THE ECONOMIC IMPORTANCE OF NON-MOTORIZED TRANSPORT AND ITS IMPACTS ON TRAFFIC CONGESTION MANAGEMENT

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Paper Prepared for the Second Annual Conference, The Transportation Science Society of the Philippines JULY 29, 30 - 1994

ABSTRACT

This paper is intended to make three simple points. First, the use of non-motorized transportation in many Asian cities is not a reflection of underdevelopment, but is a legitimate economic response to a set of public policies designed to constrain elite consumption and encourage savings and investment in order to promote economic growth. Dense cities with high levels of non-motorized vehicle and public transit use are, in fact, the spatial manifestation of the official export-oriented growth models adopted by many Asian NICs. In fact, our recent study indicates that higher levels of bicycle ownership and use are correlated with higher per capita income levels and higher growth rates rather than lower per capita incomes and lower growth rates. Second, the economic importance of non-motorized transportation is extremely significant in some countries and is usually completely ignored by most cost-benefit procedures utilized by multilateral lending agencies and national governments in on-going transportation planning activities. Third, for many years transportation planners believed that the best way to fight traffic congestion was to expand road capacity. But empirical evidence indicates that over the last twenty years expanding capacity has proven to be ineffective in slowing worsening motor traffic congestion, largely because the number of new vehicles on the road continually outstrips the amount of new road infrastructure that governments are able to afford to build.

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I. INTRODUCTION

This paper is intended to make three simple points. First, the use of non-motorized transportation in many Asian cities is not a reflection of underdevelopment, but is a legitimate economic response to a set of public policies designed to constrain elite consumption and encourage savings and investment in order to promote economic growth. Dense cities with high levels of non-motorized vehicle and public transit use are, in fact, the spatial manifestation of the official export-oriented growth models adopted by many Asian NICs. In fact, our recent study indicates that higher levels of bicycle ownership and use are correlated with higher per capita income levels and higher growth rates rather than lower per capita incomes and lower growth rates. Second, for many years transportation planners believed that the best way to fight traffic congestion was to expand road capacity. But empirical evidence indicates that over the last twenty years expanding capacity has proven to be ineffective in slowing worsening motor traffic congestion, largely because the number of new vehicles on the road continually outstrips the amount of new road infrastructure that governments are able to afford to build. Third, the economic importance of non-motorized transportation is extremely significant in some countries and is usually completely ignored by most cost-benefit procedures utilized by multilateral lending agencies and national governments in on-going transportation planning activities.

II. THE ECONOMIC IMPORTANCE OF NON-MOTORIZED TRANSPORT

The most dynamic region of the global economy in the past two decades has been east and southeast Asia. In fact, it has been the successful economic rise of Japan, Korea, Taiwan and most recently China which has forced a reconsideration of traditional economic development theory. The nature of urbanism in East and Southeast Asia has played an important role in constraining consumption and encouraging saving and investment while simultaneously minimizing the cost of labor and maximizing the competitiveness of Asian exports. In other words, the high levels of non-motorized vehicle use, lower rates of motorization, dense urban areas, cramped housing and congested streets typical of many Asian cities are not a sign of underdevelopment. In fact, this form of urbanism lies at the heart of the success of the so-called "Export-Oriented Growth Model".

Achieving rapid rates of economic growth requires that economic surplus is invested in to new production rather than consumed by the more elite segments of the population. Automobile consumption is a particularly onerous form of elite consumption. Not only does each purchase represent thousands of dollars of lost productive reinvestment but growing dependence on automobile transportation usually translates in to growing dependence on imported oil and vehicles and international debt. Dedicating road infrastructure to low-cost bicycles and buses instead of only private cars and motorcycles encourages savings and investment rather than consumption which allows for higher growth rates in the long-run.

In the U.S., 86% of the labor force has no alternative but to commute by private automobile and each employee must be paid and average of $4,500 for the purchase and maintenance of their vehicles (Facts and Figures, 1990). These expenditures are indirectly reflected in the market price of U.S. products. Meanwhile, in China, with the highest economic growth rates in the world, the majority of the population is able to commute by walking or bicycling. With bicycles consuming 1/12 of the road space of a private motor vehicle and about 1/20 the space for parking, much less public infrastructure must be constructed to serve the country's transportation needs. If China were to have as many automobiles per capita as the U.S., they would have to pave over 40% of their arable land. Moreover, the U.S. has sacrificed up to 60% of its urban land to road infrastructure to accommodate motor vehicle traffic. Automobile-based transport systems tend to encourage low-density suburbanization, imposing important and costly inefficiencies in public service provision such as telecommunications, electricity, water, sewerage and postal service. Rail and bicycle-based transport systems typical of Japan and other NICs have lead to the development of cost-effective higher density clusters both in central cities and other regional metropolitan centers. For example, because of the ability to rely on walking, bicycling and commuter rail systems, residents of Tokyo use 1/7 the gasoline consumed by residents in many large U.S. cities. While many scholars have asked why the U.S. has lost the competitive edge in the production of automobiles, fewer have asked why the country consumes so many. It is indeed ironic that Japanese automobile workers commute to work by bus in order to minimize company transport costs while in Detroit, auto plants located in distant suburbs are accessible only by private automobile, ensuring workers are also customers.

There are widely varying levels of bicycle and other non-motorized vehicle usage within and between both high and low-income countries worldwide. Using simple regression analysis, there is no statistically significant correlation between GNP per capita and the number of total trips made by bicycle. While there is an obvious positive correlation between the modeshare of the automobile and higher levels of GNP (.61), as auto use increases with income, it is not at all clear that trips by non-motorized modes are the first to be displaced. In Asia, countries with low per capita incomes, such as Bangladesh and higher per-capita income countries such as Japan exhibit high levels of non-motorized trip-making.While per capita income tends to be the strongest indicator of motor vehicle mode share (explaining 59% of the variance), 41% of the residual is explained, in large measure, by differences in public policy applications. More interesting, perhaps from the perspective of economic development, is that there is a significant negative correlation between the level of automobile ownership and levels of economic growth (-.23) while there is a high positive correlation between levels of bicycle usage and faster growth rates (.36). this is likely due to the fact that motor vehicle consumption tends to be consumed by the wealthiest segment of the population - the same segment that posses the ability to invest in other productive enterprises. Thus, there is a fairly significant negative correlation between automobile mode share and domestic savings rate. The importance of non-motorized vehicles from a micro-economic perspective is that they provide an environmentally friendly intermediate technology which can improve transport productivity levels at a cost affordable to a far greater percentage of the world's population than motorization alone.

III. THE ROLE OF MULTILATERAL DEVELOPMENT BANK COST-BENEFIT PROCEDURES IN TRANSPORT PLANNING

Currently, the only way that non-motorized vehicles enter World Bank cost-benefit analysis is as a negative externality on motorized traffic (Hoban & Archando-Callao, 1992). In other words, it treats slow-moving vehicles in the same way it treats low pavement quality, as a factor to be considered only with respect to the negative impact it has on the travel times of motorized vehicles.

While some have argued that travel time is not important in countries with high levels of underemployment, (Addus, 1989) recent analysis of labor patterns in less-developed countries indicates that the [problem is not "underemployment" but <u>low-productivity employment.</u> Historically, the level of an individual's production as generating a sufficient surplus to produce goods for trade in the market is the measure of individual productivity. However, the time that it takes to generate sufficient economic output for survival should at least have a value roughly equivalent to the subsistence wage. therefore, with respect to transportation infrastructure improvements, whether the time any individual is saved by a transport improvement is actually remunerated or not, it has societal value and impact. Thus, the economic impacts, the economic impacts of a change in road policy (such as segregating traffic in to motorized and non-motorized lanes or banning all non-motorized traffic completely) or a road investment (e.g. widening) the economic impacts on all potential users of the investment must be taken in to consideration when costs and benefits are weighed. If not, the economic impact of a policy such as banning non-motorized vehicles will obviously have a higher rate of economic return than providing a slow-moving vehicle lane, as road-side friction would be reduced, measured as zero cost, and thereby ignoring the impact on alternative users who do not have access to a private vehicle.

It must be accepted that transportation services <u>do not</u> offer an infinite number of trade-offs between travel time, trip cost, trip convenience and trip safety. Transport consumers may only travel with respect to the options provided for them. As a result, people taking one mode may have actually been willing to pay more or less to take a slower or faster mode <u>were it available as an option</u>. Therefore, when calculating the economic costs and benefits of the impact of a projected road-infrastructure project and/or transportation policy application on non-motorized road users, the following must be considered:

a) the change could induce people to switch between bicycling, pedi-cab or walking to a more expensive mode (bus, para-transit) which may or may not be faster;

b) through traffic generation serving latent demand, the change could induce people to switch between bus, para-transit to bicycling, pedicab or walking which may or may not be faster.

For example, in the case where a slow-moving vehicle lane is added to a road, the benefit of such a change can be measured by taking the net present value of a stream of benefits by adding:

* the money saved in any period by all generated non-motorized road users who used to use a more expensive mode less the value of any time lost related to switching, plus:

* the value of the time saved by all new non-motorized road users who used to walk, less the increased costs of the trip related to bicycle ownership and repair, plus:

* the value of increased or decreased travel time costs for all current non-motorized users.

Another reason why economic impacts on non-motorized users have long been ignored (although related to the above) is that many of the factors which significantly affect non-motorized vehicle use are demand-management techniques or policy applications and <u>not</u> infrastructure issues. Current methods (such as the World bank's HDM III model) are not able to measure economic effects under a diversity of policy regimes. For example, it may be the case that increases in motorized traffic speeds discourage the use of road infrastructure by non-motorized users. For example, in the U.S., which has one of the most bicycle-hostile environments in the world, there are now more than 100 million bicyclists, more than half of these are adults. this represents an astounding 33 % increase in only the past 10 years. However, this increase in bicycle ownership has had little impact on actual mode share. this is not, however, because Americans are unwilling to bicycle, but rather because the urban environment is hostile to bicycling. Currently 76% of the population commutes by private automobile, but 25% would commute by some other means if it were available , and of these, 13% said they would bicycle or simply walk (<u>Bicycle Reference Book,</u> 1993). The U.S. Department of Transportation, long unsympathetic to bicycling, currently has plans to double the amount of total trips made by bicycle from 7.9% to 15.8% Indeed, pedi-cabs have come back to the streets of New York City!

Bicyclists may fear for their safety in the absence of lanes to separate non-motorized from motorized vehicle users. Banning non-motorized vehicles from using or crossing high-speed roads will obviously have clear economic impacts on those without access to an automobile. Cost-benefit analysis, if it is to measure real economic costs, is going to have to be able to develop ways to measure the economic costs and benefits of various different policy options. There are many other policy decisions to evaluate besides a build and no-build scenario. Unless these economic impacts which are critical to the economic development potential of the vast majority of developing-country populations are given significantly greater value in cost-benefit procedures, the emphasis of World Bank lending or variations on these analyses adopted by developing country governments will continue to have minimal impact on the economic productivity of the majority of the population.

IV. NON-MOTORIZED VEHICLES AND TRAFFIC CONGESTION MANAGEMENT

Among OECD countries between 1970 and 1990 the miles of road infrastructure increased by between 4% and 9%, while the number of vehicle miles traveled increased by closer to 50%. In developing countries there is even less likelihood that road infrastructure expansion will be able to reduce congestion levels. With motor vehicle fleets expected to double by the year 2010 in developing countries, the cost of providing sufficient road infrastructure to accommodate this increase in traffic is likely to be prohibitive.

TABLE I

Capacity/Volume Ratios By Mode

Mode or Type of Way	Capacity of Way (persons/meter/hour)	Speed (kmph)
Non-Motorized Modes		
Walkway	3609	3
Bikeway	1467	13
Rickshaw/Pedicab	1000	8 - 12
Motorized Road-Based Modes		
City Streets		
Motorbike w/ 1 occupant	190 - 330	18 - 25
Cars w/1.5 occupants	143 - 251	16 - 24
Cars w/4 occupants	381 - 669	16 - 24
Minibus (10 passengers)	492	16
Bus, Mixed Traffic, (40 passengers)	2700	10 - 15
Bus in Separate Dedicated Bus Lane	5200	35 - 45

Expressways (without congestion)		
Cars w/ 1.5 occupants	885	64
Cars w/ 4 occupants	2362	64
Minibus (10 occupants)	3937	64
Bus (40 passengers)	6562	64
Urban Rail		
Tram (15,000 pass./line hour)	3000	12 - 15
Light Rail (18,000 passengers/line hour)	3600	25
Metro or Urban Rail - high volume (54,000 passengers/line hour)	9000	35
Suburban Commuter Rail (25,000 passengers/line hour)	4000	45

Sources: Transportation Strategies for Human Settlements in Developing Countries 1984. UNHCS/Habitat. Wright, C. 1990 Fast Wheels/Slow Traffic (Philadelphia: Temple Univ. Press) Gallagher, R. 1992. The Rickshaws of Bangladesh, (Bangladesh: University Press Limited)

Congestion is a problem of insufficient road capacity to handle a given "flow", or the number of vehicles at a given speed per hour. The best strategy to control increasing traffic congestion in the long run is to encourage passengers to switch from single occupancy motor vehicles to alternative modes with higher capacity/flow capacities. In Table I capacity/flow ratios of different modes are estimated. Any combination of policies which increase the number of trips and vehicle miles traveled (vmts) on a mode with a higher capacity/flow ratio and decreases the number of trips and vmts on modes with a lower capacity/flow ratio will improve road traffic congestion.

It must be kept in mind, however, that the capacity/flow ratios in Table I are assuming a zero congestion scenario. If, for example, traffic speeds on expressways slow to the same speeds as on city streets, then the capacity/flow ratios for motor vehicle travel on expressways will be the same as on city streets. For example, in many U.S. cities right now rush hour travel speeds are actually higher on surface streets than on expressways. Expressways in Japanese cities at rush hour have average travel speeds around 10 - 15 kilometers per hour. In other words, achieving the expressway travel speed levels listed below assumes that congestion has been mitigated, either by extensive capacity expansion, which is unlikely, or through congestion pricing, which is still relatively seldom used.

As is clear from the Table, the private motor vehicle with only one or two occupants in slow traffic such as on city streets is by far the most space-intensive means of transportation by an order of magnitude. Thus, any shift from the single occupancy motor vehicle to a mode with a higher capacity/flow ratio will improve the congestion situation.

A) The Role of Non-Motorized Vehicles in Reducing Road Traffic Congestion

Non-motorized vehicles play an important role in providing an alternative to private automobile travel in many developed countries, most notably Holland, Japan, and Denmark. Non-motorized vehicles also play an important role in developing countries such as China, Vietnam, Indonesia, India, and Bangladesh. Walking and animal-drawn vehicles, of course, also play an important role in both developed and developing countries.

There are two important ways that non-motorized vehicles can improve the traffic situation for motor vehicles. First, because bicycles and pedicabs use less road space per person per lane per hour than private motor vehicles even with high occupancy levels, if passengers switch from private motor vehicles to bicycles or pedicabs it will have a positive impact on road traffic congestion. In countries where there is already a high level of non-motorized vehicle use, and they are being slowly displaced by increased motorization, policies promoting the use of non-motorized vehicles can at least slow the increase in the displacement of non-motorized modes.

The second and equally important role of non-motorized vehicles in reducing road traffic congestion is in expanding the catchment area for people using metros or other mass transit modes with very high capacity/flow ratios. In developed countries people are only willing to walk about .5 - 1 kilometers to reach a commuter rail or metro line, and only about .15 kilometers to reach an express bus line. However, they are willing to bicycle 2 - 5 kilometers to reach a metro, commuter rail or express bus stop. Thus, while the bicycle consumes more road space than walking, the use of the bicycle instead of walking increases the catchment area around mass transit station from about 1 square kilometer to some 25 square kilometers. (Replogle, 1983, p.33) By making the use of metros, commuter rail, and express buses more convenient to more people, non-motorized vehicles are playing an important role in increasing the use or at least stemming the decline in use of mass transit.

B) International Trends in Non-Motorized Transport Usage

There are only a handful of countries where the use of the bicycle is actually increasing as a share of total passenger trips nationally. In the Netherlands, for example, 30% of all trips are made by bicycle, and they plan to increase the bicycle kilometers traveled by 30% between 1990 and 2010. They have estimated that such an increase would account for 8.75% of the desired reduction of motor vehicle traffic. (Netherlands, Ministry of Transport, 1990)

In China the mode share of the bicycle is also increasing. Between 60% and 90% of all non-walking trips are currently made by bicycle, and the percentage of total trips made by bicycle is increasing. The economic reforms have made it easier for people to purchase bicycles, and many people are switching from the overcrowded buses to bicycles. Thus, for China, where the bicycle is already intensively used, the discussions in Shanghai are how to move people from the bicycle to vehicles with higher capacity/flow ratios, such as buses in dedicated bus lanes or to metros. In Vietnam as well the mode share of the bicycle is also increasing for similar reasons.

In Manila, where pedicabs which had almost entirely disappeared re-emerged in the 1980s as an important mode in some areas. This contrasts sharply with recent trends in Indonesia and some other South Asian countries where the use of pedicabs has been sharply curtailed by government bans on their use. The pedicabs, primarily used on small residential streets in residential neighborhoods or kampungs, have been replaced by motorized tuk-tuks or mini-taxis which are not only more expensive and more polluting, they also take up more road space and thus have worsened the traffic congestion problem. On top of this, nearly 200,000 becak drivers lost their jobs.

While the bicycle is very critical to the Japanese transportation system, its role as a primary mode for a trip fell slightly. In most countries, however, including Japan, where bicycles are very extensively used, the bicycle as the primary mode for a trip is still falling. Some 50% of all trips in Japanese cities nationwide are made by either walking or bicycling. If we look just at Tokyo, walking accounted for 42.8% of total trips in 1968 and still accounted for 27% in 1988. In 1988 bicycling alone accounted for 18% of total trips. For commuting in Tokyo, bicycling and walking accounted for 25.8% of all commuting trips in 1968, and fell only slightly to 21.7% of all commuting trips by 1988. Rail accounted for 51.9% of all commuting trips in 1968, and still accounted for 46% in 1988. The automobile accounted for only 12.9% of all commuting trips in 1968, and now accounts for some 29.4% of all commuting trips. (Replogle, 1992)

The role of the bicycle in reaching mass transit stations, however, has increased dramatically in many cities around the world, particularly in developed countries. In Denmark at least 25% of total trips to metros and commuter rail stations are now made by bicycle, and the numbers are increasing.

In Tokyo the use of the bicycle for reaching urban rail lines has increased dramatically. In 1975 there were only 300,000 bicycles parked at commuter rail stations throughout the country. By 1981, this figure had risen to 1.25 million, and is now closer to 3 million, with 1 million of them in Tokyo. In moderate and lower density suburban areas around major cities between 15% and 45% of rail station access is by bicycle. For Tokyo as a whole bicycle access to rail lines rose from 4% in 1975 to 11% in 1980 to 13% in 1985 to closer to 15% today. This growth in bicycle use has not been exclusively in the lower income areas but has been at least as prevalent in higher income neighborhoods. (Replogle, 1992)

The increased use of the bicycle to reach commuter rail lines is thus in part responsible for the fact that despite rapid motorization in Japan and despite heavy subsidies to road-based transportation the use of rail for commuting has fallen by only 5% over the past 20 years and remains at 46%, the highest rail use for commuting among OECD countries. The use of rail to reach the three central wards of Tokyo has actually increased from 88% to 91% in the past decade. In this way the use of the bicycle has been critical to traffic congestion reduction in Japan.

The increase in bicycle use for reaching commuter rail lines is primarily the result of two factors. First, increasing road traffic congestion is slowing the travel speeds of both automobiles and buses. Bicycles are actually able to maintain faster travel speeds in conditions of hyper-congestion because they can go around the cars. In Tokyo where road travel speeds have slowed to around 7 - 10 kilometers per hour, and on some New York streets traffic has slowed to around 5 km per hour, the bicyclists are able to make faster time than private automobiles.

The other phenomenon in many countries is that as housing becomes more widely dispersed people are having to travel farther distances to reach transit nodes. Where most people used to walk to mass transit stations in Japan increasingly people are living in new developments farther and farther from the rail station. With automobile parking prohibitively expensive, the bicycle has become the mode of choice.

C) Economic Advantages of Increasing Non-Motorized Vehicle Use as a Congestion Mitigation Strategy

The enormous cost required to provide the necessary road and parking infrastructure to accommodate a majority of commuters in low-occupancy private motor vehicles relative to modal mixes where non-motorized vehicles and urban rail modes predominate can be seen when looking at aggregate cost data from Japan and the U.S. In Japan, where rail and non-motorized modes predominate, only some 10.7% of GNP is dedicated to transporting all of society's goods and people. In the U.S., however, where 86% of the population is locked into commuting by the private automobile, we spend 17.9% of our GNP on transportation. These enormous cost differences are reflected in all the products produced in the U.S. and may partially explain the U.S.'s deteriorating competitive economic performance relative to Japan, particularly when it is noted that some 45% of the U.S. trade deficit is from automobile and oil imports.

Controlling traffic congestion by promoting the use of non-motorized vehicles makes particularly good sense in lower income countries. Over 80% of the world's population is able to afford a bicycle, while in many developing countries only 5% or 10% can afford a private automobile. This means that even in relatively economically successful countries like Mexico, in Mexico City where roads are congested to near gridlock this gridlock is being caused primarily by the wealthiest 12% of the population which is able to afford a car.

V) Policies Necessary to Increase or Sustain the Use of Non-Motorized Vehicles to Reduce Traffic Congestion

A) Improving Bicycle-Related Infrastructure and Facilities

Actually increasing the amount of non-motorized vehicle use as a primary mode or for reaching transit stations requires a complex array of public policies. Clearly encouraging the use of the bicycle to reach urban transit stations requires the provision of proper parking facilities. In Japan where bicycle use for reaching transit is growing rapidly, this process has been facilitated by several public policies, some promoting non-motorized modes with subsidized supporting infrastructure, others by constraining alternative modes such as the low-occupancy automobile through pricing policies.

Japan's Bicycle Law, passed in 1977, first provided public funding and tax incentives for the construction of bicycle parking facilities. The 1980 Bicycle Law requires that newly constructed or enlarged department stores, supermarkets, and banks must provide bicycle parking. Japan has spent around $10 billion on bicycle- related infrastructure over the past two decades, which led to the construction of some 8735 parking facilities holding some 2.77 million bicycles. About 75% of these are controlled by provincial or local governments, 13% by public authorities such as the railroad, and 12% by the private sector. Roughly 66% of these parking spaces were within 100 meters of a rail station entrance, and most hold from 500 to 1000 bicycles. One half to one third of the capital costs for construction can be paid for from public subsidies, and tax benefits and subsidized financing is available to the private sector from the development banks for bicycle parking provision. Once Japanese employees make it to a commuter rail line their rail fare is generally paid for by their employer, another important incentive to use the train system. (Replogle, 1992)

The Netherlands has also dramatically increased bike parking space at metro stations. They now have a bicycle parking space for every 3 passengers boarding, and larger stations have guarded parking. In U.S. 47% of metro and commuter rail riders said they would consider bicycling to transit stations if facilities for bicyclists were improved. (Herman, 1993)

In some countries security is a key issue. Theft rates are extremely high in the U.S., at least five times higher than in Japan, and twice as high or more as in Germany. Where theft is a significant danger the importance of secure or guarded parking facilities increases, and this also drives up costs. In most cases, however, the costs of expanding road infrastructure to accommodate the extra motor vehicles or the costs of resulting road traffic congestion are higher than the costs of subsidizing secure parking facilities for non-motorized vehicles at mass transit stations.

Another solution to the security problem is to make rental facilities available. In Holland and Japan many train stations have rental facilities at train stations, which allows a person on the work end of their commute to not have to worry about leaving their bicycle at a train station overnight. Permitting bicycles on trains also facilitates bicycling at both ends of a commuter rail journey. In France bikes are put in a special freight car. Metro North in New York allows bikes w/ a bike pass but reserves the right to refuse access if the train is overcrowded. Berlin allows 48 bikes per every 8 car train. Bikes are permitted on many mass transit systems and rail systems around the U.S. usually with certain conditions. Trains built with special areas for bikes helps keep them out of the way of passengers. In countries where commuter trains are very congested, however, such strategies make less sense.

A network of safe and pleasant bikeways throughout the city and particularly around rail stations is also particularly important. In Japan most bicyclists share wide road-level sidewalks with pedestrians, although they are also allowed on roads. In Copenhagen bicycle commuting increased by 50% in only 5 years when the city replaced curbside parking with curbside bicycle lanes. In Erlangen, Germany, the development of an extensive network of bicycle lanes doubled cycle trips to 30% over a 12 year period. Traffic calming on residential streets and bike paths through major parks also help to create a pleasant bicycling and walking atmosphere to encourage their use. Thus, networks of bike lanes and bike-friendly streets are important to increasing the popularity of bicycling, but this must not be used as an excuse to ban bicycling on normal roads.

Clearly banning non-motorized vehicles on major streets will do nothing to ease congestion. As pedicabs are four times as efficient users of road space as the low-occupancy motor vehicle, banning will probably only worsened the already nightmarish traffic congestion there. It is also important to avoid severing non-motorized vehicle and pedestrian ways with highways or other obstructions. Major highways without overpasses or underpasses can force non-motorized users miles out of their way without proper provision of overpasses or bypasses. Bridges without bicycle lanes and/or banned to bicycle traffic can also be a major impediment. In New York City, which is on 3 islands, for example, bicyclists have considerable difficulty moving from one island to another because they are banned on the Verranzano, Throgs Neck, Whitestone and Outerbridge Crossing bridges. Some bridge pedestrian ways and road overpasses which are available are only accessible by stairways, making them inconvenient for bicyclists. (Herman, 1993)

B) Providing Dis-Incentives to Use Low-Occupancy Private Motor Vehicles

In countries where bicycling has become an important part of the transportation system and successfully reduced motor traffic congestion, apart from incentives to use the bicycle there have also been severe dis-incentives against using the private automobile. In Japan, for example, a car owner must prove that they own a parking space before they can register their car in Tokyo, and parking is enormously expensive. It can cost over $100 to park for a day in some areas in downtown Tokyo, in part because of taxes. Parking violations can result in fines of up to $1500. Then fuel taxes are very high, accounting for 47% of the price of gas in Japan, and with import duties on oil the cost of gasoline is 3.1 times higher than in the U.S. Meanwhile, a driver can pay the equivalent of $98 in tolls to drive from Osaka to Tokyo, about as far as from New York to Washington where the tolls will cost a U.S. driver from zero to $14.00 depending on the route. The total tax levy on a car in Japan is roughly $1285 per year, compared to $232 per year in the U.S. Another crippling cost of driving in Japan is called the "shocken". Every two years drivers have to have their cars inspected. The cost of inspection is roughly $900.00, and if the car does not have the inspection sticker by the end of the year the cost is doubled. Above and beyond this you have to pay mandatory replacement costs on all sorts of vehicle parts. (Ishi, 1989; Replogle, 1992; Newman & Kenworthy, 1989) Furthermore, most Japanese employers pay for the entirety of their employees commuting expenses if they commute by public transportation. As a result, families tend to only have one car and treat it as a luxury, using it for weekend outings, rather than as a means of commuting.

Holland has brought about the increase in bicycle and non-motorized transportation use by spending some 10% of its surface transportation budget on bicycle facilities, by increasing fuel and automobile purchase taxes by 50%, and increasing subsidies to mass transit by $5.7 billion a year. In Denmark a similar result has been achieved by imposing a 200% sales tax on automobile purchases, increasing taxes on fuel to the point where a gallon of gas costs $3.79. These extra funds were used to underwrite the costs of expanding bicycle lanes and parking facilities.

Area pricing schemes as used in Singapore, and in the near future electronic congestion pricing will be able to more closely charge road users in relation to the amount of road space they consume. Revenues from congestion pricing could be an important source of funding for the sorts of low-cost infrastructure needed to support non-motorized vehicles.

VI) Conclusion

Non-motorized vehicles can be part of a successful strategy at reducing road traffic congestion. While many people from developing countries may view environmentally-benign bicycles and other non-motorized vehicles as a sign of underdevelopment, the fact that they are increasing in importance in Japan, Denmark, Holland, and other highly industrialized countries indicates that they are actually an integral part of the most modern transportation systems in the world.

The importance of non-motorized transportation lies mainly in the fact that its utilization addresses the mobility needs of the majority of the population and at a lower overall individual and societal cost. Overcoming obstacles to the use of affordable and environmentally-friendly technologies has the potential to yield economic rates of return much higher than current estimates for infrastructure projects currently reflect.

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