Economic Importance of Nonmotorized Transportation

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The use of nonmotorized transportation (NMT) is not an indication of underdevelopment. Instead, higher levels of nonmotorized vehicle use can have a positive impact on economic growth. Extensive use of NMT may be one factor explaining higher domestic savings and investment rates in Asia, which in turn are related to the region's superior growth performance. Conversely, the relative lack of nonmotorized vehicle use in Africa may be related to lower levels of domestic savings and immobility among the poor. The availability of intermediate, appropriate transportation technologies has important economic advantages, which is demonstrated. The economic benefits of nonmotorized vehicle use are largely overlooked in most cost-benefit procedures because they ignore nonmotorized modes. The economic benefits of nonmotorized transport are investigated from macroeconomic and microeconomic perspectives.

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MACROECONOMIC PERSPECTIVE

NMT and Underdevelopment

Many people tend to equate the bicycle with underdevelopment, and bicycle use with less developed countries, but this view is statistically insupportable. Using a sample of more than 40 cities around the world (Figure 1), bicycle ownership per 1,000 population rises consistently with increasing incomes, as does car ownership. In other words, the higher the per-capita income, the higher the number of bicycles per 1,000 population. Bicycle ownership and car ownership levels tend to rise and fall together.

Even the United States has an extremely high level of bicycle ownership per 1,000 population. In the Central and Eastern European countries, public transit use has fallen since 1989 but both motor vehicle ownership and bicycle ownership have risen substantially, and growth rates for bicycle ownership are faster than growth rates for private cars in cities such as Budapest, Hungary, and Krakow, Poland (*1*). Bicycle ownership and use also exploded in China after 1989, explaining most of the sharp, recent upsurge in global bicycle use and production (*2*). In sub-Saharan Africa in the past decade both motor vehicle fleets and bicycle fleets fell in the 1980s (*3*). Thus, when countries accumulate more wealth, their residents tend to own more bicycles and more cars, rather than fewer bicycles and more cars.

Bicycle ownership is not necessarily, however, a good indicator of bicycle use. In countries such as the United States, most people who own bicycles use them primarily for recreational purposes. It may therefore be more instructive to look at the degree of correlation between the bicycle's share of total work trips and the gross national product (GNP) per capita (Figure 2). In this case, bicycle and nonmotorized vehicle use vary widely among high-income and low-income countries. The regression line indicates the level of bicycle use predicted by GNP per capita alone. The enormous divergence from this line indicates that there is no statistically significant correlation between GNP per capita and the number of total work trips made by bicycle.

If walking trips are separated from bicycling trips, it is seen that the poorest countries in Africa tend to make very few trips by bicycle (with a handful of exceptions) and many trips by walking. In Asia, by contrast, countries with low per-capita income (e.g., Bangladesh) as well as those with higher per-capita income (e.g., Japan) tend to make many trips by bicycle or pedicab. Pedicabs are used predominantly in the lower income countries, where labor costs are low and crime is a problem, whereas bicycles are used mainly in higher income countries with lower crime rates. Isolating the determinants of variations in bicycle use worldwide would require a much larger and more sensitive data set.

The level of private motor vehicle use, however, can be predicted with greater accuracy. In Figure 3 the mode share of the private motor vehicle in 72 major metropolitan areas is plotted against the national GNP corresponding to those cities. (Mode share data used were the most recent figures available. Most of the figures are from the mid- to late 1980s. This introduces some inaccuracies into the chart, but there is no systemic bias in the age of the data that should distort the significance of the observed correlation.) If the level of GNP were the only variable explaining the level of motor vehicle mode share, all points should fall neatly on the regression line. There is not only significant variation from the regression line, there are significant regional effects. The level of private motor vehicle use in East Asian cities, where GNP grew at 6.1 percent annually between 1980 and 1992, is either roughly consistent with or lower than would be predicted by their GNPs. This contrasts sharply with Africa, where despite negative growth over the past decade, the use of private motor vehicles is considerably higher than would be predicted by GNP. Private motor vehicle mode share is much higher in Lagos, Nigeria, and Dar es Salaam, Tanzania—which are very low-income countries and have been growing at less than 0.5 percent a year since 1965—than in Hong Kong, Shanghai, Singapore, Bangkok, and Tokyo, all of which have averaged over 4 percent annual growth since 1965.

There is a positive but weak correlation between private motor vehicle mode share and increasing GNP per capita, but there is no positive correlation between lower nonmotorized vehicle mode share and higher GNP per capita. Thus, automobile use increases with income, but nonmotorized vehicle use may or may not be the

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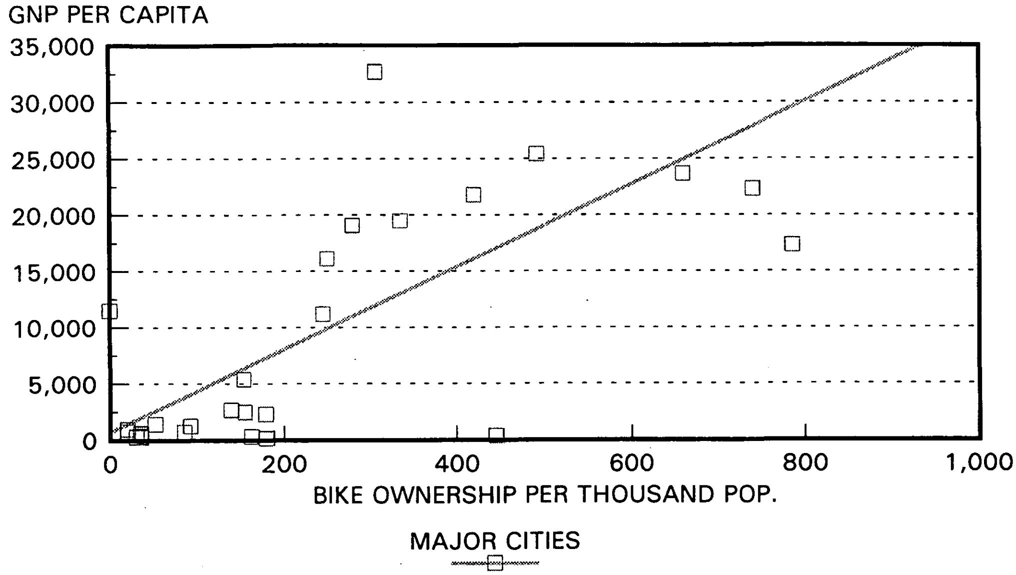

FIGURE 1 Bicycle ownership and income (*10,15*).

mode most likely to be displaced. Anecdotal evidence from around the world indicates that public transit trips, particularly bus trips, are as likely to be displaced by increasing private motor vehicle use as are nonmotorized vehicle trips.

NMT and Macroeconomic Growth

The most dynamic region of the global economy in the past 2 decades has been East and Southeast Asia. In fact, it has been the successful economic rise of Japan, Korea, Taiwan, and most recently China that has forced a fundamental reconsideration of dependency theory and development theory more generally. Many recent studies have tried to identify the key factors in this economic success (*4*).

One common element to this economic success pointed out by theorists from all schools of economic thought is the high level of domestic savings and domestic investment in Japan and the newly industrializing countries (NICs). As Barrett and Chin point out, "by world standards the East Asian NICs were outstanding in their ability to increase rates of domestic savings and reinvestment during this period of rapid industrialization" (*4*). These higher savings rates not only reduced the cost of capital, which acted as an incentive for firms to invest in new technology, but also reduced the dependence on foreign capital. With the possible exception of Indonesia, the other NICs all managed to avoid the debt trap of the 1980s that killed economic growth in much of Latin America and Africa.

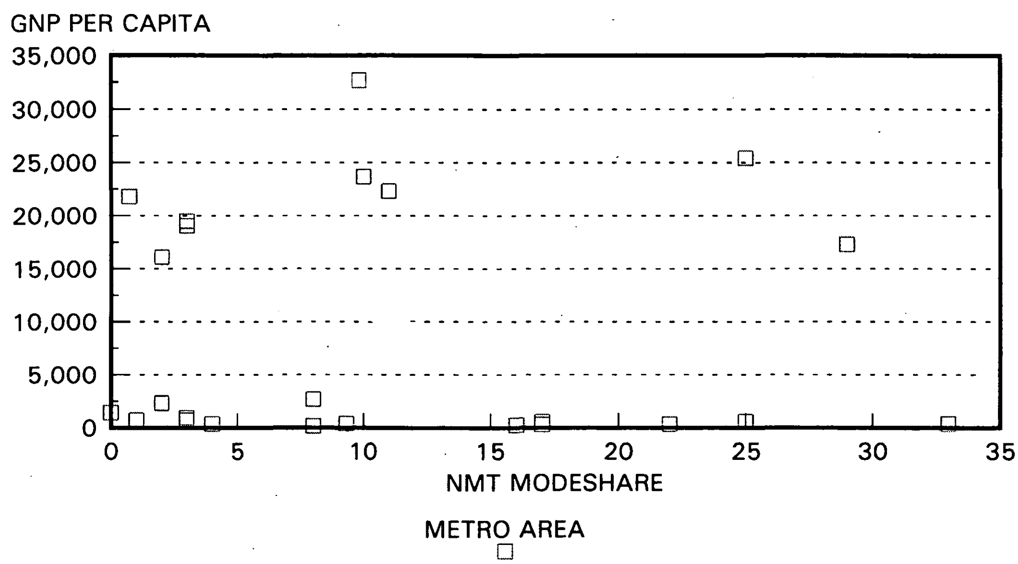

FIGURE 2 NMT mode share and GNP per capita (World Bank, *15,16*)

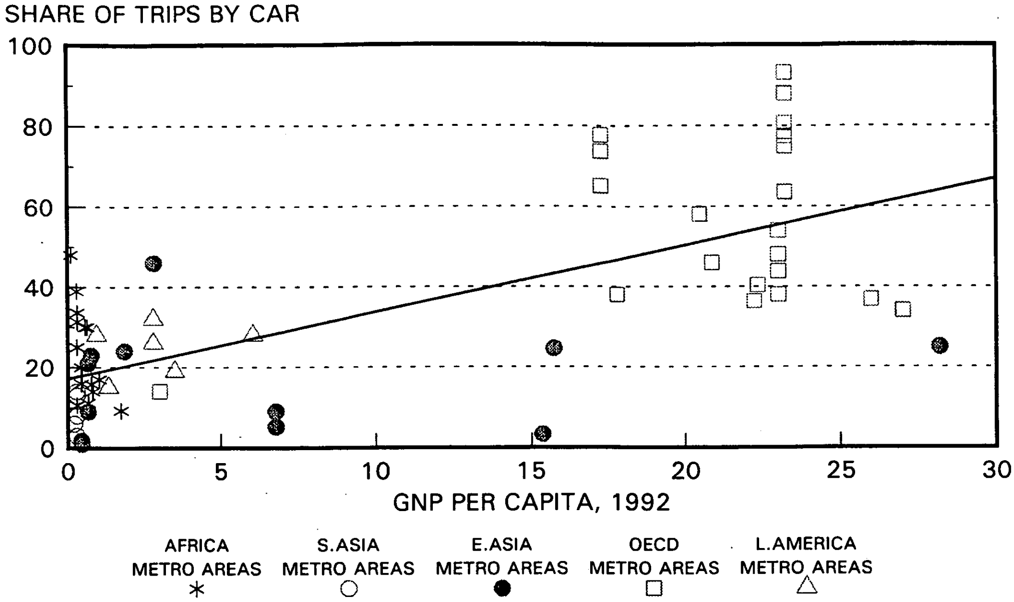

FIGURE 3 Car mode share by GNP per capita by region, 1992 (World Bank).

There is considerable debate in the literature as to what caused this high level of domestic savings. Many authors argue that high savings rates result from a cultural propensity to save, but this appears unlikely given that these savings rates are an entirely post–World War II phenomenon—for most of the NICs, a post-1960 phenomenon. It is unclear why cultural factors would have suddenly changed in East Asia after 1960.

One possible, often overlooked factor that may have influenced the propensity to save was the nature of urbanism in East and Southeast Asia. Urban policy in some East Asian countries such as China, Singapore, and Hong Kong played an important role in constraining consumption and encouraging savings while at the same time minimizing domestic labor costs. These two factors may have facilitated the competitiveness of East Asian exports. In other words, the high levels of bicycle use, low levels of motorized vehicle use, dense urban areas, cramped housing, and congested streets typical of Asian cities are not a sign of underdevelopment; they are, instead, the spatial manifestation of the so-called export-oriented growth model, which lies at the heart of the NICs' economic success.

As negative growth in Africa and Latin America in the 1980s has been attributed largely to the debt crisis that led to a net capital outflow from many of these countries for nearly a decade, it is significant that more than half of low- and lower-middle-income countries import more than 90 percent of their commercial energy. Low-income developing countries, excluding China, spent an average of 33 percent of their merchandise export earnings in 1985 on energy imports, and many of them spent more than 50 percent (*5*). East Asia's transportation systems are less dependent on private motor vehicles, and NMT is far more important there than in other parts of the developing world. This insulated them from the shocks of the oil crisis and the related debt trap.

Firms need to pay their employees sufficient wages to cover the costs of living and commuting to their jobs. These costs of living and commuting, however, vary widely between countries. In the United States, 86 percent of the labor force commutes by private car, but more than 40 percent of these commuters claimed that they would commute by an alternative means if it were practicable for them (*6*). Under such conditions, each employee must be paid more than $4,700/year for the purchase and maintenance of an automobile to carry him or her back and forth to work each day (*7*). Furthermore, taxes must be collected to pay an estimated $2,400/passenger car of public subsidy to make automobile transportation viable (*8*). These costs are reflected in the costs of goods produced in the United States, albeit indirectly. Meanwhile, in a country like China, where most of the population can commute to work by walking or bicycling, all of a worker's commuting costs can be covered by a one-time $100 investment in a bicycle and less than $25/year in maintenance. These cost differences will be reflected in the relative costs of U.S. and Chinese products.

Moreover, the U.S. has sacrificed some 60 percent of its urban land to road and parking infrastructure to accommodate motor vehicle traffic, compared with about 15 percent in most East Asian countries (*9*). The United States has considerable land available per person, but if China were to have as many automobile operators per capita as the United States, China would have to pave over 40 percent of its arable land to accommodate all the cars (*10*).

Japan, which has been growing faster than the United States throughout the postwar period, possesses the best, most extensive public transportation system among the countries of the Organization for Economic Cooperation and Development, and by far the lowest level of automobile use, at about 50 percent of total trips nationally compared with 86 percent in the United States. As a result, the Japanese spend only 10 percent of their GNP on transportation, compared with 18 percent in the United States (*11*).

When high-density urban form, high user fees for automobiles, low levels of investment in road infrastructure, and other policies are used to discourage the consumption of private cars, people tend to save their money rather than spend it on luxury cars. Dedicating road space to buses and low-cost bicycles instead of to private cars and motorcycles encourages savings instead of consumption, allowing for much higher levels of investment and hence faster economic growth.

Automobile-based transportation systems, such as the ones in the United States, tend to undermine the realization of agglomeration economies, or returns to scale in the provision of transportation and other basic services, whereas the rail- and bicycle-based transportation systems more typical of Japan and other NICs have led to the development of higher-density clusters both in central cities and around rail stations. The low-density U.S. pattern imposes important inefficiencies in the provision of many other forms of infrastructure and public service, such as telecommunications, electricity, water, sewerage, postal service, and drainage. A recent study by Phillips and Gnaizda (*12*) and an older study by the U.S. Department of Housing and Urban Development (*13*) indicated that the cost of providing housing in low-density, unplanned suburban areas was 60 percent higher than that of providing the same number of units in planned, higher-density areas. More than half of these costs are underwritten by taxpayers. In low-density sprawling human settlements, the costs of providing roads and streets are 4 to 15 times higher, the costs of copper pipe and utility pipe for water supply 5 times higher, the costs of providing postal delivery 300 times more expensive, the costs of heating five times greater, and the amount of water and electricity consumed were double (*12*). Because of the ability to rely on walking, bicycling, and commuter rail, residents in Tokyo use a seventh of the gasoline consumed by residents in large U.S. cities.

The macroeconomic implications of these cost differences, which are reflected ultimately in the costs of U.S. products, are disturbing. In Asia, agglomeration economies realized through increasing returns to scale in the transportation sector tend to be captured in the form of higher rents. The land intensity of economic activity in Japan in large measure explains the high rents in Japan. These rents, many of which are captured by Japan's largest industrial firms, constitute an interest-free pool of investment capital that has been used to finance Japan's industrial expansion. High rents in turn encourage investment into the built environment, increasing the efficiency of Japanese cities as sites of production. This way, higher density encourages a higher level of gross domestic investment.

Furthermore, countries with higher domestic savings rates do not need to borrow as extensively from foreign countries. One of the major reasons that countries became trapped in the debt crisis of the 1980s was to pay for imported oil and imported private cars. For example, 43 percent of Brazil's total import bill is for oil, 30 percent of which is consumed entirely by private automobiles that are used by only the wealthiest 10 percent of the population (*5*). The debt crisis in Brazil, which basically halted growth for a decade, was brought on by the rapid rise in oil prices and the rapid increase in interest rates on loans to pay for imported cars and oil.

One of the major reasons that the U.S. economy is hemorrhaging is its trade deficit. U.S. dependence on the automobile also is exacerbating the trade deficit. In 1989 Japan produced 9,052,000 passenger cars but consumed only 4,404,000. In the same year the United States produced only 6,823,000 passenger cars but consumed 9,853,000 (*14*). According to the U.S. Commerce Department, 65 percent of the United States' annual trade deficit is related directly to imported automobiles, which is why they have been the ongoing focus of U.S.-Japanese trade talks.

Though insufficient data were available to test the specific macroeconomic impact of nonmotorized vehicle mode share on economic growth, and urban density indicators also proved to be unreliable indicators of agglomeration economies, a path diagram was developed to indicate the strength of various effects on car mode share and economic growth (Figure 4).

Figure 4 maps the results of three regressions: the dependent variable is first economic growth, then gross domestic investment, then motor vehicle mode share. Data on urban density (people per hectare) and the percentage of total trips made by private automobile in 72 major cities around the world were assembled from various sources (*15–19*) and added to World Bank development report data and other indicators used by Barro (*20*) to predict economic growth rates. (The data tables are available from ITDP, 611 Broadway, Room 616, New York, N.Y. 10012.) As possible determinants of car mode share, the national annual output of oil, presence or lack of motor vehicle manufacturing facilities, and other variables were compiled and tested. That data from several cities in certain large countries such as the United States, Germany, and China have been used is probably for the better, as greater weight is given to countries with large populations than ordinary growth tables for which data from each country are given equal weight.

The regression of economic growth indicated that 80 percent (adjusted R^2) of the variation in economic growth from 1965 to 1990 can be explained by the following variables: average level of gross domestic investment from 1965 to 1990 (GDI6590 = .82), level of government expenditure as a percentage of GNP (GOVEXP = .26), literacy rate in 1960 (LIT60 = .29), car mode share (CARSHARE = −0.16), and location of the country (whether in Asia) (ASIA = −0.15), indicating regional growth dynamics. Car mode share and Asia were not quite significant (T = 1.62 and 1.81, respectively). GNP in 1992 had no significant direct correlation with economic growth, nor did a host of other variables. Urban density had no significant direct correlation with growth rates. (The density indicator, people per hectare, does not quite capture the desired concept, as it is driven primarily by the location of the municipal boundaries. Data sets with more sophisticated indicators of variations in urban density are needed.)

Consistent with the author's theory, growth is driven primarily by the level of investment. Savings and investment data run roughly parallel. There is considerable debate in the economics literature as to whether investment determines the savings rate or savings determines the investment rate. The author's inclination is toward the former view, but because the two are roughly equivalent, it will not disrupt the model.

The determinants of gross domestic investment proved harder to predict, with only 47 percent of the variation being explained by these variables. The strongest predictors of gross domestic investment proved to be the location of the country (ASIA = .62) and the level of oil production (OILPROD = .62). Again, Asia reflects the level of investment driven by Japanese investment and other regional effects. A high GDP in 1992 (GDP = −0.44) had a negative impact on investment, which may indicate some validity of the neoclassical view of diminishing returns to capital (*20*). Barro's political instability indicators—the average number of assassinations per million people per year (ASSASS = −0.43) and average number of coups d'état and revolutions on average from 1960 to 1985 (REVCOUP = −0.45)—proved to be strong predictors of investment levels. Each of these variables was significant ($t >$ 1.96). The next strongest predictor of investment levels was car mode share (CARSHARE = −0.36). This result indicates that money not spent on cars is more likely to be invested. The variable was not quite significant at the 95 percent level, however (t = −1.4). Government expenditure was correlated positively with

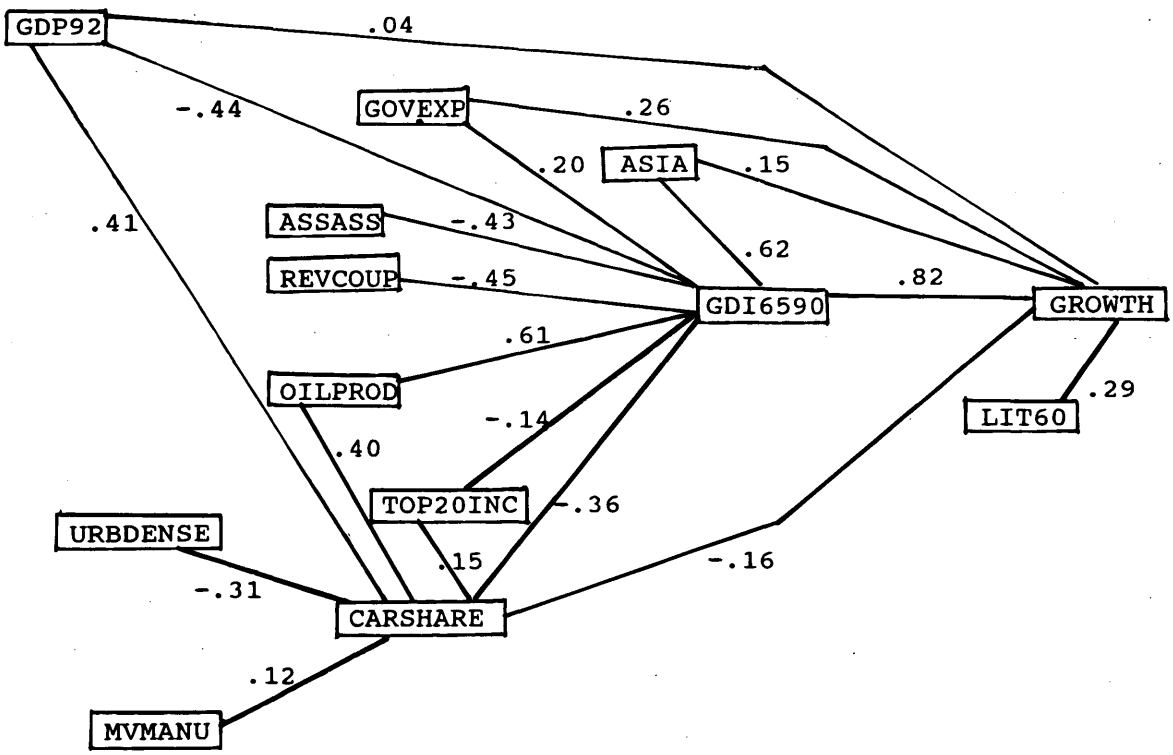

FIGURE 4 Causal path diagram of impact of automobile dependence on economic growth.

gross domestic investment (GOVEXP = .20), and income inequality was correlated negatively with domestic investment (TOP20 = −0.14) but neither was significant ($t > 1$, but < 1.96). Indicators for urban density and for deviations in the exchange rate from purchasing power parity were not significant, nor was the level of oil consumption. (The author tried to demonstrate negative growth effects by showing that car use was correlated with higher levels of oil consumption, and higher levels of oil consumption with lower levels of domestic investment, and higher debt, but could not demonstrate any significant set of relationships here. What this may indicate is that except in times of oil shocks, the effect of automobile dependency on the economy is less a result of its relation to oil consumption than of the consumption of the vehicles themselves and their effect on the efficiency of urban form. The data on oil consumption were not complete, however, so it would be worth testing these relationships again with better data.)

The regression predicting car mode share explained some 75 percent of the observed variation. By far the strongest predictors of car mode share were GNP per capita in 1992 (GDP92 = .41) and the amount of oil produced in the country (OILPROD = .40). The level of oil produced in the country affects car mode share both through the price of gasoline in the country and the political power of the domestic oil industry to push for urban policies that support private motor vehicle users. Getting comparative data from a significant number of countries that could act as proxies for these policies would be an area for further research. The next most powerful predictor of motor vehicle mode share is urban density (URBDENSE = −0.31). Perhaps with better data this would be higher. Each of these variables was significant ($t > 1.96$)

The income inequality indicator (percentage of total income going to the top 20 percent of the population) was also a good predictor of car mode share (TOP20 = .15), and the variable is almost significant ($t = 1.92$). Because in developing countries only the wealthiest people can afford motor vehicles, it follows that elite consumption of motor vehicles would be greater if the elite had more money. This elite consumption is potential investment capital.

The presence of motor vehicle manufacturing in the country is also a good predictor of car mode share (MVMANU = .12), although the variable is not quite significant ($t = 1.3$). This variable again captures the power of the domestic highway lobby over domestic transport and land use policy.

National density proves to be a weak and insignificant indicator of car mode share. There is no evidence that low car mode shares in Japan and the NICs are being driven by higher national population densities.

From Figure 4 one can conclude that car mode share has a total effect of −0.46 (direct plus indirect effects). Of this, .19 is the result of the correlation between higher GNP, higher car mode share, and slower growth. Thus, it can be concluded that the total effect of car mode share on economic growth not caused by higher GNP is −0.27. These conclusions are tentative because neither of the car mode share variables is significant with 95 percent assurance.

Thus, doing simple regression and correlation analysis of a data set from 40 major cities around the world from developed and developing countries lends statistical support to the notion that encouraging bicycle use and discouraging automobile use will encourage rapid economic growth, largely because of its effect on the investment and savings rate but also because of its effect on urban form and the level of oil dependency.

Microeconomic Evidence

Though there is considerable macroeconomic evidence that promoting nonmotorized vehicles and constraining the consumption of private automobiles is likely to encourage economic growth, there is also considerable microeconomic evidence that a major obstacle to development is extremely low productivity in the movement of goods and low-income people. Furthermore, these low productivity levels are not primarily the result of insufficient road infrastructure but the result of the fact that people with very low incomes cannot afford to use available vehicle technologies. The importance of nonmotorized vehicles from an economic perspective is that they provide an intermediate technology that can improve transport productivity levels dramatically at a cost more affordable to a far greater percentage of the world's population than are alternative, motorized technologies.

Unfortunately, the infrastructure focus of most governments and major development organizations such as the World Bank has resulted in minimal attempts to develop methodologies to quantify these economic benefits. Left unquantified, these benefits until recently have been left out of most cost-benefit analyses. World Bank cost-benefit analyses of road projects in developing countries increasingly estimate the value of passenger travel time saved, but these benefits are restricted to road users in motorized vehicles. Until the recent initiative by the World Bank, the benefits and costs to nonmotorized road users—such as pedestrians, bicyclists, informal cart vendors, and rickshaw drivers—had *never* been measured, nor had a methodology for their measurement been developed.

For example, in recent economic assessments for a highway and traffic realignment project in Shanghai, China, which planned to ban bicycle use on major downtown streets, only a minimal attempt was made to estimate the economic impact of the project on bicyclists and pedestrians, despite the fact that 71 percent of all trips in the area are made by these modes (*21*).

New road projects can have severe negative impacts on nonmotorized vehicles, either as a result of banning them from the new road or by creating severance problems in which people wishing to cross the road have to travel long distances or cross awkward overpasses to reach their destinations. Although these severance effects are now included in World Bank environmental impact assessment guidelines (*22*), they are ignored in all economic assessments, even though they have serious travel time and hence economic implications for what are in some cases the users of the predominant mode.

On the other hand, the important positive economic effects of the inclusion of lanes for slow-moving vehicles, nonmotorized vehicle parking at public transit stations, and other infrastructure investments are also ignored, not to mention their enormous impact on road safety.

Not valuing these factors has been justified in part by the fact that it is administratively very difficult and expensive to collect data on nonmotorized vehicle users, data that are highly dependent on local conditions. However, as long as these factors remain exogenous there is no way to estimate their economic significance.

Some have argued that travel time is not important in countries with high levels of underemployment, but recent analysis of labor patterns in less developed countries indicates that the problem is less *under*employment than it is *very low–productivity* employment. Transportation is an important part of this low productivity. In Beira, Mozambique, women involved in primarily subsistence agriculture spend as many as 3.36 hr/day transporting agricultural materials and produce and another 3.6 hr/day transporting water and firewood for the household (*23*). Spending 7 hr/day on transport-related tasks on top of child rearing and education and household maintenance tasks can hardly be called underemployment, but it is certainly an example of low-productivity employment. This low productivity in transportation can greatly inhibit the ability to dedicate labor to agricultural or supplementary income-generating activities.

A similar study in Tanzania indicated that women spend 1,648 hr and men spend 531 hr/year on transporting basic necessities. In Ghana, women spent roughly 980 hr/year on transport, with 30 percent related to marketing crops, 30 percent related to direct agricultural production, and 40 percent related to household maintenance activities, mostly collecting water and firewood (*24,25*). Whether or not these production activities are in the modern sector of the economy, it is clear that these people are not underemployed so much as their productivity level is very low, largely because of the lack of proper mobility.

Whether the level of an individual's production is generating enough surplus to produce goods for trade in the market or not, the time it takes to generate sufficient economic output for survival should have a value roughly equivalent to the subsistence wage. Therefore, whether the time of the person saved by a transport improvement is remunerated, it should be valued at roughly the equivalent of at least the subsistence wage. Unless these economic activities, which are critical to the economic development of almost all developing country populations, are given much greater value in cost-benefit procedures, the emphasis of World Bank lending on infrastructure projects that may have minimal impact on most of the population will continue.

Another reason that economic impacts on nonmotorized road users have long been ignored is that many of the factors affecting nonmotorized vehicle use will be policy issues rather than infrastructure issues, and economic evaluation methods until recently have been less than adept at measuring the economic effects under a diversity of policy regimes. It may be the case that increases in motorized traffic speeds alone will act as a barrier to the use of road infrastructure by nonmotorized modes. Bicyclists may fear for their safety in the absence of lanes to separate nonmotorized from motorized vehicle users. Banning nonmotorized vehicles from using or crossing high-speed roads will obviously have a serious negative impact on nonmotorized road users, but again this results from a policy decision, not from the improvement of the infrastructure per se. Cost-benefit analysis, if it is to measure real economic costs, must be able to measure the economic costs and benefits of these policy options. Many policy decisions besides the build/no build options are all too often ignored.

Until recently, the only way that nonmotorized vehicles enter World Bank cost-benefit analysis is as a negative externality on motorized traffic (*26*). In other words, it treats slow-moving vehicles in the same way it treats low pavement quality, as a factor considered only in light of its negative impact on the travel time of motorized vehicles. This negative impact is real, and should be incorporated into the model, but in the same sense, the presence of too many motorized vehicles could be argued to be a major cost to nonmotorized users. These costs must also be calculated. Thus, the economic impacts of a change in road policy (such as segregating traffic into motorized and nonmotorized lanes or banning nonmotorized vehicle traffic) or a road investment (widening or straightening the road) on all vehicles must be considered, not just the impact on motorized road users. Otherwise, the economic impact of a policy such as banning nonmotorized vehicles will have a higher economic return than providing a slow-moving vehicle lane, as the roadside friction would be removed at what would be measured as zero cost, ignoring the harm done to the nonmotorized road users themselves.

The economic costs and benefits of the impact of road projects and policies on nonmotorized road users can be estimated in the following way. Transportation services do not offer an infinite number of trade-offs between travel time, trip cost, trip comfort, and trip safety. As a result, people taking one mode may actually have been willing to pay more or less to take a slower or faster mode were it an option.

Thus, the impact of a change in road quality, road policy, or other transportation-related investment could have the following effects on nonmotorized transport:

- It could induce people to switch between bicycling or walking and a more expensive mode (bus, paratransit) that may or may not be faster,
- It could induce people to switch between bicycling and a more or less expensive and slower mode such as walking or animal or pedicab, or
- It could speed or slow the travel time and affect the maintenance costs of all current nonmotorized users.

When a slow-moving-vehicle lane is added to a road, for example, the benefit of such a change can be measured by taking the net present value of a stream of benefits into eternity calculated by adding

- The money saved in a particular period by all generated nonmotorized road users who formerly used a more expensive mode *minus* the value of any time lost related to switching modes,
- The value of the time saved by all new nonmotorized road users who used to walk *minus* the increased costs of the trip related to bicycle ownership and maintenance, and
- The value of the increased or decreased travel time costs for all current nonmotorized users.

It is important to point out that the nature of the road infrastructure, whether there are lanes for slow moving vehicles or not, is often less important as an issue than the availability of nonmotorized vehicles. Often the lack of up-front capital for low-income people to buy the vehicles, lack of facilities to rent nonmotorized vehicles, and an underdeveloped private sector engaged in nonmotorized vehicle production or importation are larger problems than the nature of the infrastructure. This is an important point because it may be that World Bank projects focusing on these projects will show a higher rate of return than projects focused specifically on infrastructure.

Example of Shift from Bus to NMT

In one area of Masaya, Nicaragua, for example, the average person spent $442/year to commute to a job downtown by bus. At the time, shortages of oil and spare parts resulted in buses that were overcrowded, moved very slowly, and broke down often. With a bicycle one could make the trip in roughly the same amount of time, or slightly less time, for the cost of a $99 bicycle and $24 in annual maintenance. The savings in 1 year of using the bicycle rather than the bus were $319. In this case the obstacle to bicycle transportation was not the nature of the infrastructure but the lack of up-front capital to purchase the bicycle. It should, however, be possible in the case of a change in road infrastructure to study the impact of the change on generated nonmotorized vehicle traffic. Though predicting the impact on nonmotorized vehicle traffic levels of a particular investment is likely to have a wide margin of error, this problem is endemic in cost-benefit analysis in the transportation sector. The bigger problem is that there are very few studies (perhaps none) on which to develop a predictive model.

Example of Shift from Walking to NMT

In many poor countries, the inclusion of nonmotorized vehicle lanes (assuming nonmotorized vehicles are available) may lead to a shift from walking to NMT. The benefit is primarily in the form of travel time. Changes in travel time should be measured at some fixed fraction of at least the minimal survival wage rate in the country. In the studies in Beira, Mozambique, NMT was able to decrease the travel time by 50 percent over walking. Given total travel time, residents were able to save some 72.9 hr/month. The average subsistence wage in the area was roughly $0.10/hr, which gives an estimated economic value of the time saved at $7.29/month. Whether this value is justified could be determined by a study of the impact of the saved travel time of total aggregate personal income, but such studies do not exist. The costs of vehicle ownership and maintenance then must be deducted from this value.

Economic Development Impacts

Measuring the economic development benefits of an infrastructure project is complex. Economic development benefits for motorized vehicle users are rarely included in economic assessment procedures, and are not included in the HDM model. If economic development benefits to motorized users are included, however, some effort to measure the economic development impacts to nonmotorized users should also be made.

One economic benefit of making NMT options viable is that it allows microenterprises to expand the market area for their goods. In the case study in Beira, Mozambique, the introduction of nonmotorized modes allowed local fishermen to bypass middlemen, with an enormous impact on their income. During the fishing season (6 months a year), the ability of fishermen to use nonmotorized vehicles to take their goods directly to market and bypass middlemen increased their income by $90.05/month. From an aggregate economic perspective, however, the economic benefit would have to be calculated using welfare economics, adding the new income to the fishermen and the increased consumers resulting from a fall in the price of fish in the market minus the fall in income of the middlemen.

It must be again pointed out that the benefit came not from changing the road infrastructure or road policy but from overcoming market failures inhibiting the access to vehicles. Nevertheless, the same methods could be used to measure the economic effects of infrastructure by looking at the impact of the project or policy on generating or inhibiting nonmotorized vehicle traffic.

CONCLUSION

Although NMT has been seen by many policy makers in developed and developing countries as a sign of underdevelopment, the most rapidly growing economies in the world are turning more often to nonmotorized transportation. Not only does bicycle ownership increase with income, contrary to popular belief, but even such labor-intensive vehicles as pedicabs have begun to reappear in countries as diverse as the United States, the Philippines, and Holland, just as they are being driven out by hostile public policies in developing countries. Private motor vehicle technologies have been around since the 1860s, roughly contemporaneous with the advent of the rickshaw in Japan in 1868. Motorized as well as nonmotorized vehicles have been significantly modernized since then, although developing countries have ignored important improvements in their productivity levels that could be achieved easily and inexpensively by modernizing their human-powered vehicle fleets and production facilities, many of which are still operating with technology that has been outmoded for decades. Bicycle use and ownership has risen and fallen and risen again in most developed countries, paralleling the rise and fall of the mass production economy. Motor vehicle sales are stagnant in the developed world, which explains the efforts to develop markets in developing countries. Planners should consider leapfrogging to the most modern transport technologies of extremely lightweight and low-cost electric powered and nonmotorized vehicles rather than becoming a dumping ground for vehicles that in developed countries may soon be outmoded.

REFERENCES

1. Pettinge, A. Ujpest Pilot Project: Bicycle-Friendly District in Budapest. Final report on Dutch technical assistance. Grontmij Consulting Engineers, Zeist-Amersfoort, The Netherlands, 1995.
2. Brown, L., and E. Ayres. Bicycles Surpassing Automobiles as Leading Form of Personal Transport. Vital Signs Brief No. 6. Worldwatch Institute, Washington, D.C., 1992.
3. Howe, J., and R. Dennis. The Bicycle in Africa: Luxury or Necessity? Presented at velocity conference, The Civilized City: Responses to New Transport Priorities, Nottingham, U.K., 1993.
4. Deyo, F., ed. *The Political Economy of New Asian Industrialism.* Cornell University Press, Ithaca, N.Y., 1987.
5. *World Energy Statistics and Balances 1971–1987.* International Energy Agency, OECD, Paris, 1989.
6. Bicycle Federation of America. *Bicycling Reference Book: Transportation Issue.* Bicycle Institute of America, Washington, D.C., 1994.
7. *Facts and Figures of the U.S. Automobile Industry.* Motor Vehicle Manufacturers Association, Washington, D.C., 1990.
8. Renner, M. Rethinking the Role of the Automobile. Paper 84. Worldwatch Institute, Washington, D.C., 1988.
9. Lowe, M. Alternatives to the Automobile. Paper 98. Worldwatch Institute, Washington, D.C., 1990.
10. Heierli, U. *Environmental Limits to Motorization.* Swiss Center for Appropriate Technology, St. Galen, 1993.
11. Hook, W. The Role of Nonmotorized and Public Transportation in Japan's Economic Success. In *Transportation Research Record 1441,* TRB, National Research Council, Washington, D.C., 1994.
12. Phillips, M., and R. Gnaizda. New Age Doctrine is Out to Lunch on Three Issues. *CoEvolution Quarterly*, summer, 1980.
13. *The Costs of Sprawl.* U.S. Department of Housing and Urban Development, Washington, D.C., 1974.
14. *World Motor Vehicle Data, 1991.* Motor Vehicles Manufacturing Association, Washington D.C., 1991.
15. Replogle, M. *Non-Motorized Vehicles in Asian Cities.* The World Bank, Washington, D.C., 1992.
16. Barrett, R. Satisfying Urban Public Transport Demands. World Bank Urban Transport Working Group, Yaounde, Cameroon, 1990.
17. Armstrong-Wright, A. *Urban Transit Systems.* The World Bank, Washington, D.C., 1988.
18. Newman, P., and J. Kenworthy. *Cities and Automobile Dependence.* Gower, Melbourne, Australia, 1989.
19. Bertaud, A. Land Markets, Urban Form, and the Environment. Presented at 2nd Annual World Bank Conference on Environmentally Sustainable Development, Washington, D.C. 1994.
20. Barro, R. Economic Growth in a Cross Section of Countries. *Quarterly Journal of Economics*, Vol. 106, 1991.
21. *Shanghai Metropolitan Transport Project.* World Bank Staff Appraisal Report. The World Bank, Washington, D.C., 1993.
22. *Environmental Assessment Sourcebook.* The World Bank, Washington, D.C., 1991.
23. Overton, K. Women Take Back the Streets: Overcoming Gender Obstacles to Women's Mobility in Africa. *Sustainable Transport*, July 1994.
24. Dawson, J., and I. Barwell. *Roads Are Not Enough.* Intermediate Technology Publications, London, 1993.
25. Howe, J., and D. Bryceson. Rural Household Transport in Africa: Reducing the Burden on Women? African Studies Center, Leiden, Holland, 1993.
26. Hoban, C., and R. Archondo-Callao. HDM-Q: Highway Design and Maintenance Model HDM-III with Congestion Analysis Capabilities. The World Bank, Washington, D.C., 1992.