sickness and death for infants and children.

To help improve the prospects for sustainable water and sanitation services for megacities in developing countries, a U.S. National Research Council panel focused on five areas that should receive the attention of national governments; external aid agencies; technical consultants; scientists; technicians; providers of water, wastewater, and other sanitation services; health services; and the leaders of the affected communities. (As used here, the term "sustainable" simply means that the services are capable of being continued over time without deterioration.) The result was a set of five approaches for achieving improved megacity water and sanitation services.

1. **Improved Sanitation.** Water and sanitation professionals must take a broader view of sanitation to prevent disease resulting from a wide range of activities and multiple exposure routes. The provision of a potable water supply and wastewater removal are necessary but not sufficient conditions for improving public health. Water supply and wastewater management should be well integrated with other community, environmental, health, and nutritional programs to create a more robust and effective approach to healthcare and disease prevention. As opposed to the setting of standards by particular programs, activities, or media, an integrated approach should focus on end

results by considering and giving equal attention to all strategies and means for achieving those results in a cost-effective manner. Successful integration implies the avoidance of institutional barriers to the implementation of nontraditional approaches.

2. **Participatory Planning.** Public water and wastewater service providers, health institutions, municipal and federal governments, and external aid agencies need to work together to place a higher priority on providing incremental water and sanitation improvements to the unserved residents of urban communities. This can be accomplished through participatory planning with the community, public education, and an openness to innovative technical approaches. These strategies should be compatible with the aspirations of the communities involved, their ability to maintain and upgrade the system, and the services people want and for which they are willing to pay.
3. **Financing.** All people, including the very poor, are willing to pay a reasonable fee for convenient and reliable access to safe drinking water and the safe elimination of household waste. It follows that providers of drinking water and wastewater services should strive to become financially sound and self-sufficient entities that can collect revenues from customers sufficient to maintain and expand system services as needed.
4. **The Role of Technology.** Technical innovation should be based on carefully considered performance criteria appropriate to maintaining a healthy environment. The private sector can be an important contributor to the development of locally new technology and the provision of services. However, the participation of the private sector in service delivery and technology innovation requires the right market incentives, sound government policy, and appropriate and enforceable laws and regulations.
5. **Water Conservation and Reuse.** By their very nature, megacities have larger impacts on water resources and suffer greater constraints on obtaining water than smaller urban or rural settlements. Effective management of water resources requires a holistic approach that considers water quantity, quality, and use within an entire watershed or catchment area. Conservation of water resources should be a priority for all megacities, and the value of water should be reflected in the design of tariffs and the metering of users. With appropriate treatment, reclamation and reuse of municipal wastewater for nonpotable uses can become an increasingly cost-effective conservation measure.

INTRODUCTION

This paper examines the challenge of improving water and sanitation services in the megacities of the developing world. Following a review of the current situation, it presents approaches to improved services in five areas: improved sanitation, participatory planning, financing, the role of technology, and water conservation and reuse.

REVIEW OF THE CURRENT SITUATION

After the United Nations declared the 1980s the Drinking Water Supply and Sanitation Decade, concerted efforts were made by both governments and external support agencies to improve the delivery of drinking water and sanitation services in developing countries (United Nations Development Programme, 1994). Yet while the coverage of urban drinking water services has improved over the last decade, the number of urban residents without adequate means to dispose of their household wastes has continued to grow (World Bank, 1992) (see Figure 1). In providing for wastewater removal, governments have generally focused on constructing sewers in city centers. Wastewater services rarely reach the poor residents living on the urban periphery or in informal settlements, where open drains and ditches commonly collect household waste. In most developing-country megacities, wastewater is rarely treated prior to disposal, and urban streams and rivers have become little more than sewage canals, carrying almost undiluted human and animal excreta, refuse, and industrial waste.

Where drinking water service is presumed to be adequate and safe, the distribution systems are often poorly maintained and may suffer from leaks and intermittent system pressure. Negative pressure inside the pipe allows contaminated water from the surrounding soil to infiltrate the distribution system. Tests of household tap water in Mexico City, for example, showed significant variation in the percentage of samples that met the standard for microbiological safety (as measured by the chlorine residual), ranging from full compliance to as low as 16 percent among the political jurisdictions of the metropolitan area (National Research Council, 1995).

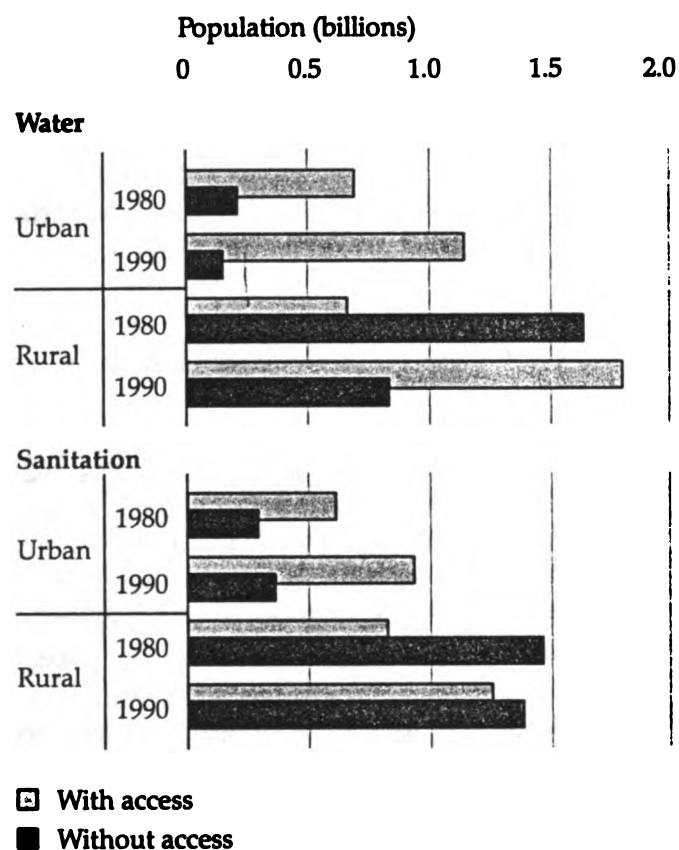


FIGURE 1 Access to water and sanitation service in urban areas of developing countries, 1980 and 1990. Sanitation service in this figure indicates public sewers. Source: Adapted from World Bank (1992) from World Health Organization data.

Foreign aid and other investments have traditionally focused on the development of drinking water supplies to the exclusion of wastewater systems and other aspects of sanitation. Relative to the amount spent on water services, sanitation has received only 15 percent of the total lending in the water and sanitation sector of the World Bank over the past 30 years (Bartone, 1994). This emphasis has reflected, in part, the priorities of borrower governments. From an economic perspective, investment in water supply encourages industrial and commercial development and has contributed to the growth of megacities. These large cities are often the engines that drive the development process for countries in the early stages of modernization. The demand for a convenient and adequate water supply for the urban family is often seen as a higher priority than wastewater removal, especially for poor urban residents. However, part of the reason for the perceived lack of demand for wastewater services is that very few options have been available or presented to unserved communities.

The health consequences of inadequate drinking water and wastewater services fall most heavily on the poor. Urban populations in developing countries are growing most rapidly in the low-income, high-density districts, including the informal settlements (also termed squatter areas, *favelas*, shantytowns, and *villas misérias*) that can be found in most developing-country megacities. In these areas, there are few or no facilities for proper disposal of human wastes; water for household use is rarely convenient or sufficient and is often contaminated; hygiene is poor; and in the event of illness, access to medical treatment is difficult. Diarrheal diseases from gastro-intestinal and parasitic infections and acute respiratory illnesses resulting from these conditions are among the leading causes of sickness and death among infants and young children in the developing world (World Bank, 1993). It is estimated that in the developing countries, 3.2 million children under the age of 5 die each year from diarrheal diseases (World Health Organization, 1992). The disparity between those with and without access to clean water and a clean environment is strikingly evident within most large urban areas. Mortality rates are between 2 and 10 times higher for children living in the squatter areas of a city than for children living in areas with adequate drinking water, wastewater, and medical services and better nutrition and hygiene practices (Stephens, 1995). Even with deteriorating services, the more well-to-do can afford to either boil water or subscribe to services that guarantee convenient and good-quality water.

The problem of lack of coverage for water and wastewater services has been the subject of numerous international forums and reviews. A declaration and plan of action to improve health, including safe water, wastewater removal, and other aspects of sanitation, was adopted in 1990 at the United Nations World Summit for Children and had been joined by 174 countries as of July 1995. The growing threat to public health and the environment from the scarcity and misuse of fresh water was recognized by 100 countries and 80 international, intergovernmental, and nongovernmental organizations at the International Conference on Water and the Environment in Dublin, Ireland, in 1992. In March 1994, representatives of governments met at the Ministerial Conference on Drinking Water and Environmental Sanitation in The Netherlands to assess the Drinking Water and Sanitation Decade of the 1980s and to develop an action program to implement the United Nations

Conference on Environment and Development Agenda 21. The resulting statements stressed the need for integrated water resources management and a recognition that safe water in sufficient quantities and proper sanitation need to be provided to all people. Other resolutions from the Ministerial Conference focused on the need for emphasizing waste reduction and pollution prevention, enabling local partnerships to deliver local services in accordance with expressed needs and a willingness to pay, and giving priority to populations at greatest risk. Many of the themes of these international forums are reflected and reinforced in the approaches presented in the next section of this paper.¹

Historically, high subsidies in many countries have allowed large numbers of people to have access to drinking water and wastewater services at artificially low cost. While subsidies for these services are often promoted as antipoverty measures, the beneficiaries tend to be the wealthier residents of the city. Residents in low-income areas generally do not have in-home or on-property access to drinking water and must make do with high-cost and/or labor-intensive substitutes, such as carrying water long distances or paying high prices to water vendors. It is well documented that the urban poor not only pay a high proportion of their income for water (often 20 percent or more), but often pay more per month. In some cases, drinking water from vendors costs 25 to 50 times more per unit of water than the cost to households connected to the subsidized municipal system (World Bank, 1993). As a result, there is often insufficient clean water for the basic necessities of personal hygiene, household cleaning, and food preparation.

With the false security of subsidies, government agencies that manage water and wastewater services have had little incentive to build institutional capacity or a sense of responsibility to the consumer. Water use is rarely metered, and billing systems are dysfunctional. Given the general scarcity of all public revenues and the escalating problems of large cities, water subsidies are shrinking in many places. Without the necessary operating funds, water and wastewater service providers lack the capacity to perform needed repairs or expand systems to serve new users. Service deteriorates, customers lose confidence, and revenues decline. In such circumstances, service providers have difficulty obtaining new loans or investments.

The short- and long-term consequences of inadequate water and wastewater services are costly to society as a whole. Infectious and parasitic diseases linked to poor sanitation are the third leading cause of poor worker productivity in the developing world (World Bank, 1993). Without a piped water supply, one or more members of each household may spend otherwise productive hours each day carrying water from a standpipe, tubewell, spring, or stream.

¹ It should be noted that there has been no attempt to be comprehensive in the topics presented in this paper. See United Nations Development Programme (1994) for a summary of the major international meetings on water resources, water supply, and sanitation.

By their very nature, megacities have larger impacts on water resources than do smaller urban or rural settlements. Large quantities of surface water may be diverted, denying water supplies to downstream users. As a result of inadequate wastewater management, surface waters can become severely polluted, compromising the quality and availability of future supplies and creating future health risks. While ambient water quality improved in industrialized countries during the 1980s, it did not improve in middle-income countries, and it declined sharply in lower-income countries (World Bank, 1992). Large-scale development can impair important ground water recharge areas. Ground water is often extracted in excess of the aquifer's natural recharge rate, and the results may include falling water tables, land subsidence, increased pumping costs, degraded water quality, and eventual exhaustion. All of these activities can change the character of the area's water resources, potentially reducing their ability to provide for the future.

Over the next two decades, population growth and migration will add an estimated 1.3 billion new urban residents who will require sanitation services (Bartone, 1994). Of these, 25 percent will live in megacities with populations of over 10 million. The growing periurban areas present a serious public health and environmental problem that will not be solved by traditional approaches to water and wastewater planning. Given these circumstances, how can the delivery of water and wastewater services be improved and expanded?

The challenge is great. Water and wastewater service providers, health institutions, municipal and national governments, community organizations, and external aid agencies need to work together to improve incrementally the health, productivity, and quality of life of megacity residents. We turn now to some approaches by which this can be accomplished.

APPROACHES TO IMPROVED SERVICES

Improved Sanitation

Progress in improving public health requires parallel and integrated improvements to drinking water supplies, wastewater management, and other aspects of sanitation.

Sanitation is defined as the management of environmental conditions and the provision of services to prevent and control the spread of disease and enhance the welfare and well-being of human populations. Sanitation encompasses a wide range of activities, including the safe disposal of human and animal excreta and other domestic wastes; personal cleanliness; proper food handling; animal vector control; air quality control; proper management of wastes from urban commercial, industrial, and agricultural activities; and provision of a safe, sufficient, and convenient supply of water for household and other community needs.

Among water professionals, however, the term "sanitation" has become synonymous with wastewater collection and disposal in urban settings or with latrines in rural settings. Consequently, urban water and sanitation planning has focused on large, central water and wastewater management systems. This narrow view of sanitation diverts attention from important preventive strategies that are more appropriate for the rapidly growing cities of the developing world. To be effective in improving human health, programs for water supply, human waste disposal, and municipal wastewater management should be well integrated with other environmental, health, and nutrition programs. Continued high rates of disease and death, as well as chronically depressed worker productivity, argue strongly for a higher profile, a broader definition, and better funding for sanitation than in the past (UNICEF, 1995).

As opposed to the setting of standards by particular programs, activities, or media, an integrated approach should focus on end results by considering and giving equal attention to all strategies and means for achieving those results in a cost-effective manner. Successful integration implies the avoidance of institutional barriers to the implementation of nontraditional approaches. For example, major gains have been achieved in reducing the incidence of dracunculiasis or Guinea worm disease--a debilitating water-borne disease--through integrated programs that link water supply, health education, and surveillance (World Bank, 1993). Integration also means avoiding institutional overlap, redundancy, and rigid boundaries. To illustrate, Lauria et al. (1993) describe a situation in the Philippines in which the responsible institution did not have the flexibility to respond to the principal concern of the affected communities--their solid waste problem--because the externally funded program was set up to deal exclusively with wastewater management.

In western industrialized countries, many infectious diseases were brought under control by improved sanitation long before curative treatments became available. In the United States, broad sanitary improvements during the early 1900s were associated with declines in typhoid, gastrointestinal infections, and other diseases (McKinlay and McKinlay, 1977). In France, the provision of piped water in many major cities did not significantly improve public health until it was accompanied by the covering of open sewage drains and adequate disposal of wastewater (Preston and van de Walle, 1978). Similar circumstances have been cited for Great Britain (McKeown and Record, 1962).

The epidemiological evidence from developing countries indicates that improving hygiene and disposal of excreta and ensuring a sufficient quantity of water close to the home environment (e.g., an in-house tap or one on the premises) has a larger impact on human health than do improvements to drinking water quality alone, and this evidence is more compelling in urban than in rural locations (Esrey, 1996; Esrey et al., 1991; Bateman and Smith, 1991). Incremental improvements in disposal of excreta are clearly associated with fewer parasitic infections, better growth of children, and lower mortality rates (see also Butz et al., 1984; Esrey and Habicht, 1988; Esrey et al., 1992; Koopman et al., 1981; Yee, 1984; Young and Briscoe, 1987). Several studies also indicate that better hygiene practices, including disposal of infant feces, significantly improve health (Aulia, 1994; Huttly, 1994;

Zeitlin, 1995; Dikassa, 1993). VanDerSlice and Briscoe (1995) caution against putting too much faith in the apparent benefits of a specific intervention because of interactions among many factors. It is clear that the provision of a potable water supply and wastewater removal are necessary but not sufficient conditions for improving public health; all aspects of sanitation will need attention.

The rapid evolution of drug-resistant strains of infectious diseases emphasizes the need for better preventive measures to control disease. *Shigella* infection, for example, is an important cause of diarrheal morbidity and mortality in less-developed areas of the world. Shigellosis occurs in conditions of crowding, poverty, inadequate water supplies, and poor personal hygiene. The use of tetracycline to treat shigellosis has been abandoned because of widespread microbial resistance, and strains of *Shigella* are now increasingly resistant to amoxicillin and to more expensive drug therapies. Resistant strains have emerged in the United States among travelers, on American Indian reservations, and in other endemic settings (Tuttle and Tauxe, 1995). In these situations, the decision to prescribe antimicrobials must be weighed against the public health risks of promoting drug resistance. The U.S. Centers for Disease Control has recommended improving sanitation as the most effective way to prevent exposure to the pathogens and incidence of shigellosis (Tuttle and Tauxe, 1995).

In developing countries, improvements in sanitation will require better training and involvement of sanitation professionals. Yet the number of people trained as sanitarians has been decreasing. This trend has been caused by a number of factors, including decreased emphasis on sanitation in public health programs, fewer specialized academic and continuing education programs, relatively low salaries for sanitarians, and a lack of knowledge and understanding by the public about sanitation services relative to other public services. The growing sanitation challenges of megacities require expanding the scientific and technical base of sanitation, developing systems to disseminate that information, and fielding trained workers to apply the knowledge and make it available to communities. Hygiene education should be an integral part of future water and sanitation programs, and recent information on strategies for improving sanitation should be provided to the medical profession. Interdisciplinary and intersectoral approaches should be taken for research, planning, training, and evaluation of programs to improve health (see Boot and Cairncross, 1993).

The role of education in promoting better personal and community hygiene is illustrated by a community educational program in Egypt (El-Katha and Watts, 1994). Many communities had been provided with upgrades in potable water service, but diarrhea rates remained high. The new program provided for education in health clinics to advise parents with sick children, and special summer camps were set up to educate older children (and, indirectly, their parents).

Participatory Planning

Sustainable water and wastewater improvements must address the informed preferences of the community. Participatory planning, combined with public education, can identify those services that people want and for which they are willing to pay.

Historically, water and sewer projects in developing countries have been characterized by a "top-down" planning approach that involves principally government officials and consultants of the external support agencies. Recipients of the services and other stakeholders are rarely consulted, and poorer communities, especially informal settlements, are typically ignored. More recently, however, community participation has taken a more prominent role in lender policy (World Bank, 1996).

The principle of participatory water management was enunciated at the 1992 Dublin International Conference on Water and the Environment. According to this principle, "water development and management should be based on a participatory approach, involving user, planners, and policy makers at all levels...with decisions taken at the lowest appropriate level" (United Nations Development Programme, 1994). Institutionally, this means planning must be done at a level that allows local and regional agencies to make effective and coordinated water management decisions. For a system to be sustainable, all stakeholders must believe that their needs are being met satisfactorily. (As used here, the term "sustainable" simply means that the services are capable of being continued over time without deterioration.) The community should be consulted and drawn into the planning process in an effort to identify local needs and preferences and determine whether there exists sufficient willingness to pay for improved services.

Most urban households, regardless of income level, desire affordable water and sanitation services. It is well documented that even the poor in developing countries are willing and able to pay the full cost of a potable water supply (Crane, 1994; Okun, 1991; Whittington and Choe, 1992; World Bank, 1992). Nearly all studies of major cities in developing countries show that monthly water expenses are a much larger share of income and often larger in absolute terms for the poor as compared with the wealthy (Crane, 1994; Ingram et al., 1995; Roth, 1985; World Bank, 1992). When public water service is inadequate or nonexistent, people must obtain their water in other, much more expensive ways.

Where public drinking water service or wastewater collection and disposal systems have not been made available, some communities, often aided by nongovernmental organizations, have become involved in the planning and delivery of these services. In such cases, institutional and technology alternatives need to be developed and offered, including options that are not routinely used for centralized systems in industrialized countries.

Community-based service delivery places the users in a command position, enabling them to choose more directly the delivery technology, the level and quality of service, and, consequently, the cost of the service. This engenders a sense of ownership and respect for the system and a willingness to pay. Moreover, it relieves the central government agency of

the costly and often unsatisfactory provision of these services. Of course, the central government should create an environment that fosters such an approach, and this may require hiring people with the appropriate community-development skills.

Formal institutions (utilities and municipalities) have combined with informal institutions (community groups and nongovernmental organizations) in producing low-cost, innovative wastewater collection services in Brazil. A community initiative, which started in northeast Brazil, was financed by the World Bank, and the strategy is now widely used in other regions of the country.

Communicating and providing information to the consumer is usually necessary to raise public awareness regarding the importance of sanitation to public health and the value of water. Informed consumers are more likely to become willing participants in programs designed to improve their lives.

The Condominial Sewerage System in Brazil

The "condominial" sewerage system is the brain-child of Jose Carlos de Melo, a socially committed engineer from Recife. Its name has two sources. First, a block of houses is treated like a horizontal apartment building or *condominial* in Portuguese. Second, "Condominial" was a popular Brazilian soap opera, associated with the best in urban life. The system has an innovative layout, with a shorter grid of smaller and shallower "feeder" sewers running through the back yards and with the effects of shallower connections to the mains rippling through the system. These innovations cut construction costs to between 20 and 30 percent of those of a conventional system.

The more fundamental and radical innovation, however, is the active involvement of the population in choosing their levels of services and in operating and maintaining the feeder infrastructure. The key elements are that families can choose (1) to continue with their current sanitation system; (2) to connect to a conventional water-borne system; or (3) to connect to the condominial system, whereby individual households are responsible for maintaining the feeder sewers, and the formal agency tends to the trunk mains only.

The condominial system is now providing service to hundreds of thousands of urban people in northeast Brazil and is being replicated on a large scale throughout the country. The danger, however, is that the clever engineering is seen as "the system." Where the community and organizational aspects have been missing, the technology has worked poorly (as in Joinville, Santa Catarina) or not at all (as in the Baixada Fluminense in Rio de Janeiro).

Source: Adapted from World Bank (1992).

Financing

Subsidies should not be squandered on services the public is willing to finance. Where external funds are available, they should be reserved for services with collective benefits, such as wastewater treatment. It follows that providers of drinking water should strive to become financially sound and relatively autonomous entities that can collect revenues from customers sufficient to maintain and expand system services as needed.

Given the general scarcity of public revenues, the levels of external funding historically provided for drinking water service are no longer available. Water authorities realize that they must look to their customers for the funds to construct, operate, and maintain improved facilities.

The practice of cost recovery requires the technical and administrative ability to operate an effective pricing system (Gunnerson, 1991; Bahl and Linn, 1992; Ostrom et al., 1993). A pricing system requires metering of the water supply to each customer. However, unless the public has confidence in the system, they will not connect, will not pay, and may break the meters. Thus, the initial installation of meters must be supported by an adequate system of maintenance and repair (including recalibration of meters at appropriate intervals). The meters must also be read at regular intervals. Water accounts should be prepared and bills delivered with the least possible delay after meter reading. Finally, payment of accounts within a reasonable time must be enforced, with genuine penalties for late payment. Improvements to administrative and technical capacity must go hand in hand with policy innovations, such as tariff reform, if the desired results are to be achieved. Though not likely to happen initially, the goal of water pricing is to cover the replacement cost of supply, including capital costs, operation and maintenance, and administration (Rogers, 1993).

The financing strategy for water and wastewater systems should reflect the population's willingness to pay for water supply services and the need to address social goals, including fairness and equity. Operationally, this may mean subsidizing the very poor to ensure that a minimum quantity of water is available for basic sanitation needs. In Monterrey, Mexico (a heavily industrialized metropolitan area of 3 million), there is 100 percent metering. Low-income households pay a modest fixed monthly tariff for consumption of less than 20 cubic meters per month. For consumption in excess of this minimum, every cubic meter is charged a unit price. Thus large users pay more on average and effectively subsidize the low-consuming households.

Care should be taken that such subsidies do not affect the overall financial viability of the system. The full recovery cost of the system needs to be established before the tariffs are set to effect this cross-subsidy. Whittington (1992) describes a situation in Kumasi, Ghana, where the poor were using more water per connection and being charged higher rates than the rich because of multiple family use of a single, metered connection. In situations such as this, every effort should be made to ensure that each family is billed appropriately for water use, even if meters are not available for each unit. Without such financial incentives, there will be inequity and free-rider problems, even among the subsidized poor.

Innovative Sewerage in a Karachi Informal Settlement: The Orangi Pilot Project

In the early 1980s, Akhter Hameed Khan, a world-renowned community organizer, began working in the slums of Karachi. He asked what problem he could help resolve and was told that "the streets were filled with excreta and wastewater, making movement difficult and creating enormous health hazards." "What did the people want, and how did they intend to get it?" he asked. What they wanted was clear: "People aspired to a traditional sewerage system...it would be difficult to get them to finance anything else." And how they would get it, too, was clear: they would have Dr. Khan persuade the Karachi Development Authority (KDA) to provide it free, as it did (or so the poor perceived) to the richer areas of the city.

Dr. Khan spent months accompanying representatives of the community to petition the KDA to provide the service. When it was clear that this would never happen, Dr. Khan was ready to work with the community to find alternatives. (He would later describe this first step as the most important thing he did in Orangi, liberating the people, as he put it, from the immobilizing myths of government promises.)

With a small amount of core external funding, the Orangi Pilot Project (OPP) was started. It was clear what services the people wanted; the task was to reduce the costs to affordable levels and to develop organizations that could provide and operate the systems. On the technical side, the achievements of the OPP architects and engineers were remarkable and innovative. Thanks partly to the elimination of corruption and the provision of labor by community members, the costs (for an in-house sanitary latrine and house sewer on the plot and underground sewers in the lanes and streets) were less than \$50 per household.

The related organizational achievements are most impressive. OPP staff members have played a catalytic role: they explain the benefits of sanitation and the technical possibilities to residents, conduct research, and provide technical assistance. The OPP staff never handle the community's money. (The total costs of the OPP's operation amounted, even in the project's early years, to less than 15 percent of the amount invested by the community.) The households' responsibilities include financing their share of the costs, participating in construction, and electing a "lane manager," who typically represents about 15 households. Lane committees, in turn, elect members of neighborhood committees (typically representing about 600 houses), which manage the secondary sewers.

The early successes achieved by the project created a "snowball" effect, in part because of the increased value of properties with sewerage systems. As the power of the OPP-related organizations increased, they were able to put pressure on the municipality to provide funds for construction of trunk sewers.

The OPP has led to the provision of sewerage services to more than 600,000 poor people in Karachi. It has also led to recent initiatives by several municipalities in Pakistan to follow the OPP method and, according to OPP leader Arif Hasan, "have government behave like a nongovernmental organization." Even in Karachi, the mayor now formally accepts the principle of "internal" development by residents and "external" development (including trunk sewers and treatment) by the municipality.

Source: World Bank (1992).

In Jakarta, poor residents are unable to afford the one-time cost of a water hook-up, even though they may pay more over the long term to purchase water from private vendors. In

such cases, subsidies or the availability of small loans for a hook-up would enable new customers to gain access to the system. In Santiago, Chile, the central government, through the municipalities, pays a lump sum subsidy for qualifying urban poor. This ensures that low-income households have access to drinking water and wastewater services without compromising the financial viability of the water agency.

The appropriate financing arrangements for wastewater collection, treatment, and disposal are complex because the benefits perceived at the individual household level are different from those to larger aggregates of society. Individuals are more willing to pay for services that provide direct benefits to their family and property and less willing to pay for services that provide environmental benefits they do not perceive. A household will place high value on a private, convenient, and sanitary facility for removing excreta and wastewater from the property. Moving up a level, to that of the neighborhood, residents may value services for removing excreta and wastewater from the neighborhood or rendering these wastes innocuous through treatment. Neighborhoods and cities, however, do not exist in isolation, and wastes discharged at one point may affect the health of people downstream. National economic, health, and environmental concerns over water quality and water allocation may also come into play (Bartone, 1994; see also National Research Council, 1993a). The provision of wastewater collection, treatment, and disposal services may thus need to be subsidized from water revenue or other sources. Central governments should seek ways to facilitate the autonomous operation of local water utilities. Such policies include (1) enacting legislation that will enable utilities to function independently and assume local responsibility, (2) eliminating political interference in the operation of local utilities, (3) providing and enforcing regulations for oversight and protection of consumers, and (4) working for the development of in-country financing of water and sanitation independent of external support agencies.

The policies and consequent good performance discussed above may be and sometimes are achieved by government. However, where existing public sector performance is poor, attempts at reform often fail because of entrenched special interests and inappropriate incentives. Over the last decade there has been a considerable increase in experimentation with various forms of private sector participation. This alternative can be useful if it introduces competition or other constructive economic incentives, which in turn stimulate better performance (Idelovitch and Ringskog, 1995). Private sector participation may range in form and degree from simple service and management contracts for a defined activity (e.g., maintenance or bill collection) to complete divestiture, where private firms competitively purchase assets from the government and assume complete control. Most falls somewhere between these extremes (see Walker, 1994, for a detailed overview of the options). The City of Abidjan in the Ivory Coast has had its water services operated by a private company under a lease contract (initially foreign-owned, the company is now majority-owned by Ivorians) (World Bank, 1994). This arrangement has been highly successful in getting quality services at reasonable cost to all people, and in attracting investment (the company, SODECI, trades shares on the stock market in Abidjan).

Successful private sector participation and community-based options can deliver many benefits: meeting consumer demands at lower cost, removing the need for government subsidies, assisting in capital formation, and promoting economic efficiency and

Meeting the Demand for Sanitation Services: The *Favelas* of São Paulo

In the 1980s, the Brazilian city of São Paulo made extraordinary progress in providing all its residents with water supply and sanitation services. In 1980, just 32 percent of the *favelas* (low-income informal settlements) had piped water supply, and less than 1 percent had a sewerage system. By 1990, the respective figures were 99 and 15 percent.

SABESP, the state water utility serving São Paulo, is a technically sophisticated water supply organization. Until the emergence of democracy in Brazil, SABESP had defined its role narrowly and technocratically. Specifically, it did not consider provision of services to the *favelas* to be its responsibility because this could not be done according to its prescribed technical standards and because the *favelas* were not "legal." Meanwhile, a small agency (COBES) was experimenting with new technical and institutional ways of providing water and sanitation services to the poor. On the technical side, this did not involve the provision of inferior service, but reduction of the cost of providing in-house services by using new materials and approaches that enabled service in narrow roads where access was limited. On the institutional side, the community had to assume significant responsibility for community relations and for supervision of the work of contractors.

As the military regime withdrew and was replaced by a democracy in the early 1980s, the pressures on SABESP to serve the *favelas* increased. Community pressure was channeled through the municipal agencies and responsive officials and politicians, including the mayor and governor. Since COBES had shown how it was, in fact, possible to serve the *favelas*, SABESP had no option but to respond.

The lesson from São Paulo is that where institutions are responsive and innovative, progress can be made in the provision of water and wastewater services at full cost to the poor.

Source: World Bank (1992).

development. However, its success requires sound policy, relevant laws, and regulations that are adequately enforced, which means that government and local institutions must be strengthened. As a first step, existing public water and wastewater institutions need to recognize poor communities as part of their customer base.

The Role of Technology

Megacities need more technology choices to provide services in flexible, adaptable, and affordable ways. In particular, service to the informal settlements of metropolitan areas will require innovative and incremental approaches.

Although the obstacles to meeting the water, sanitation, and wastewater needs of megacities are many, there are at least two reasons to expect that technological change can play a role in overcoming them. First, the dearth of existing water and wastewater infrastructure means that megacities in developing countries need not be locked into technical approaches that are poorly suited to them. Second, the scientific understanding underlying water and wastewater treatment technologies has greatly advanced since the processes were developed in the first half of the twentieth century. Therefore, a rethinking of technology in

the context of megacity needs may lead to novel technological approaches that are less expensive to build and operate and more compatible with the needs and capabilities of the user communities.

Innovation may be essential to addressing the needs of areas that have been difficult or impossible to serve under existing arrangements. Innovation is defined here as the first adoption by a culture or society of a method for providing goods and services that the society uses. Thus, innovation involves not only what is new, but also what is *locally* new. Innovation involves aspects of technology, organization, community, and financing.

Many of the informal or squatter settlements lack authorization, land ownership, public rights of way, public services, and reasonable access. Incomes are low, living conditions are harsh, and illness and disease are widespread. Conventional water and wastewater technologies are at least inefficient under these conditions, and may be completely unfeasible. New approaches are clearly needed.

Advances in hydraulic theory and technology, as well as experience, have provided the basis for modifications in the standards governing certain design parameters for conventional sewerage. The result has been a variety of sewerage systems that provide service levels similar to those of conventional sewerage at a fraction of the cost (Wright and Bakalian, 1990a). Some examples include flat gradient sewerage using smaller-diameter pipes; condominial sewerage; and other modifications to minimum depth, minimum slopes, minimum diameters of pipes, and the spacing and location of manholes. Solids-free sewerage (also known as small-bore sewerage) uses an interceptor tank to retain solids (Wright and Bakalian, 1990b). The tank is located between the house sewers and the rest of the system and allows flatter slopes and smaller diameters for sewer pipes. The key question for these and other alternatives is whether the lower capital costs would be offset by higher costs from operation and maintenance of the system. The suitability of alternative sewer systems needs to be demonstrated on a case-by-case basis for high-density urban areas.

Consideration should be given to the development of strategies that foster continuous incremental improvements in the provision of water supply and wastewater services, especially for the poorly served communities within the metropolitan region. Planning should consider the local ability to finance, operate, and maintain the system; the potential for building institutional capacity; the need to upgrade systems to accommodate future population growth; and the community's long-term vision of a high-performance system. As discussed earlier, planning for drinking water and wastewater services should be well integrated with other health and nutritional programs.

The effective application of technology depends on the existence of carefully considered performance criteria that are appropriate to the megacities of the developing world. The continued use of effluent discharge standards borrowed from industrialized countries may hinder, rather than promote, meaningful innovation. Many of these standards simply reflect the capability of conventional technology rather than the needs of a particular environment or population. Adoption of such standards effectively precludes consideration of novel applications of technology, since the latter approaches will not necessarily produce the same results as conventional processes. An alternative is to apply performance criteria,

which describe the desired effects on human health (reduced exposure to pathogens), the environment (ecosystems to be protected), and human activity (human uses of the environment).

Most industrialized countries rely on technology-based standards rather than performance criteria. A critique of U.S. policy has indicated that this approach effectively discourages technological innovation, does not allow for regional differences, and has prevented the development of cost-effective water quality management programs (National Research Council, 1993a). On the other hand, the development and implementation of technology-based standards require less institutional competence than most alternatives. It is important that developing countries consider the pros and cons of any regulatory approach, rather than simply following the lead of industrialized countries.

It must also be remembered that many megacities are especially vulnerable to natural hazards, such as floods, earthquakes, and high winds. The larger and more unplanned the city, the more difficult it is to organize rescue and respond to disaster. In the event of a natural disaster, the water and wastewater infrastructures are susceptible to blockage and rupture. The result can be contamination of water supplies and the spread of infectious disease. Thus planning for natural hazards should be part of any program to improve water and wastewater services (Institute of Civil Engineers, 1995).

Given the right incentives, the private sector can often respond by creating new technologies that meet the needs and opportunities of megacities. In Japan, the private sector is creating and installing a new generation of technologies for water and wastewater treatment in smaller rural communities. The availability of capital in Japan has permitted joint government-industry efforts to research and develop new technologies, such as hybrid treatment reactors (combined activated sludge and biofilm), anaerobic treatment processes, and microaerobic processes (Rittmann, 1996). Based on anticipated growth, the influx of capital, and the potential to enter the large Asian market, a French consortium is developing sophisticated drinking water technology for Macau, near Hong Kong.

Unfortunately, the poorest megacities may not receive this kind of attention from the private sector because their consumer markets are less certain. The World Bank is experimenting with private sector involvement under difficult economic circumstances, and has reported progress in such places as the Republic of Guinea and the City of Abidjan, as mentioned in the preceding section (World Bank, 1994). Chile has passed legislation to decentralize the water sector and has changed incentives to encourage privatization (Lauria, 1993). The private sector is stimulated to develop and apply new technologies when there is a demand of adequate size and constancy. Additionally, regulatory or administrative barriers to new technologies must be minimized, and the need of the private sector to generate a return on investment must be accepted.

There are many other examples of technology innovation that may be useful for megacities in specific situations. These include low-cost water hook-ups, automated and remote meter reading, and low-cost materials and technology for neighborhood water and sewer systems. The use of water to carry away human wastes could, in some situations, be

replaced by nonwater options, such as the use of dry toilets and composting of wastes for agricultural or garden applications.²

The sustainability of innovative water, wastewater, and other sanitation projects will depend on the availability of indigenous human resources, as well as financial capital. The cadre of technical experts in the developing world needs to be expanded. Such experts are especially important for merging specialized knowledge with local conditions, experience, and financial realities. They must be skilled as facilitators and able to handle the ambiguity of human decision making, as well as the discipline of technical information. Local experts are also needed to evaluate the suitability of technology that may be offered and promoted by private concerns through sophisticated marketing strategies.

Water Conservation and Reuse

Effective water resource management requires a holistic approach that considers an entire watershed or catchment area relative to water quantity, quality, and use.

Water is a renewable resource that should be managed so that future generations can obtain the same benefits as those enjoyed by current users. Such a resource should have a future value that is, on average, not less than its value today.

Water resources are complex systems serving many users in different ways. This is particularly true for surface water resources. Surface waters provide fish and wildlife habitats, supply water to humans and human activities, and support the movement of goods and people. Achieving sustainability requires that each use of a resource be evaluated in the context of all other uses and stresses, and that no use be permitted which adversely affects the capability to support future uses. It also requires institutions that can implement effective laws and regulations.

Current surface water withdrawals may or may not have an impact on future use, but ground water withdrawals frequently do. A lack of control over industrial waste discharge and a lack of wastewater treatment invariably threaten the sustainability of surface and ground water resources. Too often, the surface waters are grossly polluted and unsuitable for any use except as a sink for more waste. Ambient water quality standards that are reasonable and appropriate to local environmental, social, economic, and cultural conditions need to be established and enforced (see National Research Council, 1993a).

Ground water is a far more important resource than is often realized. Excluding the water locked in glaciers and icecaps, about 97 percent of the world's fresh water is ground water, while streams, rivers, and lakes hold only about 3 percent (Bouwer, 1978). The potential for human pathogens and toxic contaminants to leach into ground water depends on

² Note that this paper is not meant to provide an assessment of technology options, but merely to highlight their potential importance.

many factors, such as the composition of soils and geologic materials, the depth of the water table, the recharge rate, and environmental factors that can influence the mobility or degradation of contaminants (National Research Council, 1993b). Once ground water has become contaminated, the prospects for remediation are uncertain and expensive. Moreover, remediation may require long time periods (in some cases centuries) because of the complex properties of the subsurface environment and the complex behavior of contaminants (National Research Council, 1994a). In-situ bioremediation is a technology that is gaining momentum, but careful evaluation is necessary to determine whether it works (National Research Council, 1993c). Moreover, the costs of remediation are high. The potential cost of ground water remedial activities in the United States may be as large as \$750 billion in 1993 dollars over the next 20 to 30 years (National Research Council, 1993b). Thus comprehensive ground water research, monitoring, and protection programs will be cost-effective investments in sustainability (e.g., see National Research Council, 1993b; National Research Council, 1995).

To identify multiple-use and temporal conflicts in water resource allocation, it is necessary to take an integrated approach to the planning and management of the resource, and where appropriate, within a defined watershed or catchment area (see National Research Council, 1993a). Planning must consider all activities, present and future, within that region. Integrated management can be understood to address two outcomes: (1) the systematic allocation of resource services among competing users in the same time period, and (2) the consequences of that allocation for future availability and allocation of resource service flows. The criteria governing the first outcome typically include such things as economic efficiency, equity, fairness, and existing property rights. The second outcome addresses the issue of sustainability and fairness to future generations.

Conservation of water resources should be a priority for all megacities, not only those that are located in arid or semiarid climates. In many megacities, a significant amount of water (reportedly 40 percent or more in some cases) leaks from the system or is otherwise unaccounted for because of poor metering, theft, or accounting errors. Together with proper maintenance and metering, water conservation requires changing people's behavior through voluntary or involuntary demand management measures. Involuntary policy tools include water rationing, retrofitting of low-flow plumbing equipment, new construction codes, and water reuse regulations. Voluntary policy tools, in contrast, focus on the way people are charged for water and the use of public education campaigns. Voluntary tools have been less commonly utilized, but have the potential to be more cost-effective. The institution of appropriate water rates requires that users first be metered, which also reduces lost and unaccounted-for water. Tariff design must take into account the principles of cost recovery, demand (i.e., what people are willing to pay), fairness, and equity.

As cities grow, water for urban uses becomes increasingly valuable as compared with other uses, such as agriculture. Water transfers, frequently a major component of water resource management, can involve the diversion of water to a new location or a change in the type of water use. When water is viewed as a commodity, its allocation can be driven by market forces, and these forces can act to enhance the efficiency of its use. However, water markets cannot be expected to resemble more conventional markets for a variety of historical, cultural, and ethical reasons. As with any policy option, there are benefits and

costs. The recognition and protection of third-party interests are essential if water transfers are to meet their potential to satisfy new demands (National Research Council, 1992).

Another means of conserving a community's potable water supply is the practice of water reuse, which involves reclaiming industrial or municipal wastewater for the many nonpotable urban uses in a city. In this sense, reclamation and reuse of municipal wastewater represents a significant source of water, one that will become increasingly cost-effective.

Nonpotable reuse applications for reclaimed municipal wastewater may include agricultural irrigation, ground water recharge (replenishment, salt water intrusion barrier, subsidence control), recreational uses (impoundments, lakes, fisheries, snowmaking), and general urban uses (fire protection, toilet flushing). Planning for new urban developments should consider the potential for incorporating water reuse in their design. The major public health concern associated with most uses of reclaimed water centers around infectious agents and the possible spread of disease among the human population. However, the health risk will be minimal if the wastewater is properly treated prior to use. The characteristics of the source water and the intended use of the reclaimed wastewater dictate the type and degree of treatment that must be provided in reclaiming municipal wastewater for nonpotable reuse (see National Research Council, 1982, 1994b; U.S. Environmental Protection Agency, 1992).

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**Transportation Options
for Megacities
in the Developing World**

A Working Paper

Transportation Research Board

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EXECUTIVE SUMMARY

With very few exceptions, rapid growth in demand for motorized transport has overwhelmed the transport capacity of cities in the developing world. Traffic congestion reduces the productivity of urban agglomerations everywhere, but the consequences in developing-country megacities are greater. Not only is the level of congestion higher in developing-country megacities, but many of these same megacities create a major part of their national gross domestic products. Therefore, reducing urban congestion is a central element of economic growth in these settings. Moreover, reducing congestion will also reduce automobile emissions and thus urban air pollution, which is currently a major health problem in most megacities. This paper examines a wide range of options for addressing the challenges of transportation in the developing world.

Traffic and Demand Management. Principal tools for confronting rapid motorization in developing-country cities are traffic and transport management. Nothing else can be implemented at a sufficiently high level or as rapidly. Relatively simple measures, such as the introduction of one-way systems and reversible-flow traffic lanes, improvements in street conditions, and improved training of engineers and traffic police, can do much to improve traffic flows quickly and inexpensively. Additionally, financial measures for demand management, which include increased fees for parking in congested areas, congestion pricing, and higher taxes on fuels, can greatly influence demand for private motorized transportation.

Environmental Measures. Air quality requires serious attention in all megacities. Eliminating leaded gasoline and requiring catalytic converters are the most cost-effective approaches to reducing automobile emissions. Additional controls on widely used two-stroke engines, such as timed fuel injection and catalytic exhaust aftertreatment, can significantly reduce emissions from these vehicles. Other measures discussed in the paper, such as land-use planning and encouragement of transit, can also help reduce emissions from transport.

Technology offers additional opportunities for reducing emissions. For instance, several cities in India are actively pursuing the conversion of rickshaws and other small vehicles to electric power. Since such vehicles can be recharged at night (when electricity is cheaper and reliable) and have low power needs (thereby requiring small batteries), they

could be an attractive option for some cities and regions. Natural gas vehicles may also be attractive in some cities for economic, trade, and energy supply reasons. Developing nations should keep a close watch on opportunities for both telecommunications and technology breakthroughs in coming years. Electric micro cars and, perhaps in the longer run, fuel cell vehicles powered by hydrogen could provide both mobility and air quality gains.

Private-Sector Participation. It will also be necessary to begin planning for new and upgraded transit facilities and for new high-capacity road facilities for cities built in the prehighway era. An important proactive and early step in this process is the preservation of government-owned or -controlled corridors and right-of-ways. These facilities should be commercialized to the maximum extent possible and with the participation of the private sector. Private financing and management can better ensure that services are priced at their full cost, thereby minimizing capital and operating costs and giving proper market signals for capacity expansion. International experience is quite well documented in the areas of private bus services, private toll roads, and development charges. In addition, there are a number of examples of successful transit privatization efforts in Chile, Sri Lanka, and across the globe. Key to the successful inclusion of the private sector have been public practices to ensure fair and adequate competition in bidding for new facilities and for the management or operation of existing facilities.

Linkage of Land-Use Planning and Transportation Investment. Land-use planning is an imperative in the face of rapid urban development (3 to 5 percent or more annually) accompanied by rapid motorization (over 10 percent annually). Motorization, particularly automotive transport, unleashes pressures for cities to decentralize; the sprawling, low-density development patterns characteristic of many western cities would not be possible without the automobile. Full-cost pricing of transportation can help constrain these pressures, as can public guidance of land development to ensure the transit serviceability of auto-generated suburbs. However in cities with high population densities and rising incomes, the pressures to decentralize will not be fully limited even by full-cost pricing. An example of guidance through land-use planning is provision for a regional polynucleated development pattern, with relatively high-density outlying nodes connected to the center by high-capacity road and bus service. Such a strategy can reduce land consumption while accommodating reduced population densities at levels high enough to support transit. Few cities are likely to be able to replicate the successes of Curitiba, Brazil, in this regard, but Curitiba does offer a model for future megacities. At a smaller scale, high-density development can be encouraged along transit stops and at major road intersections.

Multimodal Transportation Systems. It is also extremely important to design traffic systems that can cope with the large variety of transport modes, all with different performance characteristics, negotiating the streets of most developing-country megacities. The range of transport modes in developing-country cities is far wider and richer than that of cities in the industrialized regions. The number and variety of transport modes observed in Jakarta or Shanghai, for example, present both different problems and opportunities than the cars, buses, and subways of New York or London. One cause of the extreme diversity in

modal choice in developing countries is income; because much of the population of the developing world is unable to afford private or motorized transport, walking and other means of nonmotorized transport need to be an integral part of transportation policies and investment strategies. Traffic systems also need to be accommodating of informal transit modes, such as jeepneys, becaks, and minibuses, because in many cities, the informal sector provides a significant share of the transportation services. Planning for efficient multimodal transport is difficult for both institutional and systemic reasons. However, some cities have made important contributions to their multimodal integration through single-fare arrangements and compatible scheduling between pairs of modes. In addition, the inhabitants of developing-country cities are generally more reliant on less-polluting modes, and building on this history represents a distinct advantage in terms of the environmental costs of future development.

The current trends of urbanization and motorization in developing countries are in many ways reproducing the patterns followed in developed countries. With the inevitable growth in population and the accessibility provided by motorized transport, residents are increasingly locating on cheaper land at the urban periphery. Changing residential patterns usually induce a substantial decentralization of employment, and in almost every case, these patterns are associated with an increase in the number and length of vehicular trips. The pattern followed in the industrialized cities has had environmental costs that can be avoided while the city still enjoys the substantial economic and mobility benefits provided by motorized transportation. Effective traffic management, full-cost pricing, environmental controls on fuels and vehicles, alternative technologies and fuels, privatization, land-use planning, and improved integration of multimodal transportation are all capable of ameliorating the grave mobility problems of megacities. Their effects are cumulative, and in important cases, they multiply each other's significance.

INTRODUCTION

The effective functioning of megacities depends in the most basic way on an efficient transportation system. In many parts of the developing world, however, urban transport is characterized by a rapid growth in demand that has overwhelmed transport capacity. The resulting high level of congestion in many large developing-country cities, particularly in Southeast Asia, China, India, and many parts of Latin America, has negative implications for the level of economic development that can be achieved. In Bangkok, Thailand, for example, where infrastructure improvements lag well behind the growth in travel demand, estimates suggest that 3 million person hours are lost daily in the metropolitan region as a result of average traffic delays of 2 hours per trip during much of the day (Sussman and Bonsignore, 1993). In addition, the strains placed on the road networks of many large cities have led to significant declines in safety, as well as poor-to-terrible air quality in many places. Perhaps the most compelling aspect of these problems is that the urban poor bear the brunt of both congestion and deteriorating environmental quality because they often face the longest commuting times and spend much of their lives out of doors on congested, noisy, and polluted streets.

Developing countries look to the industrialized nations to provide them with models, technologies, and strategies for dealing with growth in both urbanization and motorization. Certainly the experience of cities of the developed world with motorized transportation infrastructure planning and investment exhibits much that is attractive. Large cities in developed countries are productive urban agglomerations whose residents are frequently able to work in the dense center of the urban area while living in more spacious suburbs. Although many also rely on some form of rail-based mass transit, their life-style is, in most instances, based primarily on a high-quality road infrastructure.

Yet western models of urban transport are of limited value for meeting the transportation needs of developing-country megacities. For one thing, the benefits of a transportation system designed around the private automobile have come at significant cost in large cities of the developed world. Moreover, given the great differences among the world's megacities, it is important to recognize both the benefits and costs associated with various strategies for mobility and to choose the investments that hold the most promise for a specific urban setting.

This paper begins, then, by highlighting the distinguishing features of urban transport in megacities of the developing world. The sections that follow examine various transportation policies in some detail and emphasize strategies that can help developing-country megacities improve mobility, reduce congestion, and avoid some of the more costly consequences associated with heavily auto-dependent societies. Some of the options available to developing-country megacities--such as using full-cost pricing to guide transportation use and investments--are less possible in many cities of the developed world, primarily because of existing infrastructure investments, established land-use patterns, and prevailing cultural norms. The options examined fall into seven areas:

- Improved traffic management
- Full-cost pricing
- Environmental measures
- Transport facility financing through private-sector participation
- Linkage of land-use planning and transportation investment
- Multimodal transportation systems
- Dissemination of knowledge and technology advances

We conclude with a brief summary and conclusions.

TRANSPORTATION PATTERNS IN DEVELOPING-COUNTRY MEGACITIES

There are a number of fundamental differences between the process of motorization taking place today in developing-country cities and that which took place in the cities of the developed world. Most important among these is the pace of motorization (Gakenheimer, 1994). In the developed countries, cities and their surrounding regions had several decades to respond to the challenges posed by the widespread use of private automobiles and increased reliance on trucking for transporting freight. In many cities in the developing world, an equivalent growth is occurring over only one or two decades. In Bangkok, for example, motor vehicle registrations have increased at the rate of 12 percent a year for the past 10 years, while even in China, one of the world's least motorized nations, the growth rate of motor vehicles has exceeded 18 percent per year since 1985.

Moreover, many large cities in the developing world have followed a dense pattern of development that complicates the process of providing roads and public transport services to urban residents. In Asian cities such as Shanghai and Calcutta, for example, the integration of work, residence, and commerce in the urban core is very high. Developing-country cities frequently have much less space allocated to roads than was true of western cities during their initial phase of motorization. In Chinese cities, for example, the amount of land devoted to road space is often less than 10 percent, while even in 1910, when New York City was at its most dense in terms of population per hectare, roads comprised fully 15 percent of the urban land area in Manhattan (Gakenheimer, 1995; Jackson, 1984).

The dense development and relative lack of land devoted to roads make it more difficult to build and operate efficient forms of transportation and increase the cost of acquiring land for expanding the road network. At the same time, developing countries often have fewer resources to devote to the provision of urban transportation infrastructure than did large cities of the industrialized world at the turn of the century. Many industrialized cities had well-established sources of funding for public infrastructure that could be expended over a reasonable time horizon to modernize infrastructure. In contrast, megacities of the developing world must apply limited public revenues to a score of pressing public needs that include not only transportation, but also water and sanitation services, telecommunications, and power supply. In most developing-country cities, demand for public transportation (both motorized and nonmotorized) has also grown much more rapidly than the population and has far outstripped the growth in revenues available for transportation infrastructure (Armstrong-Wright, 1993).

Furthermore, most residents of developing-country megacities are not in a position to afford motorized public transport, let alone purchase a private vehicle. Any public investment that provides additional capacity for private vehicle use must often come at the expense of investment in public transport or nonmotorized modes that could potentially benefit a far greater number of people.

Additionally, megacities in developing countries face more problematic obstacles to the implementation of transportation policies than is true of megacities in industrialized nations. In some cases, the obstacles are primarily institutional in nature and include overlapping and uncoordinated institutional structures, inadequate or poorly trained technical staff for planning and implementation functions, a lack of legal capacity to enforce regulations and laws, and limited institutional support for new, and often poorly understood, policies. In other instances, the major impediment to the implementation of transport strategies is the political framework in which decision making takes place (Daniere, 1995). These obstacles can be overcome only through a better understanding of the links between policy design and implementation in each particular city, as well as through changes in domestic legislation, the transfer of institutional skills, better training of personnel, and enhanced citizen participation. Although the majority of these strategies fall outside the rubric of traditional transportation policy and are not discussed here in any detail, it is important to recognize the effect of these obstacles on policy implementation. Transportation strategies that are transparent in nature, benefit the elite as well as the average citizen, and do not require large institutional changes are more likely to succeed in the developing-country context, and thus are emphasized in this paper.

In some cases, megacities in developing countries have important transportation advantages relative to cities of the developed world. Compared with their counterparts in industrialized nations, for example, developing-country urban residents are much less reliant on forms of transportation that pollute the environment and/or are heavily subsidized, and are more open to using different transportation modes. According to recent estimates, walking trips account for two-thirds of the total trips in large African cities such as Dar es Salaam. Walking and cycling trips account for between 40 and 60 percent of the total trips in large cities on the Indian subcontinent, while a 1990 study in Tianjin, China, found that 75 percent

of all work trips are made by bicycle (Khisty, 1993; Ren and Koike, 1993). Bicycles, cycle rickshaws, pedal cars, and bullock carts are among the many forms of nonmotorized transport used by inhabitants of the developing world. Inevitably, as demand for urban transport and incomes have risen in megacities, the dependence of urban residents on motorized modes of transport has increased as well. The growth in demand for motorized transportation is not limited to those able to purchase private automobiles (although these are certainly a main source of increased congestion), but also comprises the behavior of a far larger number of people who switch, for example, from bicycles to motorcycles or from walking to using buses or informal motorized transportation (e.g., jeeps or converted trucks).

Even within the motorized transport sector, there is a far wider range of options available in developing-country cities than in the developed countries (Gwilliam, 1995). Urban areas in Africa and Asia are served by a multitude of two- and three-wheeled vehicles, such as auto rickshaws, six-seated passenger vehicles, two- and four-stroke motorcycles, and motor scooters. In these regions, and in Latin America as well, urban roads contain a rich assortment of four-wheeled motor vehicles that includes converted pickups in addition to regular taxis, minibuses, and private cars. The streets of the developing countries are also full of heavy motorized vehicles, including buses, trucks, and tractors. In Latin America, for example, public buses are the dominant transport mode in most large cities. Importantly, moreover, much of the transportation service in the developing world is provided by the private sector and receives no public subsidy.

At the same time, urbanization patterns in developing countries are in many ways following the model established by developed economies. With the inevitable growth in urban populations, residents are increasingly locating on cheaper land in the urban periphery. Frequently, moreover, changing residential and intercity transportation patterns also induce a substantial decentralization of employment. In general, suburbanization is associated with an increased reliance on motor vehicles and an increase in the number of cars per household, both of which raise the overall level of motorization further.

Finally, despite many similarities among developing-country megacities, it should be emphasized that their motorization levels and modal shares for different types of transport differ widely. In Latin American countries, for example, few people use bicycles, while in Mexico, Argentina, Uruguay, and Brazil, as many as a third of all urban residents own private automobiles. This situation is dramatically different from that of China or India, where bicycles are very prevalent, and a much smaller percentage of the population uses public transit or has access to private cars. Analysis of these patterns must be a basic component of any transportation plan or investment for a particular megacity. The options discussed in the sections that follow may or may not be appropriate for a specific urban setting.

The differences between developing- and developed-country cities elaborated above suggest that planning and investing in an automobile-dependent transportation system will be even more costly and difficult in the former than it has been in the latter. At the same time, greater reliance on nonpolluting modes of transportation in developing-country cities, coupled

with strong integration of residential and economic activities; suggests those cities may be in a position to avoid some of the most costly mistakes of transportation investment in the industrialized countries. The thrust of this chapter is not to persuade developing countries to accept inferior transport to that of developed countries or to have any lower aspirations for personal mobility. Rather, while we recognize that increased motorization is desirable, we emphasize that choosing transportation policies differently might well result in a more efficient urban form than many western cities have been able to achieve. It should also be emphasized that this paper is aimed primarily at megacity leaders and policymakers of the developing world. Thus while the discussion is firmly grounded in the literature, it is not focused at a technical level.

IMPROVED TRAFFIC AND DEMAND MANAGEMENT

Traffic and demand management measures attempt to increase vehicle speeds on existing transportation system infrastructure through technological improvements and traffic adjustments, financial restraint measures, and physical restraint measures.

Technological Improvements and Traffic Adjustments

A broad range of technological improvements and traffic adjustments can be implemented to improve the efficiency of vehicle flow in urban or congested areas. These measures include traffic signal synchronization, on-street parking bans, one-way systems and reversible-flow traffic lanes, time segregation of freight deliveries (providing incentives to businesses to schedule freight deliveries during less congested evening hours), high-occupancy vehicle lanes, work scheduling, incident response services, improvements in street conditions, and improved training of engineers and traffic police. Below we discuss a subset of these measures that seem to be particularly appropriate for developing-country megacities.

Traffic signal patterns can play a key role in improving traffic flow in city centers. In many urban areas, traffic signals are synchronized to produce a relatively smooth flow of traffic by minimizing the number of stops and delays and maximizing average speeds. Shorter traffic signal cycles can also improve traffic flow.

Unrestricted on-street parking (or on-street parking available because of unenforced restrictions) occupies road space and causes drivers to obstruct traffic flow while searching for parking. At the same time, large supplies of low-cost center city parking can encourage private vehicle travel and contribute to increases in traffic volume. Complete on-street parking bans in center cities, if enforced well, can improve traffic flow by offering more road space for moving vehicles (Pucher, 1988). For cities requiring a more intermediate solution, one method of restricting on-street parking is by providing metered space, which also raises revenue for the city. (See also the discussion of off-street paid-parking facilities in the subsection on financial restraints below.)

To satisfy growing demand within existing infrastructure, cities can opt to implement a system of one-way streets to manipulate demand during peak traffic periods. One-way systems require fewer stops on heavily traveled routes and can use road space more efficiently, especially if they are implemented on major commuter routes during morning and evening hours. Another way to increase available road space is to create reversible-flow general traffic lanes that change direction according to peak-hour requirements. A number of cities have introduced with-flow or contra-flow bus-only lanes with good results. Other measures include regulations that provide for bus- and tram-only cross-traffic turns and give priority to buses and trams at traffic signals. Despite opposition from motorists, these schemes often provide benefits for all road users, including operators of private cars and commercial vehicles, as well as buses and trams. In some cases, with no reduction in general traffic speeds, reserved bus lanes have permitted bus journey speeds to increase to more than 20 kilometers per hour (Armstrong-Wright, 1993).

Roads with poor driving surfaces or illegible street signs are common in developing-country cities and greatly hamper transport system performance while leading to safety hazards, premature aging of vehicles, inefficient fuel use, and increased pollution. Improving street conditions by eliminating potholes, paving roads, and posting legible signs is a cost-effective way to enhance road travel. Bus lanes, pedestrian facilities, and nonmotorized transport lanes should be properly marked and, if appropriate, physically separated from facilities for private motorized modes. Separation not only improves safety for all modes, but also smoothes traffic flow, raises awareness of the rights of different vehicles, and may even encourage travelers to switch to public or nonmotorized transport modes.

What is heartening about the traffic management measures discussed here is that they represent relatively simple improvements and/or modifications to existing transport systems that can improve traffic flows relatively quickly and inexpensively. Often, however, these measures are not implemented because traffic engineers are not aware of some of the more recent and successful modifications that can be made at relatively low cost, or because there exist institutional problems, such as a lack of authority to enforce changes in the traffic system or a lack of priority given to basic maintenance activities such as signage and road repairs. Road maintenance, in particular, is traditionally underemphasized by the public works department in many countries because it is a much less visible and prestigious type of expenditure than new highway or road construction.

Traffic measures such as the above can be implemented more effectively if they are combined with the improved training of engineers and traffic police--the individuals with primary responsibility for designing and implementing the traffic flow patterns prevalent in all cities. New design techniques and lessons can be communicated through workshops and training sessions, perhaps relying on video techniques or using data available from the WorldWide Web, and held in the developing countries themselves. In congested situations, manual control of signals and traffic flow is often the rule, and it is crucial that personnel be

trained to handle these situations as well as possible. Providing such training is one way developing countries can improve traffic patterns in large cities for a relatively low cost.

Financial Restraint Measures

Road pricing, a financial method for traffic management, employs a market mechanism to encourage the use of higher-occupancy vehicles and more efficient use of road space. The basic idea of pricing the use of roads for revenue purposes is an old one. In many countries, turnpikes of the late seventeenth and early eighteenth centuries were built as private toll roads. During the modern era, numerous toll roads have been built by public agencies, and tolls have long been used to finance unusually expensive bridges or tunnels. A newer variation on this idea is that of congestion pricing, i.e., charging each motorist a fee that is directly related to the amount of congestion he or she causes in using a road. In other words, roads are priced according to demand, making it more expensive to drive during peak periods than during low-travel periods (Gómez-Ibáñez and Small, 1994).

One advantage of congestion or peak road pricing is that it encourages motorists to find many ways of reducing congestion rather than promoting only a few, such as public transit and carpooling programs. For example, flexible motorists can change the time of day, route, location, or frequency of their travel, as well as switch to other modes. In addition, congestion pricing applies to all motorists who are causing congestion during peak hours and not just to captive groups such as commuters.¹

Area pricing measures represent a form of road pricing within specific physical boundaries that does not necessarily require sophisticated technology. Area pricing schemes charge drivers if they enter a designated area; normally, the driver must buy a pass in advance or pay a fee at a toll booth located at the entrance to the area. Yet it should be noted that area pricing schemes can result in traffic jams at collection points and should be implemented with alternative forms of downtown transport to protect downtown business activity.

Several urban centers have experimented with area pricing schemes to earn revenues for road construction. Singapore, however, developed an area licensing scheme in 1975 to reduce central city car traffic (Gómez-Ibáñez and Small, 1994). The scheme was initially limited to cars entering the central business district in the morning rush hour. Carpools of four or more people were exempt; other car owners who wanted to enter the center city area during the restricted morning hours were required to purchase a sticker in advance and place it on the windshield of their automobile. The program immediately reduced the number of

¹ The economic theory underlying the concept of congestion pricing is well developed and argued by numerous authors. Some particularly accessible discussions are provided by Hau (1992a, 1992b) and Transportation Research Board/Commission on Social and Behavioral Sciences and Education (1994).

vehicles entering the central business district during the morning rush hour and shifted many people's morning commuting habits.

Singapore has updated its area licensing scheme over the years through the implementation of a number of measures, including extending morning restricted hours, raising fees progressively, expanding the area in which the scheme is applied, putting restrictions on evening hours, eliminating the carpool exemption, and including motorcycles and taxis in the restrictions. The scheme was supported by necessary improvements in public transport, such as the expansion of the bus system, the installation of a rapid mass transit line, and the provision of park-and-ride lots. Further deterrents to driving were also introduced, including a 100 percent increase in parking charges at public car lots within the restricted area and very large increases in car purchase fees. The combined impact of these measures has been dramatic. They caused a 25 percent drop in peak period traffic, which has been sustained despite rapid economic and population growth. In addition, private car traffic entering the zone during the restricted hours was reduced by 70 percent, the share of buses in the modal split increased by 8 percent, carpool levels doubled, and emission levels within the restricted area were reduced by 30 percent.

There are several examples of peak road pricing methods that rely on advanced electronic technologies, such as those in use in Bergen and Oslo, Norway, and, most recently, in Los Angeles, California (Gómez-Ibáñez and Small, 1994; Ayres, 1996). Hong Kong was the first city to pilot test the technological feasibility of large-scale electronic road pricing between 1983 and 1985. Although the system functioned properly, political and administrative problems prevented it from being implemented.²

Despite Singapore's success with congestion pricing, and although most transportation economists, planners, and engineers believe that it is an excellent idea, experience in other democratic countries suggests that congestion pricing is likely to be introduced on a piecemeal basis. Nonetheless, congestion pricing is being implemented even in countries where political resistance to charging for roads has always been high.

Another market mechanism, off-street paid-parking facilities in city centers, can complement congestion pricing schemes, provide an incentive to drivers to use their cars more wisely, and make public transport more competitive. In addition, off-street parking can help eliminate the problem of parked vehicles infringing on travel space. Research in the United States (Shoup, 1994) suggests that individuals respond rationally to price signals implied by parking fees, particularly if the fees cover most of the full costs associated with driving and parking in a congested urban area.

² Of particular concern to Hong Kong motorists were the high fees they would be expected to pay for using the roads, as well as the potential loss of privacy that might result from the capability of the government theoretically to monitor drivers' movements at all times. The policy change in Hong Kong may also have been the result of a new administration in the midst of reorganizing its whole fiscal program ahead of the anticipated events in 1997 (Gómez-Ibáñez and Small, 1994).

In some developing-country megacities, there is currently a shortage of urban parking. In China, for example, there are few parking facilities available for private vehicles in most of the major cities. Given burgeoning demand for private cars, new auto owners are beginning to engage in searches for parking. The need for parking may will spark the redevelopment of urban parcels into parking structures as the prices bid for parking spaces rise. Redevelopment may, in turn, exacerbate traffic congestion in Chinese cities as it has in other motorizing countries. When this process begins, it is very important to charge users for the full costs of both parking and congestion. Despite the apparent benefit of providing parking, an ample supply of free off-street parking can hurt urban transport by promoting private vehicle travel. Studies show that parking policy in the United States, for example, where 75 percent of commuters park in free off-street parking provided by employers, strongly favors automobile use.

Another complement to or possible surrogate for congestion pricing is gasoline taxation, particularly if the funds are spent to finance transportation improvements. Taxing of fuel is relatively transparent to implement, administer, and enforce. Taxation at the pump generally induces all drivers to consume less fuel and to use their vehicles more prudently than they would otherwise. Although taxing of fuel is a very imperfect proxy for congestion pricing, in many cases it may be the only practical measure in terms of enforcement and collection, particularly in the context of developing countries. In addition, if the revenues are dedicated to transportation investment and improvements, taxpayers are generally willing to accept the extra cost.

Physical Restraint Measures

In general, measures based on physical restraint of vehicle movement are more problematic and ambiguous in their outcome than the financial restraint measures discussed above. One of the most common physical restraint measures is heavy-vehicle restrictions, which attempt to minimize the congestion, noise and air pollution, and premature road deterioration these vehicles can cause. While such bans can be effective, they can also adversely affect urban business and commerce, and need to be coordinated with other shipping policies, such as limitations in delivery hours or transfers to more environmentally acceptable vehicles for local delivery.

Traffic flow has been reduced in some cities by dividing the central business district into cells. Cars can travel freely within one cell or zone, but must travel by an outer-ring road to enter the next zone. These zoning systems are designed to limit through-traffic on dense center city streets, increase city street safety, and reduce transport-related air and noise pollution in the center city. Public transport, pedestrian, and nonmotorized transport facilities can be developed to allow for travel between zones. The city of Gothenburg, Sweden, for example, developed such a cell system, which successfully decreased traffic accidents by 56 percent and lowered center city traffic volume by 45 percent between 1970 and 1982 (Organization for Economic Co-operation and Development, 1988). The completed

first phase of a similar scheme in Tunis has produced promising results that may be replicable in other cities where spare capacity is available on routes bypassing the city centers. In other cities, the cost of providing additional capacity for intracity travel, together with the cost of additional fuel consumed in more circuitous journeys, needs to be carefully weighed against the benefits of reduced congestion and traffic accidents in the city center.

Several cities, such as Mexico City, Santiago, Chile, and Athens, Greece, have implemented day-long vehicle travel bans according to license plate numbers. Although somewhat successful in encouraging people to carpool or ride public transport, these schemes have faced many problems, including extreme public backlash. They also create a market for cheap, second-hand vehicles that are generally more polluting and less efficient than newer models and subvert the intent and the impact of the ban. Moreover, while vehicle bans may be effective short-term rationing measures to alleviate crisis situations, they also curtail demand indiscriminately without regard to the transport need to be met.

Overall, sophisticated measures of traffic and demand management, such as congestion pricing or zoning systems, are likely to be difficult to administer, while simple ones, such as vehicle bans, may have perverse side effects. Given these drawbacks, it is clear that successful traffic and demand management initiatives in developing-country megacities will depend on the development of better enforcement and regulatory capabilities. Developed nations may well be in a position to help with the development of these capabilities through assistance programs targeted specifically at improving the enforcement and regulatory departments of transportation ministries.

FULL-COST PRICING

Motorists impose different costs on one another and society. At a minimum, "full" costs would include charges sufficient to cover the cost of building, maintaining, and operating transportation facilities and the delay costs that users impose on one another in congested conditions (Transportation Research Board/Commission on Behavioral and Social Sciences and Education, 1994).³ Full-cost pricing is often defined to include environmental, safety, and other costs that users impose upon others, but although a good deal of research is under way to develop estimates of the economic costs of environmental damage, there is not consensus on the appropriate economic value to assign to these kinds of costs.

Most countries underprice the use of roads in highly congested urban areas, giving individuals an incentive to rely on motorized transport, particularly private motorized transport, for getting to and from high-density central business districts. These subsidies have contributed to sprawling urban form, increased congestion, and environmental degradation. In addition to the financial measures discussed in the previous section, full-cost

³ As indicated in Appendix B of Transportation Research Board/Commission on Behavioral and Social Sciences and Education (1994), economists distinguish between short-run marginal costs, such as delay and operating costs, and long-run capital costs of providing facilities; under a plausible set of assumptions, it can be shown that pricing highway investment needs according to short-run marginal costs will generate sufficient revenues to just cover the cost of providing new facilities.

pricing can provide consumers with market-based signals regarding the use of motorized transport and, consequently, dampen demand for private automobiles.

Developing-country cities still in the midst of building their road infrastructure have the opportunity to set the price of various transport services equal to the actual cost of those services. Such full-cost pricing--charging users the full cost of transportation activities, including congestion costs--can influence the relationship between city form and urban infrastructure investment. Private automobile users in the developing world have relatively high incomes and can help pay the costs of the infrastructure they require for their vehicles. Moreover, fuel taxes that exceed the costs of road construction and operation--as are applied in European nations--can be justified based on the economic costs of air pollution (Small and Kazimi, 1995). Relying on such pricing measures to provide optimal incentives to individual households can help developing-country cities achieve better urban economies.

ENVIRONMENTAL MEASURES

One of the primary motivations for all of the transportation options discussed in this chapter is the contribution of motorized transport to environmental degradation, particularly with respect to air quality. Transport vehicles burning fossil fuels emit pollutants such as hydrocarbons (HC), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), suspended particulate matter, and lead. Moreover, when these pollutants combine, they are potentially more damaging than in their separate forms, and the adverse effects of all pollutants are intensified by the high concentration of motor vehicles and congested driving conditions in most urban areas. Many pollutants can damage human health as well as the environment, but the two most harmful types of pollutants are probably particulates and lead.

Studies released in the last few years indicate that particulates may be the most serious urban air pollution problem. By correlating daily weather, air pollutants, and mortality in six U.S. cities, scientists discovered that nonaccidental death rates are strongly correlated with daily levels of particulates, but not with other pollutants (Dockery et al., 1993). Other research in 15 U.S. cities indicates that sulfates and fine particulate air pollution are associated with a difference of 16 percent in mortality risks between the most and least polluted cities (Walsh, 1996). Certain particulates, including diesel particles, appear to be especially hazardous because of their chemical composition and extremely small size.

A growing body of data on the adverse health effects of lead, especially in young children, indicates there may be no "safe" level, and that lead in gasoline contributes to behavioral problems, lowered IQs, and decreased ability to concentrate in exposed children. The U.S. Environmental Protection Agency has also uncovered evidence linking lead in the blood and high blood pressure (Schwartz et al., 1985). In addition, the lead scavengers that accompany leaded gasoline have been identified as human carcinogens.

Inhabitants of cities in developing countries face greater risks from particulates and lead than many developed-country residents because the lead content of gasoline is usually considerably higher in the former countries (e.g., Thailand, Indonesia, Pakistan, and India) than in the latter (e.g., the United States or Italy) (Birk and Zegras, 1993). In general, the

levels of local automotive pollution in many large developing-country cities are the source of considerable concern. They result from many of the same factors apparent in industrialized countries, including the content of the fuel, the level of vehicle technology, the level of maintenance and age of a vehicle, driving conditions within the metropolitan area, and the number of vehicles. Unfortunately, in many megacities of the developing world, these variable factors are particularly conducive to high levels of pollutants.

Individual vehicle efficiency and emissions can be improved through improvements in fuel quality, advances in vehicle technology, and the adoption and enforcement of national standards. The actions that should receive the highest priority involve improved fuel quality, particularly the removal of leaded gasoline from urban roads, but the best and most successful strategies rely on a comprehensive approach, such as that adopted in Mexico City in 1990 (Walsh, 1996).

Integrated Program Against Air Pollution in the Mexico City Metropolitan Area

This program comprises 42 specific measures that include changes in fuel composition to reduce pollutant emissions from mobile sources, changes in the refining and distribution infrastructure for automotive fuels, new catalyst-forcing emissions standards for gasoline vehicles, replacement of existing taxis and minibuses with vehicles meeting emission standards, implementation of a vehicle inspection and maintenance program, improvements in parking and traffic management systems, and the authorization of new private bus routes. The program also encompasses a number of measures intended to develop data and analytical techniques that can support more effective air quality management, as well as measures to increase the supply of trained personnel to plan and execute air quality programs. Examples of the latter are a global air quality study being conducted in cooperation with the U.S. Department of Energy's Los Alamos National Laboratory and an epidemiological study intended to evaluate the health impacts of air pollution in the Mexico City metropolitan area.

Mexico's Integrated Program constitutes a major step forward in air pollution control in the Mexico City metropolitan area and appears to have been responsible for an approximately 50 percent improvement in CO levels over the last 5 years. Fuel improvements have led to the most significant progress to date, although important contributions have also been made by the adoption of stringent standards for new vehicles, especially passenger cars; the replacement of older taxis and minibuses with new catalyst-equipped ones; and the conversion of large numbers of cargo trucks to liquefied petroleum gas fuel using certified, closed-loop, three-way catalysts. Although severe air pollution problems remain, in the last 6 years Mexican officials have moved forward more comprehensively, quickly, and aggressively than has been observed in virtually any other city in the world.

Improved Fuel Quality

Fuels used in many developing countries are of a poor environmental quality and often contain excessive lead, in the case of gasoline, and excessive sulfur, in the case of diesel fuel. Besides being a direct health hazard itself, lead in gasoline eliminates the possibility of incorporating catalysts as a vehicle exhaust treatment technology because lead renders catalysts ineffective. Switching to low-lead or unleaded fuels is a very important and relatively easy way to reduce harmful emissions.

Governments are gradually requiring that gasoline sold in their countries contain less lead, as well as making greater use of unleaded fuels. In 1992, the Taiwanese government introduced unleaded gasoline and reduced the lead content of regular gasoline to below 0.12 gm/liter. In India, the lead content of gasoline will be reduced to 0.15 gm/liter by 1998, and lead content is scheduled to be progressively reduced to ensure lead-free gasoline by the turn of the century. With a few exceptions, such as Mexico and Thailand, progress in this area is quite slow, primarily because the costs of modifying refineries to produce unleaded fuel are high and immediate, while the long-term health consequences of continuing to burn leaded gasoline are not widely appreciated by consumers.

Reducing the Lead Content of Gasoline

In Thailand, largely as a result of the deteriorating air quality in Bangkok, the national government supported the introduction of reduced-lead and unleaded gasoline in 1991. As of January 1996, the use of unleaded gasoline has been mandatory. The government has encouraged demand for unleaded fuel by using a tax subsidy to make it cost-effective for local refiners to produce unleaded gasoline. Reduced-lead gasoline is taxed 10 percent less and unleaded fuel 25 percent less than leaded fuel. In addition, the government recently decided to reduce the sulfur level in diesel fuel from the current 0.5 standard to 0.05 by the year 2000.

Indonesia, with abundant oil reserves and a well-developed refining industry, is also in a good position to reduce the lead content of its gasoline. The country's government introduced gasolines with reduced lead content in 1989 and unleaded gasoline in 1994. A recent study in Indonesia indicates that unleaded fuel and the substitution of natural gas for gasoline are economical for that nation because of their effects on health-related costs (World Bank, 1993). Compressed natural gas, in particular, is an attractive alternative for countries like Indonesia that have natural gas supplies, since it can be burned in gasoline-powered engines with only minimal adaptation. About a half-million vehicles worldwide, about half of these in Italy, currently operate on compressed natural gas. Vehicles optimized for natural gas would generally have about 10 percent greater efficiency than gasoline vehicles, create less pollution, and have lower fuel costs, but would cost about \$700 to \$1000 more up front because of the need to install high-pressure fuel tanks (Sperling, 1995). Conventional vehicles powered by natural gas or alternative fuels are, at best, an incomplete answer to the problems of vehicular air pollution, but can represent an improvement in terms of the levels of greenhouse gases and critical pollutants emitted relative to gasoline-powered transport.

Without lead, refiners must raise the octane levels in gasoline through more costly measures, such as improved refining techniques and the addition of other high-octane blending components. This increases the cost of fuel at the pump, which represents a problem for car owners in most developing countries. However, despite the barriers involved, unleaded gasoline is available in most industrialized countries. Many other nations, such as Brazil, Chile, Korea, and a number of Eastern European countries, are expanding the availability of unleaded fuel, with plans to mandate its use in the future.

The most direct strategy for eliminating lead in gasoline is to ban its use; several countries have adopted this approach. Failing a ban, the production of unleaded fuel and alternative fuels, such as compressed natural gas, can be actively encouraged by governments motivated to improve air quality. The promotion of unleaded gasoline, for example, is relatively straightforward, and a number of countries have devised ways of encouraging existing refineries to modify their systems sufficiently to produce unleaded fuel. Thus, passing laws that require all new motor vehicles to use unleaded fuel while at the same time increasing the price of leaded gas relative to unleaded gas or alternative fuels can make a major improvement in urban air quality for a relatively small cost.

It is desirable for the introduction of cleaner fuels to be accompanied by appropriate pricing strategies that acknowledge the costs of environmental damage caused by motor vehicle emissions. Taxing fuel, particularly leaded fuel, at a high rate also has the effect of lowering emissions simply because of its effect on consumption of gasoline. Recent research by Eskeland (1993) in Mexico City, for example, finds that a gasoline tax can reduce the cost of emission reductions by as much as 24 percent if the gas tax rate is set appropriately. Eskeland argues that the use of both technical controls, such as catalytic converters and the use of cleaner fuels to make cars cleaner, and a gasoline tax, to give users an incentive to economize on the use of cars, mimics the incentives that would be provided by an emissions fee--the most efficient albeit currently impractical way to reduce the level of emissions from motorized vehicles.

Finally, taxing fuel and requiring all new vehicles to use unleaded fuels require relatively less reliance on enforcement mechanisms than do other types of strategies. These measures are straightforward, can be implemented easily and uniformly across a wide geographic area, and do not need to rely on trained staff or sophisticated equipment to achieve their ends.

Vehicle Technologies

In addition to improved fuel quality, new emission and propulsion technologies can play a large role in improving urban air quality. In North America, Europe, and Japan, catalytic converters are, of course, widely used as the technology to limit HC, CO, and NO_x emissions from gasoline-powered engines. In addition, the combination of lead-free gasoline and catalysts can facilitate very substantial reductions in other harmful pollutants, such as aldehydes and polynuclear aromatic hydrocarbons. These emission reductions can occur simultaneously with equally significant improvements in fuel economy and reductions in vehicle maintenance. Based on studies in Canada, reduced maintenance with the use of unleaded as compared with leaded gasoline can save about 2.4 cents per liter (Walsh, 1996).

Other available technologies for reducing emissions in gasoline-powered cars include the recirculation of exhaust gases, ventilation canisters for capturing evaporative emissions, electronic control of engine performance, and advanced combustion techniques. In two-stroke motorcycles, which comprise a large portion of Asian vehicle fleets, timed fuel injection and catalytic exhaust aftertreatment can significantly reduce emissions. In the case of vehicles that run on diesel fuel, emissions can be controlled by changes in engine design and combustion characteristics and the use of catalytic converters (Faiz et al., 1990). Many emission-control technologies, such as better fuel injection, can improve fuel efficiency by decreasing the amount of fuel consumed. In the long run, we can look forward to technologies, such as electric and fuel cell vehicles, that create no emissions on city streets.

In some regions, particularly in countries with substantial supplies of hydro or nuclear power, the use of battery-powered electric vehicles may be highly attractive since electric vehicles will generally be recharged in the evening, when electric power plants are otherwise underused and the cost of supplying electricity is lower. Electricity supply at night tends to be more reliable in developing countries than that during the day because of lower demand. In Sao Paulo, electric buses, an essentially pollution-free alternative, have been in use for years, although they have not gained in importance mainly because of political and economic problems. Increased reliance on electric buses would result in substantial improvements in air and noise pollution (Walsh, 1996). Small electric vehicles, such as rickshaws and microcars, also hold promise for developing-country megacities because they use far less energy than cars, and thus do not pose the battery limitations that currently represent a major barrier to widespread production and use of electric cars in industrialized nations.

Taiwan's Environmental Protection Agency recently mandated a 5 percent market share for electric motorcycles by 1998 in an effort to limit air pollution caused by the high number of motorcycles, many of them with two-stroke engines, in that country. The mandate accompanies strict emissions standards applied to all new motorcycles sold in Taiwan (as of 1993) and a motorcycle inspection and maintenance system. Zero-emission (electric) motorcycles are already available in Taiwan, but although they are priced similarly to gasoline-fueled bikes, sales are very low. Public resistance is related to poor performance and difficulties in recharging; many Taiwanese live in apartments and are unable to leave their motorcycles on the street at night and still recharge them. To encourage consumers to buy electric motorcycles, the government grants a tax rebate equal to approximately a sixth of the purchase price of the electric motorcycles and is developing infrastructure that will allow consumers to replace run-down batteries with fully-charged batteries in a matter of minutes (Walsh, 1996).

Given California's well-publicized 10 percent zero-emission vehicle mandate in 2005, electric vehicle technology is advancing rapidly. All major car manufacturing companies have begun to develop prototype vehicles, and the expectation is that small, affordable electric vehicles will become a reality soon. Electric vehicles emit much less pollution while greatly reducing the use of petroleum in almost all areas, except those that rely on coal-fired power plants at night (Wang et al., 1990). Electric vehicles would also tend to more

reliable, last longer, and require less maintenance than conventional gasoline-powered automobiles, although this might not be true of the first generation of vehicles. In addition, electric vehicles could offer the opportunity for the creation of a new industry and new jobs.

Fuel cell vehicles also hold promise for improving the air quality of megacities within the next two decades (Sperling, 1995). A fuel cell is a device that transforms hydrogen and oxygen into electricity; unlike a battery, which stores energy, the cell produces electricity through a continuously supplied source of fuel. Fuel cell vehicles would consume about half the energy of conventional gasoline-powered vehicles, emit no pollution or greenhouse gases, and run more quietly. Early models may run on petroleum fuels, methanol, or hydrogen made from natural gas, but scientists hope that eventually, these fuel cell vehicles will run on hydrogen made from water using solar energy.

Development of Fuel Cell Vehicles

Fuel cell demonstration projects are under way in the United States and Europe. General Motors and Daimler Benz both have major fuel cell vehicle projects. Perhaps the most advanced research is a bus project developed by Ballard Power Systems of Canada in collaboration with several other Canadian and U.S. companies. The first bus, completed in June 1993, is a 32-foot transit vehicle powered by compressed hydrogen and a Ballard proton-exchange membrane (PEM) fuel cell. A second-generation bus using more advanced PEM fuel cells and compressed hydrogen, possibly to be supplemented with a battery for peak power, is scheduled for completion in 1996. In addition, several fuel cell buses and smaller vehicles are under construction in various industrialized countries. While these technologies will not be widely available or affordable for some time to come, a great deal of progress is being made, and the governments of developing countries should consider policies that encourage the development and use of alternative technologies as they modernize their vehicular fleets.

National Standards

National standards can be an important complement to fuel quality and vehicle technology measures. Vehicle emission standards are almost always implemented at a national, rather than provincial or regional, level, usually because automobile markets in most countries are relatively small and because it is more difficult to administer and enforce regional than national standards. Many industrialized countries have regulations and incentives to promote reductions in individual vehicle fuel consumption. In Australia, an agreement between the government and the automotive industry to increase the fuel efficiency of domestic vehicles decreased the average fuel consumption of new passenger cars by over 20 percent between 1979 and 1988. A number of governments have successfully implemented policies for reducing vehicle emissions. The United States, for example, passed

the Clean Air Act in 1970, which forced automobile manufactures to reduce vehicle emissions substantially.⁴ Some governments in developing countries, including Mexico, Korea, Thailand, India, and Brazil, have in place standards requiring that new vehicles not exceed certain emission levels.

In China, the National Environmental Protection Agency has already issued 11 motor vehicle emission control standards and formulated a Management Procedure and Technical Policy for vehicle emission control.⁵ The implementation system in China, however, is quite different from that in other countries, which may explain why a complete set of standards for new and existing motorized vehicles has yet to be formed. In spite of efforts to date, the air quality in most major Chinese cities has not improved and may well be declining. In some cases, for example, national standards do not account for the more stringent needs of extremely polluted urban areas.

In many other developing countries, as noted earlier, enforcement of legal requirements is much more problematic than is the case in industrialized countries. While vehicle technology advances hold great promise for improving vehicle emissions and efficiency, urban areas in developing countries usually have little control over the average vehicle technologies that actually operate on their streets. The technology level that prevails in an urban area results from the individual consumption and maintenance decisions of the motor vehicle operators and depends critically on the incomes and choices available through the marketplace. An urban area generally lacks the political or economic clout to force automobile manufacturers to change the technological composition of the vehicle fleets they offer for sale. However, since most developing nations still import the majority of their motor vehicles, many may soon have a large enough vehicle population to demand that manufacturers meet certain standards. It is very important that these nations develop the enforcement capability required to ensure compliance.

A key complementary element of effective national standards is the implementation of improved vehicle maintenance. It is widely acknowledged that strategies to improve the maintenance of older vehicles can be a very effective tool for reducing emissions and improving fuel economy. Many countries in the developed world have yet to implement effective vehicle maintenance programs, while several developing countries, such as China, Thailand, and Mexico, have implemented maintenance programs with varying degrees of success. The impact of maintenance strategies seems to differ according to the institutional

⁴ The act's maximum automobile emission standards have been progressively tightened over the past 30 years, and manufacturers have successfully reduced automobile exhausts of the most toxic emissions by 70 to 90 percent (Birk and Zegras, 1993).

⁵ The National Environmental Protection Agency of China is in charge of formulating and revising the standards for controlling major vehicle emission pollutants, while local Environmental Protection Bureaus are responsible for supervising and putting emission standards into effect. A number of standards, including emission standards for smoke and pollutants at idle speed from vehicles with either gasoline or diesel fuel, were implemented as early as 1983. Most of these standards were revised in 1994, including standards regarding the exhaust and evaporative emissions of both light and heavy gasoline-fueled vehicles. Motorcycle emissions came under control as of January 1996. To reduce CO and HC by 30 percent on medium- and heavy-duty gasoline-fueled vehicles, exhaust emission standards for these engines were put into effect at the beginning of 1995 (Walsh, 1996).

structure and political desire to implement strong testing programs, along with enforcement mechanisms. While vehicle maintenance programs hold promise, therefore, they may not make a great deal of difference to air quality and fuel economy in the short run without substantial institutional reform.

Although fuel efficiency and emission standards can promote significant reductions in energy use and emissions, it should be noted that with rising incomes, people tend to drive more and to purchase larger vehicles, thus offsetting the benefits achieved by such standards. Thus standards must be part of a mix of solutions that includes taxes and other measures to restrain traffic growth.

PRIVATE-SECTOR PARTICIPATION

As discussed earlier, in most large cities within both industrialized and developing countries, transportation services are underpriced. Transit, i.e., buses, metros, and light rail, is often heavily subsidized because of political concerns that higher transit prices might cause widespread dissatisfaction, as well as a genuine belief that commuters cannot afford higher fares. Roads and highways are often provided for free to both motorized and nonmotorized vehicles. At the same time, cities in the developing world tend to be dramatically underserved in terms of the capacity of their transportation systems. Funds for the construction and maintenance of urban and rural roads are not available, and the resources devoted to public transportation rarely keep pace with inflation.

To help address these financial problems, many countries have recently turned to private suppliers to provide services formerly offered by public agencies. Interest in shifting to the private sector is based on the understanding that doing so would increase efficiency and/or tap new sources of funds to supplement the constrained resources of the public sector. The private sector is thought to be inherently more efficient than the public sector, and many argue that a private contractor, motivated by profit, is more cost-conscious and customer-oriented than a public enterprise. In addition, privatization offers the potential for financing infrastructure without overt increases in taxes since infrastructure can be supported by user charges. In fact, it has become a tenet of current development literature that provision of infrastructure services can be left increasingly in the hands of the private sector.

On the other hand, the efficiency and financing arguments in favor of privatization may not always reflect reality. A newly privatized state enterprise, for example, will not be more efficient if it operates in a monopoly or noncompetitive situation. Similarly, subcontracting the provision of services to a private firm may not reduce costs if the bidding process is biased or uncompetitive. Furthermore, private service provision may not increase the level of investment that is possible. A public agency can frequently issue bonds secured by revenues from infrastructure facilities, much in the same way that a private firm will raise

capital. The process of privatization can create winners and losers, and the underlying complexities posed by any privatization efforts must be carefully and thoughtfully analyzed.⁶

Nonetheless, the positive cumulative experience in the field of transportation supports further reliance on privatization, particularly in instances where it is possible to introduce important elements of competition, such as bus or bus-like services or toll highways. In addition, there is room in most developing countries for levying charges on developers for the provision of urban infrastructure, including a much-expanded application of beneficiary principles.⁷

Opportunities Within Bus Transport

Buses are the primary form of motorized public transportation in most cities of the world; frequently, buses have higher ridership than all other public modes combined.⁸ Urban bus services are particularly important in cities of developing countries, where buses typically represent 50 to 80 percent of all motorized trips. Good bus transportation can help meet the aspirations for a motorized mode in many developing-country cities. It is very important in emerging megacities, not only because so many people are dependent on buses to get to work, but also because good bus service has the potential to help forestall unnecessary growth in automobile traffic.

Almost all developing countries have experienced several forms of ownership and regulation of urban buses. Typically, urban bus services in developing countries are provided through a system comprising a mix of publicly and privately owned vehicles. Frequently, the conventional-sized buses are operated by a publicly owned corporation, while private firms provide significant minibuses services. In recent years, however, public bus services in the majority of large urban areas of the developing world have suffered declining effectiveness and viability, and have been unable to cope with the growing demand for urban transport. In most cities, the gap has been readily filled by private operators, who command a far greater share of the market. The World Bank recently completed a series of studies indicating that the private sector accounts, on average, for more than 75 percent of all bus trips in the developing world, as well as all paratransit trips. In Karachi, Pakistan, for example, the public bus company, Karachi Transport Corporation, is responsible for only 18 percent of all public transport trips, while the remaining 82 percent is provided by private enterprises operating medium-sized buses, minibuses, taxis, and rickshaws (Armstrong-Wright, 1993). And although public bus corporations continue to supply a large share of

⁶ The following discussion relies primarily on Chapters 3 and 15 of Gómez-Ibáñez and Meyer (1993), a recent and extremely thorough discussion of international experience with transportation privatization efforts.

⁷ Beneficiary principles involve requiring those who benefit from or impose additional marginal costs on an urban area to pay for those costs.

⁸ The most important modes include conventional-sized buses (with 35 or more seats) and a variety of paratransit modes, including the minibus (which has 30 or fewer seats and sometimes as few as 10 to 15) and several close relatives of the minibus, such as the shared taxi or jitney.

transport services in China and India, the importance of private operators is increasing rapidly even in these countries.

Private firms have such a large share of the market mainly because of their ability to hold costs down by reducing waste and overhead, as well as employing a minimum of staff. Public corporations, in contrast, are often dependent on revenue from government subsidies and are burdened with very large workforces, as well as higher wage rates and greater farebox revenue leakage. Consequently, the costs of public corporations are roughly double those of the private-sector bus and minibuses operators functioning on the same routes and under the same conditions (Armstrong-Wright, 1993). Even in cases where the private and public entities charge the same low fare, private operators are usually able to make small profits even while the public corporation must absorb substantial losses.

Often governments are aware of the deficit problems facing their public transport companies and attempt to privatize transportation services or, more commonly, allow other, less-regulated and privately operated modes, such as minibuses, fill the gaps not provided for by the public companies. Privatization frequently permits cities in developing countries to eliminate or check growth in transport subsidies while maintaining or expanding service, largely because of the cost differences between private and public providers. In Jakarta, for example, both the public company, the Penang Kutan Penumpang Djakarta, and one private firm operate conventional buses, while the other private firms operate minibuses. The public and private firms all charge the same fares, but the public firm needs a 50 percent subsidy, i.e., US \$30 million per year, while all the private firms make a profit (Armstrong-Wright, 1993). In a few cases, such as in Khartoum, Sudan, a private operator of conventional buses apparently charges even less than the public operator. Sometimes, private firms are allowed to charge a higher fare in return for an expansion of service, as in Rabat, Morocco, and Kingston, Jamaica.⁹

Gómez-Ibáñez and Meyer (1993) identify three main types of privatization reform within the bus sector: privatization accompanied by some public regulation (particularly for fares), privatization without fare regulation, and privatization accompanied by maintenance of subsidies for unprofitable routes. Overall, privatization with route and fare regulation can benefit all parties. Taxpayers benefit because the burden of public bus subsidies is generally reduced, while riders probably benefit much of the time, especially where services have been expanded as a result of the introduction of private operators with little or no increase in fares. Finally, labor may not lose much, or it may gain, because service expansion often implies more jobs, though sometimes at lower wages.

Privatization with fare deregulation has been attempted in far fewer countries. Colombo, Sri Lanka, and Santiago, Chile, are the two most commonly cited examples. In 1979, the government in Colombo permitted private operators to offer bus services largely

⁹ Bus service in terms of number of vehicles improved somewhat in Kingston, Jamaica, but still remains inadequate by most other measures or standards of service (Gómez-Ibáñez and Meyer, 1993).

free of fare and route regulation, but maintained the existing publicly owned bus company (the Central Transport Board). In Santiago, a publicly owned bus company that shared the market with regulated private operators was disbanded in 1980, while government fare and route regulations covering the private sector were also relaxed. In neither city were subsidies for unprofitable routes made available to private operators, although the Central Transport Board in Colombo continues to receive large subsidies.

The results of these two experiences are mixed. In Colombo, while some private operators resorted to overloading and did not serve some of the city's most unprofitable routes, ridership increased greatly, and deregulation stimulated a large increase in capacity and bus frequency. Fares did not increase significantly, apparently because of the Central Transport Board's policy of maintaining extremely low fares on its buses, which limited the private operators' ability to raise their own fares. In Santiago, the reforms brought about a dramatic expansion in public transport capacity, which was initially accompanied by large fare increases for some forms of transport, particularly buses, minibuses, and taxicabs. This occurred because these transport modes were subjected to a series of anticompetitive controls enforced by their very strong route associations. The problem was corrected through the introduction of a competitive bidding process that determines which buses will have the right to service downtown routes. As a result, bus fares in Santiago are currently determined by the market and are close to prices charged prior to deregulation.

While several lessons emerge from the cumulative international experience with privatization of urban bus operations, the most important by far is that the benefits depend critically on whether effective competition can be established and maintained in the industry. When competition exists, privatization can reduce costs and improve the quality of urban bus services; without competition, such reforms may bring little improvement and conceivably even degradation in service, as well as unwarranted increases in fares and excess capacity as route associations abuse their monopoly positions.

The prospects for effective competition among private bus operators are far greater in the developing than the developed countries. The striking feature of bus service and paratransit in the major cities of developing countries is the huge number of small private operators, at least where local governments have not severely restricted entry. Minibus service is usually provided by independent operators. Competition is often further enhanced because the minibus and standard bus operators compete not only with one another, but also with other kinds of shared-ride paratransit, including taxis, jitneys, motorized tricycles, cyclos, and rickshaws.

Although the competitive prospects are greater in developing countries, the public sector is still required to maintain or even create conditions that enhance or mimic competitive situations. Government entities can, unfortunately, be as much at fault in suppressing competition as route associations. Sometimes, governments involved in the management of large cities in the developing world are open to the notion of private conventional transportation at the same time they try to regulate market-based informal transit out of existence. Paratransit vehicles maneuver into areas where standard buses cannot go and provide frequent door-to-door service at a profit. Research indicates that the greatest variety of paratransit modes is found where there is the least amount of road

capacity per capita, and is more prevalent in cities with poor road hierarchies (Cervero, 1991). Given that paratransit addresses a clearly expressed market demand, and given the importance of the informal sector to the transportation sector's competitive environment, it is critical that governments not suppress informal transportation alternatives at the same time they try to privatize formal transport.

Other Opportunities

Privatization of other transportation services in developing countries is less common and more ambiguously successful than is true of urban bus privatization. For example, relatively few developing countries have tried to experiment with private road provision. In general, the experience of developing countries in this area illustrates two problematic issues in infrastructure privatization: the desire of the public sector to access private capital markets and the need to balance investor and user concerns in designing regulatory schemes. Developing countries are somewhat paradoxical in this respect. On the one hand, the argument that privatization might increase overall investment in the economy by providing access to new capital is more credible in developing countries because their capital markets are typically less sophisticated and integrated with world capital markets than is the case in industrialized nations. On the other hand, the regulatory environment is often uncertain and more risky in developing countries, making it difficult to attract new outside investors.

The Mexican Experience with Road Privatization

Mexico has a mixed record of success in road privatization despite devoting considerable resources and attention to the privatization of its federal toll road authority. Mexico had hoped to attract a great deal of new foreign private investment to the country by relying on build-operate-transfer schemes to create a nationwide system of toll roads. Build-operate-transfer agreements require the private firm or firms involved in a project to build and operate the service or facility for a fixed period of time and then transfer it to the public sector. Frequently, such arrangements require government guarantees or subsidies and have had mixed success, although they can also act as isolated arrangements allowing more flexible procurement and contracting in circumstances where a more general reform of public-sector arrangements is not possible. While the build-operate-transfer approach for very large-scale projects, as is now the vogue, is problematic because of the complicated assurances required by multiparty investment groups, it may represent a solution for more modestly sized transit systems.

In Mexico, build-operate-transfer agreements were created to furnish toll road infrastructure. As of 1995, however, only 3 of the 53 road concessions that had been bid out were actually functioning as commercial enterprises. The other 50 projects are being restructured in various ways to sort out problems associated with poor concession practices. As is true for many developing countries, Mexico faces special burdens in the area of medium- and long-term financing and investment instruments because its political and regulatory traditions are not as well developed or understood as those in industrialized countries, especially by foreign investors. Thus the places where access to capital markets might be most improved or enhanced through road privatization are also the places where the regulatory and political environment makes tapping new markets exceptionally challenging.

In Malaysia, the government has granted a concession for the construction of a major north-south highway, and the concessionaire is relying primarily on loans either directly from or guaranteed by the government. Since the government has limited credit on domestic and international capital markets, the concessionaire's road investments come at the expense of some other government-financed or -guaranteed investments. If the regulatory environment had been less risky, it might not have been necessary to induce private-sector participation through the use of government guarantees. Thailand seems to have done better than Malaysia, although its record is mixed as well. The private developer involved in the construction of a major expressway through Bangkok apparently made investments that provided the Thai economy with access to new capital; nonetheless, a good portion of the expressway was financed by the domestic capital market and not through greater reliance on external capital.

Developer Participation

Most developing-country cities do not apply beneficiary principles, and as a result basic infrastructure is often poorly and inadequately supplied. Within industrialized nations many of the newest urban areas, particularly in Hong Kong and the United States, rely on private developers to supply a substantial portion of urban infrastructure as part of private development projects. The developer is often required to pay not only for the cost of installing roads, sidewalks, water and sewage connections, and the like in a new development, but also for the additional marginal costs the development will impose on the current systems of transportation and other basic public infrastructure. Land impact fees, as these charges are called, often make up part of a mandatory developer contribution that must be paid into the coffers of the municipality before the development is approved. In most instances, these charges or the developer contributions are based on beneficiary principles.

Beneficiary principles can be applied in many different forms. For example, in some settings, urban areas have relied on betterment taxes, which tax residents who benefit from a particular public investment, such as a new road or public transit system, by an amount proportional to the benefit they receive. Often the benefit is based on the amount of appreciation a residence or business is estimated to have undergone as a result of the public expenditure or investment. Other urban areas, primarily in Asia, have used land consolidation schemes to recoup some of the expenses associated with public infrastructure investment. Land consolidation requires that individual property owners give up a small portion of their land to the public sector in recompense for the benefit they receive from the development of their rural property into urban land supplied with adequate infrastructure.

LINKAGE OF LAND-USE PLANNING AND TRANSPORTATION INVESTMENT

The relationship between land use and transportation is a key factor in understanding the nature and evolution of urban spaces and, as such, has extremely important policy

implications for megacities. Indeed, a strong linkage between the two can help avoid many of the problems of urban motorized transport that necessitate the other measures discussed in this paper. Transportation investments are among the largest of public investments, and their anticipated impacts play a key role in the both the current and future development within a city. Yet in many megacities, particularly those in the developing world, there is a distinct lack of linkage between land-use planning and the existing or even planned transportation systems.

Institutional weaknesses are a probable cause of the poor linkages between land use and transportation policy in many megacities. Some megacity governments lack the legal and fiscal capacity to guide urban development through transportation investments. In Bangkok, for example, it used to take up to 7 years to expropriate land legally for a transportation investment as common as an extension of a distributor road (Daniere, 1995). Others lack adequately trained staff or the support of policymakers to actually implement urban land-use plans in the face of rapid economic growth. As such, any improvements in the linkages between land use and transportation policy will most likely need to be preceded by institution strengthening, as well as legal reforms.

Consequences of Poor Linkage

The rapid growth of urban populations, coupled with limited land-use and transportation planning, is responsible for a number of important inefficiencies, including the loss of land through hopscotch development, ribbon development along major urban highways, and extensive unplanned road systems. Urban sprawl increases the cost of all infrastructure, including transportation, and decreases the positive economic gains associated with the agglomeration economies of urban areas.

Weak linkage between land use and transportation is also strongly related to increased congestion within the city center. Congestion in megacities is particularly burdensome for the poor, who often spend 3 or 4 hours a day commuting to their place of employment from homes located in relatively inaccessible parts of the city to or through an increasingly congested city center. On average, households in large urban areas of developing countries devote up to 10 percent of their urban household income on transport. Low-income households often spend even more; in the Saket residential area of New Delhi, for example, low-income groups spend as much as 15 percent of their total income on transportation (World Bank, 1986). Land-use planning to reduce trip lengths can help minimize increases in vehicle miles traveled, thus improving productivity, decreasing the costs of commuting and fuel consumption, and improving the health of urban residents.

Opportunities for Improved Linkage

A number of observers argue that many transportation problems in the future will be alleviated by the current revolution in telecommunications and information technology. Improved telecommunications has the potential to allow megacities to leapfrog certain infrastructure developments that were required in the West. In particular, megacities may be able to invest in fiber optics at the expense of public roads, highway, and transit, and still compete effectively in the global economy. Others have argued that the telecommunications revolution may well result in increased urban sprawl, raising the costs of urban transportation infrastructure, because people will be less limited in their choice of location than in the past and choose to locate their homes in increasingly remote places.

Presently, the potential impact of telecommunications and information technology on transportation systems is speculative at best. What is much more certain is that in the next 10 years, megacities will become swamped by the use of private automobiles and that most urban residents will remain poor. Transportation policy must be based, at least in the short run, on these two realities. This is not to suggest that the potential impacts of telecommunications should be ignored by policymakers in developing-country megacities, but rather that those impacts should be considered as part of all housing, employment, and transportation strategies that include an element of telecommunications. In addition, land-use plans can be designed to accommodate advances in technology as they become viable and affordable, particularly in terms of impact on transportation needs.

Planning, which includes consideration of low-income housing, roads, public transit, and potential employment sites in advance of private-sector-led initiatives, also represents a potential long-run improvement in urban form. For example, research by Maunders in India suggests that restructuring land use by locating the place of work as close as possible to the workers' residences (or vice versa) could lead to a 30 percent reduction in the number of trips by bus and more than a 100 percent increase in trips by bicycle and walking. Improved land-use patterns can thus enhance some of the basic objectives of governmental policy, including improving both productivity and environmental conditions.

In some urban areas, the central business district has faded from overall importance in urban activity. As people move from the city to the outskirts, many jobs, industries, and shopping centers follow the migration, leading to completely new living environments and travel patterns. Indeed, some of the most recently formed urban areas have bypassed the formation of a traditional central business district; instead, these areas comprise a series of small-scale urban centers linked by roads that shuttle people and goods. The new trip patterns evolving from these decentralized urban areas have often overwhelmed existing transport networks designed for traditional central business district commutes.

Although dispersed urban forms can result in new and complex traffic congestion problems, they offer the opportunity to create highly transport-efficient communities. If multiple-center, polynucleated urban areas comprise mixed land uses at relative high

densities, walking/bicycling for short trips and mass transit for longer trips can become the major travel modes. Planners and analysts suggest that such urban structures, if planned in conjunction with public transport, housing, and labor markets, as well as the established characteristics of the existing urban area, can strengthen regional employment centers and reinforce commuting patterns supportive of mass transit (Haines, 1986). Megacities, in particular, could be guided by or planned with a polynucleated urban structure, with each nucleus as a self-sufficient center and clearly emphasized satellite centers as the nodes in the public transport system. Land-use planning and density patterns affect not only the travel mode people choose, but also their travel habits. Research suggests, for example, that people traveling to and from higher-density mixed-use areas tend to spread out their trips over the entire day, thereby minimizing peak traffic periods, more than people traveling to and from homogeneous employment centers or housing suburbs (Replogle, 1991).

A polynucleated system concentrates travel demand and facilities high-capacity modes of transportation. In addition, planned polynucleated urban centers can lead to more efficient land development because this form facilitates access to rapid transit. Few cities in the developed, let alone developing, world have been successful at implementing planned polynucleation, but the first step in such a process is to acquire the legal and fiscal authority to acquire land in advance of urbanization. A project in Bangkok, Thailand, for example, has resulted in significant strengthening of the agencies charged with land-use planning and the planned purchase of land for the development of transit-based transport systems, as well as a new urban center (Hack, 1994). Notwithstanding recent successes in Thailand, planned polynucleation is probably more achievable in countries where there is a high degree of civic discipline, such as Singapore or China. It has been quite difficult, for example, to implement such schemes in industrialized nations despite the widely recognized benefits associated with managed growth, mixed-use zoning, and greater reliance on public transit.

Linking land use and transportation investments may, in the long run, also alleviate the air pollution experienced in many megacities. There is no doubt that the use of motorized vehicles in megacities of the developing world will continue to grow rapidly. Evidence suggests that even if megacities are able to provide efficient and convenient public transportation service, private automobiles will eventually prove to be the least costly alternative for many individual households.¹⁰ Simply relying on technological improvements to solve the problem of air pollution in urban areas is probably naive, and thus there is all the more reason to rely on good prevention rather than a good cure.

The industrialized nations have generally chosen to address the problem of transport-related air pollution very late in the process, when pollutant concentrations have reached

¹⁰ Baumol (1986) argues that as the cost of labor increases as a result of economic development, the cost of labor-intensive activities, such as transportation, becomes very high. Consumers come to prefer substituting their own labor in the provision of transportation services, and the private automobile offers them this opportunity. Private transport thus has major economic and service advantages because it does not require hired labor, and this means it will play an increasingly important role even in countries that are currently relatively nonmotorized.

intolerable levels for the urban population. By this time, the existing land-use patterns and the modal dominance of the automobile are difficult to undo or even influence. A cost-effective and long-term strategy for the megacities of the future involves identifying and implementing policies and measures designed to manage the process of motorization and its associated environmental impacts. Such a strategy must pay substantially greater attention to preventive actions, such as strategic land-use planning, as well as to the appropriate pricing of different transportation modes (as discussed earlier). Curitiba, Brazil offers a well-known example of the successful implementation of a strategy linking land-use planning and transportation investment with the intent of minimizing the congestion and air pollution associated with economic growth and urban expansion (Cervero, 1995; Rabinovitch and Hoehn, 1995).

MULTIMODAL TRANSPORTATION SYSTEMS

One way to avoid the problems associated with motorized transport is to foster the use of nonmotorized modes. As noted earlier, developing countries have a greater prevalence and range of nonmotorized transport than do industrialized countries. This is attributable to differences in income, as well as deficiencies in the transit services available in large cities of the developing world (Shimazaki et al., 1994). Nonetheless, many large cities in the industrialized world are seeking ways to encourage commuters and others to walk and bicycle more frequently. Ironically, many developing countries have implemented policies that encourage motorized transport, or even prohibit certain nonmotorized modes.

Importance of Nonmotorized Transport

While a much higher percentage of the population relies on nonmotorized transport in the developing than in the developed countries, it is also true that the prevalence and use of nonmotorized transport differ almost as much across the spectrum of developing countries. In particular, nonmotorized transportation, including walking, bicycles, cycle-rickshaws, and carts, plays a major role in the urban transportation systems of many Asian countries. Nonmotorized vehicles, for example, account for 25 to 80 percent of vehicle trips in many Asian cities, particularly in China, India, and Indonesia (Replogle, 1992). As Table 1 indicates, the average number of bicycles per 1000 people in Tianjin, China, was 530 in 1987, compared with only 163 in India and 35 in Jakarta in 1985. In addition, as shown in Table 2, the percentage of person trips that rely on nonmotorized vehicles in Asian cities varies from a high of 65 percent in Shenyang, China (in 1984) to a low of 8 percent in Kathmandu, Nepal (in 1987). As of 1991, nonmotorized vehicles made up 90 percent of all the vehicles in Hanoi, Viet Nam, while a mere 53.5 percent of all vehicles are nonmotorized in Phnom Penh, Cambodia (Bell and Kuranami, 1994). A recent United Nations survey shows that in several large cities in Africa, walking accounts for at least half of all trips, and bicycles make up more 70 percent of all vehicles owned by the population (Philpott, 1994). Although in comparative terms, bicycles and tricycles are far less common in many parts of

TABLE 1 Vehicles in Selected Cities and Counties (Replogle 1992)

City	Year	Bicycles (X1000)	Cycle- Rickshaws (X1000)	Motor Vehicles (X1000)	Population (X1000)	Bicycles Per 1000 Residents	Motor Vehicles per 1000
China	1988	300,000	500	1,200	1,104,000	272	1
Beijing	1982	3,773	na	na	9,231	410	na
Tianjin	1982	3,228	na	na	7,764	420	na
Tianjin	1987	4,500	na	na	8,500	530	na
Shanghai	1980	1,700	na	80	na	152	7
Shanghai	1982	2,243	na	na	11,860	200	na
Shanghai	1988	5,600	na	200	12,400	445	12
India	1985	45,000	1,700	1,500	765,000	59	2
Bangalore	1981	322	na	na	2,900	111	38
Bombay	1981	984	na	na	8,200	120	11
Delhi	1981	945	7	na	5,800	163	54
Hyderabad	1979	800	14	na	2,200	360	na
Jaipur	1979	150	9	na	900	180	na
Madras	1979	272	6	na	4,000	68	16
Indonesia	1985	na	200	na	na	100	na
Jakarta	1985	na	65	na	na	35	na
Serang	1983	10	na	3	112	89	29*
Tasikmalaya	1983	16	na	17	159	101	106*
Cirebon	1983	10	na	4	275	35	18*
Surabaya	1976	200	42	144	2,300	na	na
Yogyakarta	1975	44	6	34	400	na	na
Bangladesh	1982	1,500	633	250	na	na	na
South Korea	1982	6,000	na	na	39,000	154	na
Thailand	1982	2,500	15	400	49,000	51	53
Thailand	1988	na	na	6,300	na	na	116
Malaysia	1982	2,500	na	900	14,000	179	64
Japan	1988	1,500	na	250	na	na	na
Netherlands	1985	11,000	na	4,900	14,000	786	350
United States	1988	103,000	na	139,000	245,000	420	567

*Includes motorcycles and cars only. Otherwise includes all motor vehicles.

TABLE 2 Percentage of Person Trips by Various Travel Modes (Replogle 1992)

City	Year	Walk	Bicycle & NMV	Bus & Rail	Motor- cycle	Auto- mobile	Other	Total
Australia								
Melbourne	1979	19	2	13	--	64	2	100
China								
Tianjin	1987	50	41	9	0	0	0	100
Shenyang	1984	10	65	25	0	0	0	100
Shanghai	1986	38	33	26	--	3	--	100
India								
Kanpur	1977	72	24	0	3	1	0	100
Ahmedabad	1981	43	20	29	6	1	1	100
Bangalore	1984	44	12	36	6	2	0	100
Delhi	1981	29	18	40				100
Bombay	1981	15	11	58	1	8	7	100
Indonesia								
Bandung	1976	40	16					100
Surabaya	1984	20	25	13	26	9	7	100
Jakarta	1984	23	17	25	13	8	14	100
Nepal								
Kathmandu	1987	56	8	16			6	100
Japan								
Tokyo	1988			28	**	27	0	100
Okayama	1982	23	30	7	**	39	1	100
Matsuyama	1982	27	23	12	**	34	4	100

Notes: **Small amount included with bike, NMV category
 --Data not available or included in other categories

Latin America, the Caribbean, and Africa, there are opportunities for the transfer of these modes between Asia and those regions.

Most cities in the developing world make investments that emphasize the car and conventional means of public transportation, such as buses and metros, over nonmotorized or nonwestern means of public/private transportation. Indeed, despite the critical role played by nonmotorized transport modes in many cities, some governments have imposed constraints on nonmotorized vehicles, particularly cycle-rickshaws, claiming that they cause congestion, unfairly exploit human labor, or represent backwardness. In Jakarta, for example, authorities have seized some 100,000 cycle-rickshaws in the past 5 years, dumping at least 35,000 into Jakarta Bay as they seek to eliminate these vehicles from the city. Such strategies can reduce economic efficiency in that motorized transport is more expensive than nonmotorized modes, causes more environmental damage, and is associated with undesirable urban forms. For a given amount of road space, for example, the most efficient modes of transportation are generally rail or buses operating on their own dedicated rights of way. The least efficient use of road space is low-occupancy private cars. Bicycles fall in between this range, with road space use approaching that of buses in mixed traffic.¹¹ Moreover, these strategies ignore the role that paratransit modes, such as cycle-rickshaws and tricycles, can play in alleviating the deficiencies of modern bus and rail services. Furthermore, cities with a full variety of modes, such as Jakarta, Indonesia, are likely to have better mobility than those, such as Cairo, Egypt, where some modes are systematically excluded.

Eliminating the diversity of transport options reduces economic efficiency by forcing the movement of people or goods to conform to a few higher-cost modes, rather than allowing choice of the most appropriate and affordable means. A transportation system in which a variety of modes function within a regulated but competitive market can serve different market niches more effectively than a system that has been forced to rely on one or two modes (Cervero, 1991; Replogle, 1991).

In addition, maintaining diversity in the paratransit sector is crucial to maintaining good mobility for the poor. The choice of transportation mode in developing-country cities is very sensitive to income. While most people prefer private transport to public and motorized to nonmotorized, even a bicycle, the least expensive form of mechanized transport, is beyond the means of most in many cities. In Delhi, India, for example, 65 percent of the people living in squatter areas walk to work, while only 10 percent of low-income and 3 percent of middle-income workers rely on walking. Furthermore, the average walking and cycling trip in developing countries is five times longer than in developed countries (Gwilliam, 1995). The high level of dependence of the very poor on nonmotorized transport implies that one of the best ways to improve their quality of life is to invest in the nonmotorized transport sector.

¹¹ These estimates are obviously subject to substantial variation in different cities and towns, depending on vehicle occupancy, level of traffic congestion and traffic mix, topography, frequency of public transportation stops, quality of the track or road surface, and other factors.

For most poor households, walking accounts for the majority of all trips because when incomes are low, the value of time relative to cost for travelers is low as well. Although walking is free, it takes too much time for all but the shortest trips, and the poor must use either public transportation or bicycle for longer trips. Typically, a bicycle that will last at least 10 years costs the equivalent of 6 or 8 months of bus fare. Thus for the poor, particularly in Asia, but in other areas as well, increases in personal mobility are most commonly expressed in expanded use of bicycles and nonmotorized transport. Increased mobility for goods movement and the transportation of children and family also often relies on the greater use of cycle-rickshaws, where they are available.

It is not only low-income urban residents who rely on bicycles, however. The travel time and convenience offered by the bicycle attracts people of all income levels to bicycles in many cities, particularly those in which measures are taken to facilitate cycling. As traffic congestion in Asian cities increases and the schedule reliability and average travel speeds of public motorized transport both decrease, bicycles become a more competitive mode for longer trips because of their flexibility, convenience, and greater reliability.

While there is relatively little knowledge or expertise among transportation experts in North America about how to plan for the traffic problems posed by multimodal transport, a number of industrialized countries have had a great deal of success in combining motorized and nonmotorized transportation modes. Cities in Japan, The Netherlands, and Germany demonstrate that modern urban transportation does not necessarily require total motorization, but rather the appropriate integration of walking, nonmotorized transport, and motorized transport. In Holland, for example, bicycles account for 30 percent of all urban passenger transport and walking for another 18.4 percent (Pucher, 1988).

Multimodal Transportation Strategies

Determining the most efficient modal mix for a city requires consideration of a host of variables, including income levels, the value of time, and the price and speed of various transportation modes, as well as the externalities related to transportation. Given the wide variation in these factors, multimodal transportation strategies must be customized for different types of cities and should be an integral part of both transportation and urban development planning and policy.

One way to accommodate different modes of transportation within roads is to allocate scarce road space more efficiently. In most travel corridors, demand for transport services comprises different trip lengths, implying that a complementary combination of modes should be accommodated to meet the needs of diverse travel markets. When road space is scarce, as in most megacities, traffic management should be the first step in dealing with traffic congestion problems. As discussed earlier, improved traffic management can include such measures as restricting turns at intersections and introducing one-way street systems.

The segregation of different modes of transportation can result in even greater system efficiency. Experience in Chinese cities suggests that motorized and nonmotorized lanes must be physically separated because otherwise the conflicts at intersections become insurmountable. If street space is insufficient to accommodate demand even with separation, it is often possible to dedicate different streets to different modes and to impose or expand restrictions on private automobiles. Even in cities where streets are generally congested, it is often possible to find underused street space; an example is the use of alleys in Shanghai to provide right-of-way for a bicycle network.

The design of transportation facilities can greatly affect traffic safety. Segregating slow- from fast-moving traffic, designing intersections to maintain good sight distances and reduce turning conflicts, and channeling traffic to enhance flow predictability can all improve safety and operational performance (Thom and Clayton, 1992). On the other hand, poorly designed and improperly maintained separate cycle facilities can increase safety problems, particularly in instances where numerous intersections or driveways cross the cycling paths and sight distances are poor. In some countries, design standards from highly motorized countries have been implemented without being tailored to local traffic conditions and have contributed to the dangerous driving conditions.

Use of bicycles in combination with public motorized transportation can also be effective, as in Japan and China. To reduce long-distance commuting by bicycle and free up congested road space, the Chinese have established bicycle-subway and bicycle-bus exchange hubs in Beijing and other cities. Bicycle access to trains is also important in India, where many hundreds of bicycles can be seen at some stations. Bicycle access to public transit expands the catchment area of high-speed public transportation at a very low cost and represents the most valuable potential function of nonmotorized vehicles in megacities where average trip lengths are long. Integration of bicycles with public transportation is also an important strategy for sustaining nonmotorized and public transport mode shares in rapidly motorizing cities with mixed-traffic systems.

Regulations and policies, including taxes and import duties, fuel taxes, vehicle registration and licensing fees, and credit financing systems for vehicle purchase, have a major influence on the cost and availability of various transportation modes. Frequently, import duties favor motorized transport. In Bangladesh, for example, the government has discouraged the importation of bicycles to protect local bicycle manufacturers while offering concessions to private car buyers. In 1989, the tax rate on imported bicycles was about 150 percent, while motor vehicles faced tariffs of only 5 to 50 percent. Such stiff protectionist measures have the effect of increasing bicycle costs significantly while failing to create viable automotive industries.

On the other hand, a number of countries have implemented projects that assist low-income households in purchasing or acquiring nonmotorized vehicles. As noted above, bicycles and other nonmotorized modes remain prohibitively expensive in much of the world despite their relatively low cost. The average cost of a bicycle in West Africa, for example,

is approximately 60,000 CFA or US \$120 (assuming US \$1 = 500 CFA), depending on the model and import taxes levied (Philpott, 1994). A domestic servant in Senegal earns approximately 500 to 1000 CFA a day and undoubtedly finds it very difficult to save enough to purchase a bicycle without some form of assistance.

The World Bank has sponsored a project in Lima, Peru, that has resulted in the construction of bicycle lanes in downtown roads and involves lending money to individuals to buy bicycles. In Santo Domingo, Dominican Republic, a credit union of tricloeros helped finance vehicle purchases and a tricycle assembly workshop. In Hyderabad, India, commercial banks are encouraged to lend money to cycle-rickshaw operators for the purchase of vehicles (World Bank, 1990). These programs represent a way to increase the mobility of the poor quickly and effectively as long as they are accompanied by transportation designs that accommodate multiple transportation modes. Credit arrangements based on such successful models could be designed and promoted by researchers in the industrialized nations.

Recent research has shown that long- and short-term transportation strategies will differ depending on the city's stage of development and regional location (Dimitriou, 1993). Transportation system management strategies should be developed with consideration of appropriate choices of modal mix for various population groups and different planning horizons. These strategies should also include nontransport planning to reduce trips and trip lengths, increase energy efficiency, and retain environment-friendly transportation systems. A sample transportation system management model indicating appropriate policy and investment strategies over a 20-year time frame has been developed, which takes into account city size and degree of motorization (Pendakur, 1992). Although this model was developed for China, it is generally applicable to a wide class of low-income countries.

DISSEMINATION OF KNOWLEDGE AND TECHNOLOGY ADVANCES

In addition to the various options discussed throughout this paper, an essential element in improving megacity transportation systems is the dissemination of knowledge and recent advances in research and technology. There has been great progress in both technology and implementation of transportation policy that could, if adopted by national and municipal governments, dramatically affect the transportation situation in many large cities. One impediment to better dissemination of knowledge in the field of transportation is a lack of institutions to promote international research and share the findings of such research with practitioners and policymakers.

The United States has a successful record in disseminating knowledge and setting operational and safety standards within the transportation sector. The U.S. Department of Transportation and its predecessor agencies have played a key role in sponsoring the development of transportation-related technologies and planning techniques and in standardizing technologies and evaluations, and have also been able to insist upon the general

use of their successful innovations. The Transportation Research Board, one arm of the U.S. National Academy of Sciences (NAS), is charged with responsibility for advising the U.S. government on major transportation policies and issues. In addition, it serves as a transportation research management and information service, with the objective of producing reports that disseminate transportation research results and technology worldwide, address major national transportation policy issues, and analyze research needs. Much of the board's actual work is accomplished through the volunteer efforts of experts in the field and academia who actively participate in forums for the exchange of information with their peers.

Organizations such as the NAS and its research bodies represent a valued and independent advisor to government and the private sector on matters of science and technology. Given that most of the megacities of the future will be in the developing world, it is inevitable that many of the most problematic transportation situations, as well as promising innovations, will occur in developing countries. Thus, it is vital that developing nations look toward the development of counterpart universities and research organizations to focus on their own national policies and agendas. It is just as important for universities, governments, and research organization to sponsor research by academics from industrialized countries on developing-country transportation issues. In this connection, it may be noted that the developed world has much to learn from developing countries, such as how to integrate commercial and residential activities more closely or how to better integrate a richer variety of transport modes, and opportunities to study these successes are few and far between. Transportation policy in the industrialized nations has a mixed record of success and failure. One can argue, however, that the developed world has been relatively successful at sharing information between scientists and researchers at universities, policymakers, and the private sector.

SUMMARY AND CONCLUSIONS

Many more urban residents of developing-country megacities rely on nonpolluting technologies to reach their destinations, are served by a far richer range of both motorized and nonmotorized vehicles, and are less reliant on public subsidies for transit than is true of their counterparts in the West. In addition, the integration of commercial, industrial, and residential activity in many developing-country cities is extremely high and might be envied by many a North American city.

Nonetheless, for a number of reasons, megacities in the developing world face an immediate crisis in dealing with rapid motorization. This paper thus draws on transportation lessons learned more generally from both developing and developed countries that point to options and strategies appropriate to the urban landscapes of megacities. There are several key lessons or themes that can be drawn from the analysis presented here.

1. Congestion in developing-country cities can be ameliorated in the short run through the comprehensive implementation of traffic and demand management strategies.

Developed nations have been quite successful at implementing some aspects of these strategies, such as improved road signs and traffic signals, enforcement, and education, but have been less successful at demand management, particularly in the case of private automobiles. As a result, the flow of traffic in developed countries, while relatively smooth and reliable, is associated with unnecessary urban sprawl and a higher reliance on the automobile than might be warranted.

2. Health dangers posed by motorized vehicles in developing-country megacities are severe and of larger magnitude than those in many industrialized nations. The environmental cost of widespread reliance on private automobiles is a lesson developed countries have learned quite late in the motorization process. It is an experience that does not necessarily have to be repeated in the developing world, where fuels can be cleaner, technologies can be adopted earlier on in the process, and fuels and roads can be priced according to the environmental costs they impose.

3. Megacities should begin to rely more on market mechanisms to provide signals about the need for transportation investments, and these facilities should be commercialized to the greatest extent possible and with the participation of the private sector. Private financing and management can better ensure that services are priced at their full cost, thereby minimizing capital and operating costs and giving proper market signals for capacity expansion. Key to the successful inclusion of the private sector have been public practices to ensure fair and adequate competition in bidding for new facilities and for the management or operation of existing facilities.

4. Better land-use planning is an imperative for most of the world's megacities. It is particularly crucial in the context of developing countries because urbanization is occurring so rapidly and with so little guidance in these settings. An example of guidance through land-use planning is provision for a regional polynucleated development pattern, with relatively high-density outlying nodes connected to the center by high-capacity road and bus service. Such a strategy can reduce land consumption while accommodating reduced population densities at levels high enough to support mass transit.

5. The number and variety of transport modes observed in developing-country megacities present both different problems and opportunities than the modes prevalent in industrialized nations. One cause of the extreme diversity in modal choice in developing countries is income; because much of the population is unable to afford private or motorized transport, walking and other means of nonmotorized transport need to be an integral and key part of transportation policies and investment strategies in the developing world. Traffic systems must also be accommodating of typically unregulated transit modes such as rickshaws, becaks, and jeepneys because in many cities, such modes represent a significant share of passengers. Planning for efficient multimodal transport is difficult for both institutional and systemic reasons, but some cities have made important contributions to multimodal integration through single-fare arrangements and compatible scheduling between pairs of modes. In addition, the inhabitants of developing-country cities are generally more reliant on less-polluting modes, and building on this history represents a distinct advantage in terms of the environmental costs of future development.

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