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MOTOR VEHICLE TRANSPORT AND GLOBAL CLIMATE CHANGE:
POLICY SCENARIOS

Richard Wallace

The University of Michigan
Urban, Technological, and Environmental Planning

Driven largely by rapidly increasing atmospheric levels of greenhouse gases, such as carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (CFCs), the global climate appears to many observers (e.g., Meadows, Meadows, and Randers 1992) to be in a period of change. Computer models suggest that throughout most of the temperate zones of the world this change will take the form of rising temperatures. Motor vehicles, which are powered by fossil-fuel burning engines that emit carbon dioxide and nitrous oxide, contribute significantly to the production of potentially climate altering greenhouse gases. Simply put, carbon dioxide "is an inevitable byproduct of fossil fuel consumption and it streams out of tail pipes in direct proportion to the quantity of fuel burned" (Wilkinson 1993). On average, for every kilogram of standard motor vehicle fuel (gasoline) consumed, three kilograms of carbon dioxide are released into the atmosphere (Faiz 1993). Furthermore, motor vehicles emit other greenhouse gases, too, such as CFCs that leak from air conditioners. Thus, while improved fuel economy can have a mitigating effect on total greenhouse emissions, in general the greater the number of motor vehicles, and the more miles that they are driven, the larger their contribution to global climate change. Therefore, understanding trends in the number of vehicles registered and examining policy options to curb growth in this number can play a significant role in combating global climate change.

Worldwide, transport energy accounts for about 20 percent of total emissions of greenhouse gases (Lashof and Tirpak 1990), but this figure varies from nation to nation. In the OECD nations as a whole, transport contributes between 26 and 31 percent of all greenhouse emissions produced there, while in the U.S. transport accounts for 38 percent of domestic greenhouse emissions (International Energy Agency 1993). In the Less

Developed Countries (LDCs) and in Eastern Europe, largely due to lower rates of car ownership and use, the transport sector currently accounts for a smaller contribution to greenhouse emissions (Faiz 1993), but these nations represent a burgeoning new market for vehicles. As a result, greenhouse emissions from the LDCs are expected to rise in the near future.

By contributing significantly to greenhouse gas emissions and, therefore, to global climate change, the motor vehicle sector plays a role in the general class of phenomena known as population-environment dynamics. This dynamic, as described by Drake (1993), is characterized by transitions from one stable state to another. While the second stable state may be a more or less desirable state than the original condition, and it is often worse (e.g., the transition from forest to desert that is taking place in some regions), Drake argues, and offers supporting data, that the transition phase itself is a period of vulnerability, characterized by the potential for extremely negative outcomes. Transitions, however, also offer opportunities, and positive outcomes can occur, too, especially if appropriate policies are pursued to manage the transition. Thus, while human society and environmental systems both may survive under a new climatic regime, the transition period may prove to be the most dangerous period of all.

The field of population-environment dynamics thus leads us to see not only that transport affects the global environment, but also that transport emissions of greenhouse gases are not purely a function of the number of vehicles, miles driven, fuel use, and emissions technology. Worldwide, the ratio of people to motor vehicles varies considerably from nation to nation. While we might expect this ratio to be highly correlated with GNP per capita, a simple linear regression fails to detect a significant relationship between these two variables. Approaching this relationship geographically (see Figure 1), however, reveals a clear relationship--wealthier nations in general have a lower ratio of vehicles per person.

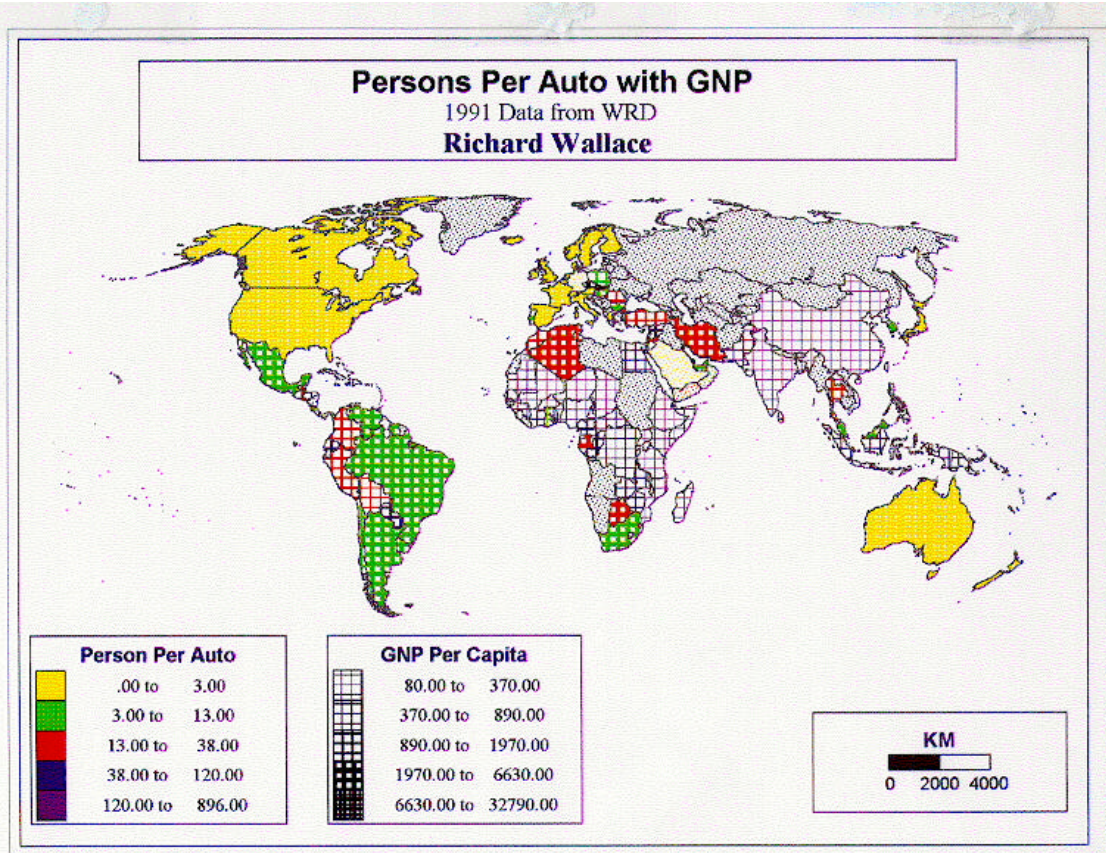


Figure 1.

Population growth, too, can have an effect on the number of vehicles. By examining trends and relationships in and between these technological and social factors, this paper seeks to investigate the efficacy of different policy options on reducing the quantity of greenhouse emissions from the transport sector. This analysis will be performed for six nations that typify the range of transport, economic, and population dynamics across the globe. By examining nations that differ in these key respects, the analysis will illustrate different dimensions of the dynamic and provide policy guidance tailored to the specific circumstances of each nation and beyond to the world community. The six nations examined here, and the patterns that they represent, are listed in Table 1.

Table 1.

Nation	Pattern
United States	Wealthy, high use of autos and energy
Japan	Wealthy, more emphasis on public transit and more energy efficient
Hungary	Former Eastern Block, dirty cars
India	Less developed, low car ownership, booming population
Mexico	Latin American, Industrializing
South Korea	Asian Newly Industrialized Country (NIC)

While no rigorous attempt will be made to justify this categorization, a few observations backed by data collected by the World Resources Institute (WRD) and the American Automobile Manufacturers Association (AAMA) provides it some legitimacy. First, vehicle technology varies substantially between the most highly industrialized nations and the rest of the world. The typical vehicle manufactured in Eastern Europe and the LDCs is only about half as fuel efficient as typical OECD-manufactured vehicles (Faiz 1993). Second, an examination of trends in the number of registered vehicles in Hungary, India, Mexico, and South Korea (see Figure 2) reveals a clear distinction between them, with the two industrializing nations (South Korea and Mexico) showing an especially steep growth curve, India showing a slower rate of growth, and Hungary showing little growth at all. Based on this evidence, these six nations do appear to represent distinct patterns.

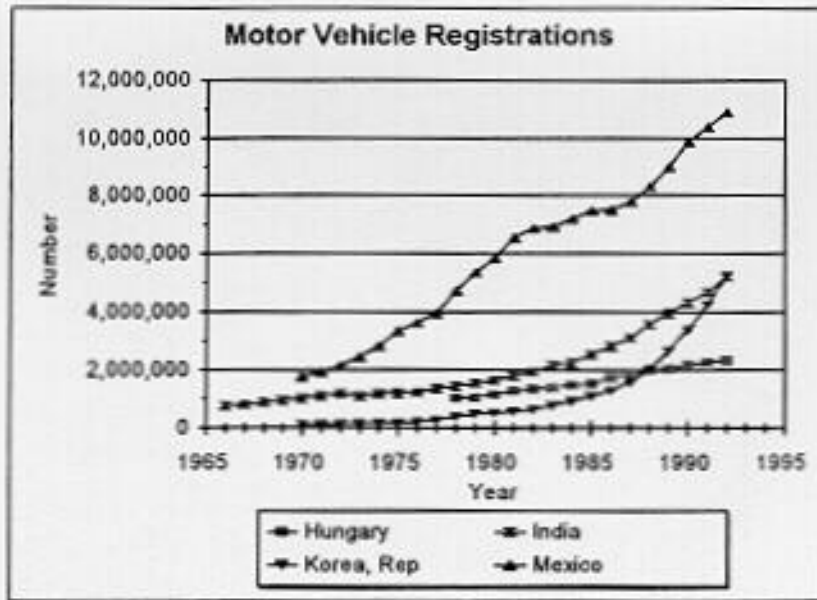


Figure 2. Source: AAMA.

Figure 2. Motor Vehicle Registrations in the six nations considered.

Patterns of Vehicle Use

Across the six nations listed in Table 1, reliance on motor vehicles for transportation varies greatly. In 1992, for example, India and South Korea each had roughly the same number of motor vehicles registered, but India's population was nearly twenty times that of South Korea. On the other hand, of these six nations, India, which had by far the highest ratio of people to vehicles in 1992, experienced the largest absolute drop in this figure over the last twenty years (see Figure 3, which is drawn to log scale so that all six nations may be viewed on one graph). Thus, while the U.S. and Japan currently are the largest contributors to greenhouse emissions from the transportation sector, population and consumption trends suggest that other nations will account for an ever-increasing percentage of transportation's contribution to greenhouse gas emissions in the future.

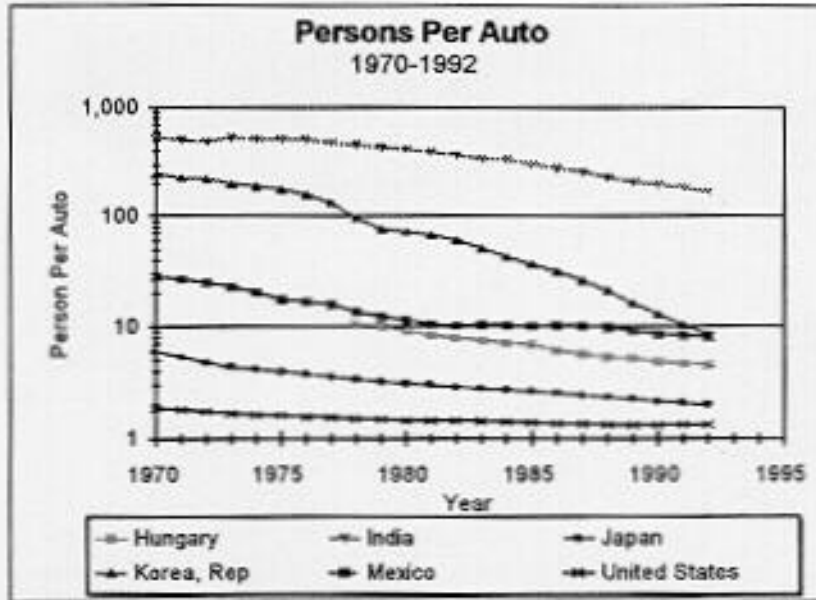


Figure 3. Sources: WRD and AAMA.

Figure 3 shows that all six nations, with the exception of the U.S., still are experiencing a decline in the ratio of people to vehicles. What is driving this trend, however, varies from nation to nation. In some cases, rising consumption, as measured by GNP growth, appears to be the driving factor, while in others increasing urbanization as measured by urban population, appears to be the culprit. Epitomizing these two dynamics are Japan, South Korea, and Hungary. In Japan (see Figure 4), the increase in vehicle registrations appears to have been driven largely by increases in population and urbanization in the early post-war years, with more recent gains appearing to be more associated with increased GNP. By comparison, South Korea (see Figure 5), displays a relationship between increased vehicle registrations and a rising GNP, with population appearing to have little effect. Finally, Hungary (see Figure 6) displays a combination of the two effects, with both urban population growth (despite a steady total population) and GNP growth associated with increased vehicle registrations during the study period.

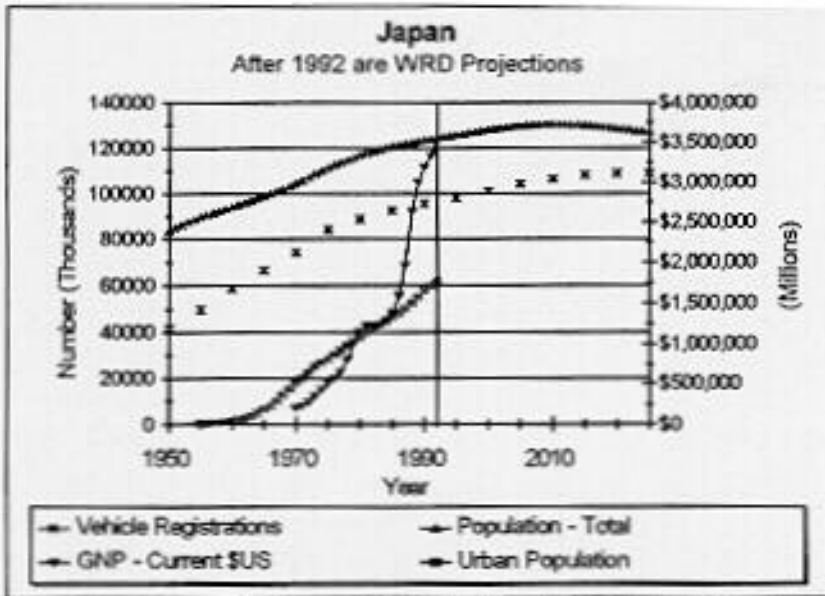


Figure 4. Sources: WRD and AAMA. Note that GNP is tied to the right-hand axis.

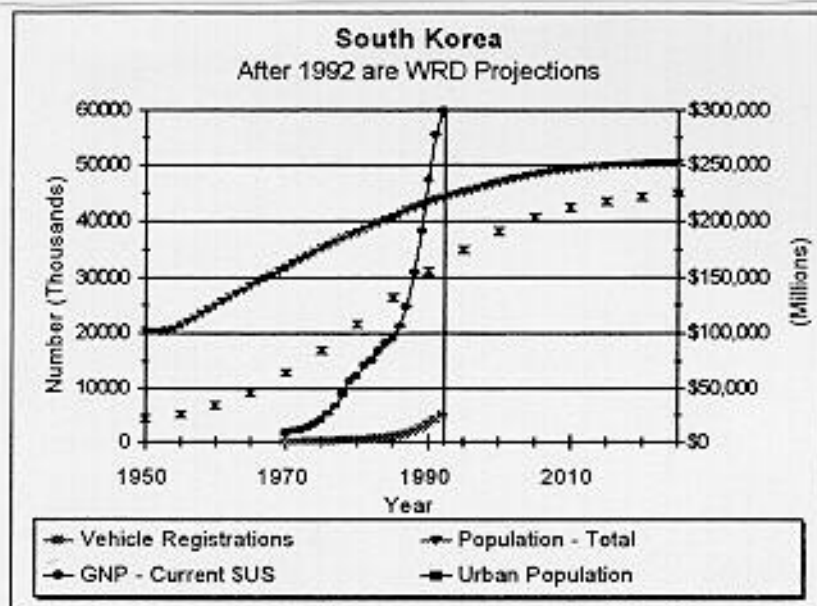


Figure 5. Sources: WRD and AAMA. Note that GNP is tied to the right-hand axis.

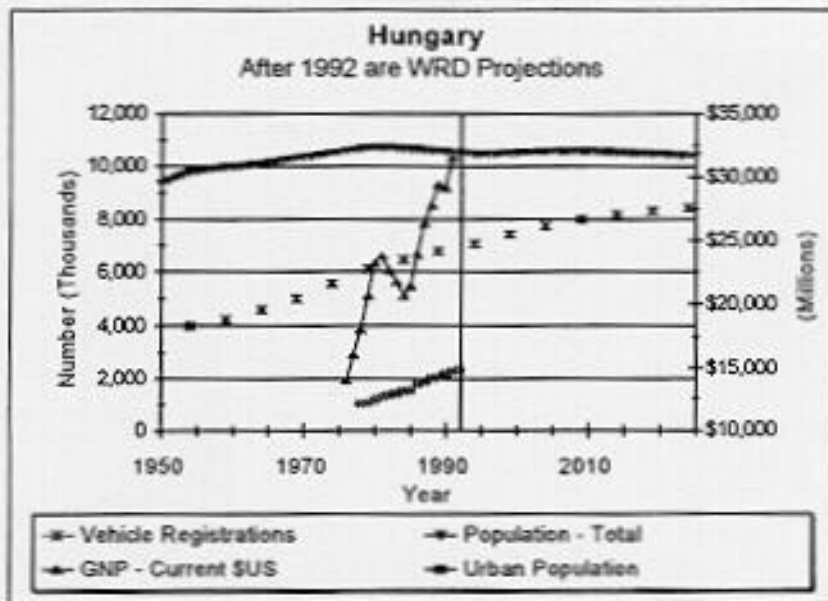


Figure 6. Sources: WRD and AAMA. Note that GNP is tied to the right-hand axis.

Policy Options

As described by Meadows, Meadows, and Randers (1992), environmental impacts can be viewed as a function of population, consumption patterns, and the state of technology. These variables also appear within the policy options available to reduce the contribution of the transportation sector to greenhouse gas emissions. Among these are: (1) increased fuel efficiency, (2) reliance on alternative fuels, (3) reliance on public transportation and other travel behavior approaches, (4) consumption limits, and (5) population-control policies. While these approaches range from technological fixes to changes in societal norms, even the technology-based approaches demand a corresponding societal component. Increasing fuel efficiency, for example, requires the political will to raise minimum standards, and increasing use of public transportation requires alteration of travel behavior. If we are to explore the likely effectiveness of each of these policies, we must first understand how and what each contributes to the reduction in emissions of greenhouse gases and, where possible, gauge how this dynamic might play out in the near future--not an easy undertaking.

Given a rather large body of research and literature in the field, gauging future technical abilities is perhaps the simplest forecasting task. DeLuchi (1993) has estimated the reduction in greenhouse gas emissions from a variety of alternative fuel sources. His findings indicate a broad range of outcomes depending on the source of the alternative power. Electric vehicles powered by coal-burning plants, for example, can be expected to lead to an increase in the amount of greenhouse emissions compared to a standard gasoline- or diesel-burning vehicle. Emissions reductions, however, would be realized from a variety of alternative fuels, including solar-powered electric, compressed natural gas, methanol (from wood), and ethanol (from several sources). The International Energy Agency (IEA; 1993) produced similar findings, also adding liquid hydrogen to the list of alternative fuels that would reduce greenhouse emissions. Using middle estimates from the latter source, anywhere from a 25 to 50 percent reduction in emissions appears feasible. Recent technological breakthroughs in the manufacture of photovoltaic panels, which suggest the possibility of producing solar energy at very competitive market rates by next year, promise to make this figure even higher (Myerson 1994).

The IEA also studied potential improvements to fuel economy and found that by 2006 a 10 to 20 percent improvement is feasible for OECD nations. This estimate is conservative and is based only on marginal improvements to currently employed vehicle technologies and materials. Other researchers, however, have cast aside such industry-bound restraints and discussed what could be done even today using technical inputs from beyond the traditional steel-centered perspective of the global auto industry. Typifying this approach, Lovins and Lovins (1994) tout the revolutionary potential of a new car design known as an ultralight hybrid. These light-weight vehicles, manufactured from high-tech composite materials such as carbon fiber, and powered by a combination of liquid fuel and a battery-powered flywheel that captures and stores energy now lost during braking, offer a tenfold improvement in fuel economy over today's typical car. These vehicles also offer equal or better safety, mostly because, pound for pound, these ultralight materials possess far superior crash resistance than does steel. As the Lovins's recognize, bringing such vehicles to market will require a major restructuring of the auto industry, but large auto companies that resist making these changes may soon be leapfrogged by other

manufacturers, such as former defense contractors, more experienced with these new materials.

Public transportation provides another alternative to reliance on motor vehicles. Although increased urbanization seems to be a factor associated with increased vehicle registrations, public transportation works best in urbanized areas. Which effect seems to dominate may be a consequence of urban density. As Newman and Kenworthy (1991) showed in their study of 32 of the world's major cities, per capita consumption of gasoline can vary considerably, even across affluent nations. They found that, generally, in high-density cities such as Tokyo, per capita gasoline consumption is far less (about 1/6) than in relatively low-density U.S. cities. Much of this difference can be explained by examining the rate of transit use between these cities. The average resident of Tokyo takes 472 transit trips per year, while the typical New Yorker takes 58 and a Detroitter only 17; vehicle ownership rates may be similar in Japan and the U.S., but vehicle use is lower in high density areas. Given the relationship between fuel consumption and greenhouse emissions, less vehicle use results in less greenhouse emissions.

Consumption limits represent perhaps the most difficult policy option to address. While draconian laws certainly hold out the promise of being effective in reducing reliance on motor vehicles, such approaches carry high social costs and appear incompatible with dominant social and political standards in much of the world. Fortunately, policies exist that achieve the goal of reduced consumption without serious intrusions on individual liberties. On the regulatory side, for example, implementation and enforcement of vehicle occupancy regulations can reduce the preponderance of singly-occupied vehicles. On the market-based side, high fuel taxes provide economic incentives for people to choose non-vehicular travel modes, as does the elimination of free parking in employment centers (Wachs 1981).

Finally, in those nations experiencing rapid population growth, policies aimed at slowing or reducing population growth may have some promise in reducing their transportation sector's contribution to greenhouse emissions. On the other hand, it may be that controlling population will increase wealth in these nations, thereby increasing demand for motor vehicles. Either way, India, with its large population of would-be

motorists, has an enormous potential to contribute to greenhouse emissions, and the ratio of people to motor vehicles in India has been falling.

Tailoring Policy to Population-Environment Conditions

Given differences in the forces influencing increased motor vehicle registrations, and therefore increased greenhouse emissions, the range of potentially effective policy options available to each nation also is likely to be different. Each of these policy options thus is best suited to a particular set of political, technological, economic, and societal conditions. A policy that promises to be effective in one country, therefore, may be inappropriate for another. Population-control measures, for example, appear to be an unlikely candidate to reduce greenhouse emissions from the transportation sector in nations such as Hungary that are experiencing little or no population growth. The task at hand, therefore, is to match policies to nations in the most effective manner. Doing so requires forecasting growth in the motor vehicle population, particularly the fossil-fuel powered motor-vehicle population, within the societal context of each nation.

To start this analysis, let us begin with the number one emitter of greenhouse gases via motor vehicles--the United States. Because the U.S. has so many more motor vehicles than any other nation, reducing emissions in the U.S. alone would signal progress toward worldwide reduction. As can be seen in Figure 7, the U.S. is undergoing a steep rise in GNP, along with a moderate rise in both total and urban population. The rate of increase in the number of registered automobiles, however, appears to be declining. The already enormous number of vehicles registered in the U.S. points to the need of reducing either the per-capita use of each vehicle or the amount of emissions per vehicle or both. This state of high wealth and an abundance of motor vehicles suggests pursuing one or more of the technological approaches listed above--California's mandate that two percent of vehicles sold be zero-emissions vehicles by 1998 (and 10 percent by 2005) is a good example--along with some modifications to travel behavior, such as increasing the importance of public transportation. Based on these policy pursuits, future vehicle registrations for the U.S. can be projected.

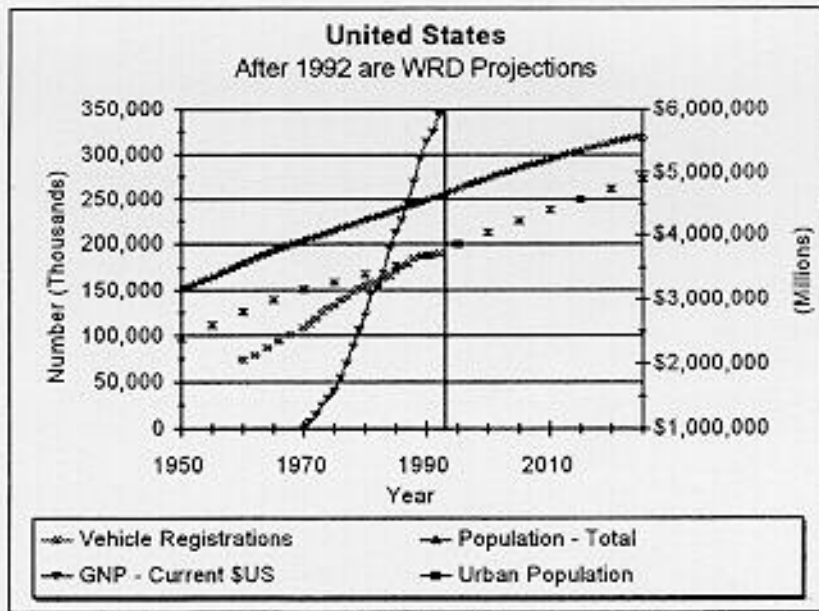


Figure 7. Sources: WRD and AAMA. Note that GNP is tied to the right-hand axis.

To begin forecasting, we first need to find a good fit to the current trend in vehicle registrations. From Figure 7, the growth in the number of motor vehicles in the U.S. appears to be S-shaped, suggesting a logistic (or other similar) function. Assuming a maximum value of 225,000,000 cars by 2025, an S-shaped curve can be fit successfully to the data. Furthermore, following California's lead, we can mandate that one percent of all vehicles registered be zero emissions by 1998. Next, we can go a step further and assume that the zero-emissions portion of the vehicle fleet will increase by one percent each year thereafter. As shown in Figure 8, this scenario implies a gradual decrease in the number of fossil-fuel powered vehicles, with this number falling below current levels by 2005 and continuing down to 160 million (more than 30 million below the current number) by 2025. While this decrease is modest, combining it with increased fuel economy in remaining fossil-fuel-powered vehicles, and at worst, no increase in vehicle miles traveled per vehicle, could multiply the result by a factor of ten or so. In effect, this means the equivalent of about 16 million of today's motor vehicles--a figure not seen in the U.S. since the mid-1920s.

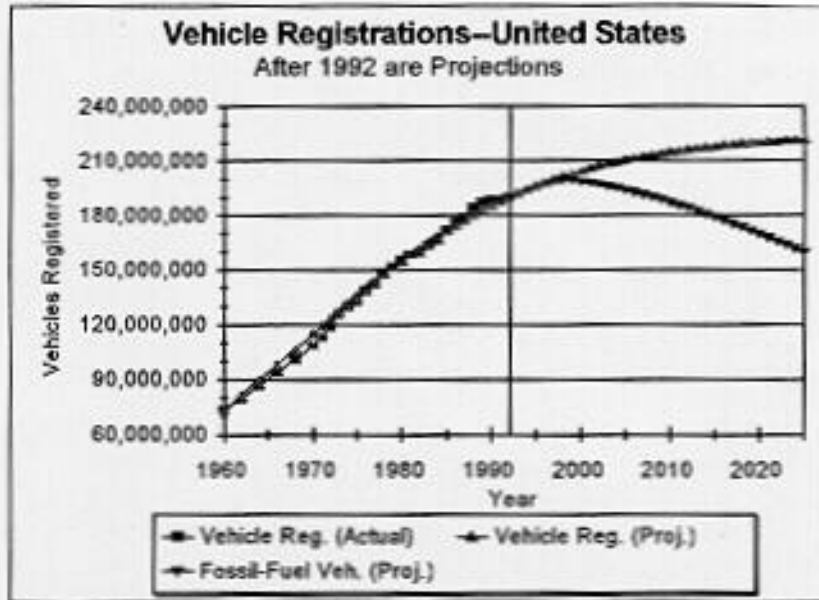


Figure 8. Source: AAMA.

For Japan, the other economic powerhouse in the analysis, technological solutions also are appealing. As can be seen in Figure 4, however, growth in motor vehicle registrations in Japan continues at what appears to be a linear rate (with $r^2=0.99$ when beginning with the year 1960, this trend is fit better by a straight line than either an exponential or logistic curve), driven by a growing GNP. If this linear trend continues, Japan will have about 125 million registered motor vehicles by 2025 (see Figure 9). Assuming a similar pattern of switching to zero-emissions vehicles as was forecast for the U.S., we find that the number of fossil fuel vehicles does begin to assume an S-shaped curve. Like the U.S., Japan would appear to have the technical and economic means to also pursue fuel-economy improvements, too. Again, another tenfold increase in effectiveness is possible, meaning the equivalent of a little more than 9 million of today's cars by 2025. As discussed earlier, Japan also displays less reliance on the cars that are registered. If this pattern also continues, then the effectiveness of Japanese efforts to reduce greenhouse emissions can be further enhanced.

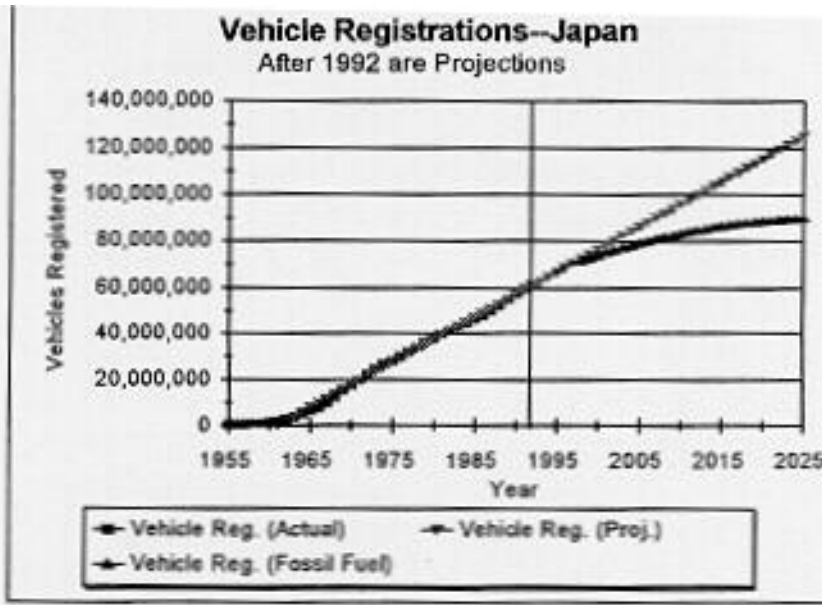


Figure 9. Source: AAMA.

In Hungary, as we saw in Figure 3, the population growth rate is close to zero. Nonetheless, the urban population continues to grow, as does the number of registered vehicles. Currently, however, Hungary has the fewest registered vehicles of all six nations included in this study, but many of these cars are relatively high polluting and inefficient vehicles based on the engine technology typical of Eastern European nations (Michelberger 1991). To a large extent, then, Hungary's contribution to greenhouse emissions is related to poor vehicle technology. Thus the ongoing replacement of its fleet of older, outdated vehicles with newer, Western-style vehicles offers a sure path to fewer overall emissions. This dynamic, however, competes with growth in the size of the vehicle fleet. This growth is fit well by both a linear and a logistic curve (with a maximum value of 5 million), with these two not diverging by much until around 2010 (see Figure 10). This result suggests that Hungarian transportation policy stands able to influence future growth in vehicles: Hungary can choose to maintain and improve alternate modes (especially public transit) or accept the consequences of a vehicle-centered society. Either way, however, Hungary will continue to have the smallest vehicle fleet in this study and can be expected to make only a small contribution to greenhouse emissions.

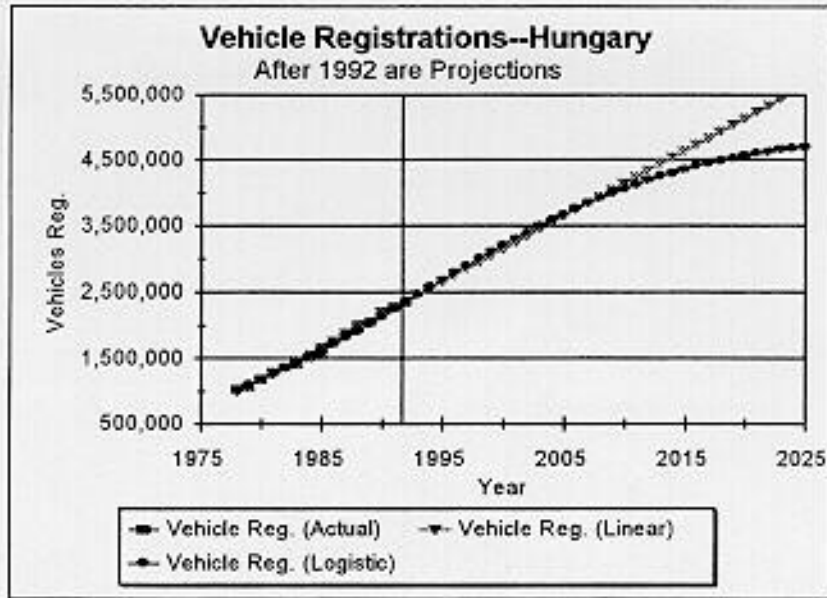


Figure 10. Source: AAMA.

India, which has yet to see its population growth rate begin declining, has been projected to soon overtake China as the world's most populous nation (see Figure 11). Relative to this enormous population, however, India has a very low number of registered vehicles. In the near term, the rate of growth in the vehicle population, however, is exponential, regardless of whether an exponential or logistic function (with a maximum value of either 140 or 200 million) is fit to the actual data (see Figure 12). Thus India's growth rate in this area may not be boundless, but current trends suggest that India eventually will meet or surpass the number of motor vehicles currently registered in the U.S.



Figure 11. Sources: WRD and AAMA.

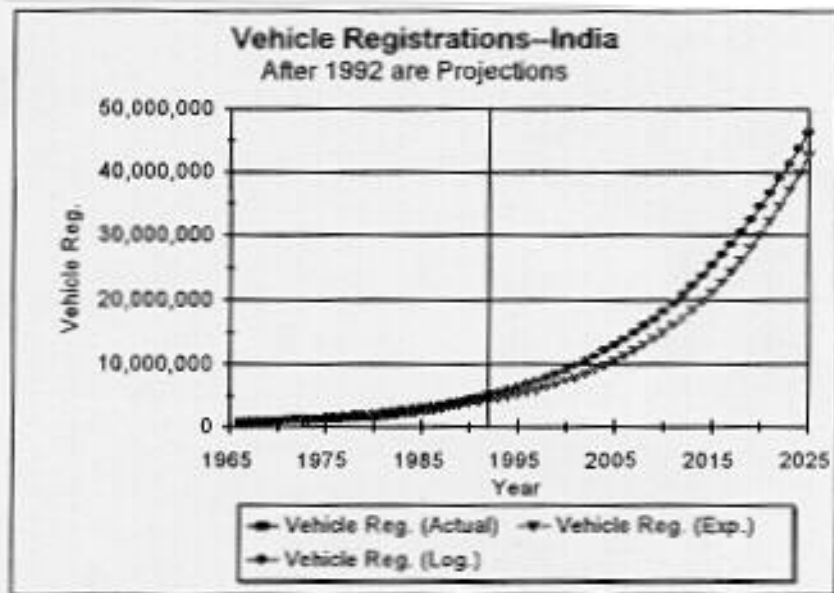


Figure 12. Source: AAMA.

Given this growth in vehicle registrations, India can be expected to experience increased negative consequences of fossil-fuel based travel, including worsening congestion and pollution, and to dramatically increase its contribution to greenhouse

emissions from the transportation sector. The level at which this growth is bounded, along with which technologies and policies India applies to mitigate these problems (e.g., alternative fuels, emissions controls, demand management), will determine the severity of future outcomes and India's contribution to greenhouse emissions. Unfortunately, however, India does not appear to have the economic strength to address this problem with technological approaches, save what may accrue naturally from advancing vehicle technology. Developing infrastructures for alternative fuels, for example, would appear unlikely in the near future. These leaves India with only one option from the above list of policies for addressing greenhouse gas emissions from transportation--travel behavior measures. In this regard, India already relies predominantly on non-motorized forms of personal transit in rural areas and on high vehicle-occupancy rates in urban areas. Restricting access to vehicle purchases--perhaps unpopular with the growing middle class--and financial disincentives, such as a high fuel tax, for vehicle travel both are options worth considering.

Excluding the U.S. and Japan, Mexico has far more registered vehicles than the other nations in this study and, as Figure 1 shows, trails only OECD nations and Australia in having a low people to vehicle ratio. As in India, in Mexico both the population and the motor-vehicle fleet are growing quickly, but Mexico possesses a much stronger economy than does India. As can be seen in Figure 13, Mexico's GNP has shown a strong increase--despite a brief setback in the early 1980s--over the last 25 years; meanwhile, both its total and urban population have grown steadily. During the period of economic decline in the early 1980s, motor vehicle registrations also stagnated, but did not decline. This suggests a strong and tight temporal relationship in Mexico between GNP and vehicle registrations ($r^2=0.87$ for a simple linear model since 1970 for a relationship that would seem to demand a time lag). Therefore, if Mexico's GNP continues to rise--perhaps as a result of NAFTA--then vehicle registrations also should soar, barring a policy intervention.



Figure 13. Sources: WRD and AAMA.

In many ways, the situation in South Korea closely resembles that in Mexico: GNP, vehicle registrations, population, and urban population all are rising--most of these rapidly. In South Korea, however, the economy did not decline in the early 1980s and the rate of population growth began declining shortly after 1950, while Mexico is just now beginning to see its rate of population growth decline. As a result, motor vehicle registrations have grown exponentially in South Korea with no break since 1970. Clearly, however, this growth cannot be unbounded, because it were it would lead to nearly one billion registered vehicles by 2025--about 200 cars per person! Therefore, we must assume a logistic growth rate, bounded at about 50 million, or one per person (see Figure 14).

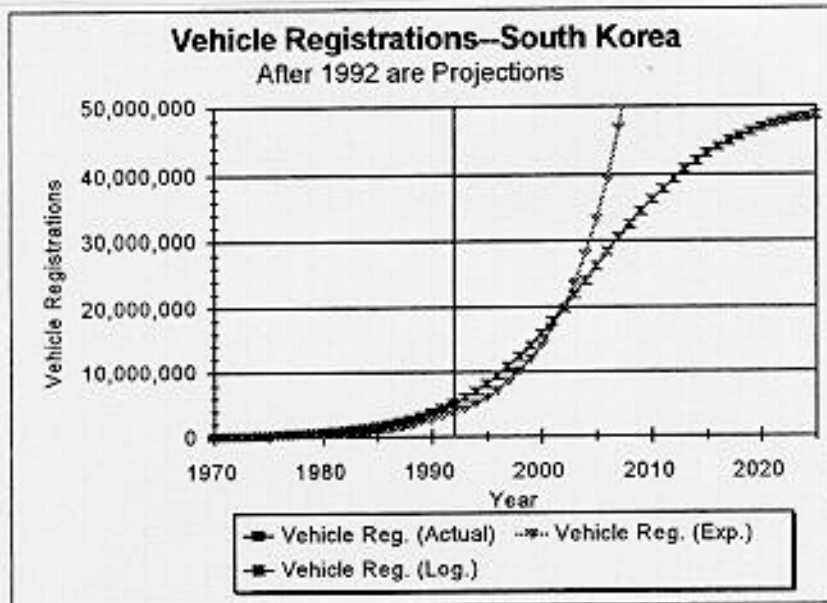


Figure 14. Source: AAMA.

This curve fit indicates a nearly tenfold increase in South Korea's motor vehicle fleet, which can be expected to increase South Korea's contribution to greenhouse gas emissions. Given South Korea's strong economic position and world class domestic vehicle production facilities, however, South Korea, like the U.S. and Japan, stands in a good position to pursue technology as one policy approach for mitigating the effects of a growing vehicle fleet. Furthermore, given that most of South Korea's population is urban, the maintenance of public transportation and the restriction of parking in city areas offer parallel options aimed at the behavioral side of the equation.

Discussion

Overall, all nations in this study displayed a propensity toward more motor vehicle registrations and, hence, increased greenhouse emissions. Furthermore, all save Hungary, either already are or soon will be large contributors on a global scale. Analysis of trend data, however, also shows that all five nations faced with this problem have available policy options that will allow them to mitigate the problem, perhaps even leading to a net decline in greenhouse emissions from the motor vehicle sector. As expected, the likely solutions that emerged from the data vary from nation to nation.

In general, the nations with high GNPs, domestic auto industries, and low rates of population growth seem best poised to pursue technologically based remedies, including transitioning to alternative fuels and mandating improved fuel economy. Such nations also appear able to benefit from changes in travel behavior. While numerous approaches to reducing the reliance on vehicular travel have been proposed, including following the European lead of internalizing some of the social costs of driving into car and fuel prices, none have been greeted enthusiastically in the U.S. In Japan and South Korea, where such policies do exist, car ownership is associated with status, prestige, and other difficult-to-overcome attributes. Two related possibilities that have some promise in all three nations are road pricing and congestion pricing. These two policies are both aimed at capturing some of the social costs of driving by introducing per-trip tolls based on mileage, time of travel, or both, thereby increasing the marginal cost of a vehicle trip (Gomez-Ibanez 1992). Congestion pricing already has succeeded in reducing traffic volume in places such as Singapore, and California soon will unveil a congestion pricing scheme in the Anaheim-to-Riverside corridor.

In Hungary and the rest of Eastern Europe, typified by little or no population growth and outdated vehicle technology, technological advances again appear to be the best path to reduced greenhouse emissions, but the relevant technologies are different than what was prescribed for the U.S. and Japan. Rather than expecting a transition to ultralights and super-efficient cars of tomorrow, Hungary and other Eastern European nations can be served well simply by allowing market forces to engender a transition from 1970s to 1990s technology, while at the same time taking steps to protect against the development of an autocentric culture. In this regard, following the lead of their Western-European neighbors and internalizing the social costs of driving should provide an ameliorative influence.

For third world nations, characterized here by India, technological solutions appear to be out of reach due to economic factors. Although the transportation sector in such nations currently makes a relatively small contribution to global greenhouse emissions, large populations and the hope of future economic development leave these nations poised to dramatically increase their vehicle use and greenhouse emissions. In these nations, a

policy emphasis on travel behavior patterns appears to be most appropriate. If pursued, such a policy may allow such nations to avoid developing an emissions problem in the first place.

Finally, for nations such as Mexico caught squarely in the middle of larger and more unstable population and economic transitions, the motor-vehicle future is far more difficult to predict. Compared to South Korea--a developing nation nearing the end of its development transition and on a par economically with the developed world--Mexico has yet to enter an exponential growth phase in motor vehicle registrations (a simple linear model better fits vehicle registrations than does an exponential curve). Probably, Mexico and similar nations have the possibility of pursuing all policies available--bringing the latest technology into their vehicle fleet when possible, promoting public transit, while at the same time bringing population growth under control--to avoid entering this vehicle growth spurt. Therefore, these nations have the opportunity to approach or match the OECD nations in economic development without falling prey to at least one of the ills of life in the industrialized world--over reliance on motor vehicles.

Thus, the transition period presents nations with two paths, and the selection of one or the other is to a large extent within the control of policy. One path--chosen explicitly or implicitly by South Korea--closely follows the Western world and leads to over-reliance on motor vehicles and increased environmental degradation on a global scale. The other path, less traveled and partially unexplored, appears to lead to economic development that is more friendly to the global environment. As described by chaos theory (see, e.g., Prigogine and Stengers 1984), periods of uncertainty may quickly give rise to irreversible outcomes. Therefore, the selection of a path to follow is crucial, and evidence from the industrialized world suggests that choosing the motor-vehicle dominated path is costly to the global environment and may dictate an undesirable future from which there may be no escape.

Conclusion

The ultimate effects of greenhouse gases on the global climate remain uncertain. Even more uncertain is how these global changes will play out at local and regional scales.

Some still argue that global climate change is either not occurring or not dangerous even if it is occurring. Others, of course, predict dire consequences if global climate change is not halted (Brown, et al. 1994). Following Drake, however, we must not neglect the possibility that the period during which the climate is changing, and not the resultant state of the future global climate, is the period most deserving of close scrutiny and remedial action. That period is now. By following some or all of the policy recommendations discussed in this paper, we may yet be able to slow the pace of change, which should serve to mitigate the negative consequences of a transitional period. Furthermore, by not delaying our policy response, we allow scientific research on global climate change to find more answers before we needlessly condemn future generations to a changed global climate of our making.

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