The World Bank, Transport, and The Environment

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Transport is central to development. Without physical access to jobs, health, education and other amenities, the quality of life suffers; without physical access to resources and markets, growth stagnates and poverty cannot be reduced. Inappropriately designed transport strategies and programs, however, can result in networks that aggravate the condition of the poor, harm the environment, ignore the changing needs of users, and exceed the capacity of public finance.[1]

Introduction

Since the beginning of the World Bank, transport lending has totaled US$60 billion, of which 25% went to railway. Today, transport accounts for 16% of Bank lending: within transport, 60% goes to highways, 15% to rail and ports, 15% to urban transport, and 10% to various other projects.

The Bank's transport portfolio has been successful, with an average economic rate of return of about 22%—half again above the average for all projects. This relative success results from an evolving approach as problems have emerged. For example, highway lending now focuses on maintenance rather than new construction because inadequate maintenance caused many countries to lose highway capacity. Likewise, Bank lending to railways has been shifted from physical investment to a focus on the railway as an institution.[2]

When the rebuilding of Western Europe after World War II was nearing completion, the Bank's lending shifted to developing countries, but the focus remained on infrastructure. With increasing experience in developing countries, the Bank realized that the effectiveness of institutions was as vital as the assets they managed; this led the Bank to focus on management, and on achieving a better balance between the policy role of the public sector and the management capability of the private sector. The Bank now recognizes three equally important dimensions to development: economic and financial sustainability, environmental sustainability, and social sustainability.

'Economic and financial sustainability requires that resources be used efficiently and that assets be maintained properly. Environmental and ecological sustainability requires that the external effects of transport be taken into account fully when public or private decisions are made that determine future development. Social sustainability requires that the benefits of improved transport reach all sections of the community.'[3]

Implementing these three objectives has led to development of tools to be used in balancing, or trading off, the benefits and costs of project components. For example, imagine the tradeoff between environment and economics in the use of catalytic converters on autos; converters reduce local air pollution emissions, but they can also reduce fuel efficiency. As another example, the poor tend to own the oldest autos which cause the most pollution. Are they to have their mobility taken away in order to reduce air pollution? Acknowledging the difficulty of the tradeoffs, how can we even be sure we have identified, much less quantified, all of the economic, environmental and social aspects of a potential project?

The Bank uses Impact Assessments to ensure that the impacts of projects are identified, quantified where possible, and compared among themselves. Today, most projects are subjected to at least a partial assessment and '...most Bank-assisted projects now avoid doing direct harm to the environment.... Furthermore, more and more transport projects, or project components, are focusing positively on improving the environment, rather than simply avoiding environmental harm.'[4]

In these assessments, the distinction between environment and social is not entirely clear. Air pollution is an environmental issue, but when it impacts disproportionately on the poor, it has social dimensions. Construction of a metro that primarily serves wealthy neighborhoods may not contribute to social sustainability, even though it may get people out of their automobiles and reduce air pollution. As a result, the Bank tries to look at all im-

Power station in Ulan Bator, Mongolia (K. Fukuma) pacts without being limited by precise distinctions.

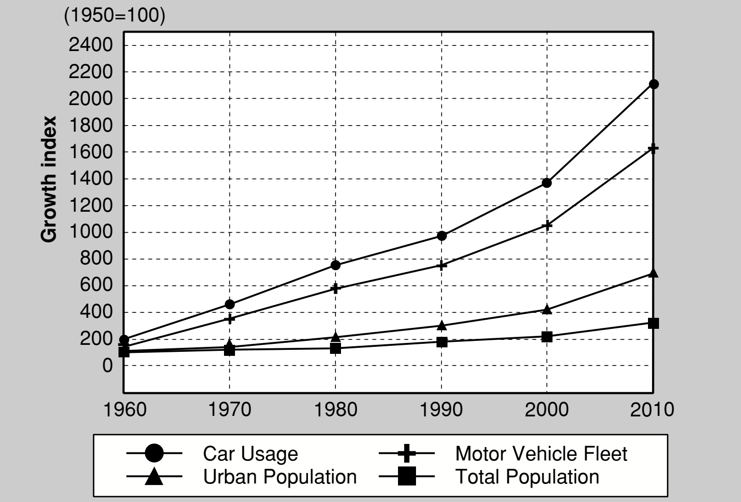
Transport and The Environment

Environmental impacts of transport can include emission of a myriad of materials (suspended particulate matter (SPM), oxides of nitrogen (NO_X), oxides of sulfur (SO_X), carbon dioxide (CO_2), ozone and lead), noise and congestion effects, traffic deaths, and inadequate access for the poor or handicapped, to name a few. For simplicity these can be grouped into five categories: localized air pollution, global air emissions, space/noise/amenities, physical safety, and social issues.

Localized air pollution

Localized air pollution is one impact of transport that will become rapidly worse. Urbanization is accelerating faster than the underlying growth in total population. Estimates indicate that the world's stock of cities larger than 1 million people will grow rapidly and most will be in developing countries. Unfortunately, the impact of urbanization is multiplied by motorization and the universal trend to own motor vehicles. Worse, motorization in developing countries is aggravated by outdated technology, which is especially polluting and energy inefficient. The result is more and more people in urbanized areas, and each person is generating more pollution. Figure 1 illustrates this phenomenon. Figure 2 contains a recent tabulation from the World Health Organization (WHO) showing 19 major cities with pollution measurements in six categories: carbon monoxide (CO), nitrogen dioxide (NO_2), lead, SPM, sulfur dioxide (SO_2) and ozone. Of these, none of the four OECD cities significantly exceeded WHO guidelines, whereas 11 of the 15 developing cities far exceeded the guidelines, 6 of them in two or more categories.

Figure 1 World Growth Trend Since 1950



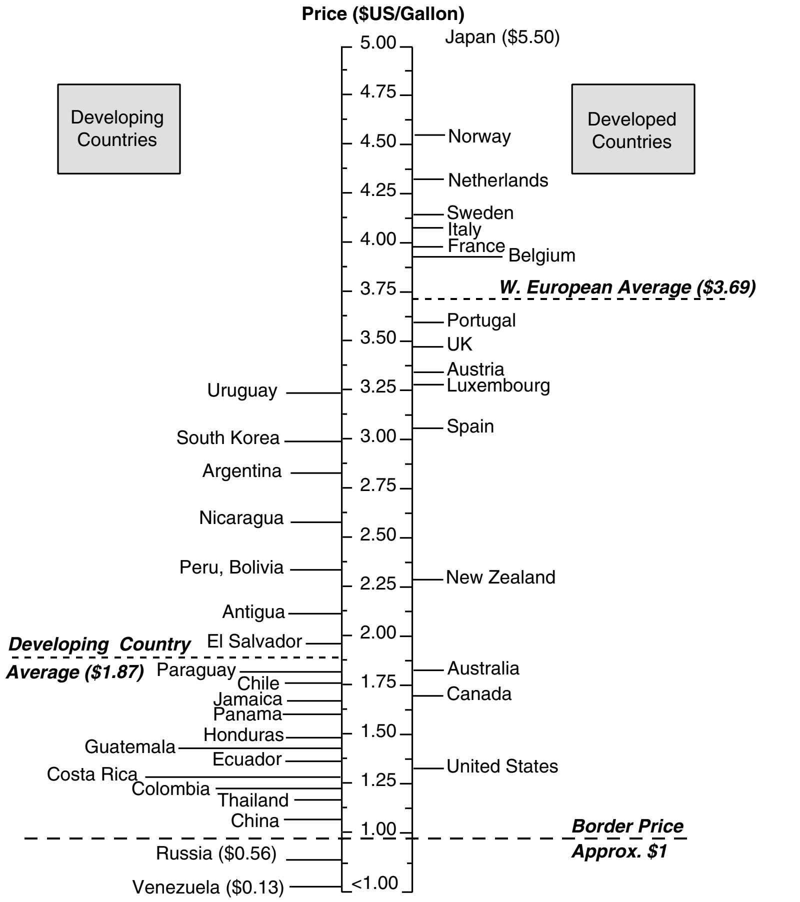
Source: A. Faiz. Automotive Emissions in Developing Countries—Relative Implications for Global Warming, Acidification, and Urban Air Quality. Transportation Research 27A (3): pp. 67–186, 1993.

Figure 2 Air Pollution in Major Cities

Cities	Pollutants: CO	NO_2	Lead	SPM	SO_2	Ozone
OECD						
London	Moderate	Low	Low	Low	Low	Low
Los Angeles	Moderate	Moderate	Low	Moderate	Low	Low
New York	Moderate	Low	Low	Low	Low	Low
Tokyo	Low	Low	?	Low	Low	Low
East Asia						
Seoul	Low	Low	High	High	High	Low
Beijing	?	Low	Low	High	High	Moderate
Jakarta	Moderate	Low	Moderate	High	Low	Moderate
Bangkok	Low	Low	Moderate	High	Low	Low
Manila	?	?	Moderate	High	Low	?
South Asia						
Karachi	?	?	High	High	Low	?
Bombay	Low	Low	Low	High	Low	?
Delhi	Low	Low	Low	High	Low	?
Latin America						
Mexico City	High	Moderate	Moderate	High	High	Low
Sao Paulo	Moderate	Moderate	Low	Moderate	Low	Low
Buenos Aires	Low	Low	Low	Moderate	?	?
Central Asia, Africa & Europe						
Tehran	High	Moderate	High	High	Moderate	Moderate
Cairo	?	?	High	High	?	?
Lagos	High	?	Moderate	Moderate	Low	?
Moscow	Moderate	Moderate	Low	Moderate	?	?

● High pollution	WHO guidelines are normally met (short-term guidelines may be exceeded occasionally).
● Moderate pollution	WHO guidelines exceeded by up to a factor of two (short-term guidelines exceeded on a regular basis at certain locations).
○ Low pollution	WHO guidelines exceeded by more than a factor of two.
? No data available	

Figure 3 Gasoline Pump Price



*Notes: * One US gallon = approx. 3.8 liters*
** Border Price means price at the border after shipping, but before import duties and taxes.*

Transport is an important emitter in many urban centers, accounting for 90% to 95% of lead and CO, 60% to 70% of hydrocarbons (HC) and NO_X, and over half of SPM. Transport emissions are almost wholly from motor vehicles, of which the automobile is the largest source, though uncontrolled buses and two-stroke motorcycles and three-wheelers can be major emitters in local cases.

There are several ways to deal with transport-caused urban air pollution. The first is better technology and fuels. Replacing two-stroke engines with four-stroke engines can dramatically reduce SPM emissions and smoke. Better engine design and catalytic converters have reduced the emissions from individual autos in the U.S. to well less than 5% of the levels prevailing in the 1960s. Compressed gas fuels have greatly reduced the emissions from 3-wheelers in Bangkok. Oxygenated fuels can reduce auto emissions during colder seasons. Overall, most of the progress to date in reducing urban pollution has been accomplished by better technology and fuels.

Another approach is getting people to drive less, or more efficiently, through pricing or physical restriction. Figure 3 shows the pump price of gasoline in a number of countries. Clearly, people in Japan face high fuel prices. Interestingly, developing countries (and the U.S.) have made much less use of pricing than developed countries. When combined with restrictions such as parking limitations or fees, or limits on access to central cities, this approach has worked in Europe, and offers promise in many developing cities.

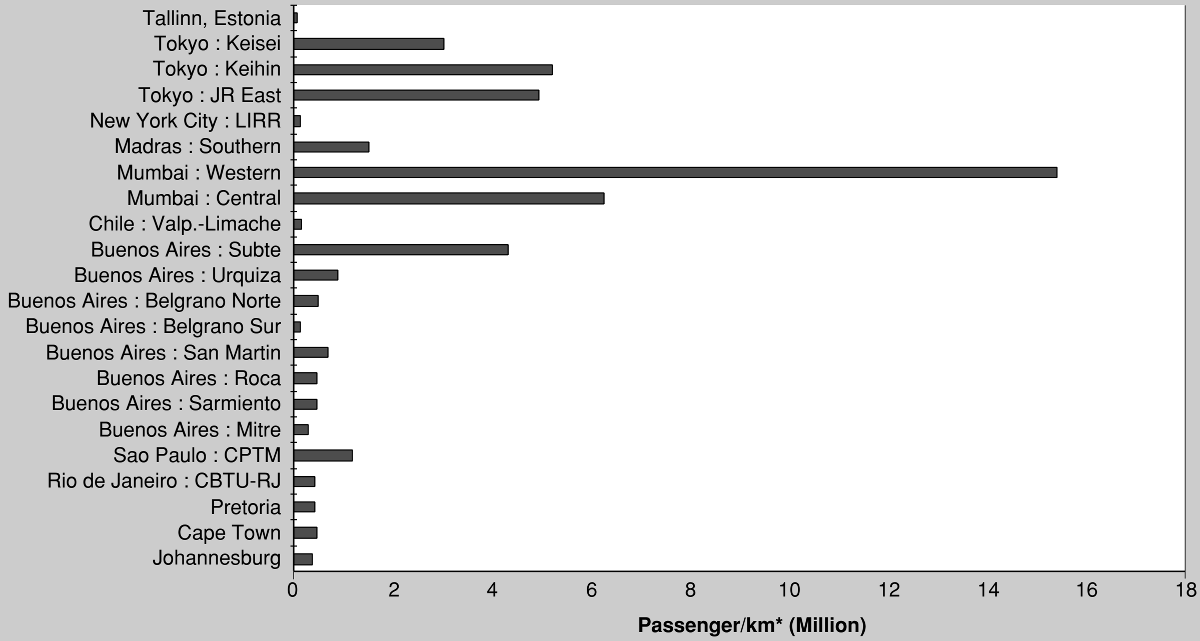
A third approach, best used in conjunction with higher prices and physical restrictions, is getting people to switch modes by offering mass transit. For example, buses can carry medium levels of passenger loads effectively and cheaply. The bus system of Curitiba, Brazil, uses exclusive busways to carry large numbers of passengers effectively and with very little impact on the urban environment. Unfortunately, though, poorly maintained buses can themselves be serious generators of pollution, and the kind of pollution buses generate (very fine SPMs) now appears to be particularly dangerous.

Where the application is appropriate, the Bank supports urban rail passenger transport because it can have significant environmental advantages. Electrified railways can carry the largest volumes of passengers of any mass transport mode, and do it with essentially no pollution at the train. If the power plant is clean and/or sited outside the urban area, the rail mode makes effectively no contribution to local air pollution. Even where the train is diesel powered, a limited number of locomotives are more easily maintained and monitored than are thousands of buses.

What is an 'appropriate' application? Figure 4 shows one of the prime determinants of viability—high ridership. If there are enough riders to support the system economically, there are likely to be environmental benefits as well. In fact, the Bank is now actively supporting the suburban and metro systems in Mumbai, Buenos Aires and Rio de Janeiro and there have been encouraging discussions in a number of other large cities in Latin America and Asia.

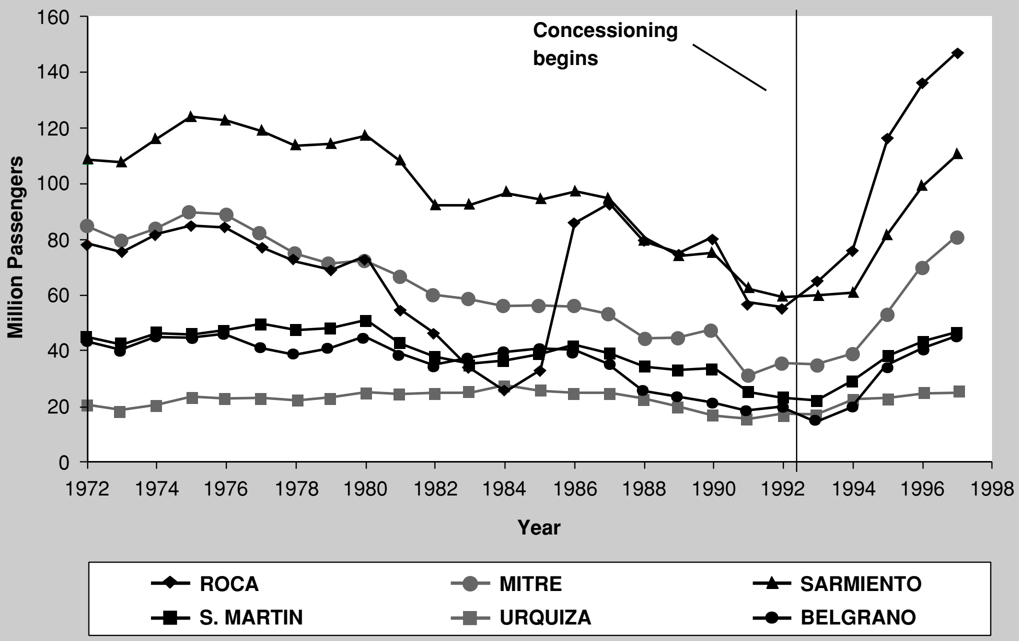
Unfortunately, however promising the potential opportunity, a poorly managed

Figure 4 Passenger/km of Suburban Rail Systems



** Passengers/km means annual passengers carried divided by kilometers of line (not passenger-km). It is calculated by dividing annual passengers carried by kilometers of line and is used as a (rough) measure of the intensity (or density) of ridership. The JR East figure is based on total JR East suburban passengers divided by total JR East km of suburban line operations.*

Figure 5 Impact of Concessioning on Buenos Aires Suburban Passengers



railway simply will not employ investment funds well. A good example is the pre-1990 railway systems in much of Latin America—Argentina in particular. Despite the obvious need for good urban transport in Buenos Aires, ridership on the suburban railways and the metro shriveled for years as the result of poor operation. In fact, the government in 1990 concluded that the railway was going to collapse without major changes in operation. The government's response, of concessioning the suburban railways and the metro to the private sector shows just how important good management can be (Fig. 5) in promoting effective use of transport resources.

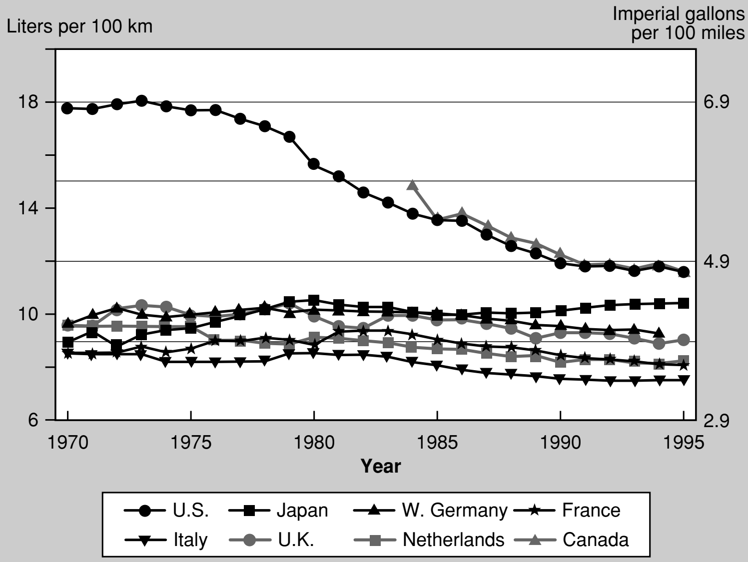
Global air emissions

Accumulation of CO_2, better known as the 'Greenhouse Effect', has only recently been understood as a serious potential problem. Localized air pollution is hard to ignore; CO_2, by contrast, is unobtrusive. Only by its gradual buildup in the atmosphere is the gas[5] threatening to increase surface temperatures and perhaps melt the polar ice caps.

Greenhouse gases are one way in which the developed and developing worlds are totally intertwined. It is possible to have clean air in Washington and filthy air in New Delhi, but greenhouse gases affect everyone equally. The environment impact of a tonne of carbon emitted, and the cost of cleaning it up, is the same everywhere. This said, the health costs of a tonne of SPM are far, far higher than those of a tonne of carbon.

Transport is only a part of the greenhouse gases problem. In 1994, transport accounted for about 30% of carbon emissions in the U.S., and about 39% in Japan.[6] Other industrialized countries fall in the same range, while developing countries probably generate a slightly lower percentage of their carbon emissions from transport. Nevertheless, transport's share of global warming problem is large

Figure 6 On-road Automobile Fuel Intensity in OECD Countries
Weighted Average of Gasoline and Diesel Fuel Intensity



Note: Includes diesel, LPG for all countries; household light trucks for US and gasoline, diesel, and LPG included at energy.

Source: Lee Schipper and Celine Marie-Liliu, p. 72

Figure 7 Diesel Locomotive Fuel Efficiency in U.S.

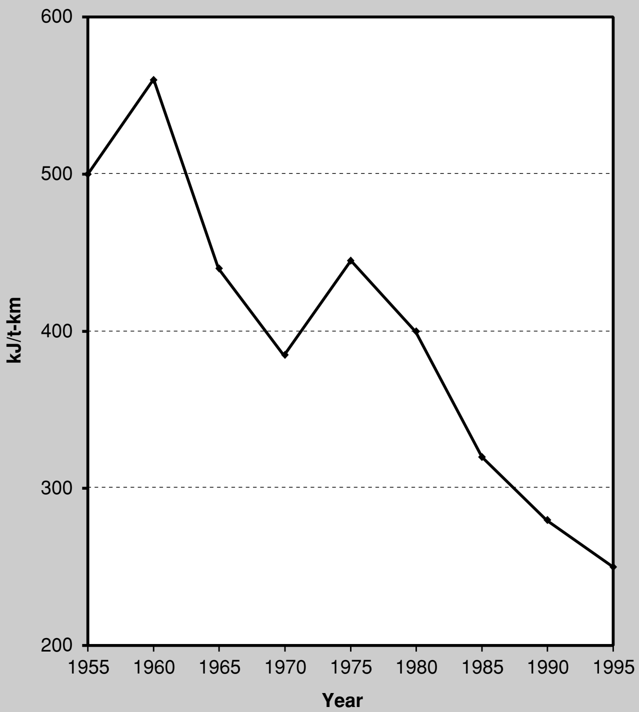


Figure 8 Freight Transport Energy Consumption Ranges

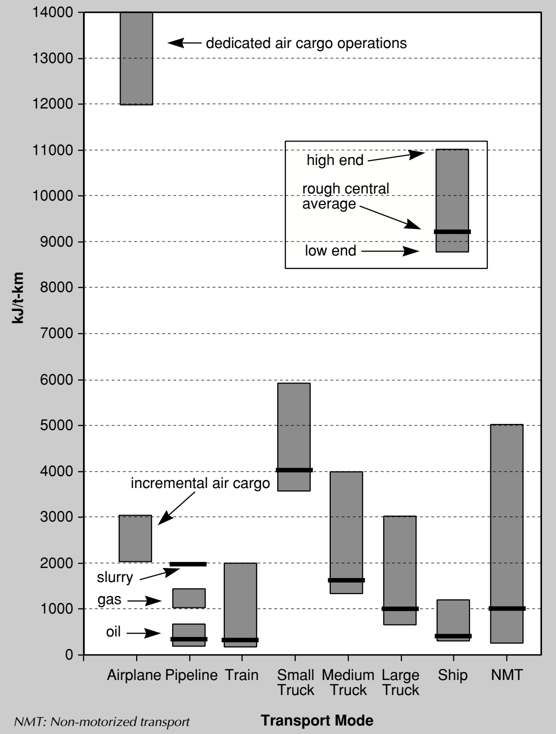
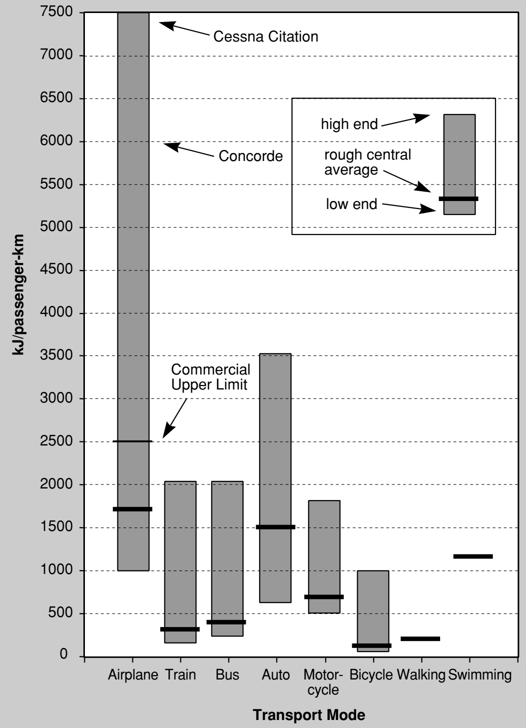


Figure 9 Passenger Transport Energy Consumption Ranges



enough to make it one of the potential avenues of attack.

CO_2 emissions are linked most directly to fuel composition and to energy efficiency. The less carbon a fuel contains, the less CO_2 emitted, so hydrogen fuel has no greenhouse effect at all. Fuels such as methane (CH_4), which generate some of their output from burning hydrogen as well as carbon, have reduced CO_2 emissions. Coal fired power has the highest CO_2 emissions. Energy efficiency is the other avenue of attack because, for each unit of output, the less fuel consumed, the less CO_2 generated. Here, again, technology can change the efficiency of individual modes, and traffic can be switched toward increasingly efficient modes.

Technology has to date been the more important source of efficiency improvements. Figure 6 shows how technology has reduced on-road auto fuel consumption, especially in the U.S. Figure 7 shows a similar improvement in diesel locomotives in the U.S. (and aircraft have improved as much or more than rail or auto[7]). Clearly technology in all modes is part of the solution.

Modes vary widely in their inherent energy efficiency, so CO_2 emissions can also be reduced by shifting modes. The problem with this strategy is twofold. First, how efficient are the different modes in practice (as opposed to theory)? Second, what does it take, and is it worth it, to induce modal changes solely in the name of CO_2 emissions?

Much has been written about the energy efficiency of various freight and passenger modes, based on engineering calculations which assume particular technologies and operating conditions. In practice, energy efficiency varies widely and can greatly reduce the potential efficiency a mode might have. Figures 8 and 9 display Bank calculations of energy consumption ranges in freight and passenger transport under realistic conditions. For example, Fig. 8 shows that while a rough average energy efficiency estimate for rail freight will be below that of large trucks, there could easily be conditions where trucks would be more efficient than rail, and very efficient freight aircraft could be more efficient than small trucks. Figure 9 shows that buses and rail are essentially the same in passenger energy efficiency—but a full auto can be more efficient than either. With more than one person (it is common in some developing countries to see three riders on bicycles and up to 5 riders on motorcycles), cycles and motorcycles can be the most energy efficient of all.

Effective operation is as important for rail energy efficiency as it is for localized air pollution. Heavy coal trains in the U.S. can operate with less than 100 kJ/t-km under controlled circumstances, but the actual U.S. average is about 350 as a result of shorter trains, lighter wagons, poorly tuned locomotives, yard switching, idling in yards, etc. Actual average fuel consumption in developing railways has been reported by the railways to be as high as 3000 kJ/t-km.

More important is that, unlike localized air pollution where the effects are immediate, energy efficiency is just one of a number of operating costs. Purchasers willingly pay more for powerful automobiles, even though such a purchase entails higher energy consumption. Passengers pay more to fly long distances even though they could potentially save money and (a little) energy by taking a train or ship. Shippers often care a lot more about freight speed and reliability than they do about tariff cost. Further, the cost of fuel only amounts to about 6% to 10% of total operating costs of rail and trucking companies (20% for airlines), so a change in fuel efficiencies or fuel prices, per se, might not have an overwhelming effect on the competitive position of the modes.

Figures 8 and 9 show that railways can, under the right circumstances, save energy, and reduce CO_2 emissions.[8] But the customer buys transport which suits his or her needs, where 'needs' include quality (speed, safety, reliability, frequency, comfort, etc.) as well as cost. The question is whether there is anything about CO_2 emissions that is so uniquely dangerous as to require direct measures rather than simply letting market prices for fuel, possibly augmented by a future carbon tax, find their appropriate place within the customer's demand pattern.

Carbon taxes have been frequently discussed as a way of finding the optimum solution to reducing greenhouse gas emissions from all sources. A carbon tax would hit all users of fuel in direct proportion to carbon emitted, and those users with the least need to consume carbon fuels would be the first to respond. One problem is that there is no agreement as to the level of such a tax ($20.00 per tonne of carbon emitted has been suggested as a tax that would begin to reflect the cost of carbon emissions) nor is there any existing mechanism for imposing, collecting, or spending the proceeds of such a tax. More important, a carbon tax of $20.00 per tonne would impose a tax of about US 6 cents per gallon on fuels which, as Fig. 3 shows, would hardly have a significant impact on total fuel prices, or demand, in most countries. In other words, it appears that a carbon tax is more likely to have a major effect in sectors other than transport.

The best way for rail to take advantage of its potential low carbon emissions is through fuel pricing that covers the cost of the fuel and any carbon taxes, thereby increasing the costs for transport modes that are less fuel efficient and that generate more carbon emissions. As a result, where railways are operated and marketed effectively, rail's energy (and carbon) advantage would be reflected in the consumers' choice of rail over other transport modes. If carbon can be successfully 'internalized' by a fuel-based carbon tax, there appears to be no reason why further direct actions would be necessary.

Environment-friendly but unconventional railcar on track in Philippines *(World Bank)*

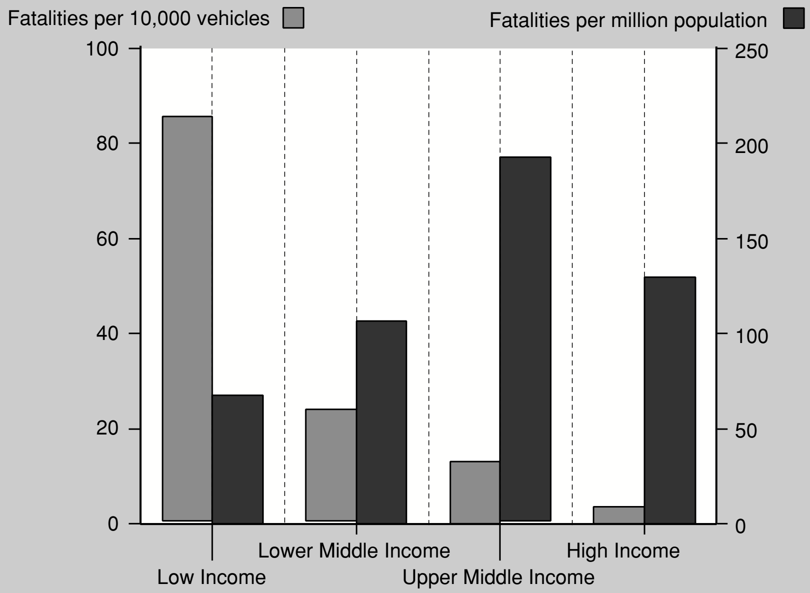
Space/Noise/Amenities

Transport facilities occupy space that has other uses in urban areas. Transport vehicles generate undesirable noise. There can be a premium on the modes of transport that minimize adverse impacts, and rail is certainly one of the more benign modes.

Rail is unequalled in its ability to produce high passenger volumes in small spaces, and it is difficult to imagine many larger cities (Tokyo, New York, London, Mumbai, Moscow) being able to function without suburban rail systems and metros. Rail systems do generate noise but, because the impact is so localized (and can be totally hidden in tunnels), rail's noise impact can be controlled and minimized. Neither rail nor highways are particularly appealing visually, but visual impact can be reduced with careful design, and rail stations are actually coming to be used as centers of attractive urban development. Overall, there is and has always been, an ample role for rail in urban transport systems on the basis of minimum impact on the surroundings.

This said, the value of space, noise and amenities impacts can be hard to quantify. It is also difficult to directly transfer developed-world ideas about amenities to the developing world where other priorities, such as health and education, might be more pressing than urban peace or pleasing architecture. For these reasons, the Bank prefers to lean heavily on local perceptions, tempered by agreed economic priorities.

Figure 10 Road Accident Rates and Levels of Motorization



Sources: International Road Federation. 1993
World Road Statistics 1988–92

Physical safety

The full costs of transport-related injuries and deaths have never received the attention they merit. In fact, in many developing countries, highway deaths (including pedestrians) are a major public health problem. Figure 10 shows two dimensions of the problem: fatalities per 10,000 vehicles, and fatalities per million population, both in relation to the average income levels of the country. There is no comfort to be drawn from the lower fatality rates per capita in developing countries for two reasons. First, total populations in developing countries are so high (India alone has more people than Europe and North America combined) that total fatalities are quite high. Second, the fatality rate per vehicle is much higher in poorer countries, meaning that as motorization proceeds, the highway safety problem will accelerate along with urbanization and localized air pollution.

One part of the transport safety problem is straightforward. Road-related pedestrian and non-motorized transport deaths can be reduced simply by providing adequate off-road pathways. Pathways should remain clear for users and not be clogged by informal shops and hawkers. Enforcement of parking restrictions reduces auto accidents significantly. Proper traffic controls at intersections are vital. Highway 'black spot' programs can rapidly decrease traffic deaths at points of particular danger. These programs taken together are among the most cost-effective interventions known, and the Bank supports them strongly.

Unfortunately, there are no reliable data on rail safety in developing countries. Anecdotal experience suggests that developing railways are much safer to travel on than highways but, at the same time, many are not nearly as safe as better management and strong attention to safety would make them. In addition, many developing railways are so hampered by years of capital (and managerial and policy) deterioration that poor track conditions and locomotive and wagon failures now make accidents and derailments a common occurrence. Railways should be inherently safe, but the advantage can be squandered by bad management. This is one of the reasons why the Bank emphasizes attention to management incentives in the rail restructuring programs it has supported.

Social issues

It may seem incongruous that transport would come up in a discussion of social issues. But, the poor need to get to their jobs, and they need to sell their farm produce in the local markets. The disabled

Two-wheel transport modes in Ho Chi Minh City, Viet Nam *(K. Fukuma)* need to have useable access to public transport as well.

For the most part, the transport needs of the rural poor can be met by better access to the longer haul transport systems, and by better use of small scale transport activities such as non-motorized transport and small motorized vehicles. Operated properly, rail can play a role in providing small rural stations that permit small shipments to be consolidated and that permit the poor to get to jobs.

Rail has potentially a larger part to play in urban transport, particularly when volumes are high enough to justify social subsidies to the mass transport modes, both bus and rail alternatives. As an example, the suburban railways of Buenos Aires are being partly subsidized by government, and government specifies the maximum fare partly in order to ensure that the poor will not be priced out of access to the systems. In many countries, urban passenger fares are kept low ostensibly for the same purposes. Such social policies need to be assessed with care, though, in order to ensure that subsidies are actually going to their intended recipients and not to the well-to-do.

Summary

Transport systems, including rail, underpin modern societies. Countries with effective transport will prosper in an increasingly interconnected world, while countries that neglect transport will be constrained in the development they can support. But transport systems have environmental and social, as well as economic, implications, and inattention to these can reduce the benefits realized from otherwise worthwhile transport investments. The Bank is learning how to fit transport needs into the broader economic, environmental and social framework of developing countries. It is very clear that rail has an appropriate role to play in the transport network of most countries, on economic, environmental and social grounds. However, rail is not a panacea, and rail management will have to work hard to ensure that theoretical benefits become actual achievements. The Bank stands ready to help. ■

Notes

1 Kenneth Gwilliam and Zmarak Shalizi, *Sustainable Transport: Priorities for Policy Reform*, The World Bank, Washington, DC, 1995, p. 1.

2 Louis S. Thompson, World Bank Support for Developing Railways of the World, *JRTR* 12, June 1997.

3 See p. 5 of Gwilliam and Shalizi.

4 See p. 54 of Gwilliam and Shalizi.

5 CO_2 is not the only greenhouse gas. Other gases, such as methane and Chlorinated Fluorocarbons (CFCs) have serious greenhouse impacts. CO_2 causes the predominant share of the problem because of the huge amounts emitted.

6 Lee Schipper and Celine Marie-Lilliu, *Transportation and CO_2 Emissions: Flexing the Link. A Path for the World Bank*, International Energy Agency and the World Bank, August 1998.

7 Ibid, p. 22.

8 It deserves emphasis that electric railways have local air pollution advantages, but do not necessarily generate lower carbon emissions. The total energy efficiency of electric traction, including electric generation and transformer and transmission losses, is not much (if any) better than diesel point sources. Further, if the electricity is generated from coal versus hydrocarbon fuelled point sources, electric traction could result in more carbon emissions, even if energy efficiency is higher. Of course, nuclear or hydro electric power would yield the opposite conclusion.

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Before joining the Bank he was Professor of Transport Economics at the University of Leeds, UK, and Professor of Economics of Transport and Logistics at Erasmus University, Netherlands. He has advised the Transport Committee of the British House of Commons, and the EEC Director General of Transport.

Louis S. Thompson

Mr Louis S. Thompson was born in Florida. After graduating with an MBA from Harvard University, he worked as a consultant engineer and economist in Cambridge, MA, and Washington, DC. He has also worked for a number of years at various posts within the US Department of Transportation. He has been Railway Adviser to the World Bank since 1986 where his responsibilities include consultation about all the Bank's railway lending activities and developing reports and policy positions. He has published articles on railways statistics, restructuring and concessioning.